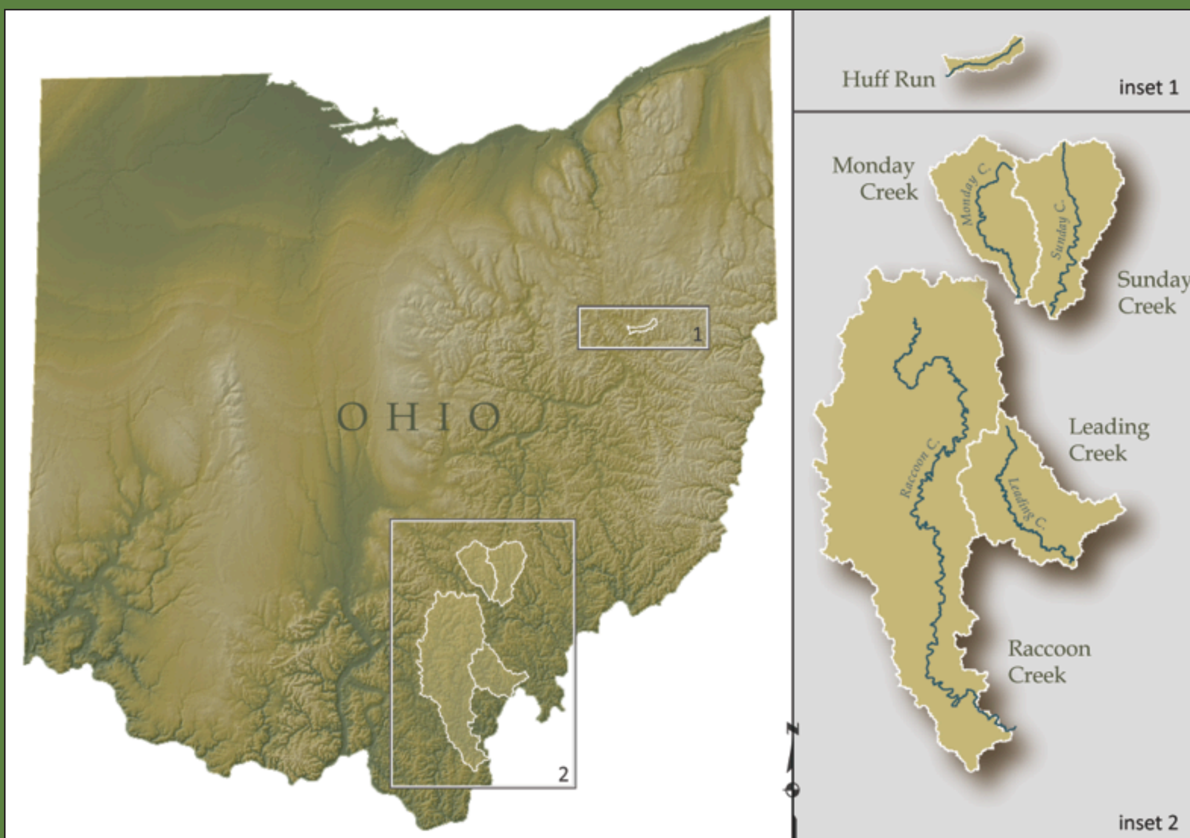
2016 STREAM HEALTH REPORT

AN EVALUATION OF WATER QUALITY, BIOLOGY, AND ACID MINE DRAINAGE RECLAMATION IN FIVE WATERSHEDS: RACCOON CREEK, MONDAY CREEK, SUNDAY CREEK, HUFF RUN, AND LEADING CREEK.



CREATED BY:

VOINOVICH SCHOOL OF LEADERSHIP AND PUBLIC AFFAIRS

AT OHIO UNIVERSITY

JENNIFER BOWMAN, NORA SULLIVAN, AND KELLY JOHNSON

6-30-2017

Intentional blank page

Table of Contents

Specific AMD project entry forms used for report 2016 can be found at (watersheddata.com)

Section IV on the website shows the completed NPS data entry form for each individual AMD project in pdf format. These reports include all information gathered about the site description, contact, monitoring plan, design and reclamation information, average water quality data (pH, net acidity, and discharge) at long-term monitoring stations, complete list of pre and post reclamation water quality and biology data, and if applicable; photos, water quality and biology reports, and site map. These reports are available to download as pdf reports from the NPS monitoring website www.watersheddata.com under the 'Reports Tab'.

