Watershed Action Plan

Raccoon Creek above Hewett Fork to below Elk Fork Watershed

2009

Ben McCament, Jen Bowman, and Qian Zhang- Voinovich School of Leadership and Public Affairs, Ohio University

Executive Summary

The purpose of the Raccoon Creek above Hewett Fork to below Elk Fork Management Plan is to maintain, improve, and restore the chemical, physical and biological integrity of the watershed. This is the objective put forth by the Clean Water Act of 1972. This plan is based on the outline provided in the Appendix 8 update to "A guide to Developing Local Watershed Action Plans in Ohio". This plan also satisfies a requirement of the Ohio Department of Natural Resources' Watershed Coordinator grant.

The Raccoon Creek above Hewett Fork to below Elk Fork Management Plan has been produced to document the restoration projects that have been completed or are currently underway, establish or monitor watershed baseline conditions, and identify restoration project needs and action plans in the watershed. Action plans are provided at the 14-digit hydrologic unit code (HUC) scale. This plan is the second of five 11 digit HUC watershed areas for Raccoon Creek.

This plan is organized into two sections. The first section provides a watershed overview for the 11-digit HUC section, the Raccoon Creek above Hewett Fork to below Elk Fork. The second section is dedicated to action plans for each of the six 14-digit HUC subwatersheds therein.

Much of the information provided in this plan was first compiled in the *2003 Raccoon Creek Headwaters AMDAT plan*, the *2004 Middle Basin Raccoon Creek AMDAT plan*, and the *Raccoon Creek Management Plan: A collaboration of Raccoon Creek partners and community members of the Raccoon Creek watershed,* produced in 2003 by the Institute for Local Government Administration and Rural Development (ILGARD) at Ohio University. The 2003 watershed plan approach considered the entire Raccoon Creek watershed.

This watershed action plan was authored under the premise of *adaptive management* which suggests that future management planning will evolve based on the findings and recommendations of this plan. Watershed conditions experience constant change and this plan attempts to identify priority projects for the next five to ten years.

Acknowledgements

The Raccoon Creek above Hewett Fork to below Elk Fork Management Plan was developed with funds provided by the Ohio Department of Natural Resources Division of Soil & Water Conservation's Watershed Coordinator Program with additional support of Ohio University's Voinovich School of Leadership and Public Affairs.

Several individuals supported and contributed to the production of this Management Plan by offering expertise, effort, insight and materials:

- Qian Zhang, student, Department of Geological Sciences, Ohio University
- Jason Akbar, student, Department of Political Science, Ohio University
- Jennifer Bowman, Environmental Project Manager at the Voinovich School, Ohio University
- Sheila North, Graduate Student, Biological Sciences, Ohio University
- Vladislav Pascal, Data Analyst at the Voinovich School, Ohio University
- Cindy Poole, Data Analyst at the Voinovich School, Ohio University
- Matt Trainer, Geographic Information Systems Specialist at the Voinovich School, Ohio University
- Sarah Watling – Voinovich School of Leadership and Public Affairs, Ohio University

This Plan contains information and data from several agencies or organizations either through published reports or from agency records:

- Ohio Department of Natural Resources - Division of Mineral Resources Management
- Ohio Department of Natural Resources – Division of Soil and Water Conservation
- Ohio Department of Natural Resources – Division of Wildlife
- Ohio Department of Natural Resources – Division of Natural Areas and Preserves
- Ohio Environmental Protection Agency
- Ohio University, Institute for Local Government Administration and Rural Development (ILGARD). *Raccoon Creek Management Plan*
- Ohio University's Voinovich School of Leadership and Public Affairs
- United States Geological Survey
- United States Forest Service – Wayne National Forest
- Vinton County Soil and Water Conservation District
- Midwest Biodiversity Institute
- United States Department of Agriculture – Natural Resources Conservation Service

Table of Contents

List of Tables

List of Figures

Appendices

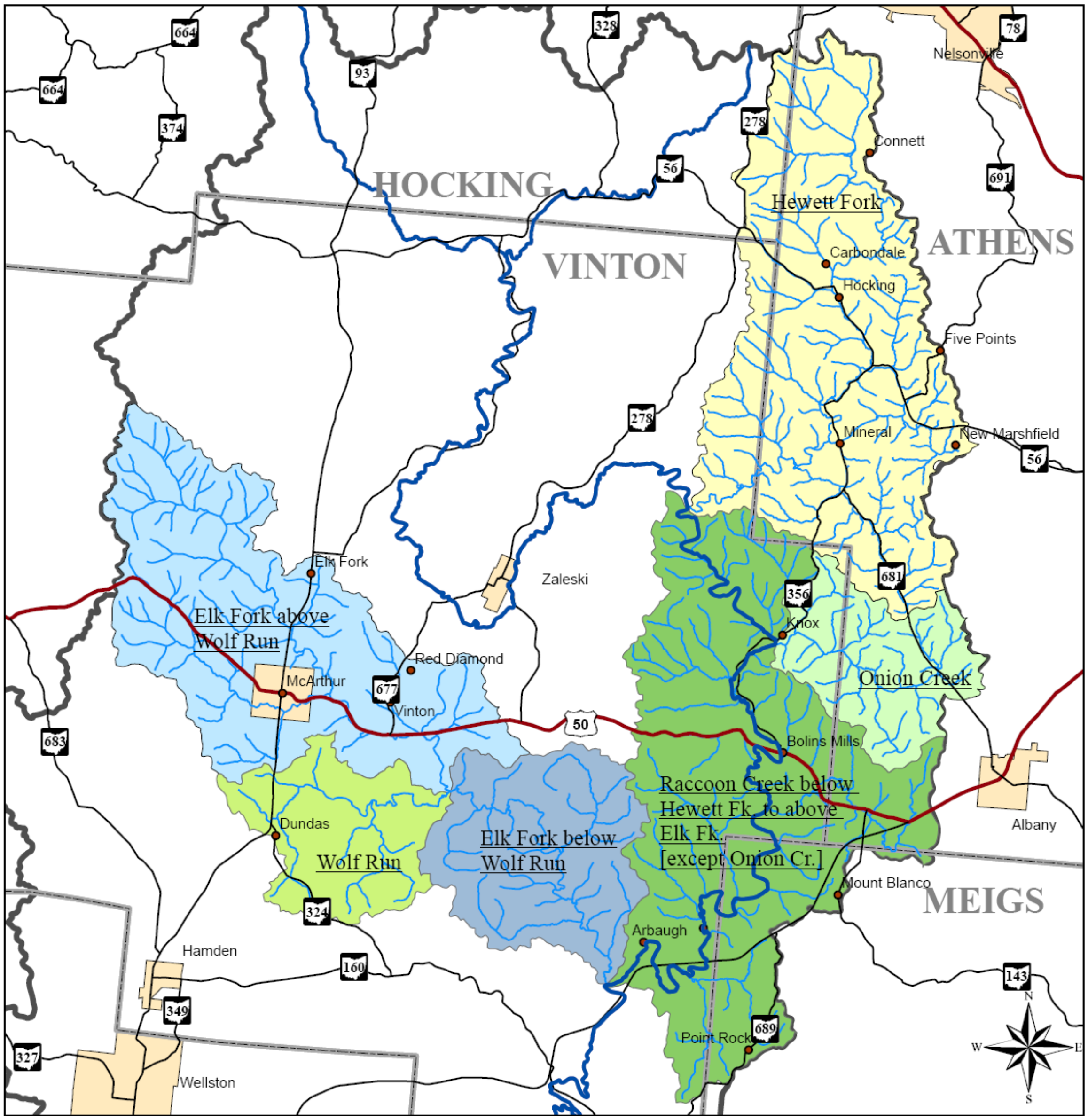
List of Maps

SECTION I.

WATERSHED OVERVIEW

FOR

RACCOON CREEK
ABOVE HEWETT FORK TO BELOW ELK FORK WATERSHED



Watershed Description

Introduction

The Raccoon Creek watershed begins at the southern boundary of Hocking County and generally flows south until it enters the Ohio River in Gallia County, south of Gallipolis (Map 1). Raccoon Creek is 112 miles in total length and the watershed covers an area of approximately 683 square miles. The watershed lies within portions of six counties: Hocking, Vinton, Athens, Meigs, Jackson, and Gallia. This Raccoon Creek comprehensive watershed management plan addresses water quality in one portion of the overall watershed, the "Raccoon Creek above Hewett Fork to below Elk Fork" sub-watershed, Hydrologic Unit Code (HUC) 05090101-030.

For planning and assessment purposes, watersheds throughout the nation are given a Hydrologic Unit Code (HUC) by the US Water Resources Council. This classification system organizes watersheds and sub-watersheds into increasingly smaller units as the code increases in digits. The Raccoon Creek watershed has been divided up into five separate 11-digit hydrologic units (HUCs), or sub-watersheds (Table 1).

Table 1. Raccoon Creek Watershed 11-Digit HUC Sub-watersheds

11-Digit HUC	Name	Acres
05090101-020	Raccoon Creek (headwaters to above Hewett Fork)	86,714
05090101-030	Raccoon Creek (above Hewett Fork to below Elk Fork)	99,233
05090101-040	Raccoon Creek (below Elk Fork to above Little Raccoon Creek)	60,789
05090101-050	Little Raccoon Creek	98,927
05090101-060	Raccoon Creek (below Little Raccoon Creek to Ohio River)	90,081

Within each 11-digit HUC watershed, sub-watersheds are delineated into 14-digit HUC watersheds. The 14-digit HUC watershed is the smallest defined watershed unit. In the Raccoon Creek above Hewett Fork to below Elk Fork sub-watershed there are six 14-digit HUC watersheds (Map 2, Table 2). Data collection and planning for watershed restoration and protection is done at the 14-digit HUC level in this watershed action plan.

The "Raccoon Creek above Hewett Fork to below Elk Fork" sub-watershed drains 60 square miles or 99,233 acres. The smallest portion is located in Hocking County, a small portion is also located in Meigs County, a portion is located in Athens County, and the largest portion is located in Vinton County. In Hocking County, the sub-watershed is located in a portion of Starr Township. In Meigs County, the sub-watershed is located in a portion of Columbia Township. The sub-watershed is located in portions of York, Waterloo and Lee townships in Athens County and Brown, Knox, Vinton, Jackson, Richland, Elk, and Clinton townships in Vinton County.

Table 2. Raccoon Creek below Hewett Fork to above Elk Fork 14-digit HUC Watersheds

14-Digit HUC	Name	Acres
05090101-030-010	Hewett Fork	25,955
05090101-030-020	Onion Creek	6,866
05090101-030-030	Raccoon Creek below Hewett Fork to above Elk Fork [except Onion Creek]	28,169
05090101-030-040	Elk Fork above Wolf Run	20,973
05090101-030-050	Wolf Run	7,076
05090101-030-060	Elk Fork below Wolf Run to Raccoon Cr.	10,241

Raccoon Creek below Hewett Fork begins near the county line between southern Hocking County and western Athens County just west of the former community of Connett. The Hewett Fork section flows south curving to the west before reaching the unincorporated community of Carbondale. Beyond Carbondale, Hewett Fork continues south until reaching the unincorporated community of Mineral where flow goes to the west until converging with Raccoon Creek in northeastern Vinton County. Raccoon Creek continues flowing south-southeast. Elk Fork begins northwest of Vinton Township where it begins to flow southeast. From Vinton Township, Elk Fork flows south-southeast until converging with Raccoon Creek south of the community of Arbaugh.

The Raccoon Creek above Hewett Fork to below Elk Fork is generally a rural area. The entire subwatershed has a population of 8,237 based on 2000 Census data. The largest population is found in the village of McArthur, the county seat of Vinton County with 1,888 inhabitants. Other population clusters are around the communities of New Marshfield, Carbondale, Mineral, and Mount Blanco.

Ohio EPA Phase II Stormwater regulations do not apply to the aforementioned communities because they are below the established population requirements for those regulations. The Raccoon Creek above Hewett Fork to below Elk Fork watershed contains large public land holdings that attract tourists from around the state for recreational activities including hunting, hiking, mountain biking, backpacking, horseback riding, camping, bird watching, canoeing, kayaking, fishing and many other recreational pursuits.

Public lands include the Waterloo Wildlife Area including Penrod Lake, a portion of Zaleski State Forest, and a portion of the Wayne National Forest. The majority of the 3,000 plus acres of the Waterloo Wildlife Area are in central portion of this watershed which is adjacent to the Zaleski State Forest. In its entirety, the Zaleski State Forest covers 26,827 in Vinton and Athens Counties. A small portion of the Wayne National Forest is located in the northeastern part of this watershed.

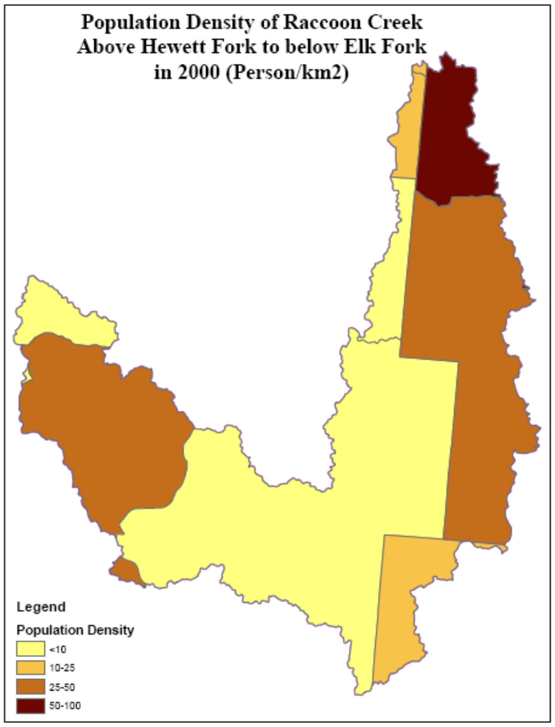
Demographic Description

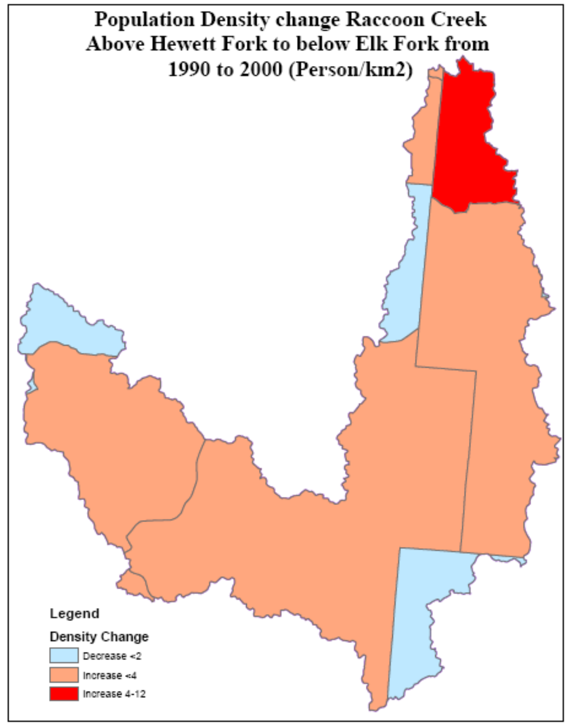
The area is comprised of a large portion of Vinton County, a smaller area inside southwestern Athens County, and additional small portions of southeastern Hocking County and northwestern Meigs County. The total population in the Raccoon Creek above Hewett Fork to below Elk Fork watershed is 7,657. The total population in the watershed is 33,327, and the population for the entire state of Ohio is 11,353,140. From these figures, it is evident that the Raccoon Creek above Hewett Fork to below Elk Fork watershed is sparsely populated. The population of this 11-digit HUC represents approximately 23% of the entire Raccoon Creek Watershed population, and is only 0.07% of the state's total population. Similarly, the density of Raccoon Creek above Hewett Fork to below Elk Fork watershed is 49.4 people per square mile, whereas the density for the state of Ohio is 277.3. This is significantly lower than the state average.

The median age in the Raccoon Creek above Hewett Fork to below Elk Fork watershed is 34.4 years of age which is slightly lower than that of the entire watershed which is 36. The average household size is 2.50 persons for this 11-digit HUC watershed, compared with 2.58 for the entire Raccoon Creek watershed. The per capita income for Raccoon Creek above Hewett Fork to below Elk Fork watershed is $15,110, drastically lower than the Ohio average of $21,003. These numbers may correspond with the levels of education in this watershed. Out of 4,831 students in the Raccoon Creek above Hewett Fork to below Elk Fork watershed, only 819 (17%) received higher education degrees. This is well below the average (27%) for the entire state of Ohio.

The demographic information and trends in this plan were measured using Geographic Information System (GIS) data and U.S. census tract data from 1990 and 2000. General trends indicate that the Raccoon Creek above Hewett Fork to below Elk Fork watershed is very sparsely populated, ranging from less than 10 to 100 people per square kilometer (Figure 1). Population density is also fairly low in the watershed and there is also no evidence of significant increased development in regard to population density changes from 1990 to 2000 (Figure 1). The Hewett Fork watershed experienced the most change in population density with an increase of 4 – 12 people per km^2. The small villages of Carbondale and Mineral are located in this watershed area.

Figure 1. Raccoon Creek Above Hewett Fork to Below Elk Fork Population Analysis





Special Districts

Special districts and organizations that serve the Athens County section of the watershed above Hewett Fork to below Elk Fork include the Buckeye Hills-Hocking Valley Regional Development District (BH-HVRDD), the Athens County Soil & Water Conservation District, the Ohio State University Extension in Athens County, the Athens County Planning Commission, and the Athens County USDA Farm Service Agency.

Special districts and organizations that offer services to the Vinton County section of the watershed above Hewett Fork to below Elk Fork include the Vinton County Development Department, the Vinton County Emergency Management Agency, and the Vinton County Soil and Water Conservation District. The Ohio Valley Regional Development Commission (OVRDC) also serves Vinton County. Jackson County's USDA Farm Service Agency provides services to Vinton County. The Ohio EPA maintains its southeast district office in Hocking County which serves the southeastern region of Ohio.

<u>Watershed Plan Development</u>

Watershed planning and restoration activities have been underway in the Raccoon Creek watershed since the mid 1980s with the formation of the Raccoon Creek Improvement Committee (RCIC) (Figure 2). The first management plan was initiated by the RCIC and developed for the Little Raccoon Creek watershed in the mid 1990s by several partnering state agencies.

Watershed coordination began in 1996 with an U.S. EPA Clean Water Act section 319 grant. A project manager was hired and based at the Vinton Soil and Water Conservation District at that time. From 1996 to 2007, a Raccoon Creek projects manager has been at the Vinton SWCD coordinating and implementing acid mine drainage (AMD) water quality improvement projects. In early 2008 to present the Raccoon Creek Water Quality Specialist works from the Vinton SWCD through the Buckeye Hills RC&D. In 2000 the Voinovich School of Leadership and Public Affairs at Ohio University partnered with OEPA, ODNR Division of Mineral Resources Management, OSU Extension, and the Ohio Coastal Management Program and was awarded the ODNR Division of Soil and Water Conservation Watershed Coordinator Grant. This program provides an opportunity for organizations and agencies to plan and implement water quality improvement programs on a watershed basis by supporting the Coordinator's position. The Voinovich School has been a partner and sponsor in this program since 2000 and has supported the employment of the Raccoon Creek Watershed Coordinator. A second Watershed Coordinator grant was awarded in 2006 and will continue through 2009. The third Watershed Coordinator grant has been proposed and is being reviewed for support from 2010 through 2012.

A comprehensive Raccoon Creek Management Plan that dealt with water quality issues throughout the entire watershed was developed in 2003 (ILGARD, 2003). This 2003 plan was created through a collaboration of Raccoon Creek partners and community members and received conditional endorsement by the Ohio EPA and ODNR. The 2003 plan took an overall approach to watershed planning and restoration and was a highly involved community effort created with a methodology based on community input and participation. The 2003 plan did follow state guidance using the "Guide to Developing Watershed Action Plans in Ohio" but did not include specific restoration or protection activities on the 14-digit HUC watershed scale as described later in the Appendix 8 update after the plan was completed.

This edition, The Raccoon Creek above Hewett Fork to below Elk Fork Action Plan, is based on activities to promote water quality restoration & protection efforts at the 11-digit HUC scale. This plan is the second 11 digit HUC watershed Action Plan following Appendix 8 guidelines for the Raccoon Creek watershed.

Planning efforts and studies related to water quality in the Raccoon Creek watershed are numerous and include the efforts of several Raccoon Creek watershed partners. Two Acid Mine Drainage Abatement and Treatment (AMDAT) plans cover the 11 HUC watershed Raccoon Creek Above Hewett Fork to Below Elk Fork area. The two AMDAT plans are the Raccoon Creek Headwaters (Rice, 2002) and Middle Basin Raccoon Creek (Rice, 2003). The Headwaters AMDAT addresses AMD in Raccoon Creek upstream of the SR 50 crossing at Bolins Mills in Vinton County and Middle Basin AMDAT covers the area downstream of this point to the confluence of Little Raccoon Creek. It should be noted that the Raccoon Creek Headwaters AMDAT covers more watershed area than the 11-digit HUC watershed scale of this management plan.

Ohio EPA completed a Total Maximum Daily Load (TMDL) study for the Upper Basin of Raccoon Creek (2003). This TMDL covers three 11-digit Raccoon Creek HUC watersheds: Raccoon Creek Headwaters, Raccoon Creek above Hewett Fork to above Elk Fork, and Raccoon Creek above Elk Fork to above Little Raccoon Creek). The Ohio EPA TMDL set targets for acid mine drainage parameters such as net-alkalinity and total metal concentrations.

In 2007, a sediment TMDL was developed by Ohio University's Voinovich School of Leadership and Public Affairs for the Upper Basin of Raccoon Creek (McCament, 2007). This TMDL study established restoration targets for habitat and channel stability.

Watershed Partners

The Raccoon Creek watershed project has operated as a collaborative group of organizations, individuals, and agencies for over a decade with a goal of improving water quality in Raccoon Creek. Partnering groups and agencies have been essential in accomplishing a broad range of Raccoon Creek goals including education, public outreach, stream monitoring, and water quality improvement projects. Many of the agencies and organizations that have contributed to the watershed project over the past decade are listed in Appendix 1.

Through various planning and fundraising efforts it became apparent that there was a need for the watershed project to formalize its structure and become a member-based organization. In 2007, the Raccoon Creek Partnership (RCP) was formed and was granted incorporation status by the state of Ohio. The RCP established bylaws and received 501(c) 3 status from the IRS in October of 2007. The mission of the RCP is "to work toward conservation, stewardship, and the restoration of the watershed for a healthier stream and community". Representation from individuals, landowners, Ohio EPA, ODNR-DMRM, Ohio University's Voinovich School of Leadership and Public Affairs, and the Vinton County Soil and Water Conservation District sat on the RCP's interim Board. In October of 2007, the RCP held its first election to replace the interim Board of Directors with elected Directors. The bylaws state that the nature of the organization "is formed as a partnership of individuals, businesses, agencies, organizations, institutions, corporations, and governmental units with the common mission and purpose of the Raccoon Creek Partnership".

The RCP's established bylaws (Appendix 2) outline the purpose, membership levels, the Board of Directors offices and duties, various committees within the Board of Directors, financial provisions, quorum stipulations, amendment procedures, indemnification, and dissolution processes. The bylaws set up a shared governance system that incorporates participation from agencies, organizations, and individuals who want to contribute to the partnership. Currently, the RCP is building relationship with important stakeholders and establishing a membership base.

Watershed partners and stakeholders in the Raccoon Creek above Hewett Fork to below Elk Fork watershed specifically include any and all individuals and entities that will be affected by this plan. This includes: local and state agencies, county commissioners and other local government officials, educational institutions, citizens groups, and non-governmental organizations. Land owners in the watershed are also critical partners for restoring and protecting water quality and habitat in the Raccoon Creek above Hewett Fork to below Elk Fork watershed. Since a portion of land ownership in the Raccoon Creek above Hewett Fork to below Elk Fork watershed is public, the U.S. Forest Service and the Ohio Department of Natural Resources (Divisions of State Parks, Wildlife, Forestry, and Mineral Resources Management) are essential partners. Other key stakeholders in the Raccoon Creek above Hewett Fork to below Elk Fork watershed include:

- The Raccoon Creek Water Trails Association: In 2005, a group of local citizens interested in recreation and stewardship of Raccoon Creek joined to form the Raccoon Creek Water Trails Association (RCWTA). The group is composed of paddlers, watershed advocates, biologists, and outdoor recreation professionals and enthusiasts. Membership is open to anyone with an interest in the watershed. The RCWTA has partnered with the Ohio Department of Natural Resources Division of Watercraft and Division of Forestry, the local non-profit Sojourners, and the RCP. The mission of the RCWTA "is to encourage stewardship, environmentally responsible recreation, and economic and scenic opportunities in the Raccoon Creek Watershed. We seek to promote natural and cultural resources through public access and education".

- The Moonville Rail Trail Association (MRTA) began in 2001 and is working to establish, maintain and promote a recreational trail system with emphasis on the use of former rail lines and connecting corridors. The MRTA is a non-profit organization that preserves local history and the environment, provides educational opportunities for trail design, use, and maintenance, assists the surrounding communities in promoting education, tourism, and economic development, and creates an awareness of the needs of different "muscle-powered" user groups. The MRTA has various volunteer committees such as: public relations and fundraising, a trail committee, and a grant committee. The MRTA holds regularly scheduled public meetings at the Hope School House, near Lake Hope.

Additional stakeholders operating in the Raccoon Creek above Hewett Fork to below Elk Fork include the Ohio Outback Conservation Corps, an AmeriCorps program of Sojourners headquartered in McArthur; the Vinton County Agriculture Society or Vinton County Fair Board; the Ohio Valley Resource Conservation and Development (RC&D) Council serving Vinton County; the Tri-County (Hocking-Athens-Perry) Community Action Agency; and the Corporation for Ohio Appalachian Development (COAD). Educational institutions include Ohio University and Hocking College which both serve the region. OSU Extension has an office in Vinton County.

Figure 2. Raccoon Planning and Implementation Timeline

Timeline of the Raccoon Creek Watershed Project Milestones & AMD Projects

This timeline demonstrates the history of the Raccoon Creek Watershed Restoration Partnership started almost two decades ago by a group of concerned local citizens. Today, the partnership consists of multiple state and local agencies and private citizens. AMD projects have been administered through the Vinton Soil and Water Conservation District and Ohio University's Voinovich Center (ILGARD), with funding from various state and federal grants but mostly from Ohio EPA's 319 program and ODNR-MRM's AMD program.

1980s
- Formation of Raccoon Creek Improvement Committee (RCIC): Grassroots citizens group to address water quality in Raccoon Creek

Early 1990s
- RCIC invites citizens from all six counties to join efforts

Late 1990s
- Formation of Raccoon Creek Watershed Partnership, a loosely based partnership of agencies to address technical AMD issues

1999 State Route 124 Strip Pit and Buckeye Furnace Project completed

2000 Little Raccoon Creek AMDAT completed
- Watershed Coordinator position funded for six years

2001 Headwaters AMDAT completed
- State Route 124 seeps project completed

2003 Mulga Run project completed
- Middle Basin AMDAT completed
- Completed management plan for Raccoon Creek Watershed

2004 Carbondale II project completed

2005 Middle Run-Salem Road project completed

2006 Raccoon Creek Water Trail Association formed
- Mission to Establish a water trail on Raccoon Creek
- Flint Run and Lake Milton Projects completed
- Watershed Coordinator three year extension funded

2007 Raccoon Creek Watershed Partnership formed 501 (c) 3

2008 East Branch Phase I AMD Project

2009 Pierce Run AMD Project
- East Branch Phase II Project

General Plan Contents

This watershed action plan has been produced to address the key concepts suggested in "A Guide to Developing Local Watershed Action Plans in Ohio". The plan's organization is based on the Appendix 8 Update to that guide. This plan is designed to identify problem areas and provide action recommendations to achieve water quality improvement and protection to meet warm water habitat standards.

This watershed action plan includes information and data from the original watershed management plan which took an overall approach to the watershed, as well as new information and data drawn from a variety of sources which is attributed to 11-digit and 14-digit hydrologic unit codes (HUC) watersheds.

This action plan will be submitted to the OEPA and the ODNR for approval. Upon receiving approval from those agencies the plan will be presented to local units of government for adoption and implementation.

Education and Outreach

The composition of this watershed action plan included the participation of several Raccoon Creek partnering agencies and organizations who have been working for more than a decade on water quality improvement projects in the watershed. The Technical Advisory Committee of the Raccoon Creek Partnership is involved in all planning and project development and coordinates activities with the RCP board of directors. The Raccoon Creek Coordinator, Water Quality Specialist, and the RCP board of directors work with landowners to implement non-point source (NPS) projects in the watershed. Implementation of this watershed action plan will be carried out through local, state, and federal Raccoon Creek partnering agencies, organizations, and individuals.

Watershed Description

Land Use

Land use is a dominant factor in determining the overall condition of a watershed. The following section presents a summary of land use in the Raccoon Creek above Hewett Fork to below Elk Fork watershed based on 2001 land use data (Map 4).

The dominant land cover in the entire Raccoon Creek watershed is forest, comprising 80% of the land base. Deciduous hardwoods account for 75% of this forest land use. Agricultural land makes up only 13% of the watershed, with only 4% in row crops and 9% in pasture and hay. The only other significant land type is low intensity residential which accounts for less than 6% of the land base.

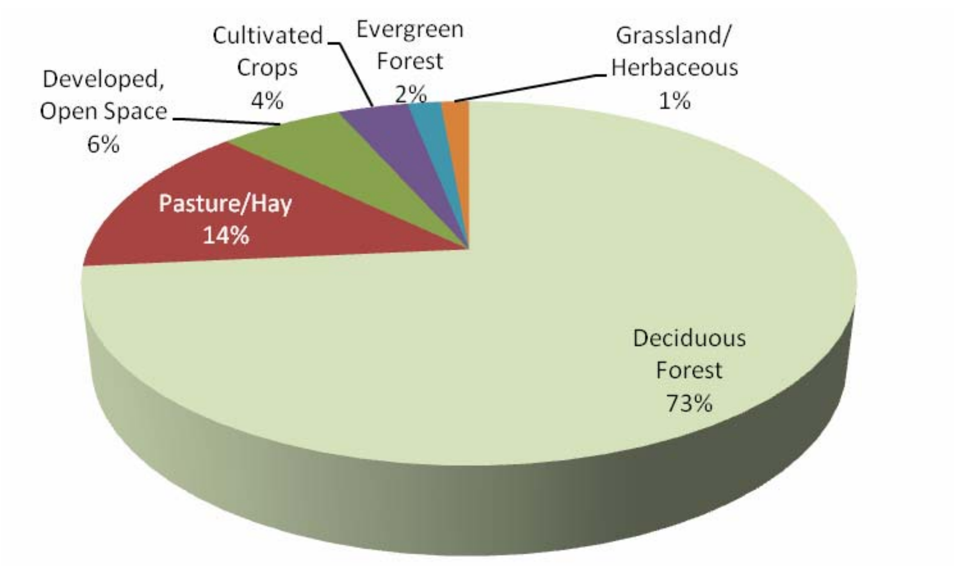
All land cover data for Raccoon Creek above Hewett Fork to below Elk Fork 11 HUC watershed is shown in Table 3 below with acreages and percentages of total. The dominant land cover in the 11-digit HUC of Raccoon Creek from Hewett Fork to Elk

Fork watershed is forest, comprising 75% of the land base (Figure 3). Deciduous hardwoods account for 73% of this forest land use whereas Evergreen forests account for 2%. Agricultural land makes up only 18% of the watershed, with 4% in row crops and 14% in pasture and hay. Another significant land type includes developed open spaces which account for roughly 6% of the land base.

Table 3. Land Cover Above Hewett Fork to Below Elk Fork Watershed
(Source: 2001 National Land Cover Database)

Land Cover Category	Acres	Percentage
Open Water	189	<1%
Developed, Open Space	5,946	6%
Developed, Low Intensity	644	<1%
Developed, Medium Intensity	99	<1%
Barren Land (Rock/Sand/Clay)	579	<1%
Deciduous Forest	70,404	72%
Evergreen Forest	1,588	2%
Mixed Forest	2	<1%
Shrub/Scrub	833	1%
Grassland/Herbaceous	1,362	1%
Pasture/Hay	13,099	13%
Cultivated Crops	3,375	3%
Forested Wetlands	8	<1%
Emergent Herbaceous Wetlands	3	<1%
Other	22	<1%

Figure 3. Primary Land Cover Above Hewett Fork to Below Elk Fork (2001)
Discrepencies in percentages from Table 3 are due to Land Cover categories only greater than 1% of total area displayed in this figure



Current land cover is not always indicative of past land uses. Trends since 1994 include a decrease in pasture/hay from 18 to 13%, a decrease in row/cultivated crops from 7 to 3% and an increase in developed/open space from 1 to 6%. This shows a small trend toward less agricultural use and more rural residential land use in the watershed. Deciduous forest cover has remained constant as the primary land use at 72% since 1994.

Additionally, Raccoon Creek and its tributaries have been subjected to a series of land use changes over the past two centuries that have had long lasting impacts on streams. The first forest clearing began in the early 1800s for agriculture with the first European settlers moving into the region. By the mid 1800s the iron furnace industry had taken hold, which led to wide scale deforestation. Each iron furnace is believed to have cleared a five square mile surrounding area for timber to make charcoal for the furnace. Coal mining began in the watershed in the late 1800s with small underground room and pillar mines, which also required large amounts of timber for roof supports and train tracks. Coal mining also led to boom-towns in the watershed. These towns reached peak population levels in the early 1900s and exist today (if at all) as a small relic of the area's industrial past. Reforestation began in the region in earnest with the Great Depression where many family farms were abandoned and left fallow. In addition, federal and state governments began buying up land and allowing reforestation to occur.

Cultural Resources

Documented human history in the watershed began with the Adena Native American tribe. The Hopewell, Shawnee and Delaware groups followed. European influences began to appear in the 1740s. In 1795, the Delaware, Shawnee and several other Native American tribes signed the Treaty of Greenville, ending the Northwest Indian War and relinquishing Native American land rights throughout the region.

In 1849, the Scioto and Hocking Valley Railroad began. By 1856, the main line of the Marietta and Cincinnati Railroad was complete, resulting in the establishment of Zaleski as a prospering railroad town from the mid-1860s to 1890s. By the 1880s, rail lines had reached McArthur and stimulated growth there as well. From the 1880s to the 1970s rail lines were the primary transportation for coal in the region until trucking and highways were established.

Points of Interest in the Raccoon Creek above Hewett Fork to below Elk Fork Watershed Include:

- **Eakins Mill Bridge Covered Bridge**: Constructed in 1871, Eakins Mill Bridge appears on the Nation Register of Historic Places. It is the oldest of Vinton County's remaining five covered bridges and spans Raccoon Creek (Figure 4).

Figure 4. Aerial Photograph of the Eakins Mill Bridge which spans Raccoon Creek

(photo taken in 2006 – Ben McCament)

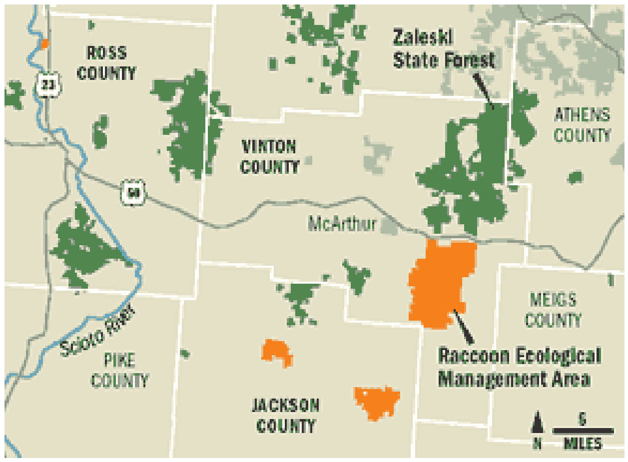
- **Bay Covered Bridge**: Constructed over Little Raccoon Creek in 1876 near the present man-made Lake Rupert. In 1967, it was transported to the Vinton County Fairgrounds.

- **Waterloo Wildlife Area**: The property is owned by the Ohio Department of Natural Resources. Waterloo is a wildlife research station in Athens County located at the junction of State Routes 56 and 356. The wildlife area provides a scenic forest habitat for many species of fish and other wildlife including approximately 80 species of birds. The area is a popular destination for hunting game species such as gray squirrels, wild turkeys, and white-tailed deer. It is presently being turned into an environmental education center (Map 3). Penrod Lake is also on the Waterloo property. For more information visit: http://www.dnr.state.oh.us/portals/9/PDF/pub048.pdf

- **King Switch Tunnel:** The King Switch Tunnel is located on the Moonville Rail Trail, which runs through Vinton County. The 120-foot structure is carved through rock and is supported by 12-foot square beams.

- **Raccoon Ecological Management Area (REMA):** The Raccoon Ecological Management Area (REMA) is a conservation easement initiated by the Ohio Department of Natural Resources (ODNR). The Mead Paper Company formerly owned this 15,896-acre region in Vinton County. However, cooperation between ODNR, the Conservation Fund, and the Forestland Group has made REMA the state's largest tract of privately owned woodland. The region is home to various endangered species, such as bobcats, black bears, timber rattlesnakes, and cerulean warblers, whose habitats will now be protected through this conservation plan (Figure 5).

Figure 5. Map of the Raccoon Ecological Management Area



- **Vinton Furnace Experimental Forest:** Located within the Raccoon Ecological Management Area (REMA), the Vinton Furnace Experimental Forest is a 2,600-acre region approximately ten miles south of McArthur. Presently, the area is a site for silvicultural and ecosystem management studies. The Vinton County Experimental Forest is managed by joint cooperation between the Mead Corporation and the United States Department of Agriculture (USDA) Forest Service's North East Research Station.

Geology

Generally, the topography of the Raccoon Creek above Hewett Fork to below Elk Fork is typical of the unglaciated region of southeast Ohio. Steep hillsides, narrow ravines, attenuated ridges, and relatively narrow stream valleys with constricted floodplains characterize the topography. Rock outcrops and overhangs are also common geologic features of the landscape. Most ridge tops have elevations of 600 to 1,100 feet. Valleys range between 0.25 and 0.50 miles wide with occasional broader stretches of undulating and gently rolling terrain. The average fall of the creek is 3.8 feet per mile. The steep topography limits land uses such as cropland to the lowland areas such as the Elk Fork Valley, and exacerbates problems with soil erosion, sedimentation, and acid mine drainage which is primarily the result of abandoned coal mining sites.

The Raccoon Creek above Hewett Fork to below Elk Fork watershed lies wholly within the unglaciated Allegheny Plateau Eco-region in the foothills of the Appalachian Mountains. Principally, the bedrock of the Raccoon Creek Watershed is composed of sedimentary rock from the Mississippian and Pennsylvanian geologic time periods. The Mississippian System, which formed 325 million to 345 million years ago, is comprised of the Cuyahoga and Logan members. The Cuyahoga member consists of shale overlain by Blackhand sandstone. The Logan member is made of sandstone, shale, and conglomerate and overlies the Cuyahoga member. The Logan member is in-turn overlain by the Pottsville and Allegheny formations of the Pennsylvanian System, which are about 280 million to 325 million years old (Slucher et al., 2006). The Logan and Cuyahoga members represent the bedrock in the western portion of this watershed until just west of the village of Vinton where the Allegheny and Pottsville formations become the primary bedrock. The northern portion of this watershed is a combination of mostly Allegheny and Pottsville intermingled with some Logan and Cuyahoga members. The southeastern boundary of the watershed has a very minimal presence of Conemaugh group formation.

In Ohio, these three formations include coal seams of various thicknesses, all of which have been mined to some degree. In addition, more than 90% of the coal produced in Ohio is extracted from the Allegheny and Monongahela Formations. In this region of Ohio, sedimentary deposits or distinctions between the major Pennsylvanian Formations were originally made based on mineral coal amounts and therefore constitute a pragmatic rather than a lithological framework for identifying formations. Coal mining in the Raccoon Creek above Hewett Fork to below Elk Fork consisted both of underground and surface mines. The underground mines were generally located in the northeastern portion of the watershed while the surface mines were concentrated in Vinton County just to the west of Elk Fork with an additional portion of surface mining in the southern tip of the watershed. The total amount of underground mined area in the watershed is 11,054 acres compared with 4,294 acres of surface mines. Total mining makes up 15 % of the total watershed area (Map 5).

Though the section of watershed, above Hewett Fork to below Elk Fork, of Raccoon Creek lie strictly within the unglaciated portion of Ohio, the glaciers that entered Ohio from the north created changes to the geology, soils, and drainage patterns of the watershed. Prior to the earliest three glaciation events, Ohio was drained by the Teays River and its tributaries. The headwaters of the Teays River originated in present day North Carolina and are believed to have flowed through West Virginia, Ohio, Indiana, and Illinois (Hansen, 1995). As glaciers moved into Ohio they blocked the Teays River, forming Lake Tight which inundated large areas of southeastern Ohio (approximately 7,000 square miles in total area). As the water level rose in Lake Tight, the water overtopped the confining hills and the present day drainage system developed. The present drainage pattern, which shaped the Raccoon Creek watershed, began forming over 300,000 years ago. The Raccoon and Little Raccoon Creeks and their tributaries presently drain into the Ohio River basin.

Soils

The topography of Hocking, Meigs, Vinton, and Athens Counties has a great influence on the formation of soils. It effects soil formation through its effects on drainage, runoff, and erosion (Lemaster & Gilmore, 1998). Soils in the Raccoon Creek above Hewett Fork to below Elk Fork and in the region are principally of sandstone and shale origin and formed from colluvium.

Generalized soil types specific to the Raccoon Creek above Hewett Fork to below Elk Fork watershed fall into six categories (Map 6). The soil units include: Omulga-Doles, Rarden-Gilpen, Steinsburg-Rarden-Clymer-Berks, Westmoreland-Guernsey-Dekalb, Westmoreland-Steinsburg, Steinsburg-Rarden-Clymer-Berks, and Wharton-Shelocta-Latham-Brownsville.

The westernmost area of this watershed includes Wharton-Shelocta-Latham-Brownsville soil units, moving eastward, the soil type changes to Omulga-Doles. The northern most portion of this watershed includes Westmoreland-Guernsey-Dekalb. The central areas in the watershed are composed of Westmoreland-Steinsburg and Rarden-Gilpen soil types. The mainstems of both Raccoon Creek and Elk Fork flow mostly through valleys containing Omulga-Doles soils with the exception of the Meigs County section of Raccoon Creek where Rarden-Gilpin soils are encountered.

The generalized soil type in the Hocking County portion of this watershed is composed of Westmoreland-Guernsey-Dekalb. Athens County soil types in this watershed are: Westmoreland-Guernsey-Dekalb, Westmoreland-Steinsburg, and Omulga-Doles. Meigs County is mainly Rarden-Gilpen with a small amount of Omulga-Doles. The majority of this watershed is in Vinton County and is comprised of all six of the soil types found in this watershed.

Steinsburg-Westmoreland-Vandalia: Moderately deep and deep, dominantly steep and very steep, well drained soils formed in residuum and colluviums from sandstone, siltstone, shale and limestone; on uplands.

Westmoreland-Guernsey-Dekalb: Deep and moderately deep, dominantly steep and very steep, well drained and moderately well drained soils formed in residuum and colluvium from sandstone, siltstone, shale and limestone; on uplands.

The Omulga-Doles soil type is generally found in valleys and some of the larger tributaries to Raccoon Creek. The Omulga and Doles series both occur on terraces and are classified as very deep. Omulga soils are moderately well drained and range in slope from 0 – 15 percent while the Doles series are poorly drained and on slopes from 0 – 2 percent. The other generalized soils types found in the watershed are found mostly on hills and hill slopes, are shallower, and moderately drained. The Steinsburg series is the steepest soil type in the watershed with slopes up to 70 percent.

Rarden-Gilpen soils are sloping to very steep, are moderately deep, moderately well drained to well drained. Gilpin soil types and are derived from sandstone, siltstone, and shale while Rarden soil types are shale residuum.

Biological Features

Historically, the native plant community of the Raccoon Creek above Hewett Fork to below Elk Fork was predominately deciduous hardwood forest (98%) typical of the

Allegheny Plateau region. Major forest associations included mixed oak forests, mixed mesophytic forests and bottomland hardwood forests. These forest types were composed of canopy species such as American chestnut, and chestnut oak on knobs and ridges while red, black, and white oaks occupied the ravines. White ash, yellow poplar, American beech, hemlock, sugar maple, and hickory (sp) were also common species of the mixed mesophytic forest. The bottomland hardwoods were dominated by sycamore, cottonwood, black willow, yellow buckeye, green ash, red and silver maple, red and American elm and river birch. Prominent understory woody plants include flowering dogwood, redbud, spicebush, bladdernut, paw paw, rhododendron, and wahoo.

Currently, forest covers 309,209 acres or 80% of Raccoon Creek watershed, consisting mainly of "second growth" mixed mesophytic deciduous forest. Extensive timbering, agriculture, iron ore industry, and coal mining have reduced the percentage of mature forest in the watershed since settlement, however many of these acres have reverted or are presently reverting to woodland.

Historically, wildlife denizens of the watershed include large mammals such as the mountain lion, woodland bison, and timber wolf. However, by the late 19th century, these species were extirpated from the region by unregulated trapping, hunting, and destruction of habitat. Forest recovery during the mid-twentieth century led to the reintroduction of formerly extant species such as the white-tailed deer, beaver, and wild turkey, all of which have returned to healthy populations within the watershed. The forest also furnishes important breeding habitat areas for sensitive neo-tropical bird forest species such as the cerulean warbler and black and white warbler.

The Ohio Department of Natural Resources, Division of Natural Areas and Preserves (DNAP) maintains a list of rare, threatened, and endangered plant and animal species in the State of Ohio. Important endangered species found in the watershed are the bobcat, Uhler's Sundragon, blue corporal, and Madagascar ruffle lichen. A summary of all listed species is found in Table 4 and Map 7. It is important to note that these are confirmed occurrences of these species and other rare plant and animal species are likely present in the watershed but have not been officially reported. Occurrences of rare plant and animal species may be reported to the Ohio Department of Natural Resources, Division of Natural Areas and Preserves (614-265-6453; http://www.ohiodnr.com/dnap/about.htm).

Invasive Nonnative Species

Several noxious and invasive plant species occur throughout the watershed. The Division of Natural Areas and Preserves has identified more than 60 nonnative plants that negatively impact forest regions in Ohio. Some of the top invasive species such as Japanese honeysuckle (*Lonicera japonica*), bush honeysuckle (*Lonicera* species), garlic mustard (*Alliaria petiolata*), and well as multiflora rose (*Rosa Mulitflora*) occur within the watershed.

Bush and Japanese honeysuckle are especially disruptive to forest ecosystems because they suppress and displace native shrubs and trees, altering the structural features (groundcover to canopy layering or strata) and composition of the forest. Consequently, structural disturbances created by invasive plants eliminate important niches for breeding birds, thereby potentially reducing native bird populations. Similarly, garlic mustard competes and supplants native herbaceous ground cover, particularly spring wildflowers such as spring beauty, wild ginger, bloodroot, and trilliums. Invasive plants, according to the ODNR Division of Natural Areas and Preserves are a major threat to natural forest plant communities in Ohio and a critical management issue that is difficult to resolve. The division offers management suggestions and information on invasive plants through facts sheets and brochures, which are free to the public and available on-line at http://www.ohiodnr.com/dnap/about.htm.