Acknowledgements

The Stream Health Report is a collective effort by many dedicated watershed professionals. This report is made possible with the dedication and support of our watershed partnership. I would like to thank and acknowledge the following people for their input and contributions towards this project:

Ohio Department of Natural Resources – Division of Mineral Resources Management (ODNR-MRM) - Ben McCament, Kaabe Shaw, Tammy Richards, Chad Kinney, Jeff Calhoun, Mary Ann Borch, Mike Gosnell and Todd Gleydura for funding, data collection, guidance, and being a supporter and partner in this project.

Watershed Groups –
Raccoon Creek: Amy Mackey and Sarah Cornwell
Monday Creek: Nate Schlater and Tim Ferrell
Sunday Creek: Michelle Shively
Huff Run: Marissa Lautzenheiser
Leading Creek: Jim Freeman
I would like to thank the watershed groups for their cooperation and patience in this project for doing everything from data collections, participation in trainings, gathering historical data, data validation and verification, and data entry on top of their busy work schedules.

Rural Action's AmeriCorps Watershed Crew – 2016 field crews for MAIS data collection and chemical water sampling: Andy Nolen, Sarah Homan, Caitlyn Park, Miranda Hayes, Kara Roberts, Chad Gatt, and Meredith Price-Mullins.

Ohio University Biological Sciences - Kelly Johnson – conducting the MAIS training, macroinvertebrate laboratory identification, biological data analysis, macroinvertebrate data collection, method development, and guidance.

Voinovich School – Steve Porter (GIS and data analysis), Elkan Kim (watersheddata.com), Lindsey Siegrist (graphic design), Kyoung Lim (assistant programmer), Natalie Kruse (research) and Sebastian Teas (Voinovich School student).

ABSTRACT

The Voinovich School of Leadership and Public Affairs at Ohio University created an evaluation system to track changes in chemical and biological data for the following watersheds: Monday Creek, Sunday Creek, Raccoon Creek, Huff Run and Leading Creek. The annual monitoring and reporting system was developed for the Ohio Department of Natural Resources Division of Mineral Resources Management (ODNR-DMRM) in 2005 to track progress towards the targets of the state's 2005 Non-Point Source (NPS) management plan for acid mine drainage (AMD) on an annual basis. ODNR-DMRM is committed to tracking chemical and biological changes in the watersheds where active AMD abatement and treatment reclamation is planned and implemented.

The NPS annual reporting website (www.watersheddata.com) integrates water quality and biology data from watershed groups' with project status details including: maps, graphs, charts, photos, and printable reports to address the progress with respect to AMD treatment and reclamation. Water-quality and biological trends are compared through time at long-term monitoring stations and acid load reductions are measured at AMD reclamation project discharges. Incremental changes in pH, net alkalinity, iron, and aluminum are reported along stream reaches within key restoration areas, identified by river mile and sample site IDs.

Total number of stream miles impaired by acid mine drainage were evaluated during 1994-2001 and are considered the baseline conditions for this study, 341 stream miles were impacted at that time. Each year the number of stream miles surveyed that suggest they are meeting Warmwater Habitat WWH based on acid mine drainage targets are recorded, based on their fish and macroinvertebrate index scores. As of 2016, 46.5 additional stream miles of the 142 miles assessed for biology suggest they Warmwater Habitat Status based on on acid mine drainage targets. In Headwaters of Raccoon Creek from East Branch and West confluence to Lake Hope dam, 20 stream miles were improved to meeting targets from both macroinvertebrates and fish. Along Raccoon Creek mainstem from Elk Fork tributary to Flat Run tributary, 20.3 miles improved to meet targets. In the Sunday Creek Watershed along the West Branch of Sunday Creek a 6.2 mile section of stream now meets targets suggestive of meeting Warmwater Habitat based on acid mine drainage targets. In addition to tracking the number of stream miles meeting their fish and macroinvertebrate target levels, incremental water-quality changes are also tracked, pH values show 193 miles of the 211 miles monitored met the pH 6.5 water quality standard in 2016. Since baseline conditions established approximately in 2000, a total of 93.2 miles are now suggestive of meeting Warmwater habitat based on acid mine drainage targets, 82 in Raccoon Creek Watershed and approximately 11 miles in Sunday Creek's West Branch.