Table 4. Ohio Department of Natural Resources Rare and Endangered Species List for the Raccoon Creek Above Hewett Fork to Below Elk Fork Watershed

Common Name	Scientific Name	Year	State Status
Plant List – Rare			
Blunt-leaved Milkweed	*Asclepias amplexicaulis*	1999	Potentially threatened
Wild Kidney Bean	*Phaseolus polystachios*	1998	Potentially threatened
Butterfly-pea	*Clitoria mariana*	1997	Potentially threatened
Green Adder's-mouth	*Malaxis unifolia*	1998	Potentially threatened
Bartley's Reed Grass	*Calamagrostis porteri ssp. Insperata*	2001	Threatened
Rock Skullcap	*Scutellaria saxatilis*	1991	Potentially threatened
Carolina Thistle	*Circium carolinianum*	1997	Threatened
Butternut	*Juglans cinerea*	1998	Potentially threatened
Canada Milk-vetch	*Astragalus canadensis*	1979	Threatened
One-sided Rush	*Juncus secundus*	1990	Threatened
Netted Chain Fern	*Woodwardia areolata*	1991	Potentially threatened
Round-fruited Hedge-hyssop	*Gratiola virginiana*	1992	Potentially threatened
White Milkweed	*Asclepias variegata*	1987	Threatened
Bradley's Spleenwort	*Asplenium bradleyi*	1988	Threatened
Tubercled Rein Orchid	*Platanthera flava*	1995	Potentially threatened
Hairy Mountain-mint	*Pycnanthemum verticillatum var. pilosum*	1991	Endangered
Large Marsh St. John's-wort	*Triadenum tubulosum*	1998	Threatened
Thyme-leaved Pinweed	*Lechea minor*	1982	Threatened
Pale Green Panic Grass	*Panicum laxiflorum*	2005	Potentially threatened
Downy White Beard-tongue	*Penstemon pallidus*	2005	Threatened
Short-fringed Sedge	*Carex crinita var. brevicrinis*	2005	Threatened
Tennessee Pondweed	*Potamogeton tennesseensis*	2005	Endangered
Bicknell's Panic Grass	*Panicum bicknellii*	2005	Threatened
Flat-spiked Sedge	*Carex planispicata*	1991	Endangered
Fringe-tree	*Chionanthus virginicus*	2006	Threatened
Animal List - Rare			
Timber Rattlesnake	*Crotalus horridus*	1991	Endangered
Bobcat	*Felis rufus*	1961	Endangered
Rough Green Snake	*Opheodrys aestivus*	1963	Special concern

Four-toed Salamander	Hemidactylium scutatum	1964	Special concern
Mud Salamander	*Pseudotriton montanus*	1963	Threatened
Pygmy Shrew	Sorex hoyi winnemana	1976	Special concern
Sharp-shinned Hawk	*Accipiter striatus*	1977	Special concern
Indiana Bat	*Myotis sodalis*	2003	Endangered
Fungus - Rare			
Dotted Ramalina	*Ramalina farinacea*	1976	X
Texas Shield Lichen	*Canoparmelia texana*	2004	Threatened

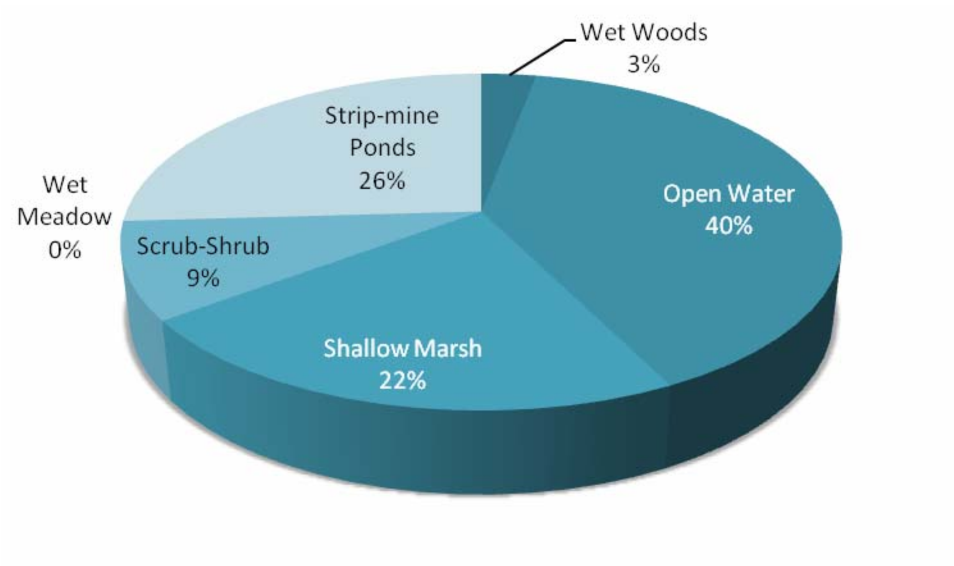
Water Resources

The watershed is located in Southeast Ohio, which in general has a temperate climate generally characterized by well-defined seasons. Typically, in winter, the average daily minimum temperature is 22 degrees Fahrenheit. The lowest temperature on record, which occurred on January 17, 1977, is -22 degrees. The average temperature for the period 1931-1980 was 53 degrees Fahrenheit. This area has an average rainfall of 40-41 inches per year (Harstine, 1991).

Wetlands

Wetland types found in the Hewett Fork to Elk Fork watershed (based on 1985-1987 LANDSAT imagery) include wet woods, open water marshes, shallow water marsh, scrub/shrub, wet meadow, and strip-mine ponds. In this watershed there are 1022 total acres of wetlands. The largest wetland category is “open water” with 40% of total wetland acreages, including deep marshes but not including rivers or streams (Figure 6, Map 8).

Figure 6. Wetland Types in Raccoon Creek’s Hewett Fork to Elk Fork Watershed



All wetlands, regardless of size and type, are ecologically valuable to maintaining a healthy landscape. Wetlands have been called the kidneys of the landscape because they can filter out sediments from surface water and absorb surplus chemicals. Wetlands also replenish groundwater supplies and serve as water retention basins, thus contributing to local flood control. Wetlands are particularly important to wildlife. Nearly 32% of Ohio's endangered species live in wetlands. Twenty percent of the endangered species found in the Raccoon Creek Headwaters are wetland species. Over one-third of Ohio's wildlife depends upon wetlands for their survival.

Although less than one percent of the Raccoon Creek watershed's land use types are wetlands, the wetlands that do exist are unique and specific to forest ecosystems, such as the buttonbush shrub swamp and submergent riverine community. Both of these wetland types furnish habitat for rare salamanders, the prothonotary warbler, and waterfowl species like the wood duck and black duck.

Groundwater

In the state of Ohio, sedimentary bedrock from the Silurian, Devonian, Mississippian and Pennsylvanian systems comprises the dominant bedrock groundwater sources, and precipitation is the primary recharge to aquifers here. The Pennsylvanian system is the bedrock of the Raccoon Creek watershed. Groundwater in this system is found in sandstone, shale, and fractured coal, with a general yield of zero to twenty-five gallons per minute. The best water-producing zone occurs in the Sharon Conglomerate and water quality depends on the presence of coal. Quality is relatively high with respect to sulfate, iron, manganese, and total dissolved solids.

Groundwater is the dominant source of domestic water supply in the Raccoon Creek watershed. However, compared to the rest of the state, southeast Ohio has relatively little groundwater, at flows of less than five gallons per minute. Most of the watershed in Vinton County yields less than three gallons of water per minute. This bedrock contains sandstone, shale, fireclay, coal, and limestone. However, a large section of the Blackhand sandstone lies in the central and north eastern part of the county and extends north to Hocking County, underlying much of the Elk Fork sub-watershed. This bedrock yields five to twenty-five gallons per minute with more mineralized water found in the east. Aquifers in this area are sand and sandstone.

The Ohio EPA Division of Drinking and Ground Waters utilizes the DRASTIC method as a primary tool in evaluating the hydrogeologic sensitivity of an aquifer to contamination. DRASTIC stands for Depth to water, net Recharge, Aquifer media, Soil media, Topography, Impact of vadose zone media, and hydraulic Conductivity of the aquaifer. A relative ranking scheme, called the DRASTIC index, is applied to ground water resources to prioritize their vulnerability to ground water contamination. However, this information is not yet available for most of the Raccoon Creek above Hewett Fork to below Elk Fork watershed, which is primarily located in Vinton County.

Surface Water

For purposes of this watershed management plan, the Raccoon Creek above Hewett Fork to below Elk Fork watershed is defined as the land area that drains Hewett Fork, Raccoon Creek between Hewett Fork and Elk Fork, Onion Creek, and Elk Fork. There are eighteen named streams (including Raccoon Creek) listed in the ODNR Gazetteer of Ohio Streams within the Above Hewett Fork to below Elk Fork watershed (Table 5). Ten are direct tributaries to Raccoon Creek: Elk Fork, Brush Fork, Flat Run, Russell Run, Merrit Run, Tedroe Run, Onion Creek, Laurel Run, Hewett Fork, Sandy Run (all in Vinton Co.) and Long Run (in Meigs Co.). Three drain into Hewett Fork: Rockcamp Creek, Pine Run, and Grass Run, and Coal Creek drains into Rockcamp Creek (all are in Athens Co.). Four drain into Elk Fork (Alman Run, Flat Run, Wolf Run, and Puncheon Fork (all in Vinton Co.).

There is a USGS stream gage maintained by the U.S. Geological Survey in the Raccoon Creek above Hewett Fork to below Elk Fork located near Bolins Mills. The gage is located on the left bank of Raccoon Creek at the state route 50 and 356 intersection, at approximately river mile 86 and can be found online at http://waterdata.usgs.gov/oh/nwis/uv?03201902. It monitors a drainage area of 205 square miles and records real time flow data. Real time water quality data is not monitored at this gage station.

Table 5. Streams in the Raccoon Creek above Hewett Fork to below Elk Fork
(source: ODNR, Gazetteer of Ohio Streams)

Stream Code	Stream Name	Flows Into	County (at mouth)	Length (miles)	Elev. (source)	Elev. (mouth)	Ave. Fall (ft/mile)	Drains (sq. miles)
389.24	Elk Fork	Raccoon Creek	Vinton	18.6	857	635	11.9	59.8
389.2401	Alman Run	Elk Fork	Vinton	2.9	790	650	48.3	2.23
389.2402	Flat Run	Elk Fork	Vinton	3.6	820	655	45.9	3.7
389.2403	Wolf Run	Elk Fork	Vinton	7.1	835	670	23.3	11.1
389.2404	Puncheon Fk	Elk Fork	Vinton	5.6	855	695	28.6	9.92
389.25	Brush Fork	Raccoon Creek	Vinton	2.8	755	645	39.3	5.43
389.26	Long Run	Raccoon Creek	Meigs	3.4	850	650	57.8	3.38
389.27	Flat Run	Raccoon Creek	Vinton	6.8	755	655	14.7	5.85
389.28	Russell Run	Raccoon Creek	Vinton	2.4	815	660	64.6	2.16
389.29	Merrit Run	Raccoon Creek	Vinton	1.6	840	665	110	0.9
389.30	Tedroe Run	Raccoon Creek	Vinton	1.7	760	665	55.8	3.39
389.31	Onion Creek	Raccoon Creek	Vinton	5.9	830	670	27.1	10.7
389.32	Laurel Run	Raccoon Creek	Vinton	2.3	785	670	50	2.6
389.33	Hewett Fork	Raccoon Creek	Vinton	15.4	915	680	15.3	40.5
389.3301	Rockcamp Ck	Hewett Fork	Athens	4.4	815	700	26.2	7.28
389.330101	Coal Run	Rockcamp Ck	Athens	1.5	840	720	80	0.89
389.3302	Pine Run	Hewett Fork	Athens	1.1	750	715	31.9	0.21
389.3303	Grass Run	Hewett Fork	Athens	2.7	880	725	57.5	2.75
389.34	Sandy Run	Raccoon Creek	Vinton	6	850	685	27.5	11.5

Physical Attributes

The terrain of the Raccoon Creek above Hewett Fork to below Elk Fork consists of steep hillsides with narrow to wide valleys with highly erodible soils. Surface elevations range from 600 – 1,100 feet above mean sea level. Although gradients of most headwater channels and small tributaries are relatively steep the gradient of Raccoon Creek valleys and some valleys associated with larger tributaries is fairly low. For example, the average gradient in Raccoon Creek for the Above Hewett Fork to Below Elk Fork section is 2.39 ft/mile. The low gradient of Raccoon Creek is due to the fact that Raccoon Creek lies in several valleys created by pre-Wisconsin Age glaciation rivers of the Teays River system. These ancient valleys with both pre-glacial and glacial outwash soils house streams in the Raccoon Creek drainage that are typically undersized for the valley type.

The majority of streams in the study area are defined by pool/riffle/run morphology, with locally glide/pool dominated morphology. The dominant substrate material in Raccoon Creek is sand, with clay, silt, and gravel sub-dominant in certain locales. Large material (i.e. cobble and boulder) are only present in locations when the stream encounters a hillside and recruits bedrock (shale and sandstone) into the stream substrate. Habitat varies from stream to stream but is generally described as slow moving water with deep pools, abundant woody cover, sand substrate, and few riffles caused by coarse substrate. Smaller tributaries of course have higher gradient and thus have more riffle habitat and a higher degree of larger substrate. Raccoon Creek is typically deep and slow with abundant woody vegetation and riparian habitat. Of the twenty-two (22) sites scored by OEPA for QHEI (Rankin, 1989) throughout the Raccoon Creek above Hewett Fork to below Elk Fork watershed in 2002 and 2005, only four (4) had QHEI riparian metric scores of less than 6 (out of 10 possible) points.

Hughes and McCament (2006) found that suspended sediment load in the Upper Basin of Raccoon Creek was higher than expected in a Sediment Total Maximum Daily Load (TMDL) for the Upper Basin of Raccoon Creek in 2006 (McCament, 2006). The TMDL set targets for both channel stability and total QHEI. The QHEI target was based on Ohio EPA's statewide target of 60. A channel stability index (Simon and Downs, 1995) was collected at 12 sites in the Upper Basin. Channel stability targets are based on Simon and Downs (1995) which demonstrated that unstable channels have higher sediment loads than stable channels. Managing for stable channels provides a good functional goal to reduce sedimentation, especially in watersheds where bank erosion is most likely the highest source of channel sediment. Physical attribute and habitat data will be discussed in more detail in each 14-digit HUC action plan in Section II.

No impoundments or low head dams have been recorded on the mainstem of Raccoon Creek. However, beaver activity is high in the region and many streams are constantly changing due to beaver dams being built and washed away by flood stage waters. Although many small channels have been altered or channelized for agriculture historically, this remote area of Raccoon Creek appears to have had few channelized streams. In fact, it appears that the mainstem of Raccoon Creek has not been channelized for any considerable length throughout this section of the watershed (above Hewett Fork to below Elk Fork) region. Channel alterations from railroads and former mining towns are still apparent in small reaches but negligible overall.

The maximum discharge measured at the Bolins Mills USGS gage on Raccoon Creek was 5,000 cubic feet per second (cfs) in 2004. This event reached a flood stage of 17.05 feet, approximately six feet over bank full stage. This USGS gage was installed in 2003 and has only been recording discharge and stage for the last four years. The highest monthly mean flow is April with 450 cfs and the lowest is August with 34 cfs. Discharge of approximately 1,000 cfs, which is close to top of bank flows, has occurred 3 – 4 times per year over the past four years of record. Floodplain connectivity appears to be quite good with flooding a common yearly occurrence in the watershed. The floodplains in the watershed are undeveloped with no towns or villages located along the mainstem of Raccoon Creek in this section. The village of McArthur is located on Elk Fork and Puncheon Fork.

Water Quality

The Ohio EPA uses several structural indices to measure habitat quality and assess the health of aquatic communities in order to determine use designations. Indices used by the Ohio EPA are the Index of Biotic Integrity (IBI), the Invertebrate Community Index (ICI) and the Qualitative Habitat Evaluation Index (QHEI). Additionally, the Raccoon Creek Partnership and other watershed groups utilize an index called the Macroinvertebrate Aggregated Index for Streams (MAIS) as described below. MAIS has been approved by OEPA as certified Level II water quality data for the WAP ecoregion of Southeast Ohio.

The IBI is a measure of fish species populations and species diversity. The criteria used to establish the index reflect the biological performance exhibited in natural or least-impacted habitats. The IBI index is a number that reflects total native species composition, indicator species composition, pollutant intolerant and tolerant species composition, and fish condition. The highest possible score is 60, with higher scores indicating healthier aquatic ecosystems. Depending on the pollution tolerance of individual species, the IBI is a general indicator of which species are likely to be found in a given stream. The ICI is derived from measurements of the macroinvertebrate communities living in a stream or river. The ICI is particularly useful in evaluating stream health because a large number of macroinvertebrate taxa are known to be either pollution tolerant or intolerant. Like the IBI, the ICI scale is 0-60, with higher scores reflecting healthier macroinvertebrate communities and therefore more biologically diverse aquatic ecosystems.

The MAIS (Smith & Voshell, 1997) requires identification of aquatic macroinvertebrates to the family level (versus OEPA/ICI's genus or species level requirement), relies on natural substrate methods (versus OEPA/ICI's artificial substrate samplers), places a stronger weight on the diversity and abundance of taxa (found in the dip net samples) than ICI and requires only one field trip for site collection. Nine metrics comprise the final MAIS index score and each is assigned a score from 0 to 2. Individual metric scores are summed to produce a single numeric score between 0 and 18. Scores are divided into four categories: 0-7 = "Very Poor (VP);" 8-11 = "Poor (P);" 12-15 = "Good (G);" and 16-18 = "Very Good (VG)."

The QHEI is a quantitative assessment of the physical characteristics and in-stream geography of streams and rivers (Rankin, 1989). The QHEI is essential in evaluating land use practices and stream disturbance. Six variables comprise the QHEI metric: substrate type and quality, in-stream cover, channel morphology, riparian zone, pool quality, and riffle quality. The QHEI scale is 0-100, with higher scores reflecting less disturbed and therefore higher quality streams.

The Ohio Water Quality Standards stated in chapter 3745-1 of the Ohio Administrative Code contain language that defines designated uses and chemical, physical, and biological criteria for surface waters, and are designed to represent measurable properties of the environment. Rivers and streams in Ohio receive "use designations" that reflect the aquatic habitat the stream can support and how the water is used. Water quality standards are then established to support those uses. In applications of Ohio water quality standards to management of water resource issues, aquatic life use criteria frequently control protection and restoration requirements. Generally, emphasis on protecting aquatic life results in attaining water quality suitable for all uses, hence the emphasis of aquatic life uses in water quality reports and planning. The four different aquatic life uses currently defined in the Ohio water quality standards which are potentially applicable to streams in the Raccoon Creek watershed, and the intent of each with respect to the role of biological criteria, are described in the following section. Table 6 summarizes the minimum biological criteria scores for each habitat designation in the Western Allegheny Plateau Ecoregion, of which southeast Ohio is a member.

Table 6. Ecoregion Biocriteria: Western Allegheny Plateau (OEPA, 1997)

	EWH	**WWH**	**MWH**	**LRW-AMD**
QHEI	75	60	45	NA
ICI	46	36	30	8
IBI*	50	44	24	18
*wading and headwater sampling methodology				

Exceptional Warmwater Habitat (EWH)

This designation is for waters capable of supporting and maintaining an exceptional or unusual community of warmwater aquatic organisms. These assemblages of organisms are characterized by a high diversity of species, particularly those that are highly intolerant, rare, threatened, endangered, or special status species. Biological criteria for EWH apply uniformly across Ohio. The EWH designation represents a protection goal for water resource management efforts dealing with Ohio’s best water resources.

Warmwater Habitat (WWH)

This designation defines the typical warmwater assemblage of aquatic organisms in Ohio’s rivers and streams; waters so designated are capable of maintaining a balanced, integrated, and adaptive community of warmwater aquatic organisms. Biological criteria are stratified across five ecoregions for the WWH designation. This aquatic use designation represents the principal restoration target for the majority of water resource management planning in Ohio.

Modified Warmwater Habitat (MWH)

This designation applies to streams and rivers that have been found incapable of maintaining a balanced, integrated, and adaptive community of warmwater organisms. Streams and rivers designated MWH have been subjected to extensive and essentially permanent hydrological modifications. Aquatic assemblages in these streams generally comprise species that are tolerant of low dissolved oxygen, silt, and high nutrient concentrations. Biological criteria for MWH designation are stratified across five ecoregions and three major modification types: channelization, free-flowing water impoundments, and extensive sedimentation due to mine runoff.

Limited Resource Water (LRW)

This designation applies to waters that have been found lacking the capacity to support any appreciable assemblage of aquatic organisms. Use attainability analysis has demonstrated that extant organisms are substantially degraded, and that the potential for recovery to levels characteristic of any other aquatic designation is precluded. Causative factors for the LRW designation include extensive channel modifications, acid mine drainage, and other factors relating to extensive urbanization. No formal biological criteria exist for the LRW aquatic use designation. The LRW-AMD designation applies to streams and rivers that 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 comprised of species that are tolerant to low pH, silt, metals, and overall poor habitat quality.

The Ohio EPA 2008 Integrated Report, which only lists attainment status on the 11-digit HUC scale, states that two categories of aquatic life use exist in the Raccoon Creek Above Hewett Fork to Below Elk Fork watershed, and that impairments to those uses exist. The two aquatic life uses listed are Warm Water Habitat (WWH) and Limited Resource Water (LRW). Twenty-five data points exist for secondary tributaries (< 5 mi2), sixteen data points exist for primary tributaries (5 – 50 mi2), and four data points for principal streams (50 – 500 mi2) from years 1995, 2000, and 2002. Nine of the secondary tributaries and five for the primary tributaries were not meeting their designated aquatic life use. Approximately eighteen percent (18.3%) of primary tributaries were non-attaining, 51.9% are partially attaining, and 29.8% are fully attaining their aquatic life use. Twenty six miles of principal streams were assessed and 53% are in full attainment, 47% are in partial attainment, and 0% are in non-attainment. The next scheduled assessment by Ohio EPA will be in 2019. As listed, causes of impact include metals, zinc, iron, nutrients, pH, siltation, salinity, TDS, chlorides, oil and grease. Sources of these causes as listed include acid mine drainage, surface mining, subsurface mining, petroleum activities, and minor industrial point sources.

Water quality in the Raccoon Creek above Hewett Fork to below Elk Fork is mostly affected by non-point source pollution. The dominant non-point source pollutant is Acid Mine Drainage (AMD). AMD is generated when coal mining, either surface or underground, exposes iron pyrite in bedrock units to water and air. The result is an oxidation reaction that creates sulfuric acid. A simplified version of this reaction is listed below.

$$4FeS_2 + 15O_2 + 14H_2O = 4Fe(OH)_3\text{-} + 8H_2SO_4$$

Pyrite + Oxygen + Water = Ferric Hydroxide + Sulfuric Acid

The sulfuric acid then dissolves heavy metals in the bedrock in high concentrations. These heavy metals, mostly iron, aluminum, and manganese in highest concentrations, convert to hydroxides and precipitate as a solid when buffered and pH is raised. This solid is referred to as flocculent (floc) or yellow boy due to its yellow-orange color caused by iron oxides.

Point sources of pollution are rare in the Raccoon Creek above Hewett Fork to below Elk Fork watershed because it is so undeveloped. Four entities have National Pollutant Discharge Elimination System (NPDES) permits in the watershed. They are: Vinton Austin Powder Company, Vinton Buckeye Automatic Division, Vinton Industrial Timber & Land, and Vinton Village McCarthur. Austin Powder Company discharges into an unnamed tributary to Raccoon Creek upstream of the village of Zaleski (identified as "Austin Powder Trib" in Table 7 below). No recent spills and illicit discharges have been recorded.

According to the Ohio EPA 2003 Upper Basin TMDL, biological data indicate that none of the streams where data were collected are attaining their designated use. Four streams are listed as partial attainment and four are listed as non-attaining (Table 8). However, two streams where the aquatic life designated use was listed as Limited Resource Water – Acid Mine Drainage (LRW-AMD) have been recommended to be upgraded to Warm-Water Habitat (WWH).

Table 7. Biological Data and Aquatic Life Use Information (1996- 2000) for the Raccoon Creek Above Hewett Fork to Below Elk Fork Watershed (OEPA, 2003)

Stream (stream code)	River Mile	IBI	ICI	QHEI	Designation	Recommended Designation	Attainment Status	Causes of Impairments
Hewett Fork (09-563)	8.3-13.4	17	V. Poor	74	LRW-AMD	WWH	NON	pH
Carbondale Creek (09-586)	0.5	12	V. Poor	51.5	Undesignated	WWH	NON	pH
Rockcamp Creek (09-564)	1.8	44	Fair	55	WWH	N/A	PARTIAL	Unknown
Grass Run (09-567)	0.1	30	Fair	55	WWH	N/A	PARTIAL	Metals
Pine Run (09-566)	0.1	--	Poor	--	WWH	N/A	NON	Metals, pH
Coal Run (09-565)	0.1	30	Fair	58	WWH	N/A	PARTIAL	Metals, pH
Onion Creek (09-561)	1.4	30	V. Good	76.5	WWH	N/A	PARTIAL	Habitat, sedimentation
Tedrow Run (09-560)	0.1	28	Fair	54	WWH	N/A	PARTIAL	Metals
Merrit Run (09-559)	0.1	34	Poor	63	WWH	N/A	NON	Unknown
Russell Run (09-558)	0.6	36	Good	48	WWH	N/A	PARTIAL	Oil & gas
Long Run (09-556)	1.4	38	Fair	69	WWH	N/A	PARTIAL	Oil, salinity
Elk Fork (09-530)	0.1-18.6	36-44	36-54	54-75	WWH	N/A	PARTIAL	Metals, pH
Wolf Run (09-533)	2.5	--	Fair	--	LRW-AMD	WWH	NON	Metals, pH
Austin Powder Trib (09-578)	0.1-2.95	--	Fair	--	WWH	N/A	PARTIAL	Metals
Flat Run (09-557)	1.3/1.6	36	Good	51	WWH	N/A	PARTIAL	Unknown

The primary causes of non-attainment of water quality standards in the Raccoon Creek above Hewett Fork to Below Elk Fork watershed are pH and metals related to AMD. The Upper Basin Raccoon Creek TMDL by Ohio EPA in 2003, which covers three 11-Digit HUC watersheds including the Raccoon Creek above Hewett Fork to below Elk Fork watershed, states that “due to the overwhelming presence of AMD in the Upper Raccoon Creek Basin, capturing and treating all the affected water would be difficult and cost prohibitive.” Additional causes of impairment (as listed above & below) include habitat, flow alteration, sedimentation, dissolved oxygen (DO), nutrients, total dissolved solids (TDS), ammonia, chloride, salinity, oil, gas, and grease.

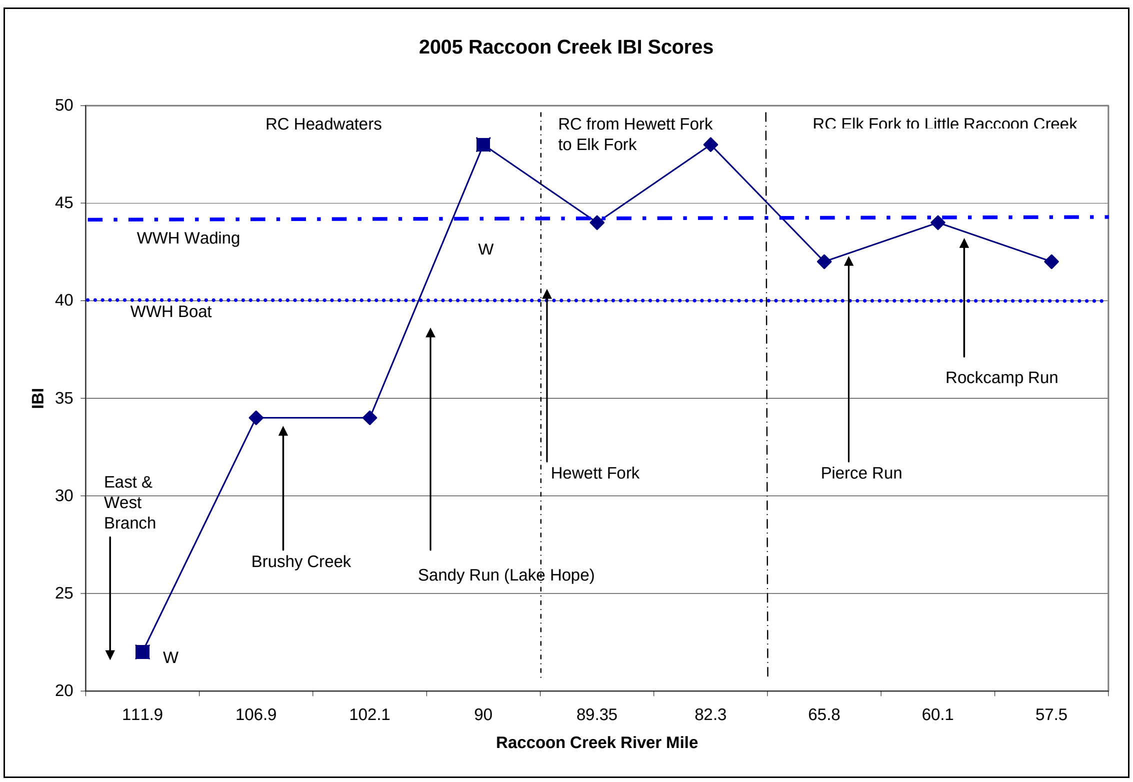
Table 8. EPA 303(d) Listed Waters in the Raccoon Creek Above Hewett Fork to Below Elk Fork Watershed
(source: Ohio EPA Upper Basin TMDL, 2003)*

Waterbody Segment Description [Identification Number]	303(d) Status As of 2002	Major Causes 303(d)
Hewett Fork OH30-50	X	pH
Carbondale Creek OH30-50.1	X	Metals, pH
Rockcamp Creek OH30-51	X	Cause unknown
Grass Run OH30-54	X	Metals
Pine Run OH30-53	X	Metals, pH
Coal Run OH30-52	X	Metals, pH
Onion Creek OH30-48	X	Cause unknown
Tedroe Run OH30-47	X	Metals
Merrit Run OH30-46	X	Cause unknown
Russell Run OH30-45	X	Oil & grease
Long Run OH30-43	X	Salinity, TDS, Chloride, Oil & grease
Elk Fork OH30-35	X	Metals, pH, siltation, Cause unknown
Wolf Run OH30-38	X	Nutrients/organic enrichment, DO, pH, metals
Austin Powder Trib. OH30-40	X	Metals, ammonia, nutrients, flow alteration
Flat Run OH30-44	X	Oil & grease, Cause unknown

There is a general trend of improving water quality in the watershed due to AMD treatment projects by the Raccoon Creek Partners, mine land reclamation by ODNR Division of Mineral Resources Management, and natural attenuation of acidic mine spoil piles. Water quality is most impaired by acid mine drainage in the Raccoon Creek Headwaters and in Hewett Fork. IBI data shown in Figure 7 below (representing the three upper 11-digit HUCS of the Raccoon Creek watershed) shows the most degraded fish populations in the upper reaches of Raccoon but improvements in the Hewett Fork to Elk Fork section before degrading again downstream of this Action Plan HUC watershed.

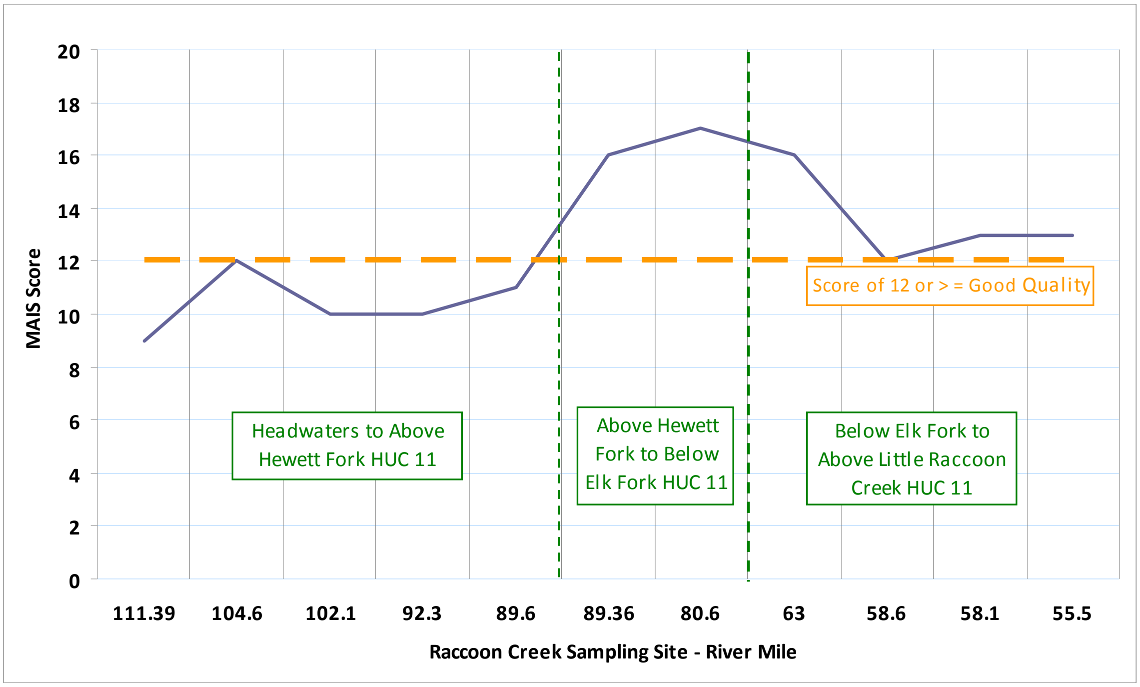
At the two sampling locations in this Action Plan HUC watershed, fish are attaining WWH criteria for boat sites with an IBI of 40 or greater for 2005 data. It should be noted that no biological stations on Raccoon Creek exist between river mile 82.3 and 65.8, a total of 16.5 miles. Elk Fork enters Raccoon Creek at river mile 66.64. A biological sampling location should be established upstream of Elk Fork on Raccoon Creek to further refine the understanding of biological performance in this section of stream. Family level macroinvertebrate data also shows "very good" quality streams in this section of Raccoon Creek. A MAIS score of 16 - 20 indicates a good quality macroinvertebrate population for streams in the Western Allegheny Plateau (WAP) eco-region (Smith and Voshel, 1997). Both sites, RM 89.36 and 80.2, have scores of 16 or greater according to 2008 data (Figure 8). Overall, the Raccoon Creek mainstem is in good biological condition in this 11 digit HUC watershed section according to the most recent fish and macroinvertebrate data.

Figure 7. 2004 – 2005 IBI Scores on the Mainstem of Raccoon Creek; River Miles 111.9 to 57.5



** W indicates wading site for fish sampling, all others are boat sites*

Figure 8. 2008 MAIS Scores on the Mainstem of Raccoon Creek; River Miles 111.9 to 55.5



SECTION II.

WATERSHED ACTION PLANS FOR 14 DIGIT-HUC WATERSHEDS

<u>Hewett Fork</u>

14 Digit HUC: 05090101-030-010
Location: Confluence with Raccoon Creek at River Mile 89.54
USGS Quadrangle: Mineral, The Plains, Nelsonville, Union Furnace
Drainage Area: 40.55 square miles, 25,955 acres

Watershed Description

Hewett Fork (Map 9) is the fourth largest tributary to Raccoon Creek at 40.55 square miles. The watershed is located mostly in western Athens and eastern Vinton counties. The main stem of Hewett Fork is 15.4 miles long and has a gradient of 15.4 feet per mile. Named tributaries to Hewett Fork include Carbondale Creek, Trace Run, Pine Run, Mudlick Run, Rockcamp Creek, and Grass Run. Additionally, Coal Run is a tributary to Rockcamp Creek, and Excellent Creek is a local name for a headwater tributary to Carbondale Creek.

The watershed is primarily rural with 82% of land cover forested. In addition, 11% of land use is dedicated to agriculture, and less than 1% of the area is residential. Historically, coal mining was conducted within this region. Underground mining affected 3,634 acres, approximately 14% of the watershed's 25,942-acre area. Surface mining occupied less than 1% of the area. The watershed contains large amounts of public lands including the Waterloo Wildlife Area, Zaleski State Forest, and Wayne National Forest.

Water Quality

Biological

Hewett Fork was ranked fourth on the priority list for AMD abatement and restoration of the Raccoon Creek Headwaters (Rice, 2002). AMD discharges in Hewett Fork have historically rendered the system virtually lifeless for miles and periodically impacted Raccoon Creek at low flow. The majority of AMD sources are attributed to underground room and pillar mines in the watershed that were abandoned in the early to mid 1900s. The largest AMD loading source is located just east of the village of Carbondale at river mile (RM) 11 of Hewett Fork. The discharge originates from the 33-acre Rice-Hocking room and pillar coal mine, which was abandoned in 1923. However, based on underground mine maps and discharge measurements from mine seeps, it was concluded that the Rice-Hocking mine was hydraulically connected to a series of large previously abandoned underground mines up-dip of Carbondale (Shimala, 2000). The mine discharge is highly acidic and contains high levels of iron, aluminum, and manganese. In 1997, Ohio EPA listed Hewett Fork as non-attaining of its LRW-AMD classification due to low pH and high conductivity (Table 9). AMD is invariably high in ferric iron and aluminum, eliminating treatment options such as anoxic limestone drains and rendering vertical flow wetlands ineffective. Thus, to remediate these impacts and to restore biological health to the system, the Ohio Department of Natural Resources Division of Mineral Resources Management (ODNR-DMRM) installed an AquaFix water wheel type limestone (CaO) doser in late 2003, the first of its type to be installed in Ohio (Figure 9) at Hewett Fork RM 11.0. The doser, referred to as the Carbondale doser due to its location adjacent to the town of Carbondale, works off a water-powered wheel and auger system that dispenses calcium oxide fines at regular intervals. The calcium oxide mixes with the AMD in a concrete channel before entering Hewett Fork.

The Carbondale doser on Hewett Fork is located immediately downstream of the main underground mine seep at the abandoned Rice-Hocking Mine for remediation of AMD impacts. The doser has been operational and using calcium oxide pellets since June of 2004, using water from the underground mine discharge to propel a water wheel and auger that releases calcium oxide fines into the AMD water that runs through the doser building. A second underground mine discharge from the same mine complex, HF132, enters the concrete channel constructed for the project downstream of the doser. The concrete channel meanders to Carbondale Road where it goes under the road through a culvert and into Hewett Fork at RM 11.1. The concrete channel includes a dozen small gradient jumps (waterfalls) to encourage mixing. Results show that this active treatment system has resulted in biological improvement that continues today and is described below.

Table 9. Ecoregion Biocriteria: Western Allegheny Plateau (OEPA, 1997)

	EWH	WWH	MWH	LRW-AMD
QHEI	75	60	45	NA
ICI	46	36	30	8
IBI*	50	44	24	18
MAIS**	16	12	8	0

* wading and headwater sampling methodology
** pending

Figure 9. Limestone Doser at Carbondale, Hewett Fork Mainstem (RM 11.1)

Prior to treatment in 2003, macroinvertebrate data collected along Hewett Fork was consistently dominated by tolerant taxa with little to no presence of sensitive or intolerant "high quality" taxa. While quantitative ICI scores are not available, heavily impacted sites at RM 8.1 and 13.1 had "Very Poor" macroinvertebrate communities, with very low densities of all benthic invertebrate organisms. The most numerous taxon at these sites was the AMD-tolerant megalopteran genus Sialis. River Mile 8.3, opposite the Waterloo Wildlife Station, was "biologically dead" in 2000 (Rice 2002) despite high quality surrounding habitat including a mature hardwood riparian corridor, natural sinuosity, and abundant in-stream cover. Low embeddedness was also observed at this location, likely due to the metals in this highly acidic segment remaining in dissolved form prior to downstream precipitation as stream bottom flocculants. Nigronia (a tolerant species) was noted to be the dominant macroinvertebrate taxa. Both ICI and MAIS scores calculated for 2002 and 2003 data equaled 3 or "Very Poor," and fish IBI scores were also "Very Poor" in 2000 at 22, 20, and 12 for RM 13.1, 9.8, and 8.3, respectively (Table 10).

Table 10. Biological Data for Hewett Fork Watershed (Pre-Carbondale Doser)

Stream	River Mile	Year	IBI	ICI / Qual
Hewett Fork	13.1	2000	22	VP
Hewett Fork	9.8	2000	20	VP
Hewett Fork	8.3	2000-2003	12	VP
Carbondale Creek	0.2	2000	12	VP
Pine Run	0.1	1995	N/A	P
Rockcamp Creek	1.5	1995	44	F
Grass Run	0.1	1995	30	G
Coal Run	0.1	1995	30	F
Excellent Creek	0.1	2000	16	G

The biological response along mainstem Hewett Fork was dramatic after dosing began, and a long term monitoring program was established to collect data at nine locations, including one site upstream and eight sites downstream of the limestone treatment doser. This monitoring data shows that while the total number of organisms collected and taxa richness has declined immediately downstream of the doser (resulting from the treatment effects of aluminum and iron precipitate), immediate increases in diversity were documented within months two to three miles downstream of the doser at RM 8.3. Fish populations increased from zero in 2000 to 8 fish species in 2004. Macroinvertebrate diversity increased at this site as well from 10 families documented in 2003 (pre-doser) to 15 families present in 2005. Fish and macroinvertebrate data show increasing ecological complexity with distance downstream, as aquatic communities restabilize with improved water quality (Figure 10). The furthest downstream sampling sites (RM 0.9 and 3.9) recorded MAIS rankings of "good" and Index of Biological Integrity (IBI) scores near or above the criteria of 44 for wading sites for the protection of aquatic life for warm-water streams in the WAP Ecoregion of Ohio from 2005 – 2007 (Table 11, Figure 11).

Figure 10. Macroinvertebrates Along Mainstem Hewett Fork, 2006 – 2007

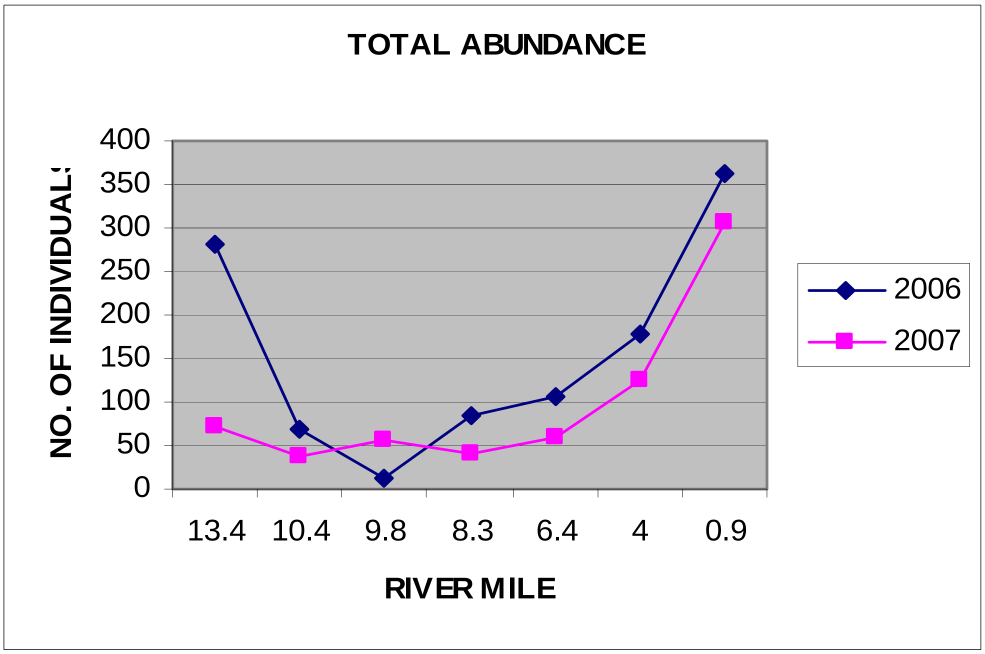
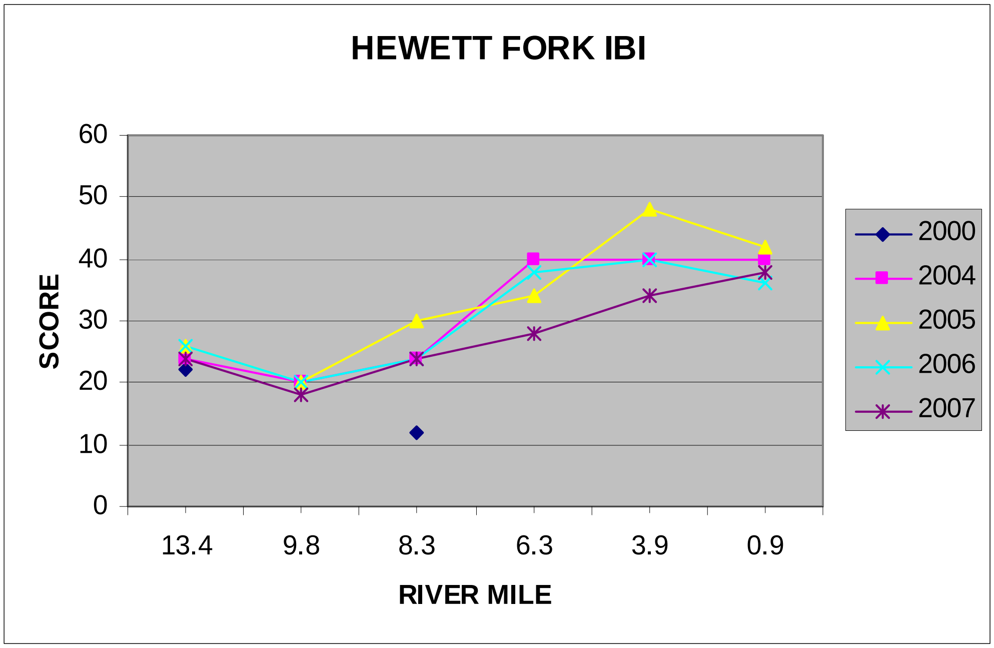


Table 11. Hewett Fork Post-Treatment Biological Data

Stream	River Mile	IBI (Year)	MAIS (Year)
Hewett Fork	13.4	24 (2004), 26 (2005)	11 (2006), 8 (2007)
Hewett Fork	10.4	N/A	10 (2006), 3 (2007)
Hewett Fork	9.8	20 (2004), 20 (2005)	4 (2006), 3 (2007)
Hewett Fork	8.3	24 (2004), 30 (2005)	7 (2006), 3 (2007)
Hewett Fork	6.4	40 (2004), 35 (2005)	9 (2006), 9 (2007)
Hewett Fork	4.0	40 (2004), 48 (2005)	13 (2006), 13 (2007)

Figure 11. IBI Data for Hewett Fork, 2000 – 2007



Physical/Habitat

Forested conditions in the Hewett Fork watershed allow for an intact, mature hardwood riparian corridor, natural sinuosity, and abundant instream cover. While dams and channelization are generally absent from Hewett Fork, beaver dams are known to occur along the mainstem and its tributaries. Road densities are extremely low, and the lower four miles of the Hewett Fork mainstem are only accessible by foot. Only one pasture farm is documented along Hewett Fork. Thus, despite its severely impacted water quality, Hewett Fork generally demonstrates high QHEI scores. While no biocriteria targets for QHEI are available for LRW-designated waters of the WAP, many scores along Hewett Fork met or exceeded the WWH QHEI target of 60. Scores collected at these sites in 2004 to 2006 are listed in Table 12.

Table 12. QHEI at Hewett Fork Mainstem

River Mile	2004	2005	2006
0.9	59.5	77.5	67
3.9	48	47.5	56.5
6.3	58	59.5	62.5
8.3	65	57	67
9.8	66	62	52
11.1	62	54	N/A
13.4	61.5	64	72

QHEI scores are also available for tributaries to Hewett Fork from 1995 and 2000 (Table 13).

Table 13. QHEI at Hewett Fork Tributaries

Name	River Mile	1995	2000
Rock Camp Creek	1.5	55	N/A
Carbondale Creek	0.2	N/A	51.5
Excellent Creek	0.1	N/A	66
Coal Run	0.1	58	N/A
Grass Run	0.1	55	N/A

The primary physical impact in Hewett Fork is reduced substrate quality, resulting from AMD and treatment precipitate. Channel evolution data was also collected at RM 3.9 and 6.3 as part of the 2007 Upper Basin Sediment TMDL (McCament, 2007). Channel Stability Index scores were 18 at RM 3.9 and 17.4 at RM 6.3. These deviated 2 to 3 points from the target score of 15. Based on the channel evolution model, percentages of total stream bank instability (totaling both banks) were 11-50% at RM 3.9 and 51-75% at RM 6.3. (McCament 2007) This compares to percentages generally greater than 50% through most of Raccoon Creek's Upper Basin. Sediment loading and transport varies during flow events based on event magnitude, precipitation intensity, channel characteristics, sediment sources and substrate type.

Chemical

Basin analysis by Hughes et. al (1996) indicated that Hewett Fork has been contributing high acid loadings to the mainstem of Raccoon Creek, discharging 2,629 lbs per day of acid to the system. Loading from the Rice-Hocking Mine at Carbondale is variable seasonally but averages 758 lbs/day for acidity and 165 lbs/day for iron, aluminum, and manganese metals combined (Shimala, 2000). All of the acid-producing waterways affecting Hewett Fork are located upstream of the SR 356 bridge which crosses Hewett Fork at Waterloo Wildlife Station. These include the Carbondale wetland (where an anaerobic wetland was installed in 1991 by ODNR immediately downstream of the current doser treatment site but performed unsatisfactorily over time), Trace Run and Carbondale Creek (together adding approximately 376 lbs of acid to the system per day) (Rice 2002).

With acid loads from the Carbondale discharge remediated in 2004 by the doser, immediate improvements in alkalinity and pH were documented downstream along Hewett Fork. Approximately 100 feet downstream of the doser, pH increased from a mean of 4.7 pre-doser to 10.3 post-doser. At four downstream sites in Hewett Fork, an increase in pH was documented where pre-doser data existed. As expected, sites closest to the doser experienced the largest pH increase. Two additional large AMD sources from adjacent underground mine complexes enter Hewett Fork downstream of the Carbondale doser. Carbondale Creek enters at RM 10.8 and Trace Run enters at RM 10.3. Trace

Run has a mean acid load of 385 lbs/day, and Carbondale Creek loads 314 lbs/day (2000 – 2007 data). Because of these AMD sources, pH and alkalinity increase immediately downstream of the doser but steadily decline as these additional AMD sources enter Hewett Fork. Both alkalinity and pH rebound further downstream as other non-AMD impacted streams recharge Hewett Fork with more alkalinity and higher pH water (Figure 12) (McCament, 2008).