Net alkalinity, iron, aluminum, pH, and macroinvertebrates were evaluated annually from 2006-2016. Incremental changes from year to year can be tracked using these indicators. Net alkalinity and pH values have improved from 2006 to 2016. The family-level biological indicator, Macroinvertebrate Aggregated Index for Streams (MAIS), were measured annually from 2006 to 2016, there have been slight fluctuations seen within each watershed, detailed in the biology section for each watershed. Macroinvertebrate data across all watersheds in 2016 indicated good results, most notable are the steady continued improvements seen in the West Branch of Sunday Creek, and mainstem of Monday Creek. For the first time the mouth of Thomas Fork (Site TF0015) has shown statistical improvement (P-value 0.026).

INTRODUCTION

The Nonpoint Source (NPS) Monitoring Project was created by the Voinovich School of Leadership and Public Affairs at Ohio University in 2005 and funded by the Ohio Department of Natural Resources Division of Mineral Resources Management (ODNR-MRM). This project was developed to address the targets set forth for Abandoned Mine Drainage in the State of Ohio's Non-Point Source (NPS) Management Plan 2005-2010. www.epa.state.oh.us/dsw/nps/NPSMP/ET/amdjumppage.html

Abandoned Mine Drainage is one of the six NPS pollutants listed as a key issue to address in Ohio to improve water quality. This plan is no longer active, however the ODNR-DMRM, watershed partners, and university researchers continue to monitor the effects of acid mine drainage and reclamation in the region. This report reflects the works of this partnership at the federal, state, and local level working together to improve water quality in the Appalachian coal region of Ohio.

As a result of the NPS Monitoring Project, an on-line reporting system, www.watersheddata.com, has been created to track environmental changes in five watersheds: Raccoon Creek, Monday Creek, Sunday Creek, Huff Run and Leading Creek. These five watersheds represent where active AMD reclamation projects are being constructed. Chemical water quality and biological data trends have been evaluated at the project level, watershed level, and collectively to monitor the changes in water quality as a result of AMD reclamation. The website provides a repository of information related to acid mine drainage reclamation and water quality including reports of: AMD reclamation projects and watersheds water quality trends. All water quality data can be viewed, entered, edited, mapped and downloaded for each watershed.

REPORTS

All AMD project descriptions are compiled in a separate document containing pertinent static information describing the AMD project, titled “Collection of Acid Mine Drainage (AMD) Reclamation Projects in the Coal-Bearing Region of Ohio”. This will eliminate redundancy in printing static project specific information each year. This report is available online at watershedata.com as well as with all partner organizations.

The “AMD project collection” report includes: a chronological collection of all projects completed since late 1990s. The ‘AMD project collection’ report displays general information about the AMD issues prior to reclamation and the AMD project description. Specifically the ‘AMD project collection’ report includes: pre and post construction photos, description of AMD problem, design and construction information, costs, contractors, dates of construction, identification of project discharge, map of site (optional), and pre-water quality data at project discharge. ‘AMD project collection’ report is a compilation of all projects completed since the late 1990s in chronological order including all past archived reports. This report is a stand-alone document. Each year, the newly completed project reports are simply added to the collection.

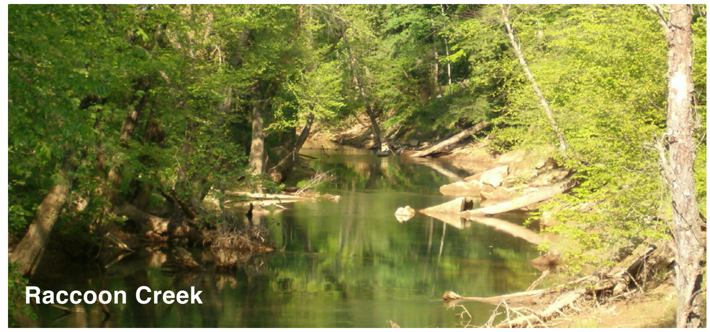
The “Annual Stream Health” report contains the dynamic yearly chemical and biological data that changes each year. This report includes the chemical and biological water quality data analysis for all target stream reaches within the five key watersheds. Stream reaches are identified as: Raccoon Creek Mainstem, Hewett Fork, Little Raccoon Creek, Monday Creek Mainstem, Sunday Creek Mainstem, West Branch of Sunday Creek, Huff Run, and Thomas Fork (Leading Creek). Data from these stream reaches are analyzed each year for changes and trends in pH, net alkalinity, iron, aluminum, and macroinvertebrates. Yearly trends of acid loading and metal loading reduction from each AMD project discharges are also displayed in this report. Long-term monitoring data, family-level macroinvertebrate data, and pre/post project discharge data collected by watershed groups and DMRM staff are utilized to generate the graphs of water quality trends along the stream reaches.

To track the overall health of Raccoon Creek, Monday Creek, Sunday Creek, Leading Creek and Huff Run, the watersheds where acid mine drainage remediation is active, chemical data were collected annually since 2005 (2009 in Leading Creek). Biological data are collected annually for family–level macroinvertebrates (MAIS) and every 3-5 years for fish (IBI, Index of Biotic Integrity). Baseline conditions were established during the time period of 1997-2001 with historic data.

2010 fish and macroinvertebrate data suggest a total of 47 miles of stream meet the use attainment criteria for WWH. These data were collected to compare these indices to the biological health targets of 12 for MAIS and IBI scores of 44/40 for wadable/boatable streams. Stream miles that improved in biological health from baseline to 2010 are shown in Figure 1 and 2. 18.4 miles were improved in the Raccoon Creek watershed and 5.3 miles improved in West Branch of Sunday Creek from 2005 to 2010.

Biological fish data collected from 2010 to 2016 suggest the following areas in green (Figure 1 and 2) meet warm water habitat (40.3 miles in Raccoon Creek and 6.2 miles in Sunday Creek).

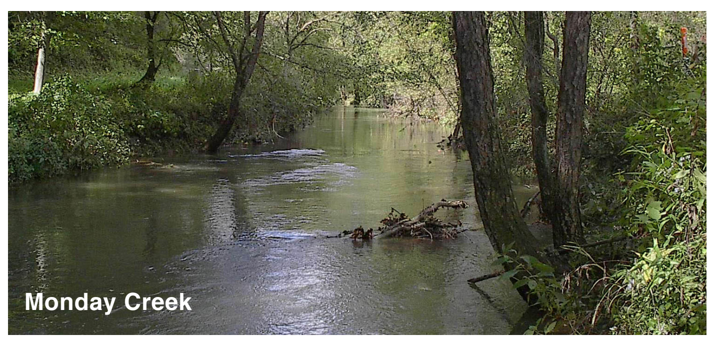
Other significant incremental water changes are also tracked and described in this report; for example, acid and metal loading reductions, pH and net alkalinity improvements. These incremental changes track progress toward the overarching goal of meeting targets. Incremental changes are tracked in the acid mine drainage project level reports and in the watershed level reports.



Raccoon Creek

Sunday Creek

Huff Run



Monday Creek

Leading Creek

Figure 1: Biological health improvements in Raccoon Creek from baseline (1997) to 2016.