Prior to treatment, the mean acid load at the doser (limestone discharge) location was 786 lbs day. Following treatment, the mean alkaline load has been estimated at 630 lbs day. Thus, acid loads from the abandoned underground mine AMD discharge have been effectively neutralized by operation of the lime doser. Iron loads have increased, however, due to the fact that the original wetland treatment system, which was removing approximately 60% of the iron load, was removed to install the lime doser treatment. Data from 2004 to 2008 show loading averages for aluminum at 48 lbs/day and iron at 200 lbs/day from the Carbondale discharge into Hewett Fork (Figure13, Figure 14) (McCament, 2008). Total iron and aluminum concentrations are most elevated proximal to the doser and decrease in concentration incrementally downstream to the confluence with Raccoon Creek (Figures 15, Figure 16) (McCament, 2008). Overall, the water chemistry in Hewett Fork post-dosing demonstrates better conditions for aquatic life in the lower reaches compared to immediately downstream of the doser, where aluminum and iron concentrations are the highest and spikes of acidity have been documented.

Figure 12. Hewett Fork pH Data Pre & Post Dosing immediately Downstream of Carbondale Doser

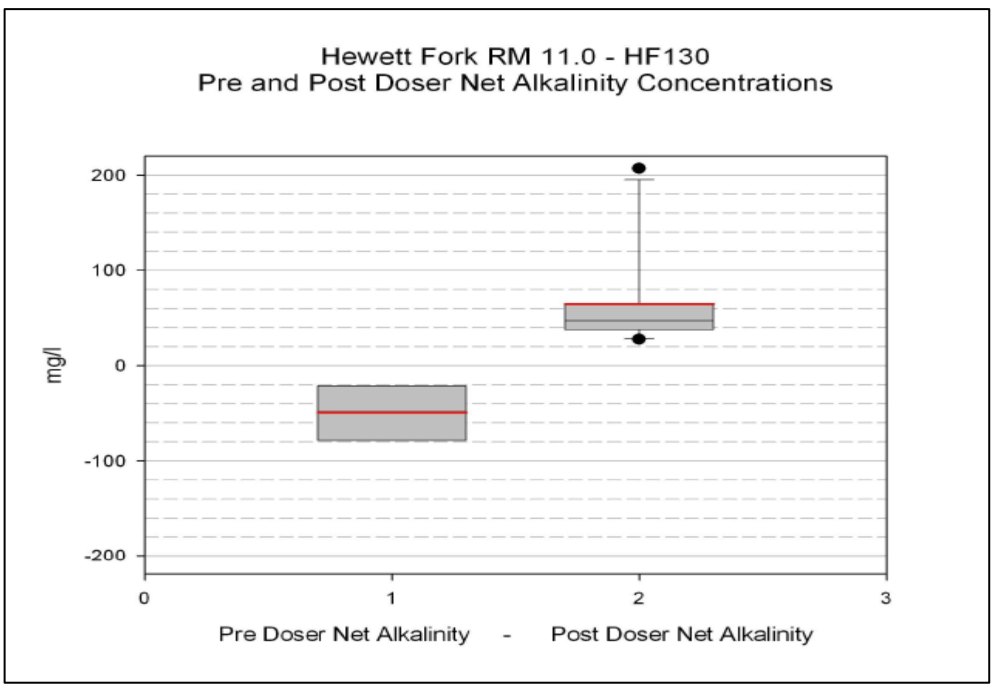


Figure 13. Hewett Fork Pre & Post Dosing Aluminum Loadings of Carbondale Doser

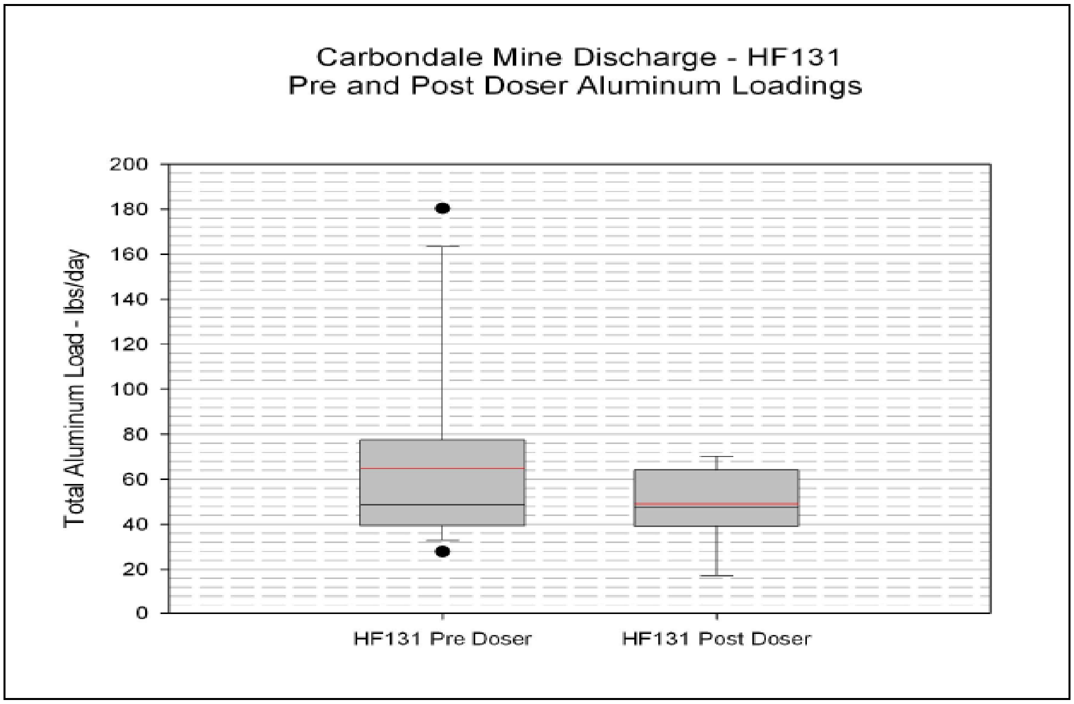


Figure 14. Hewett Fork Pre & Post Dosing Iron Loadings of Carbondale Doser

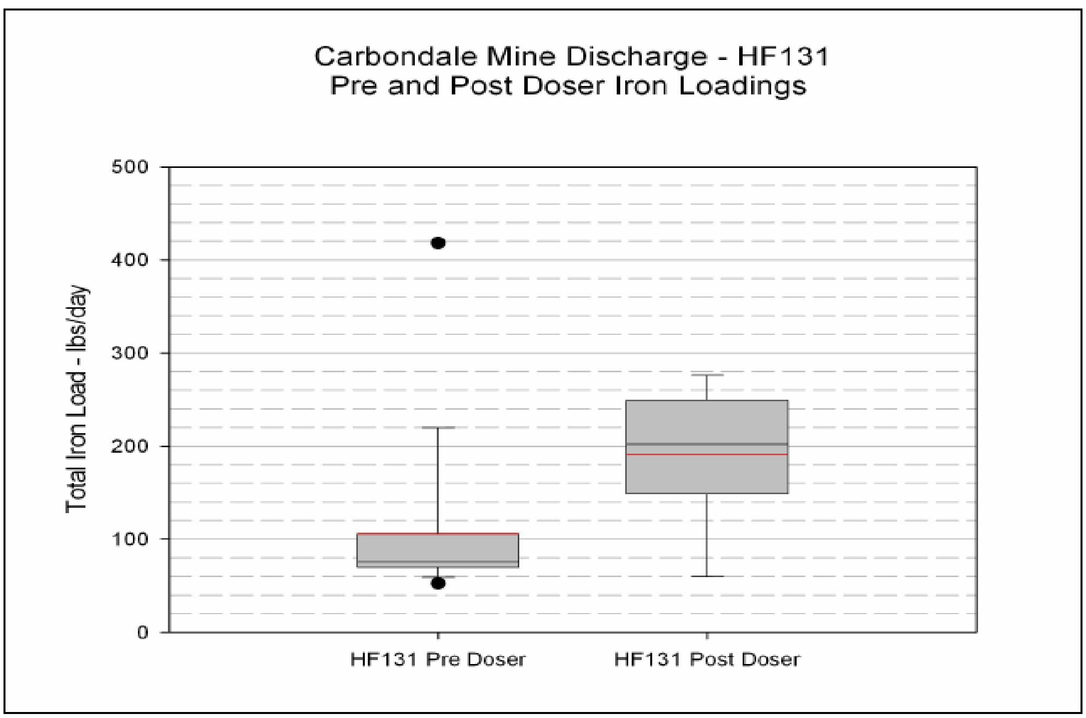


Figure 15. Total Iron Concentrations in Hewett Fork Post-Dosing

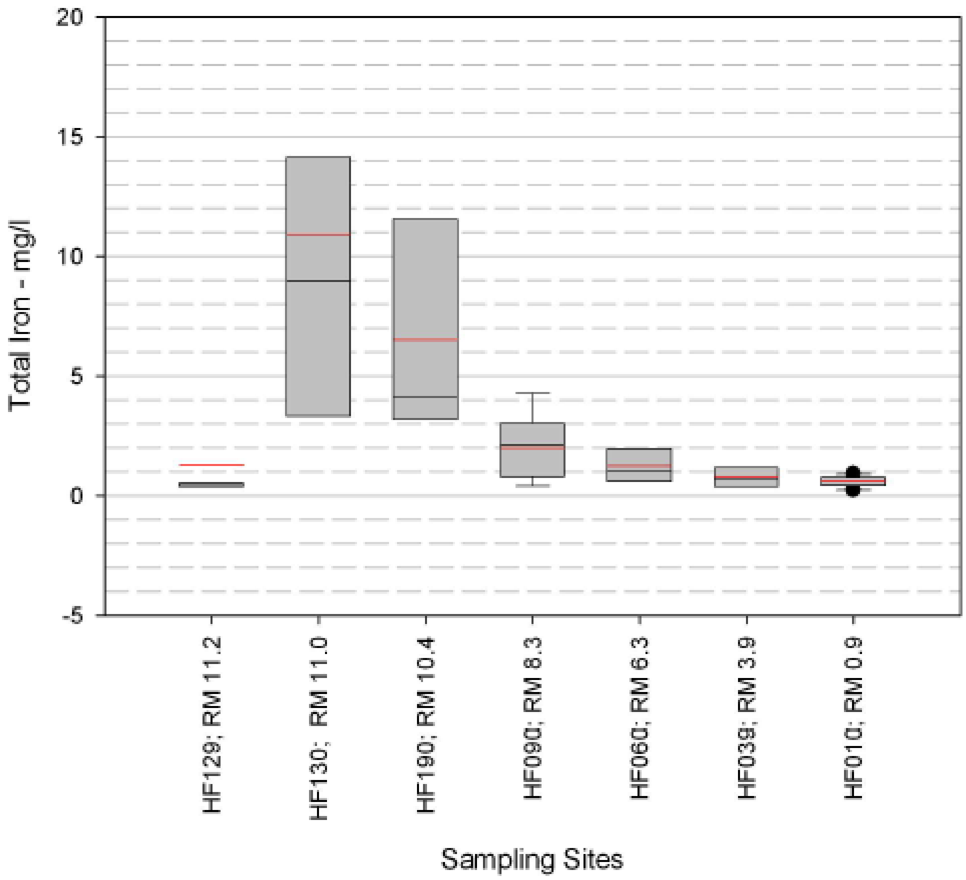
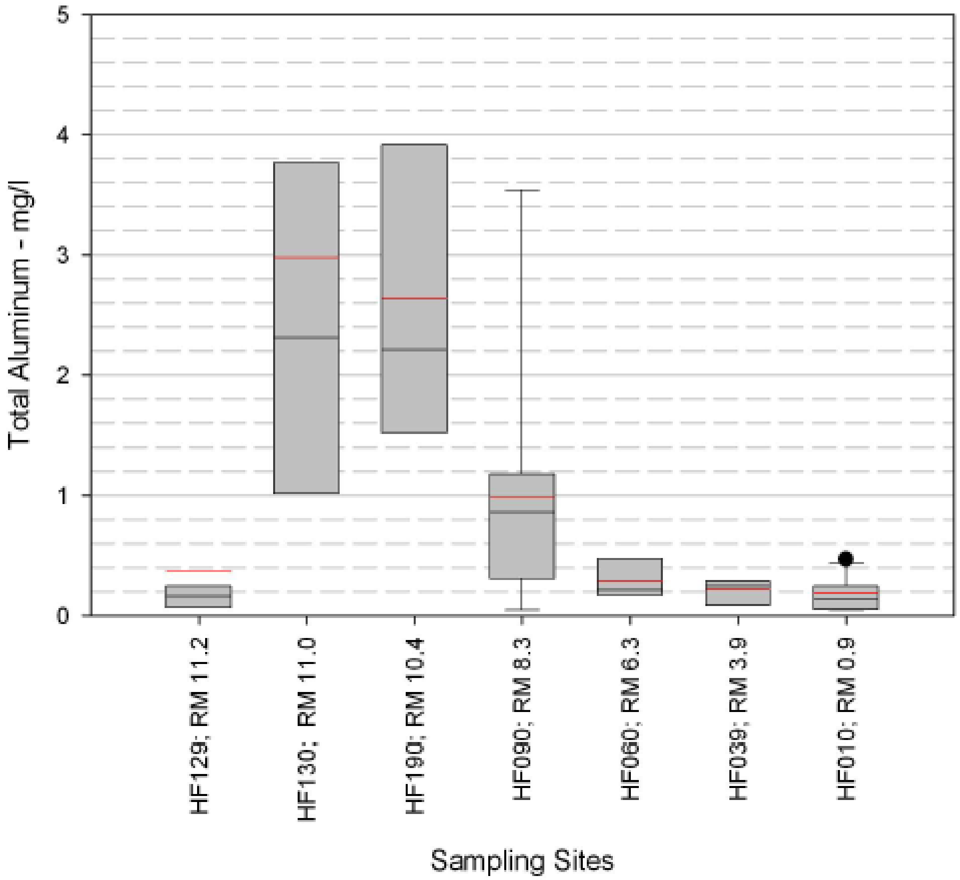


Figure 16. Total Aluminum Concentrations in Hewett Fork Post-Dosing



There are five monitoring stations located along Hewett Fork that have both pre- and post-dosing data. Chemical water quality data was collected at these stations before and after treatment (between 2000 and 2007) as part of the long-term monitoring program. The following trends are shown below:

1) At RM 11.0: increase in alkalinity (49.61 mg/l to 64.45 mg/l) and iron (5.56 to 10.91 mg/l) were observed, pH increased from 4.85 to 9.38, and aluminum concentrations stabilized.

2) At RM 10.4: alkalinity increased by 80 mg/l, aluminum decreased 50% (4.57 to 2.64 mg/l), pH increased (4.56 to 6.72) and stable iron concentrations were observed.

3) At RM 8.3: alkalinity increased by 25 mg/L, aluminum decreased from 3.2 to 0.98 mg/l, pH slightly increased (5.1 to 6.2) and stable iron concentrations were found.

4) At RM 0.9, alkalinity increased by 19 mg/l, aluminum slightly decreased (0.44 to 0.21 mg/l), pH and iron concentrations were stable.

The upstream control site (RM 11.2) experienced slight pH and iron increases (6.61 to 7.75 and 0.55 to 1.26 mg/l, respectively) but no change in alkalinity was observed.

Metal concentrations are constantly fluctuating in AMD streams and modeling metals can be difficult due to highly variable temporal and spatial solubility. Thus it is simpler and often more reliable to model net alkalinity than modeling metals. Dissolved metal concentrations decrease with increasing alkalinity and pH. Therefore, net alkalinity was used to calculate the TMDL for both pH and metals (Ohio EPA 2003). Net alkalinity concentrations meet the Upper Basin Raccoon Creek TMDL target of 20 mg/l for 4 Hewett Fork sites downstream of the doser (TMDL, 2003). However, two of those sites are in the mixing zone, less than a mile from the doser, and are severely affected by iron flocculent. Total iron concentrations exceed 10 mg/l immediately downstream of the doser, but steadily decline towards the mouth of Hewett Fork and meet USEPA national criteria of 1 mg/l or less for the lower 3.9 river miles. Total aluminum concentrations follow the same trend, averaging 3 mg/l immediately downstream of the doser and declining towards the mouth, meeting USEPA national recommended criteria of 0.87 mg/l or less in the lower 6.3 river miles of Hewett Fork. Decreasing concentrations are likely explained by storage of metal precipitates in the stream substrate, which is visible from RM 11.0 to RM 6.3. High flows (bankfull and flood stage) move precipitates downstream and into the floodplain for storage, but sampling under these conditions is difficult. Mean net alkalinity concentrations exceed 60 mg/l directly downstream of the doser, decrease at the next two sampling stations due to Trace Run and Carbondale Creek acid loads, and rise steadily again at RM 6.3 through RM 0.9.

Problem Statement

Hewett Fork (RM 8.30-13.4), Carbondale Creek (RM 0.5), and Pine Run (RM 0.1) were all listed by Ohio EPA in 2000 as non-attaining of their aquatic life use designation criteria due to pH and metals. Rockcamp Creek (RM 1.8), Grass Run (RM 0.1), and Coal Run (RM 0.1) were listed in partial attainment due to pH and metals (other than Rockcamp Creek's cause which was listed as unknown). Biological and chemical conditions have improved along Hewett Fork since 2000 with installation of the Carbondale doser but certain sections are still non-attaining. This non-attainment is likely due to pH and metals associated with the input of acid loading from Trace Run and Carbondale Creek into the Hewett Fork mainstem. Additionally, iron concentrations have increased since 2000 with removal of the wetland treatment system, which was previously removing 60% of upstream iron loads.

Goals

1) Reduce acidity at RM 10.3 (Trace Run) to eliminate the mean loading of 385 lbs of acid per day and recover one to two miles of Hewett Fork.

Action Plan

Trace Run is the recipient of discharge from the Kennard Mine portal and two associated seeps on the streambank along SR 56. Carbondale Creek was the site of a reclamation project in 1998 that reclaimed a large gob pile, closed 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 Zaleski State Forest.

The 2002 Raccoon Creek Headwaters AMDAT suggests the following for potential remediation of acid loads into Hewett Fork (Table 14):

Abate acid loading at Trace Run (HF 110) with the installation of a steel slag bed (SSLB) upstream of the Kennard discharge, which will generate about 240 lbs of alkalinity per day.

Table 14. Action Table for Hewett Fork

Objective	Action	Resources	Time Frame	Notes
To reduce acid loading at HF110 (Trace Run): Abate load from seeps at HF 114, 115 and 116	Install a Steel slag bed at Kennard Seep	$380,000	Fall 2010-Spring 2011	The SSLB will generate 240 lbs/day of alkalinity

Onion Creek

14 Digit HUC: 05090101-030-020
Location: Confluence with Raccoon Creek at River Mile 84.04
USGS Quadrangle: Mineral, The Plains, Albany, Vales Mills
Drainage Area: 10.73 square miles, 6,866 acres

Watershed Description

Onion Creek (Map 10) is located within the 11-digit HUC of Raccoon Creek, Hewett Fork to Elk Fork. This 14-digit HUC is primarily contained within Vinton County. The main stem of Onion Creek is 5.9 miles long and has a gradient of 27.1 feet per mile. There are no named tributaries to Onion Creek.

The watershed is rural with 93% of land cover split between forests and agriculture. Forests occupy 47% of the region, and agriculture accounts for 46%. Less than 1% of the watershed's 6,866-acre area is residential. Agricultural land use in Onion Creek watershed is mostly pasture/hay and cultivated crop land, which account for approximately 44.1% and 13.8% of the total land use, respectively.

Water Quality

Biological

In OEPA's 2003 TMDL, Onion Creek was listed as partially attaining its WWH designation due to habitat and sedimentation. Because scarce biological data is available on Onion Creek relative to other watersheds, analysis of biological trends over the past decade is somewhat limited. However, biological data collected by OEPA in 1995 (Table 15), and by an Ohio University graduate student in 2000, is discussed further.

Table 15. Biological Data for Onion Creek

River Mile	Source	Year	IBI	ICI Qual	QHEI
1.4	OEPA	1995	30 (Poor)	VG	76.5

Additional macroinvertebrate samplings were conducted at seven Headwater sites, including Onion Creek, by Ohio University graduate student Jennifer Last in 2000. Sites were generally sampled three times in 2000 (March, June, and September) based on OEPA sampling procedures, but Onion Creek was dry during the fall and subsequently no sample was collected in September. During spring and summer samplings, however, Onion Creek generally had higher numbers of EPT taxa and lower numbers of Dipterans than the other Headwater sites. Dominant organisms included mayflies, stoneflies, and snails, with no visible AMD impacts observed. Based on this macroinvertebrate analysis, Onion Creek was subsequently designated as the "control" site for purposes of Last's comparison to other (more AMD & nutrient impacted) Headwaters locations.

Physical

QHEI Data was collected on Onion Creek at RM 1.4 in 2005 and is listed in the Raccoon Creek Upper Basin Sediment TMDL (McCament 2007). Total QHEI score was 60.5, including a substrate score of 9.5 with heavy siltation and moderate to extensive embeddedness. QHEI metrics indicated very little riparian (score of 3.5) and reduced riffle-run quality (score 2.5). Habitat degradation was likely caused by agriculture, livestock, and channelization. A cow pasture was noted in the floodplain (with livestock access downstream of the bridge at Worley West Road) and large amounts of algae were observed, indicating a possible nitrate problem.

Chemical

Sampling of Onion Creek in April of 2000 revealed that Onion Creek was producing 722 pounds of net alkalinity per day, thus serving as a constant buffering source over a range of flows to the Raccoon Creek mainstem. Onion Creek appears to be non-impacted by AMD (Rice 2002). Additional water quality data, collected by Jennifer Last in 2000, is reported in Table 16.

Table 16. Onion Creek Water Quality Data (2000)

Date	Acidity (mg/L)	Alkalinity (mg/L)	pH	Total Al (mg/L)	Total Fe (mg/L)	Total Mn (mg/L)	Sulfate (mg/L)	Conductivity (uS/cm)	TDS
4/26	0	56.7	7.1	0.439	0.215	0.852	33.8	250	133
7/11	8.3	54.1	6.6	0.532	0.334	0.291	30.5	208	130
10/23	13.4	59.6	6.0	0.106	0.516	1.45	58.4	263	164

Problem Statement

Onion Creek is listed in partial attainment of its WWH designation because of habitat and sedimentation (TMDL, 2003). AMD impact in this water is minor; with agricultural land-use up to 50% according to 2001 NLCD (National Land Cover Dataset), habitat is likely impaired by lack of riparian, bank instability, erosion, and livestock access to the streams.

Goals

1) Collect additional biological, chemical, and habitat data in Onion Creek to determine current aquatic life use attainment and impairments.
2) Improve riparian habitat in the watershed by cattle exclusion and/or riparian planting in order to reduce erosion and excess nutrients to banks and streams.

Action Plan

To completely understand the chemical and physical impairment for further water quality monitoring is needed. The NRCS/SWCD have current EQIP projects being conducted in Onion Creek. The watershed group will work with this agency to guide further projects in areas most needing improvement (Table 17).

Table 17. Action Table for Onion Creek 14-digit HUC Watershed

Objective	Action	Resources	Time Frame	Performance Indicators
Monitor water quality in Onion Creek	Collect chemical, physical, and biological data in Onion Creek	Staff to collect data, sample collection and analysis support	2010 - 2015	Chemical data collected and analyzed in Onion Creek
Refine sites where riparian enhancement is needed	(1)Use GIS maps to identify sites to conduct geomorphic and habitat data surveys (2) Identify landowners to work with	Student(s) and staff to collect data	2010 – 2012	(1) List of sites with habitat data (2) List of landowners to work with
Improve riparian corridor	(1) Cattle exclusion (fencing) (2) riparian planting- 2 miles of the 11 miles that lack proper land cover	NRCS EQIP funding and CRP (Conservation Reserve Program) Estimated 11 miles of riparian cost of $194,400	2010-2015	(1) Habitat data collected (2) List of projects completed

Wolf Run

14 Digit HUC: 05090101-030-050
Location: Confluence with Elk Fork at River Mile 9.2
USGS Quadrangle: McArthur
Drainage Area: 11.06 square miles, 7,076 acres

Watershed Description

Wolf Run (Map 12) is located within the 11-digit HUC of Raccoon Creek, Hewett Fork to Elk Fork. This 14-digit HUC is primarily contained within Vinton County. The main stem of Wolf Run is 7.1 miles long and has a gradient of 23.3 feet per mile. Wolf Run is a tributary to Elk Fork with its confluence at river mile 9.2.

The watershed is primarily rural with 68% of land cover forested, part of watershed lies within the Vinton Furnace Experimental Forest (USDA-USFS). In addition, agriculture accounts for 19% of the land use according to the National Land Cover Data (NLCD) set (Map 4). However, most of this land overlays with strip mine coverage (Map 12), it may not necessarily be agriculture lands. Historically, coal mining was conducted within this region. Surface mining affected 1,529 acres, approximately 21% of the watershed’s 7,073-acre area. Underground mining occupied less than 1% of the area.

Water Quality

Biological

Wolf Run is currently non-attaining of its LRW-AMD designation due to AMD impacts of metals and pH (TMDL, 2003). However, Rice (2003) showed substantial improvements in the fish assemblages of Wolf Run, with IBI scores increasing from the minimum of 12 (in 1981) to scores ranging from 28 to 36 in 2002 (Table 18). Fish IBI narrative rating of Wolf Run among the Middle Basin was fair in 2002; and narrative macroinvertebrate rating was fair to poor. The 1981 samples had no fish species, while samples in 2002 ranged from 7 to 12 species, including the moderately sensitive longear sunfish and rosefin shiner. Although the macroinvertebrate assemblages were considered poor, sampling was affected by low flow and more sensitive taxa were observed than streams showing stronger AMD impacts such as Pierce Run. However, limitations to aquatic communities were still present, likely attributable to habitat degradation and siltation from land disturbance, agriculture, and residential activities. Like other streams in the Middle Basin, small streams are easily influenced by low base flows that tend to magnify the effects of stressors like siltation and sedimentation.

Physical

QHEI and IBI scores for Wolf Run were collected at RM 2.70 in 2002 and at RM 0.20, 3.8, and 5.3 in 2005. The scores are listed below (Table 18 and Table 19). Scores were generally attaining (>60) and consistent along the creek, with the exception of RM 2.70 in 2002 where moderate siltation and embeddedness were observed. Major suspect sources of habitat degradation were noted in field observations to include silviculture, urban runoff, and mining impacts as mentioned above. Site-specific comments during QHEI assessments are included below.

Table 18. Wolf Run IBI Scores and Site Assessment

River Mile	Year	Site Location	IBI Score	Causes
0.10	2002	near mouth	36	Habitat/Silt/Flow; Source: Agriculture/Land; Some habitat disturbance and excess siltation and natural low flow levels. Mining Effects not detected.
2.70	2002	N/A	28	
3.80	2002	bridge crossing on Vinton Station Road (upst and dst of bridge)	N/A	
5.30	2002	upst of bridge on Vinton Station Road in town of Dundas	36	

Table 19. Wolf Run QHEI Scores

River Mile	Year	Site Location	QHEI Score	Comments
0.20	2005	near mouth	67.0	beaver dam influenced, woody debris riffle, mostly sand and hardpan
2.70	2002	N/A	51.0	N/A
3.80	2005/2008	bridge crossing on Vinton Station Road (upst and dst of bridge)	73.0/88.5	sand in pools and runs. Lots of hardpan exposed banks. More glide habitat upst of bridge
5.30	2005	upst of bridge on Vinton Station Road in town of Dundas	85.5	a few coal fines present, dst of reach has no riparian and is culverted under RR tracks

Channel stability index data was also collected in 2005 at Wolf Run as part of the Raccoon Creek Sediment TMDL in 2007. This approach is based on the concepts of Simon and Downs (1995) and addresses channel "behavior" in relation to form, thereby providing a process-based approach to fluvial geomorphology or stream channel management. Channel stability along Wolf Run (as measured at RM 5.3) was given an index score of 17, two points greater than the target score of 15 for the TMDL. This data indicates moderate overall instability, ranging from 51 to 75% along both stream banks (McCament 2007).

Chemical

Wolf Run is listed in the 303(d) for AMD impacts due to metals & pH (TMDL, 2003). However, specific water chemistry data is unavailable.

Problem Statement

Wolf Run from 1996-2000 was listed as non-attaining of its LRW-AMD designation due to AMD impacts of metals (TMDL 2003). However, fish data collected in 2002 showed marked improvement with IBI scores reaching 28 to 36. Current water chemistry data is not available to evaluate the existing water quality conditions. Wolf Run is a small stream and is easily impacted by low base flows which could magnify the siltation and sedimentation stresses. Habitat degradation is likely caused by silviculture, residential activities, and mining impacts.

Goals

1) Collect chemical and physical data to investigate the water quality data currently in the watershed.
2) Collect additional biological and habitat data in Wolf Run to determine current aquatic life use attainment.

Action Plan

Water quality data will be collected in Wolf Run to determine current water impairment. Data will be shared with the OEPA to determine current biological use attainment (Table 20).

Table 20. Action Table for Wolf Run 14-digit HUC Watershed

Objective	Action	Resources	Time Frame	Performance Indicators
Monitor water quality in Wolf Run	Collect chemical water data in Wolf Run	Staff and volunteers to collect data, sample collection and analysis	2010 - 2015	Chemical data collected and analyzed in Wolf Run
Monitor biological changes in Wolf Run	Biological data collection	Staff, volunteers and ODNR assistance	2010-2011	Biological data collected and analyzed to indicate habitat degradation

Raccoon Creek below Hewett Fork to above Elk Fork

14 Digit HUC: 05090101-030-030
Location: Raccoon Creek at River Miles 89.54 to 66.64
USGS Quadrangle: Mineral, Albany, Vales Mills
Drainage Area: 44.01 square miles, 28,169 acres

Watershed Description

This watershed is located within the 11-digit HUC of Raccoon Creek, Hewett Fork to Elk Fork (Map 11). This 14-digit HUC is contained within Athens, Meigs, and Vinton Counties. The main stem of Raccoon Creek downstream Hewett Fork to upstream Elk Fork is 22.9 miles long with a gradient of 2.39 feet per mile. This section of Raccoon Creek has several tributaries, including Laurel Run, Tedroe Run, Merritt Run, Russell Run, Flat Run, Long Run, Speed Run, and Brush Fork.

The watershed is primarily rural with 76% of land cover forested. In addition, 15% of land use is dedicated to agriculture, and approximately 1% of the area is residential. Historically, coal mining was conducted within this region. Underground mining affected 7,035 acres, approximately 25% of the watershed's 28,155-acre area. Surface mining occupied less than 1% of the area.

Water Quality

Biological

The Raccoon Creek below Hewett Fork to above Elk Fork mainstem is in full attainment of its WWH designation throughout the 11.66 river miles from 89.54 to 77.88; the partial attainment of its WWH designation is throughout the lower half (RM 77.88 to 66.64) due to manganese and zinc resulting from AMD (TMDL, 2003). Biological criteria supporting these attainments are included below (Table 21).

Table 21. Biological Data Raccoon Creek RM 66.64 to 89.54

Streams	River Mile	Year	IBI	MiWB	ICI/QUAL	MAIS*	QHEI
Raccoon Creek	89.35 (MSBM0010)	2004	38			12	58
		2005	44				63
		2006	46	8.5			
		2007				12	
		2008				16	
	85.9	2006				13	
		2007				14	
	84.1	1995	36	6.8	38		48
	82.36	2007				9	
	80.65 (MSBM0040)	2005	48	9	38/G	13	54
		2006				14	
		2007				14	
		2008				17	
	72.2	1995	40	8.1	46		62
Laurel Run	0.15	1995			G		
	0.1	1995			G		

Physical

QHEI scores are available for 2005 on two mainstem sites in this watershed – RM 89.40 (just below the Hewett Fork confluence) and RM 80.65. RM 89.40 was meeting the target score of 60 (63.0), while RM 80.0 was not meeting the target with a score of 54.0, however in 2005, the IBI score is in attainment of WWH, meeting the goal.

Chemical

The water quality in this section of mainstem Raccoon Creek is dependent on the impact that AMD is having on the Raccoon Creek headwaters (including Hewett Fork). Prior to doser treatment along Hewett Fork, a decline in water quality and decrease in both alkalinity and pH was seen in this section of the Raccoon Creek mainstem. Basin analysis by Hughes et al (1996) indicated that Hewett Fork contributed high acid loadings to the mainstem of Raccoon Creek. The mainstem was in poor condition, carrying an acid load of 9,446 pounds per day in early July 1995 with a pH of 4.39. Sampling results were similar in 2000, with overall net acidity concentrations ranging from 4 to 17 mg/l and pH consistently below 7.0 (Rice 2002). However, with ongoing treatment of Hewett Fork since 2003, water quality along Raccoon Creek has improved and continues to increase further downstream.

Water quality was monitored extensively by OEPA from 2004 to 2007 at the Bolin Mills gage station (RM 80.6). Alkalinity follows a seasonal pattern, with higher values in the summer and lower values in the winter and spring. While high flow events can also lower alkalinity levels dramatically, Figure 17 illustrates the concentrations of alkalinity (mg/L) and discharge from 2004-2007 at Bolin Mills site and also indicates that water passing through this gage station along the Raccoon Creek Below Hewett Fork to Above Elk Fork mainstem typically approaches or exceeds the TMDL alkalinity target of 20 mg/l. Figure 18 shows the change of aluminum concentrations with flow from 2004-2007. As we can see, the 0.75 mg/L aluminum TMDL target was reached most of the time. High concentration of aluminum was observed when the high flow occurred.

Figure 19 illustrates the pattern of conductivity change with flow from 2004-2007. Conductivity is not listed as a parameter of Upper Basin TMDL report; however, it is an indicator of dissolved ions in the water. The conductivity values in Figure 19 were not high in general; high conductivity occurred when the flow was low. Figure 20 shows the concentrations of iron from 2004- 2007. The TMDL target for iron is 1 mg/L; however, the concentrations showed in the figure all exceeded the target value.

Figure 17. Alkalinity at Bolin Mills (2004-2007)

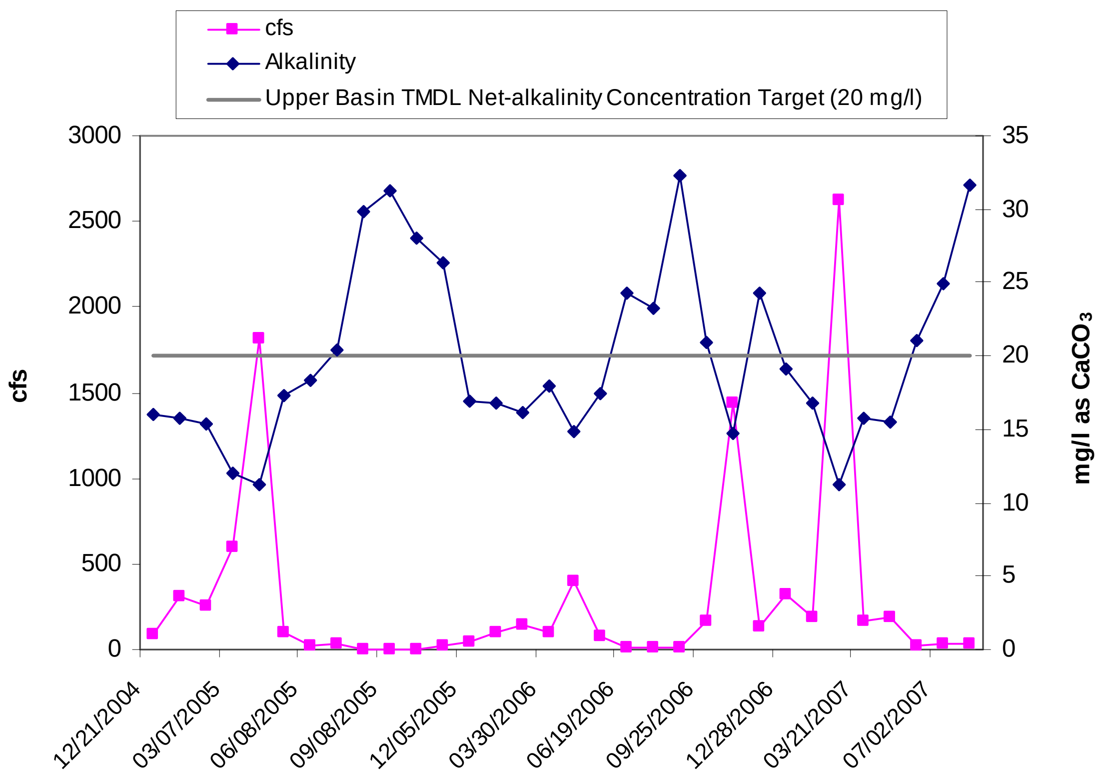


Figure 18. Aluminum at Bolin Mills USGS Gage Station (2004-2007)

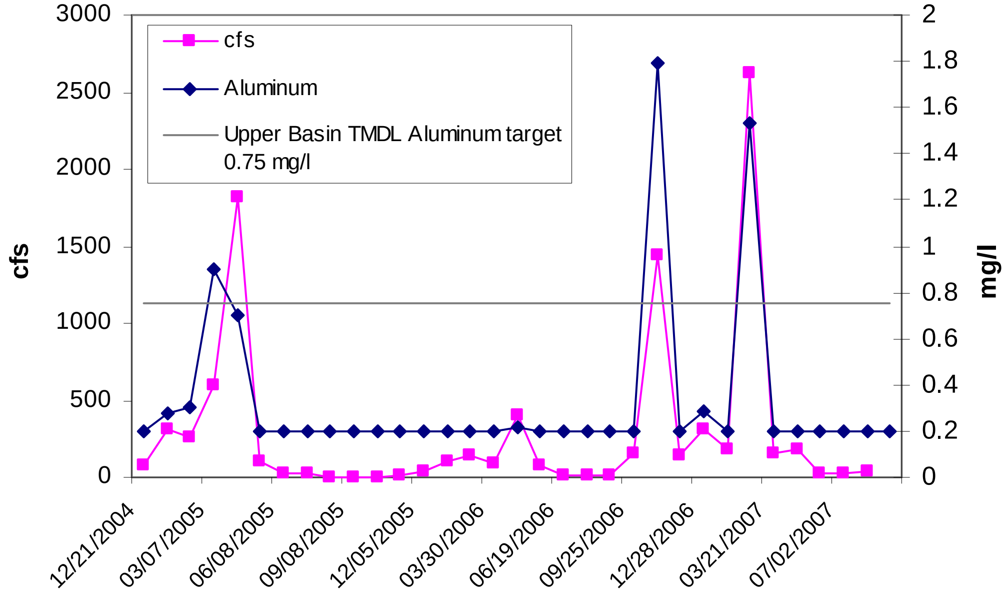


Figure 19. Conductivity at Bolin Mills USGS Gage Station (2004-2007)

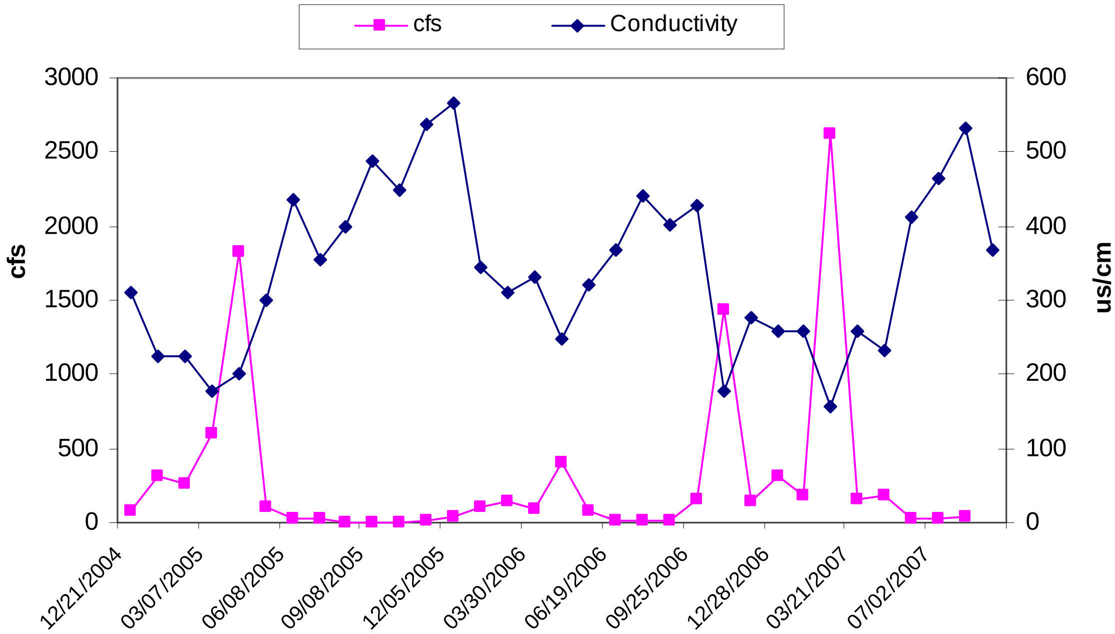
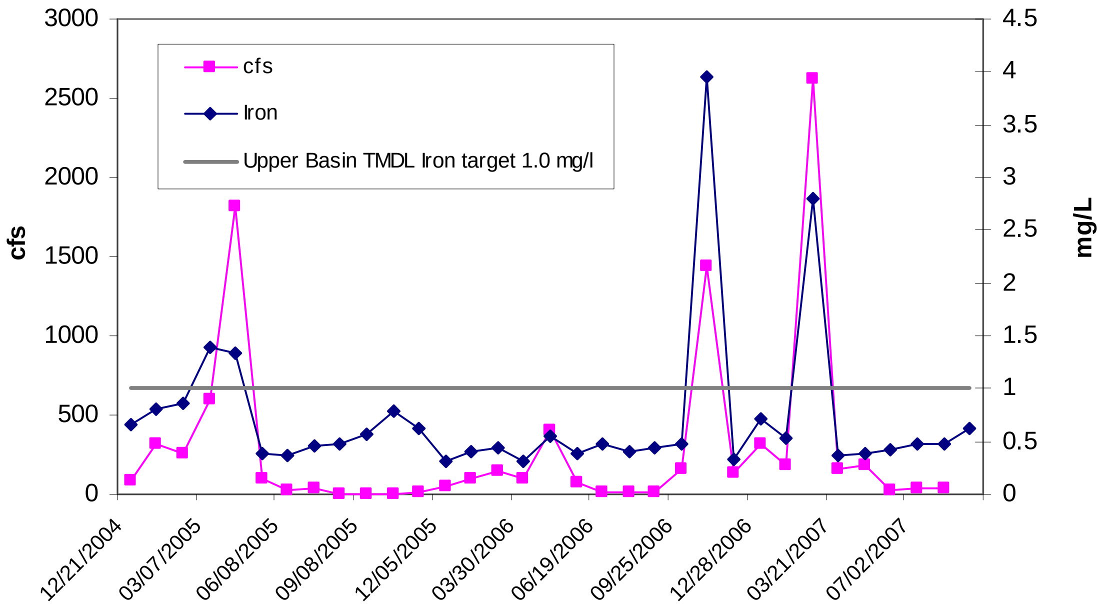


Figure 20. Iron Concentrations at Bolin Mils USGS Gage Station (2004-2007)



Problem Statement

The Raccoon Creek below Hewett Fork to above Elk Fork mainstem is in full attainment of its WWH designation throughout the river miles from 89.54 to 77.88; the partial attainment of its WWH designation is throughout the lower half (RM 77.88 to 66.64) due to AMD impacts (TMDL 2003). Biological and chemical conditions have improved along this section since 2003 with the ongoing treatment of Hewett Fork acid loads. However, high concentrations of aluminum and iron were still observed at Bolin Mills gage station (RM 80.6). Additionally, alkalinity fell below the TMDL target of 20 mg/L during the winter months with high flows.

Goals

1) Continue collecting chemical data to further assess the presence/absence of AMD in the watershed.

2) Collect additional biological data in the watershed to determine current aquatic life use attainment specifically at river mile 84.1, 72.2, and 66.64.

Action Plan

Raccoon Creek below Hewett Fork to above Elk Fork is impacted by AMD. Further chemical and biological sampling is needed to evaluate the water quality and potential problems in the watershed (Table 22).

Table 22. Action Table for Raccoon Creek below Hewett Fork to above Elk Fork 14-digit HUC Watershed

Objective	Action	Resources	Time Frame	Performance Indicators
Monitor water quality in Raccoon Creek	Collect chemical data in the watershed	Staff and volunteers to collect data, sample collection and analysis	2009 - 2015	Water quality data collected and entered into online database,
Monitor biological changes in Raccoon Creek	Biological data collection	Staff, volunteers and ODNR assistance	2010- 2015	Biological data collected, analyzed, and entered into database to indicate habitat degradation

<u>Elk Fork above Wolf Run</u>

14 Digit HUC: 05090101-030-040
Location: Raccoon Creek Tributary (upper section to Wolf Run confluence, RM 9.2)
USGS Quadrangle: McArthur, Zaleski, Allensville, Hamden
Drainage Area: 32.77 square miles, 20,973 acres

Watershed Description

Elk Fork is the second largest tributary of Raccoon Creek and the stream is heavily impacted by AMD. Elk Fork above Wolf Run (Upper Elk Fork) is located within the 11-digit HUC of Raccoon Creek, Hewett Fork to Elk Fork (Map 13). This 14-digit HUC is contained within Vinton County. The main stem of Upper Elk Fork is 9.4 miles long, beginning at its headwaters (RM 18.6) and ending above the confluence of Wolf Run (RM 9.2), and has a gradient of 11.31 feet per mile. There are two tributaries to Upper Elk Fork: Austin Powder Tributary (Austin Powder NPDES permit #0LF00003) and Puncheon Fork (note: the McArthur WWTP discharges into Puncheon Fork NPDES permit # 0PB00080).

The watershed is primarily rural with 62% of land forested. Agriculture accounts for 22% of the land use; 2% of the area is residential. Historically, coal mining was conducted within this region. Surface mining affected 2,210 acres, approximately 10% of the watershed's 20,964-acre area. Much of this land "surface mine land" is categorized as agricultural land on the land use map 4 from the NLCD data set. Underground mining occupied around 1% of the area.

Water Quality

Biological

The entire Elk Fork (Upper Elk Fork, RM 9.2 – 18.6 and Lower Elk Fork mouth to RM 9.2) is currently in partial attainment of its WWH designation, due to metal and pH impacts (TMDL, 2003). Historical and current biological data (collected in 1981, 1995 and 2008) supporting this status is included below (Table 23). As shown, IBI scores are non-attaining for all mainstem and tributary river miles except for Elk Fork RM 13.3 and Puncheon Fork RM 1.5. However, ICI scores are attaining for all sites. In 2008, the Raccoon Creek Partners and Ohio EPA sampled the fish community in Elk Fork and found a section of the stream to be severely impacted by acid mine drainage. Field reconnaissance revealed an AMD tributary originating from an underground mine seep flowing from Old Dixon Road into Elk Fork near river mile 10.5. The tributary also has several AMD seeps draining into it from reclaimed strip mines.

The stream's fish community was sampled at 6 locations between river mile 8.5 and 14.7. Three sites supported less than 5 species of fish, two sites supported 10 species, and one site supported 12 species. Tolerant species such as white sucker, creek chub, green sunfish, and bluntnose minnow accounted for the majority of species present at each site. A fish community dominated by the tolerant species mentioned above is an indicator of very poor water quality. It is evident that AMD has a negative effect on chemical and biological quality.

Table 23. Biological Data for Upper Elk Fork (1981, 1995 & 2008)

Streams	River Mile	RC Site ID	Year	IBI	MiWB	ICI/QUAL	MAIS*	QHEI
Elk Fork	16.2	EF0280	1981	32		E		65
			1995	39		36/G		70
	16.2	EF0280	2008	36				
	14.1	N/A	1995	38		54		68
	13.3	N/A	1995	44	7.6	F		75
	12.2	EF0229	1981	12	8.03	44		
	11	N/A	1995	43	8	44		52
	8.5	N/A	2008	14	3.3			
Puncheon Fork	2.2	N/A	2008	32	7.7			59.5
	1.5	N/A	1995	44		G		66
	0.3	N/A	1995	40		MG		65
	0.2	EF0250	1981	12				
			1995	41		MG		65
			2008	34	7.7			67.5
Austin Powder Tributary	0.4	EF0270	1981	18				
			1995	38		54/E		67.5

Physical

As included in Table 24, QHEI scores from 1981 & 1995 were meeting the target (60) for all sites except Elk Fork RM 10.9/11 in 1995. More recently, QHEI scores were collected in 2005 for four sites along Upper Elk Fork, where three sites met the target of a WWH designation and one site was slightly under.

Table 24. QHEI Scores for Upper Elk Fork

River Mile	Year	QHEI Score
17.40	2005	78.0
16.20	2005	76.5
14.60	2005	59.5
11.20	2005	56.0

Heavy silt, extensive embeddedness, and little to no riffle-run quality was observed at RM 11.2 and RM 14.6. RM 11.2 was noted to include agricultural and mining impacts. Quoting Ohio EPA based on a 1995 basin study (1997): "Improved chemical water quality appeared the most significant factor responsible for the recovery [of Elk Fork], as chemical impacts from mine drainage appeared largely ameliorated in 1995. However, pervasive sedimentation and its detrimental effects to substrate quality were still present and now appear the major factor limiting biological performance in the [Elk Fork] mainstem."