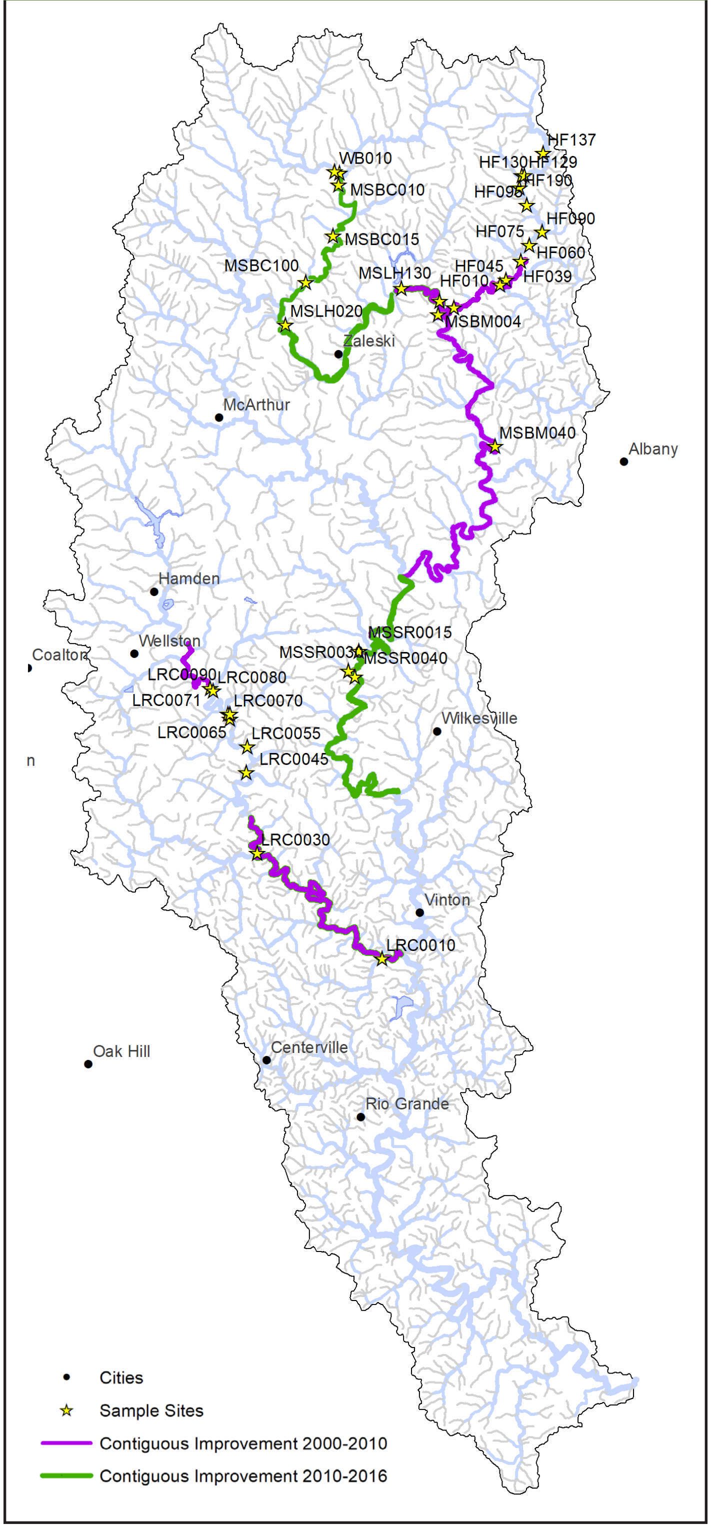


Figure 2: Biological health improvement in Sunday Creek West Branch from 2005 to 2016.

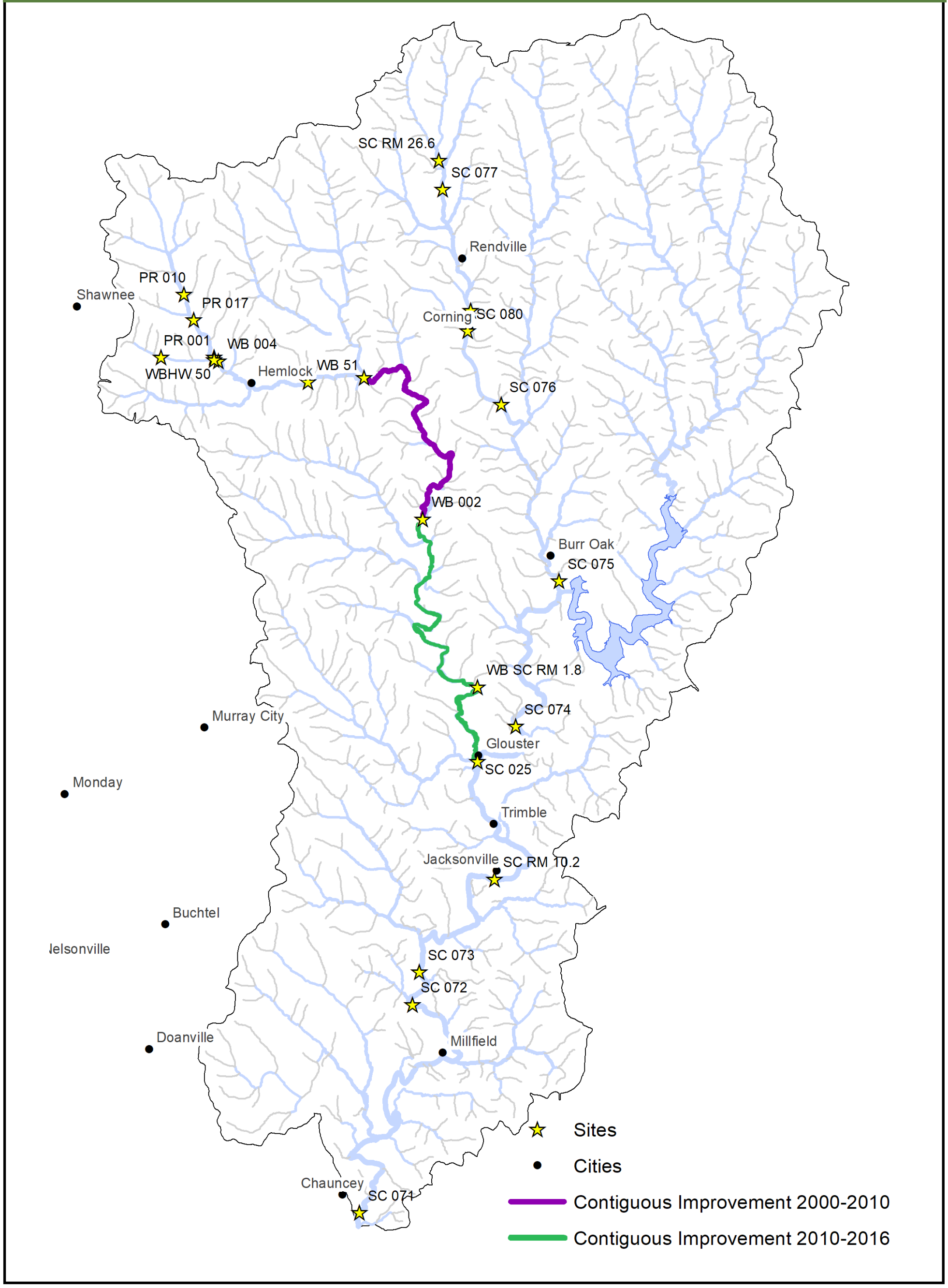


Table 1. Summary of results for each of the five watersheds evaluated in 2005 to 2016: Raccoon Creek, Monday Creek, Sunday Creek, Huff Run, and Leading Creek.

Watershed	Total number of completed projects	Total costs	Total acid load reduction lbs/day	Total stream miles improved in 2005/2010/2016 to meet IBI & MAIS Biological stream health targets	Stream miles that met the pH target	Total stream miles monitored
Raccoon Creek	20	$14,521,361	4,267	23.3/18.4/40.3 (82.0)	110	117
Monday Creek	18 (plus 5 subsidence projects, costs are not included)	$7,197,808	4,360	0/0	23	32
Sunday Creek	12 (7 of 10 are subsidence projects)	$2,618,273	22	0/5.3/6.2 (11.5)	43	43
Huff Run	14	$5,308,353	1,129	0/0	8	10
Leading Creek	2	$728,481	663	NA/0	9	9
Total	66	$30,374,277	10,441	23.3/23.7/46.5 (93.5)	193	211

Reductions

Total to date acid load reductions = 10,441 lbs/day

Costs

Total to date reclamation costs = $30,374,277

RACCOON CREEK WATERSHED REPORT

2016 NPS Report - Raccoon Creek Watershed

Generated by Non-Point Source Monitoring System
www.watersheddata.com

Reductions

Total acid load reduction = 4,267 lbs/day
Total metal load reduction = 968 lbs/day

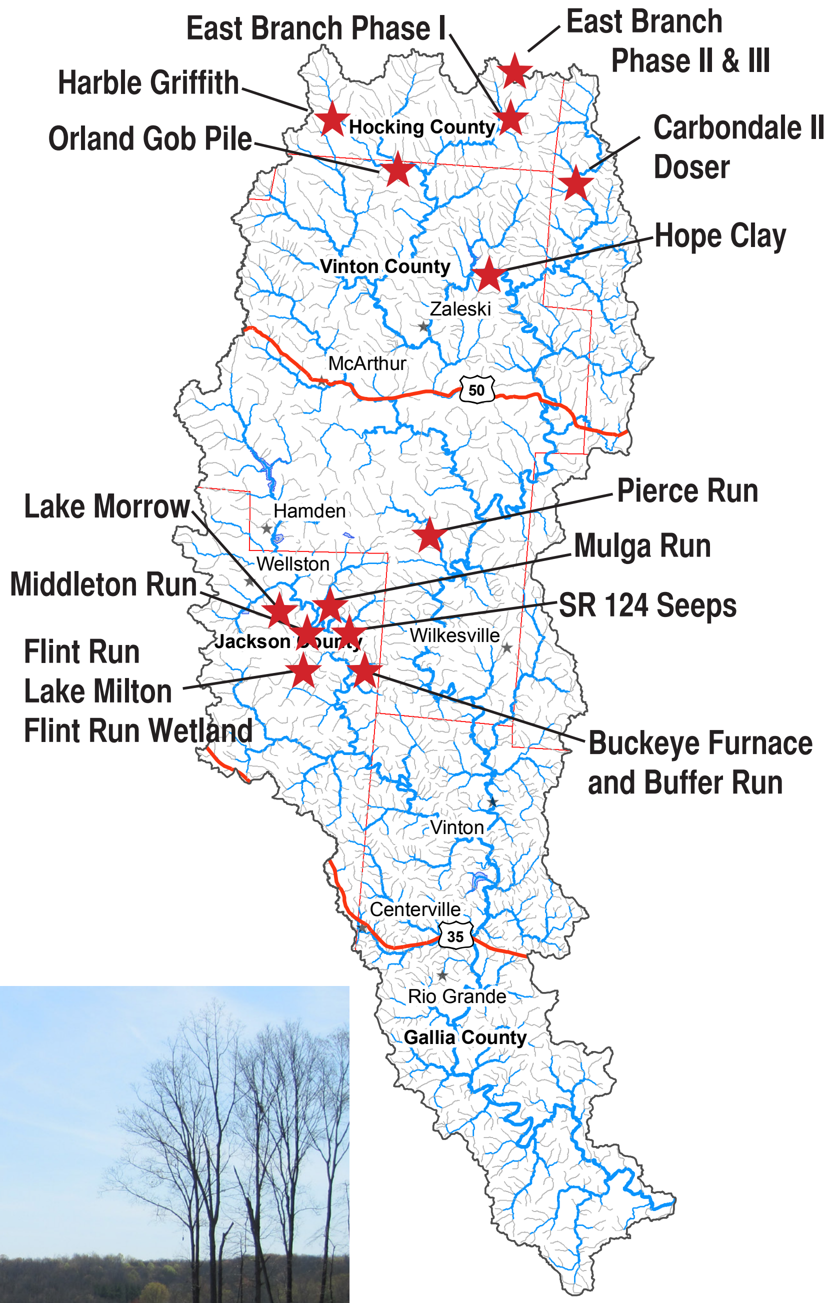
Data derived using the Stoertz Water Quality Evaluation Method (Kruse et al., 2014)