Streambank instability was estimated at 11-25% for RM 17.4 and at 76-100% at RM 11.2. Channel Stability Index scores of 8.5 and 19.5 were measured at RM 17.4 and 11.2, respectively. The target for channel stability is 15 or below. Elk Fork RM 11.2 shows channel evolution states that were unstable and adjusting (McCament, 2007) while the site further upstream (RM 17.4) shows more stable conditions.

Chemical

The stream has experienced water quality degradation due to previous coal mining activities in the immediate area. Following abatement of AMD impacts and septic system upgrades, Elk Fork has historically been a consistent net alkaline contributor to the Raccoon Creek mainstem (Rice 2003).

Historically, alkalinity levels vary, and are slightly lower in the upper reach, they are consistently at or above the 20 mg/l target level and do not reach levels that are known to affect aquatic life. In July of 1996, RM 16.2 was sampled at low flow and showed a pH of 6.85, 7.18 mg/l of acidity, 112 mg/l of alkalinity, and 109 mg/l of sulfate. Elk Fork was also assessed in March and September of 2002. Concentrations measured at RM 12.2 (EF0229) in March 2002 at high flow (24.9 cfs) were just under 40 mg/l alkalinity, 8 mg/l acidity, a pH of 6.45, and 140 mg/l of sulfate. Under low flow (0.355 cfs) in September 2002, concentrations measured approximately 60 mg/l alkalinity, <5 mg/l acidity, and a pH of 7.0.

In October 2008, several sites at Elk Fork were sampled. RM 12.3 (EF0230) had a pH of 6.08, 5 mg/l of acidity, 146 mg/l of alkalinity, and 193 mg/l of sulfate. RM12.7 (EF0232) had a pH of 7.2, 137 mg/l sulfate. Concentrations of metals vary from site to site, for example, Fe and Mn were 7.33 mg/l and 1.92 mg/l at RM 12.3, respectively, but went up to 41.2 mg/l and 17.7 mg/l, respectively, at the mouth of the underground mine tributary (Table 25). Although it is currently 303(d) listed for AMD impacts, existing data shows that Upper Elk Fork upstream of approximately river mile 13.0 is currently attaining for water chemistry and is maintaining adequate levels of alkalinity along its reach.

While, water chemistry samples taken in the AMD tributary near river mile 10.5 (originating from an underground mine seep flowing from Old Dixon Road into Elk Fork) revealed pH levels between 2.08 and 2.53 in 2008. pH levels in Elk Fork upstream of the AMD tributary ranged from 7.2 to 7.37 while levels downstream of the tributary were noticeably lower, ranging from 3.76 to 5.5.

Table 25. Summary of Chemical information of Sampled Sites at Elk Fork

Year	Site ID	River Mile	pH	Net Alkalinity (mg/L)	Sulfate (mg/L)
1996	N/A	16.2	6.85	105	109
2002	EF0229 March	12.2	6.45	30	140
	EF0229 September	12.2	7.01	54	240
2008	EF0232	12.7	7.2	N/A	137
	EF0230	12.3	6.08	141	193

Problem Statement

Elk Fork is currently in partial attainment of its WWH designation, due to metal and pH influences (TMDL 2003). Historically there have been variations in the amount of acid mine drainage and alkalinity discharging into Elk Fork. Major sources of AMD remain unknown and undocumented. Recent biological and chemical data show an undocumented impact of AMD near river mile 10.5 (Old Dixon Road). Habitat data indicate historical impact from sedimentation and poor habitat structure.

Goals

1) Collect chemical and biological data to further evaluate the AMD impacts and alkalinity loads in the watersheds and determine current aquatic life use attainment.
2) Perform a geomorphic assessment of the watershed to determine the cause and extent of channel instability and improve the watershed habitat.
3) Work with an Environmental Studies Master's student at Ohio University to gauge the severity and load of AMD affecting Elk Fork by doing field reconnaissance, sampling fish communities, and conducting monthly water sampling near the AMD tributary on Old Dixon Road.

Action Plan

Elk Fork above Wolf Run needs further investigation of both the possible impact from acid mine drainage and sedimentation. Further chemical, biological, and physical sampling is needed to evaluate the water quality and potential problems in the watershed (Table 26).

Table 26. Action Table for Elk Fork above Wolf Run 14-digit HUC Watershed

Objective	Action	Resources	Time Frame	Performance Indicators
Monitor water quality in Elk Fork	Collect chemical and biological data in the watershed	Staff, volunteers, and ODNR/OEPA assistance to collect data, sample collection and analysis	2009 - 2012	Chemical and biological data collected and entered into online database
Evaluate silt, embeddedness, and streambank instability	Perform geomorphic assessment of Elk Fork	Staff and volunteers collect data	2010-2011	Streambank data collected, analyzed, and evaluated
Monitor and determine source of impact near river mile 10.5.	Work with OU graduate student to investigate area near river mile 10.5.	OU graduate student and staff	2010	Reconnaissance report, water quality and biological data

Elk Fork below Wolf Run to Raccoon Creek

14 Digit HUC: 05090101-030-060
Location: Confl. with Raccoon Creek at River Mile 66.4 (Elk Fork mouth to RM 9.2)
USGS Quadrangle: Vales Mills, McArthur
Drainage Area: 16.00 square miles, 10,241 acres

Watershed Description

Elk Fork below Wolf Run (Lower Elk Fork) is located within the 11-digit HUC of Raccoon Creek, Hewett Fork to Elk Fork (Map 14). This 14-digit HUC is contained within Vinton County. The main stem of Lower Elk Fork is 9.2 miles long (beginning downstream of the Wolf Run confluence at RM 9.2 and ending at its confluence with Raccoon Creek mainstem) and has a gradient of 3.23 feet per mile. There are two named tributaries to Lower Elk Fork: Alman Run and Flat Run.

The watershed is primarily rural with 94% of land forested. Agriculture accounts for 1% of the land use; less than 1% of the area is residential. Historically, coal mining was not widely conducted within this region. Surface mining only affected 18 acres, approximately 0.18% of the watershed's 10,236-acre area. Underground mining was not conducted.

Water Quality

Biological

The entire length of Elk Fork (including Lower Elk Fork) is listed as partially attaining its WWH designation due to metals and pH (TMDL, 2003). Flat Run is also listed as partially attaining its WWH designation due to oil, grease, and "causes unknown" (Ohio EPA 2003). However, abatement of AMD and improved septic systems have allowed for improved biological quality over time. For example, RM 8.6 (upper portion of the Lower Elk Fork mainstem) demonstrated a significant improvement in IBI scores between 1981 and 1995. The majority of these improvements are attributed to reduction in AMD with secondary benefits from sewage upgrades (Rice 2003). Three sites were sampled in 2008 for fish, sites RM 0.2, 2.2 and 8.5. While site RM 8.5 had a low IBI score of 14 (likely attributed to the AMD impact under investigation near Old Dixon Road RM 10.5), sites RM 2.2 and RM 0.2 both had higher quality IBI scores of 32 and 34, respectively. Table 26 lists biological data for Elk Fork and one of its tributaries, Flat Run.

Table 27. Lower Elk Fork Biological Data

Streams	River Mile	RC Site ID	Year	IBI	MiWB	ICI/QUAL	MAIS*	QHEI
Elk Fork	8.6	EF0165	1981	12	N/A	N/A	N/A	N/A
			1995	37	8	N/A	N/A	54
	8.5	N/A	2008	14	3.3	44	N/A	52
	2.2	EF0045	1995	43	8	N/A	N/A	65.5
			2008	32	7.7			59.5
	0.2	EF0250	1995	42	8.3	42	N/A	58
			2008	34	7.7			67.5
Flat Run	1.3/1.6	N/A	1995-2000	36	N/A	Good	N/A	N/A
	0.2	N/A	1995	36	8.3	42	N/A	58

The following is a description from Ohio EPA (1997) of biological status along the Elk Fork mainstem: "In comparison with the results from the 1981 intensive survey, the structure, composition and organization of the fish community in 1995 were reflective of tremendous improvements in the environmental conditions of Elk Fork. Every community measure was significantly advanced (e.g., species richness, relative abundance, composition/organization, and structural evenness). Community indices were typically very near or fully consistent with WWH criteria. Although incomplete, biological recovery was clearly indicated in 1995."

Physical

QHEI scores collected in Lower Elk Fork are identified below (Table 28), with impacts based on field observations. The Alman Run site (RM 2.7) was noted to be just downstream of an exposed gob pile in the floodplain, with heavy silt and extensive embeddedness. Elk Fork RM 1.75 appeared somewhat entrenched, with high sand content but "good substrate" overall. The QHEI scores were meeting the target (60) at all mainstem sites, but not meeting at both tributary sites (McCament, 2007).

Table 28. Lower Elk Fork QHEI Data

Stream	River Mile	RC Site ID	Year	QHEI	Impacts
Elk Fork	8.6	EF0165	2005	71	Silviculture & Mining
	1.75	N/A	2005	65.5	Silviculture & Mining
	0.2	EF0250	2005	66.5	Ag, Riparian Removal, Silviculture
			2008	67.5	
Alman Run	2.7	N/A	2000	54.5	Silviculture & Mining
Flat Run	1.3/1.6	N/A	1996-2000	51	N/A

Chemical

A 1981 stream survey of the Raccoon Creek basin revealed severe impacts of AMD on the Elk Fork of Raccoon Creek. Chemical water quality has improved along Elk Fork following AMD abatement and improved septic systems upgrades in the early 1990's (Rice, 2003). Historically, alkalinity is attaining along the entire mainstem, with slightly higher concentrations in Lower Elk Fork. Figure 21 displays the data for all samples that were taken at the confluence of Elk Fork and Raccoon Creek (EF0010) in 2002.

Figure 21. Elk Fork Alkaline Load Discharge to Raccoon Creek

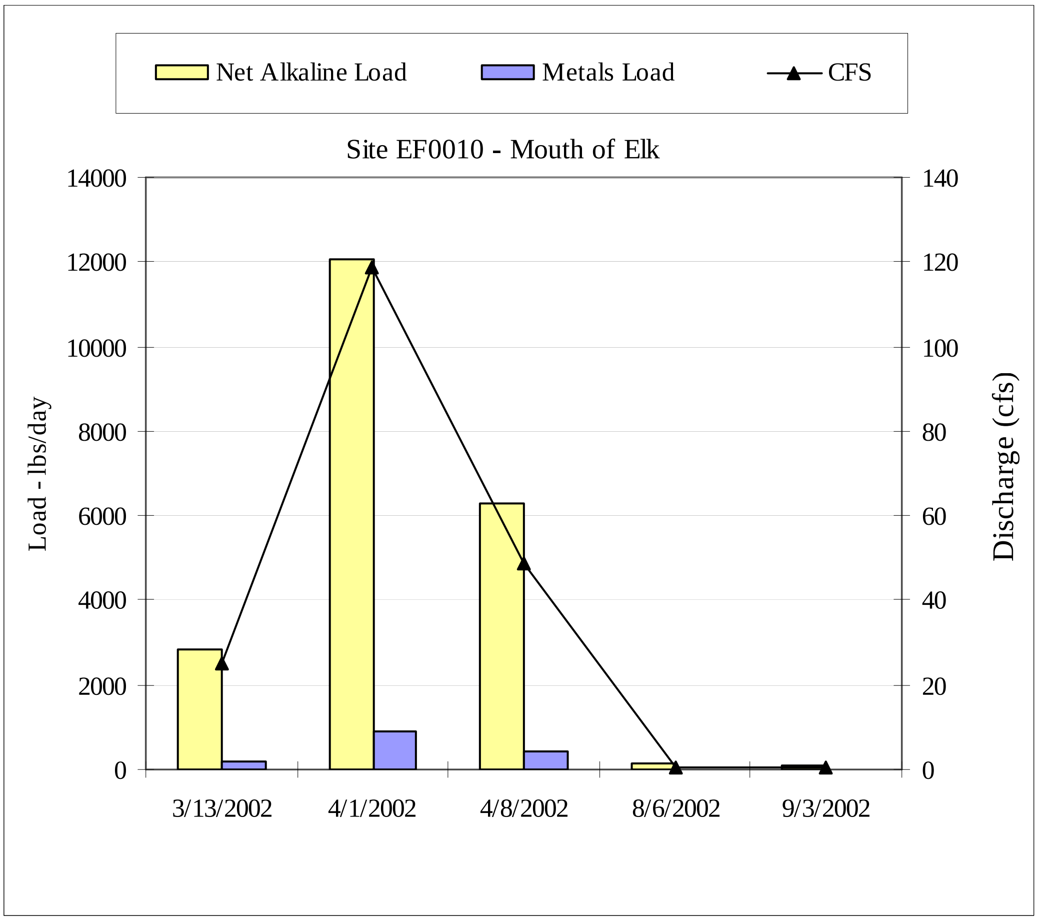
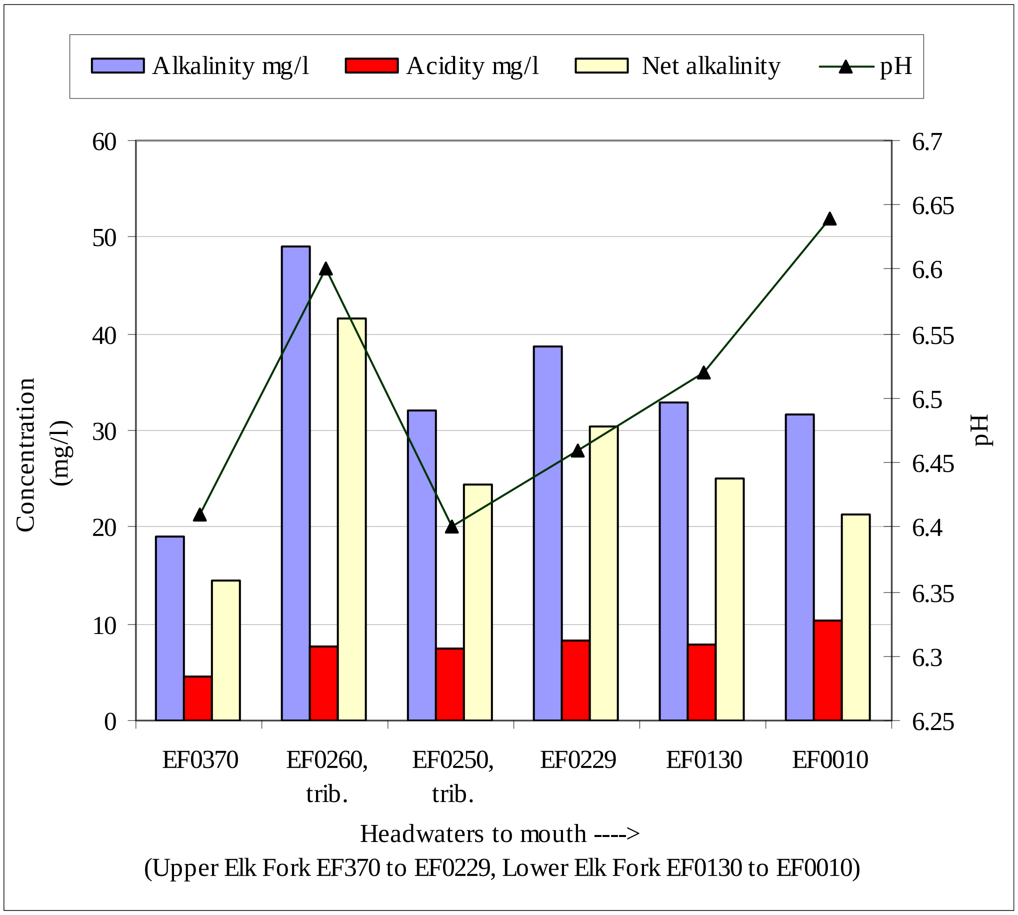


Figure 21 confirms the consistent alkaline load discharging to Raccoon Creek over varying flow regimes. The metals load represented on the graph is the sum of the iron, aluminum and manganese loads carried by the stream.

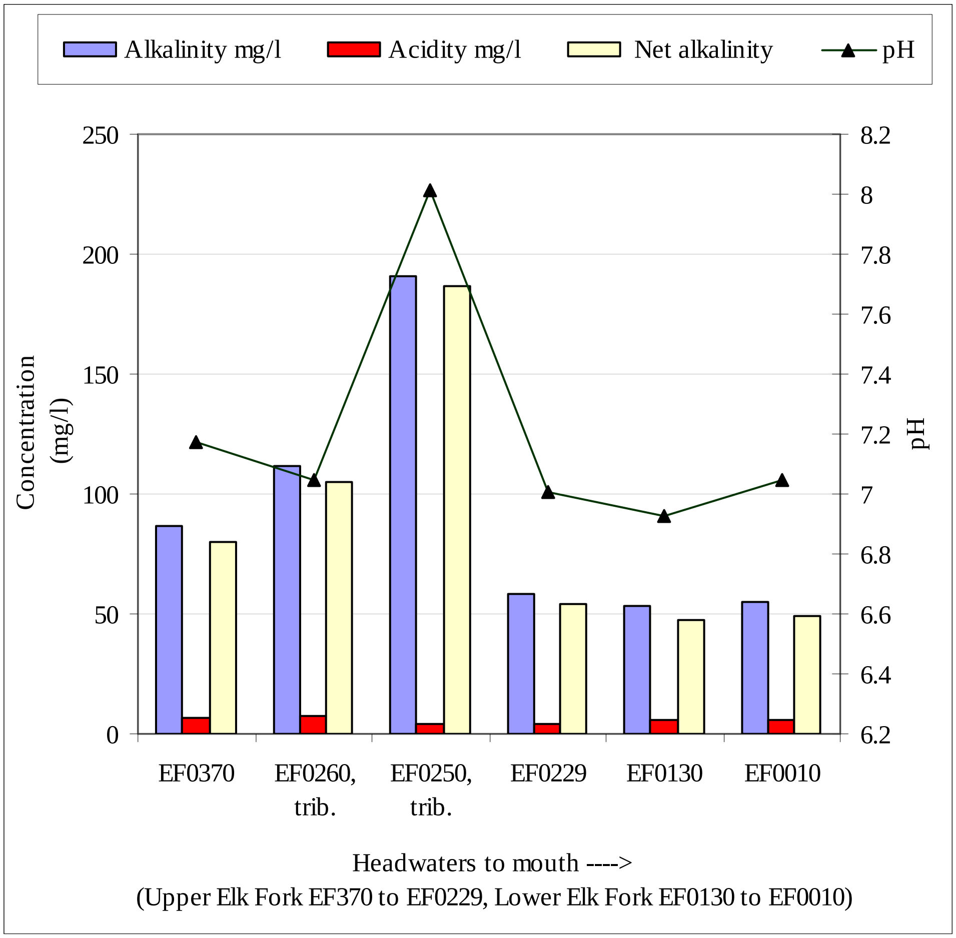
Each of the Elk Fork sub-basin sampling events shows that adequate levels of alkalinity are maintained along the entire reach of Elk Fork's mainstem. In March, Elk Fork (Site EF0010) delivered net alkaline concentration of 21 mg/l to Raccoon Creek at a rate of 25 cfs, under a moderate basin-wide flow regime (Figure 22) and maintained a net alkaline loading (Figure 24).

Figure 22. Net Concentration at Elk Fork (March 2002)



In September of 2002 a much lower flow regime (0.03 cfs) produced even higher alkalinity values across the sub-basin (Figure 23).

Figure 23. Net Concentration at Elk Fork (September 2002)



While alkaline conditions vary in Elk Fork and levels are lower in the lower reaches, conditions do not reach a level assumed to be affecting aquatic life. Even at the highest measured discharge levels, the alkalinity levels are at or above the 20mg/l target level at the confluence with Raccoon Creek (Rice 2003).

Recently, site EF0165 (RM 8.5) was sampled in October 2008. Figure 25 and 26 shows change of chemical parameters over 10 years. pH has increased from 4.5 in 1996 to 6.5 in 2008 (Figure 26); alkalinity has increased from 0 to 22.9 mg/l; aluminum decreased from 5.45 mg/l to 0.2 mg/l. However, iron showed a slight increase from 0.29 mg/l to 0.88 mg/l.

Figure 24. Elk Fork Alkaline Load Discharge to Raccoon Creek (March 2002)

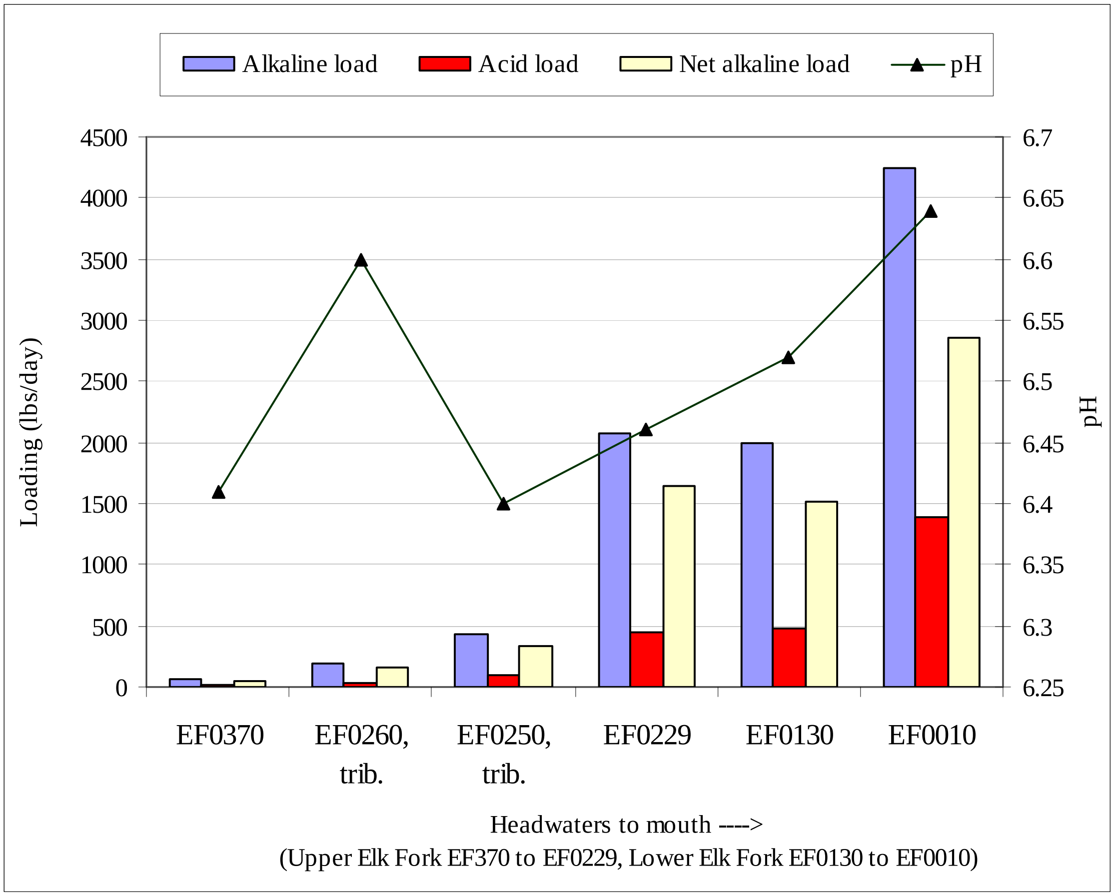


Figure 25. Parameters change over time for EF0165

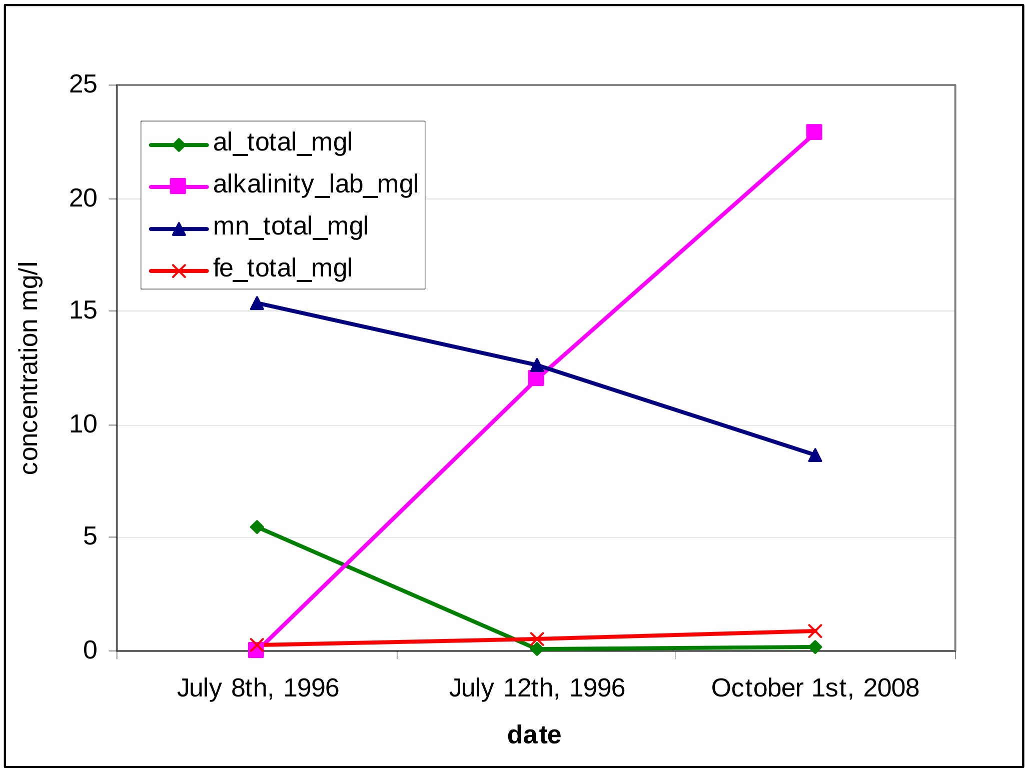
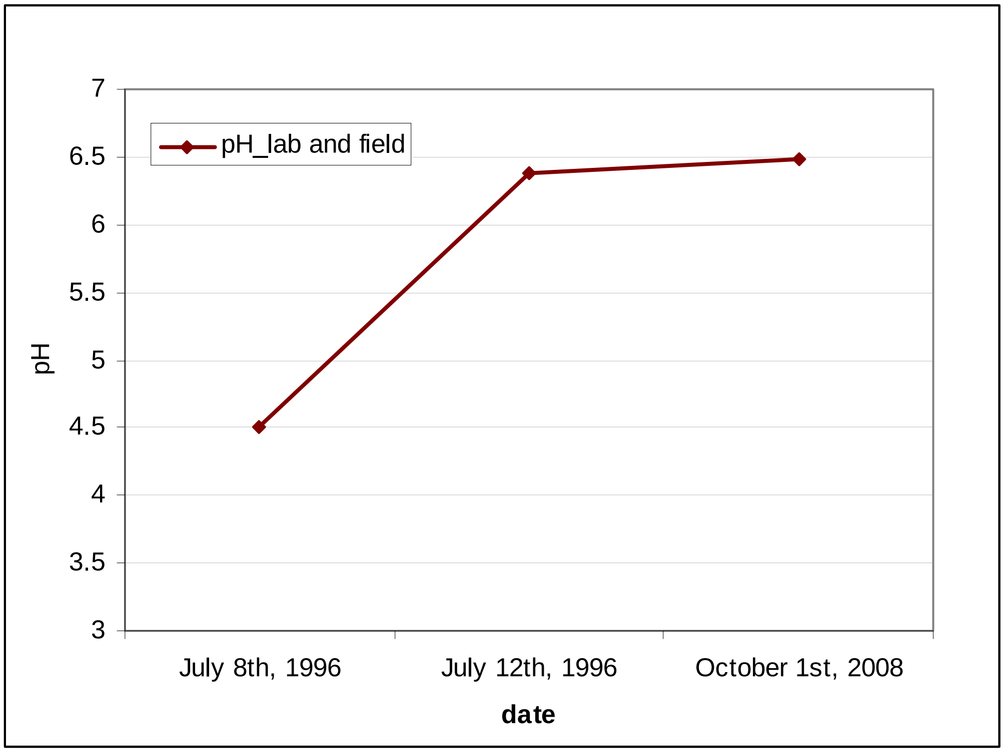


Figure 26. pH change over time for EF0165



Problem Statement

Elk Fork is currently in partial attainment of its WWH designation, due to metal and pH influences (TMDL 2003). There are areas of the Elk Fork basin that have been surface mined with much of it having been reclaimed. Some small tributaries to Elk Fork are not supporting healthy aquatic assemblages. It is not apparent whether this is due to AMD or the small drainage area and limited flow. Improvements of biological quality have been observed with time due to abatement of AMD and improved septic systems (Rice, 2003).

Goals

1) Collect additional biological data in Elk Fork below Wolf Run to Raccoon Creek to determine current aquatic life use attainment as AMD sources are addressed in Upper Elk Fork.

Action Plan

Water quality data will be collected for assessment of chemical and biological conditions in the watershed (Table 29).

Table 29.Action Table for Elk Fork 14-digit HUC Watershed

Objective	Action	Resources	Time Frame	Performance Indicators
Monitor water quality in Elk Fork	Collect chemical data in the watershed	Staff and volunteers to collect data, sample collection and analysis	2009 - 2011	Water quality data collected and entered into online database
Monitor biological changes in Elk Fork	Biological data collection	Staff, volunteers and ODNR assistance	2010-2012	Biological data collected, analyzed, and entered into database to indicate habitat degradation

References

Hansen, M. C., 1995. The Teays River. GeoFacts No. 10. Ohio Department of Natural Resources – Division of Geological Survey, 1995. Columbus, Ohio.

Harstine, L. J., 1991. Hydrologic Atlas for Ohio. Ohio Department of Natural Resources Division of Water, water inventory report no. 28. Columbus, Ohio.

Hughes, M and McCament, B., 2006. Channel evolution, instability, and sedimentation in Ohio's coal region: implications for stream restoration and water-quality management. In Conference Proceedings for the ODNR Division of Mineral Resources Applied Research Conference, *Advances in Energy Resource Extraction and Restoration*, Athens, Ohio, December 6th – 7th, 2006.

Institute for Local Government Administration and Rural Development (ILGARD), 2003. Raccoon Creek Management Plan. Ohio University, Athens, Ohio. 132 p.

Lemaster, B. D. and Gilmore G. M. 1998. Soil Survey of Vinton County Ohio. Natural Resources Conservation Service.

McCament, B. M., 2007. Sediment Total Maximum Daily Load for the Upper Basin of Raccoon Creek. Ohio University's Voinovich Center for Leadership and Public Affairs. Athens. Ohio. 26 p.

McCament, B. M., 2008. Response of Stream Biota to Acid Neutralization via Lime Dosing. 42 nd GSA North-Central Section Meeting, Evansville, IN (April 23-25, 2008).

Ohio Department of Natural Resources (ODNR) Division of Water, 2001. Gazetteer of Ohio Streams, Second Edition. Columbus, Ohio. 153 p.

Ohio Environmental Protection Agency, 1997. Biological and Water Quality Study of the Raccoon Creek Basin (1995). OEPA Technical Report Number MAS/1996-12-7. Columbus, OH.

Ohio Environmental Protection Agency. 2003. (Draft Report) Total Daily Maximum Loads for the Upper Raccoon Creek.

Rankin, E. T. 1989. The qualitative habitat evaluation index (QHEI) rationale, methods, and application. Ohio Environmental Protection Agency, Division of Water Quality Planning and Assessment, Ecological Assessment Section, Columbus, Ohio.

Rice, R. 2002. Acid Mine Drainage Abatement and Treatment (AMDAT) Plan for the Headwaters of the Raccoon Creek Watershed, Institute for Local Government Administration and Rural Development (ILGARD). Ohio University, Athens, Ohio.

Rice, R., Flemming, L., and Hoy, J. 2003. Acid Mine Drainage Abatement and Treatment (AMDAT) Plan for the Middle Basin of the Raccoon Creek Watershed. Institute for Local Government Administration and Rural Development (ILGARD). Ohio University, Athens, Ohio.

Shimala, J. R. 2000. Hydrogeochemical characterization of the Carbondale wetland, Athens County, Ohio: Evaluation of acid mine drainage remediation alternatives. Ohio University Graduate Thesis Geological Sciences.

Simon A. and Downs P. W., 1995. An inter-disciplinary approach to evaluation of potential instability in alluvial channels. Geomorphology 12: 215-32

Slucher, E. R., Swinford, E. M., Larsen, G. E., Schumacher, G. A., Shrake, D. L., Rice, C. L., Caudill, M. R., and Rea, R. G., 2006. Bedrock Geologic Map of Ohio. BG-1 Version 6. Ohio Department of Natural Resources Division of Geological Survey, Columbus, Ohio.

Smith, E. P. and J. R. Voshell. 1997. *Studies of Benthic Macroinvertebrates and Fish in Streams within EPA Region 3 for Development of Biological Indicators of Ecological Condition. Part 1, Benthic Macroinvertebrates.* Report to U. S. Environmental Protection Agency. Cooperative Agreement CF821462010. EPA, Washington, D.C.

Stoertz, M. W. & Green, D. H., 2004. Mean Annual Acidity Load: A Performance Measure to Evaluate Acid Mine Drainage Remediation. In Ohio Department of Natural Resources –Division of Mineral Resources Applied Research Conference, Dec. 8 & 9, 2004. Athens, Ohio,27 pp.

Wilson, K.S. 1985. *Surface Water Quality of Coal Mine Lands in Raccoon Creek Basin Ohio*. U.S. Geological Survey, Water Resources Investigations Report 85-4060. Columbus, Ohio.

Wilson, K.S.1988. Chemical Quality, Benthic Organisms, and Sedimentation in Streams Draining Coal-Mined Lands in Raccoon Creek Basin, Ohio, July 1984 through September 1986.US Geological Survey Water-Resources Investigations Report 88-4022.

Appendix 1. Raccoon Creek Watershed Contributing Organizations and Agencies

A-1 Key Stakeholders are included in the table below.

Organization/Agency	Individual Contact	Role / Responsibility
Vinton SWCD/RC&D	Amy Mackey 740-596-5676	- Water quality specialist - Water quality data collection and analysis - Outreach and education - Program and project development
ODNR Division of Mineral Resource Management	Mitch Farley 740-592-3748	- Project development, design, oversight, implementation, and analysis - Water quality sample analysis - Technical advice and expertise - Funding towards water quality projects, research, ArcIMS database, and annual monitoring - AMDAT development
Ohio University's Voinovich School of Leadership & Public Affairs	Jen Bowman 740-597-3101	- Coordination and fiscal sponsor - Technical support including GIS, meeting space, planning, website, database management, and technical advice. - Graduate and undergraduate student projects - Annual NPS monitoring report and analysis
Raccoon Creek Partnership (RCP)	Scott Schell, Vice Chair sschell2@verizon.net	- Education and outreach activities - Financial support - Recreational opportunities - Watershed promotion - Volunteer monitoring - Advocate and support the mission of the RCP
ODNR Division of Soil and Water Conservation	Constance White 740-596-5676	- Education and outreach assistance - Technical advisor - Project planning and development - Networking with County SWCD's in watershed
Ohio State University Extension – South Centers	Jerry Iles 740-289-2071	- Technical advisor - Education / Outreach - Project development and planning

Athens SWCD	Cathy Bobo 740-797-9686	- Education and outreach partner - Technical assistance
Ohio Valley Resource Conservation District	John Kellis 937-695-1293	- Administration support for the water quality specialist position - Technical assistance - Outreach assistance - Program and group development - Water quality project implementation fiscal support
Office of Surface Mining Reclamation and Enforcement (OSMRE)	Dave Agnor 614-416-2238 ext.112	- Funding for AMD project implementation - Technical assistance
Ohio University – Environmental Studies Program	Michele Morrone 740-593-9549	- Graduate student assistantships - Outreach assistance
Ohio University – Geological Sciences	Eung Lee 740-597-3320 Dina Lopez 740-593-9435	- Graduate student research - Data analysis and interpretation assistance - Project development
Ohio University – Biological Sciences	Matt White 740-593-2413 Kelly Johnson 740-593-0276	- Bio-monitoring program development assistance - Student assistance and collaboration - Biological data collection and analysis
Ohio University – Department of Civil Engineering	Guy Riefler 740-593-1471 Ben Stuart 740-593-9455	- Data analysis and interpretation - Data collection - AMD project assistance - Student research
ODNR Division of Wildlife	Mike Greenlee 740-589-9944	- Biological data collection and analysis - Funding for AMD projects and right of entry for AMD projects on property
ODNR – Division of Forestry: Zaleski State Forest	Tom Shuman 740-596-5781	- Partnership for annual litter clean up - Partner in AMD reclamation, water trail development, and research
Raccoon Creek Water Trail Association	Molly Gurien 740-593-4228	- Public outreach and education - Watershed promotion - Recreation opportunities
Ohio EPA – Southeast District	Dan Imhoff 740-385-5232 Kelly Capuzzi 740-385-5283	- Water quality and biological data collection, assistance, and support - Project development and planning - Technical assistance -

Moonville Rail Trail Association	Gene Mapes mapesg@ohio.edu	- Outreach partner - Partnership for water and rail trail development
Midwest Biodiversity Institute	Chris Yoder 614-403-9592	- Biological data collection and analysis - Technical assistance and bio-monitoring program development
USFS - Wayne National Forest	Gary Willison 740-753-0101	- AMD project landowner - AMD project implementation partner - Technical advising and support

Appendix 2
Bylaws
of the
Raccoon Creek Partnership

ARTICLE I. - NAME

The name of the organization shall be the ***Raccoon Creek Partnership*** and referred to as the ***RCP***.

ARTICLE II. – PURPOSE

The mission of the Raccoon Creek Partnership is "to work toward conservation, stewardship, and restoration of the watershed for a healthier stream and community".

The primary objectives of the Raccoon Creek Partnership are:

1. To partner with local, state and federal agencies and organizations to facilitate and implement water quality restoration, enhancement, and protection projects.
2. To conduct outreach activities and provide environmental education to the public and watershed partners with regard to Raccoon Creek watershed management.
3. To create, enhance, and promote recreational opportunities on Raccoon Creek.
4. To support and coordinate watershed related research activities.
5. To develop and support stewardship programs to activate and educate the local watershed community.
6. To advocate and support activities that support and further the mission of the RCP.

ARTICLE III. - NATURE

This organization is formed as a partnership of individuals, businesses, agencies, organizations, institutions, corporations, and governmental units with the common mission and purpose of the Raccoon Creek Partnership.

Said organization is organized exclusively for charitable, religious, educational, and scientific purposes, including, for such purposes, the making of distributions to organizations that qualify as exempt organizations under section 501 (c) (3) of the Internal Revenue Code, or corresponding section of any future federal tax code.

Notwithstanding any other provision of this document, the organization shall not carry on any other activities not permitted to be carried on (a) by an organization exempt from federal income tax under section 501 (c) (3) of the Internal Revenue Code, or corresponding section of any future federal tax code, or (b) by an organization, contributions to which are deductible under section 170 (c) (2) of the Internal Revenue Code, or corresponding section of any future federal tax code.

ARTICLE IV. – MEMBERSHIP

The corporation shall have two levels of membership, designated as "General" and "Supporting".

1. ***General Membership***: General membership may be extended to any agency, business, organization, corporation, governmental unit, or other entity that is interested in promoting the common mission and purpose of the Raccoon Creek Partnership. Members are considered in good standing at the first of the month in the month that annual dues are paid.

    a) General Membership in the Raccoon Creek Partnership will commence with the signing of a membership agreement and membership will be effective the date of receipt of payment of dues.
    b) Each General Member is entitled to one vote. Organizations, agencies (or divisions of), businesses, corporations, governmental units, and other entities shall designate a voting representative and an alternate.
    c) Each General Member shall have the privilege to nominate and elect board members, vote on bylaw amendments, articles of incorporation, dues, and other issues brought forth by the Board of Directors.
    d) Each General Member may bring forth issues related to the mission, purpose, function, and funding to the Board of Directors of the Raccoon Creek Partnership.
    e) General Membership may be revoked for just cause as determined by a two-thirds majority vote on the Board of Directors and a simple majority vote of the members present at the next scheduled meeting.

2. ***Supporting Membership***: Supporting membership may be extended to any individual interested in promoting the common mission and purpose of Raccoon Creek Partnership. This provision is to allow and encourage participation from individuals who desire to support the Raccoon Creek Partnership but who do not represent any entity or organization.

a) Supporting Membership in the Raccoon Creek Partnership will commence with the issuance of a membership card by the Treasurer, effective the date of payment of dues.
b) Each Supporting Member has the privilege to nominate and vote for the Board of Directors at the annual meeting.
c) Supporting Members may bring forth issues related to the mission, purpose, function, and funding to the Board of Directors of the Raccoon Creek Partnership.
d) Membership may be revoked for just cause as determined by a two-thirds (2/3) majority vote on the Board of Directors and a simple majority vote of the members present at the next scheduled meeting.

ARTICLE V. – DUES

Dues shall be reviewed and recommended annually by the Board of Directors and approved by a simple majority vote of the members present at a regularly scheduled meeting. Dues shall be renewed annually and payment will be due in full the first of the month in which dues were collected the previous year. New members shall be required to make payment in full with a signed partnership agreement.

ARTICLE VI. – MEETINGS

Meetings of the Raccoon Creek Partnership will consist of three types, “annual”, “regular”, and “special”.

a) “***Annual Meetings***” – shall be held during the last quarter of the fiscal year.
b) “***Regular Meetings***” - shall be conducted quarterly with dates to be set at the annual meeting for the next year.
c) “***Special Meetings***” – may be scheduled by the Chairperson and/or the Board of Directors. The secretary shall send out notices of special meetings to each member marked two weeks in advance.

ARTICLE VII. – BOARD OF DIRECTORS

There shall be a Board of Directors of seven (7) elected members. All Board members will be elected by the entire membership present at the annual meeting, beginning with the first annual meeting. All Board members are required to be a member of the Raccoon Creek Partnership and in “good standing”.

An interim board will be established for the organization until elections can be held at the first annual meeting of the organization.

The initial Board of Directors terms will be staggered to avoid complete turnover of the Board. Four of the initial Board members terms will be two years in length and three of the board members terms will be one year in length. Board members elected beginning with the second election and beyond will serve a two-year term. A Board of Director's term will begin with annual meeting in which elected and end at the close of the annual meeting, which their term expires. Board members may serve a maximum of three consecutive terms.

A quorum shall be required to conduct business at all board meetings. A quorum is defined as 51% of the Board of Directors. If the meeting has been advertised and scheduled in advance to the membership, the membership present shall constitute a quorum. A majority vote of the Board of Directors present shall be required to pass a motion.

When a vacancy on the Board exists, nominations for new members may be received by the Secretary or Chairperson from present Board members two weeks in advance of a Board meeting. These nominations shall be sent out to Board members with the regular Board meeting announcement, to be voted upon at the next Board meeting. A Board vacancy will be filled through nomination from the Board only to the end of the vacant Board members term when a new election will occur.

Resignation by a Board member must be in writing and received by the Secretary. A board member can be dismissed from the Board for excessive absences if he/she has three unexcused absences from Board meetings in a year. A Board member may be removed for other reasons by a two-thirds (2/3) majority vote on the Board of Directors and a simple majority vote of the members present at the next regularly scheduled Raccoon Creek Partnership meeting.

ARTICLE VIII. – OFFICERS AND DUTIES

Officers of the RCP shall serve one (1) year terms with reappointment optional each year. These officers shall be nominated and elected by a majority vote of the Board of Directors at the first Board meeting following the annual meeting. In the case of death, resignation, or inability to continue as an officer, the Board of Directors may declare the office vacant and appoint his/her successor. All officers shall be nominated and elected from the currently serving Board of Directors.

> ***Chairperson* –** Duties of the chairperson shall be to determine the regular meeting schedule, preside over all meetings of the RCP, call special meetings of the RCP and Board of Directors, determine agendas for the meetings, appoint committees, perform all acts and duties usually performed by an executive or presiding officer, and sign all membership agreements and other such papers of the RCP as authorized by the Board of Directors on their behalf.

Vice-Chairperson – Duties of the vice-chairperson shall include all duties of the chairperson in his/her absence.

Treasurer – The treasurer shall have general charge and supervision of the RCP's financial records including handling all receipts and disbursements of all monies. He/she shall serve, mail, or deliver all notices required by law and these bylaws. He/she shall make a full report of all matters and business pertaining to the office to the members at the Annual Meeting or at such other times as the president directs. He/she shall make all reports as required by law and perform other duties required by the RCP. Upon election of a successor, the treasurer shall turn over all books and other property belonging to the RCP that he/she may have in his/her possession. The treasurer shall cooperate with the president in an audit of the financial records.

Secretary – The secretary shall keep a complete record of all meetings of the RCP and make the minutes available to the membership. He/she shall make all reports as required by law and perform other such duties as required by the RCP.

ARTICLE IX. – COMMITTEES

1. **Standing Committees –** Standing Committees will operate as an entity of the board of directors and will work towards achieving specific duties of the Board and toward the RCP's mission and goals. Standing Committee Chairperson(s) will be appointed by the Board of Directors and will be responsible for conducting committee meetings and reporting to the Board about committee activities and recommendations. Standing Committee membership is open to any member of the RCP.

   a) Finance Committee - The "Treasurer" will serve as the chair of the Finance Committee, which will include at least three (3) other board members. Additional RCP members may serve on the finance committee if interested. The Finance Committee is responsible for developing and reviewing fiscal procedures, a fundraising plan, and an annual budget with staff and other board members. The Board must approve the budget, and all expenditures must be within the budget. The Board must approve any major changes to the budget. The committee shall prepare a report attesting to the financial condition of the RCP as of January 1st each year for the preceding year and submit the report to the Chairperson of the RCP prior to the annual meeting for attachment to the Annual Treasurer's Report. The financial records of the organization are public information and shall be made available to the membership, Board members, and the public.

b) Technical Advisory Committee – The Technical Advisory Committee, i.e. Raccoon Creek Forum, will assist with and develop research ideas, and investigate, plan, and recommend water quality improvement or protection projects for the RCP. The committee will provide advice, direction, and guidance on scientific and technical matters related to water quality and watershed issues to the Board and members.

c) Membership and Development Committee – The Membership and Development Committee will evaluate and provide guidance to the Board and members regarding operating procedures and policy. The committee will also be responsible for recruiting partnership members and handle membership related tasks.

2. **Special Committees** – The Board of Directors shall have the authority to appoint special committees as necessary, and at their discretion, and to appoint a chairperson of that committee from the Board. Special Committee membership is open to any member of the RCP.

ARTICLE X. – FINANCIAL PROVISIONS

The fiscal year of the organization shall begin the 1st day of January in each calendar year.

Disbursements shall be made by check, with two signatures. A check can be signed by the Treasurer, Chairperson and any other alternate person authorized by the Board. Disbursements in conformance with an approved budget of less than $500 may be made without the Board approval. Disbursements not in conformance with an approved budget or over $500 will first need to be approved by the Board.

ARTICLE XI. – QUORUM

A quorum shall be required to conduct Raccoon Creek Partnership business at partnership meetings. A quorum is defined as 51% of the Raccoon Creek Partnership General Membership. If the meeting has been advertised and scheduled in advance to the membership, the membership present at the meeting shall constitute a quorum. A majority vote of the General Membership present shall be required to pass a motion.

ARTICLE XII. - AMENDMENT PROCEDURES

Proposed amendments to the Bylaws shall be presented in writing to each member of the Board of Directors at least thirty (30) days prior to the Board of Director's meeting at which the amendment is proposed to be adopted. An affirmative vote of two-thirds (2/3) of the Board of Directors shall be necessary for adoption of amendments to the Bylaws. When the Board of Directors has approved amendments to the Bylaws, they shall be submitted to the membership of RCP for a simple majority approval at the next meeting.

ARTICLE XIII. - INDEMNIFICATION

The RCP shall indemnify every Director and officer, his/her heirs, executors, and administrators against all loss, cost, and expense reasonably incurred by him/her in connection with any action, suit, or proceeding to which s/he may be made a party, by reason of his/her being or having been a member of the Board or officer of the organization, including reasonable matters wherein s/he shall be finally adjudged in such liability, damage, or injury is covered by any type of insurance; however, this indemnification shall not cover any acts of gross negligence, willful misconduct, or with fraudulent or criminal intent. The foregoing rights shall be in addition to and not exclusive of all other rights to which such Director/Officer may be entitled.

ARTICLE XIV. - DISSOLUTION

Upon the dissolution of the organization, assets shall be distributed for one or more exempt purposes within the meaning of section 501 (c) (3) of the Internal Revenue Code, or corresponding section of any future federal tax code, or shall be distributed to the federal government, or to a state or local government, for a public purpose. Any such assets not disposed of shall be disposed of by the Court of Common Pleas of the county in which the principal office of the organization is then located, exclusively for such purposes or to such organization or organizations, as said Court shall determine, which are organized and operated exclusively for such purposes.

We certify that the forgone bylaws were duly adopted by the members on ________________, that the same are in full force and effective and have not been amended. Given under our hands and the seal of the corporation, this _______ day of _____________, 20____.

Chairperson, ____________________________________

Secretary, ____________________________________

Appendix 3: Local Endorsement of Raccoon Creek above Hewett Fork to below Elk Fork Watershed Action Plan

Raccoon Creek Partnership

Chairperson, Board of Supervisors: Heike Perko

Signature:___________________________

Date:_______________________________

Vinton Soil and Water Conservation District

Board of Supervisor: Bill Nose

Signature:___________________________

Date:_______________________________

Athens Soil and Water Conservation District

Board of Supervisor: Pete Woyer

Signature:___________________________

Date:_______________________________