Acid and metal load reductions based on projects monitored during 2016 listed here: Carbondale Doser, Mulga Run, Flint Run, Lake Milton, East Branch I, II, & III, Pierce Run, Orland Gob Pile, Harble Griffith, Lake Morrow, and Middleton Run II.

Cost

Design = $1,905,243
Construction = $12,616,118

Total Costs through 2016 = $14,521,361



Lake Milton treatment ponds in Little Raccoon Creek, Photo by Sarah Cornwell

Timeline of the Raccoon Creek Watershed Project Milestones and AMD Projects

1980s	• Formation of Raccoon Creek Improvement Commitee (RCIC): Grassroots citizen group to address water quality issues 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
2002	
2003	• Mulga Run project completed • Middle Basin AMDAT completed • Completed management plan for Raccoon Creek Watershed
2004	• Carbondale II project completed
2005	• Middleton 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 Partnership formed 501 (c) 3 • Waterloo Aquatic Education Center opened
2008	• East Branch Phase I AMD Project
2009	• Pierce Run AMD Project began • East Branch Phase II Project began
2010	• East Branch Phase II completed
2011	• East Branch Phase III completed
2012	• Water Trail map created by Ohio University Environmental Studies student, Karla Sanders • Orland Gob Pile and Harble Griffith Reclamation Projects completed • Pierce Run AMD treatment project completed
2013	• Raccoon Creek Water Trail maps were distributed, West Branch Harble Griffith 319 Grant was completed, and 2 new families of mayflies documented in the watershed
2014	• Middleton Run II – Reclamation and Lake Morrow Projects complete
2015	• Flint Run Wetland Enhancement Project complete; 4-acre metal retention wetland
2016	• OH EPA conducted watershed-wide TMDL monitoring

Raccoon Creek Projects

Acid mine drainage reclamation projects completed in the Raccoon Creek Watershed:

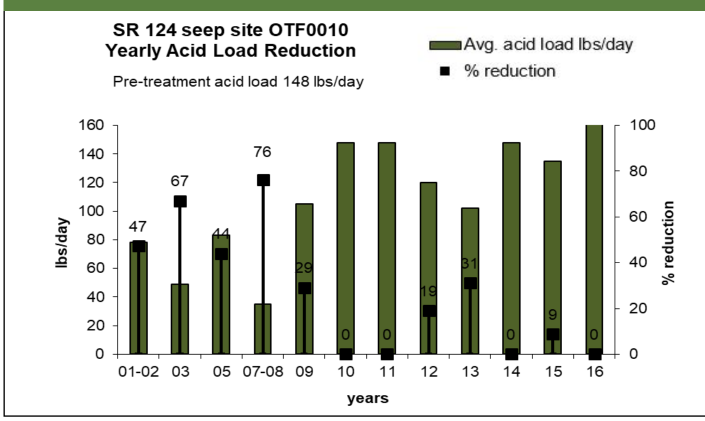
1999	Buckeye Furnace/Buffer Run (BR0010) – Passive SAPS and gob pile reclamation
2001	State Route 124 Seeps (OTF0010) – Surface reclamation and limestone drains
2004	Carbondale II Doser (HF131) – Active calcium oxide doser
	Mulga Run (MR0010) – 2 Steel slag beds and wetland enhancement
2005	*Hope Clay (HC001) – surface reclamation and limestone channels*
	Salem Road/Middleton Run (MiR0021, MiR0032, MiR0090) - limestone channels, steel slag leach beds, J-trenches, surface reclamation, and limestone leach bed
2006	Flint Run East (FR0126) – dewatering strip pits with multiple passive treatments
	Lake Milton (FR0120) – SAPS and steel slag bed
2007	East Branch Phase I (EB210 and EB 160) – 8 steel slags beds, limestone channels, gob pile reclamation, and passive settling ponds
2010-2011	East Branch Phase II & III (EB190) – 4 steel slag beds
2012	East Branch Phase I Maintenance – Valves replace, under drains extended, and new steel slag installed
	Jackson Area AMD Maintenance (Flint Run and Lake Milton) – Under drains extended, new steel slag installed, valves replaced, weir installed, and SAPS intake pipe relocated
2013	Orland Gob Pile (WB050) – Gob pile reclamation with limestone channels
	Harble Griffith (WB094, WB084, WB086) – Surface reclamation, limestone channels, and passive wetland
	Pierce Run (PR0010) – Steel slag bed
2014	Lake Morrow (FR0110) – reclaiming strip pit lakes and spoil
	Middleton Run Reclamation II (MiR0110, MiR0045, MiR0119) – surface reclamation
2015	Flint Run Wetland (FR095) – Wetland Enhancement with limestone berms across the Flint Run Valley

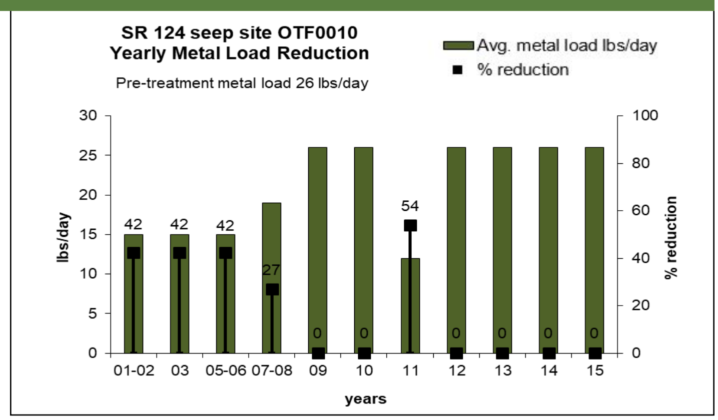
Italicized indicated projects are not actively monitored for acid mine drainage and metal load reduction purposes

Yearly acid and metal load reduction trends per project

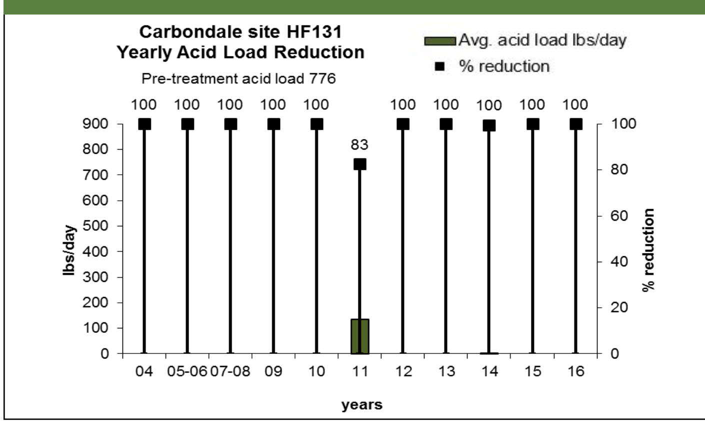
Similar to other environmental best management practices (BMPs), performance of passive acid mine drainage reclamation projects are also expected to decline with time. Active treatment systems are not expected to decline with time but sometimes need to be maintained to perform adequately. Operation and maintenance plans are designed for each existing system and are planned for future projects. The graphs below show the mean annual acid and metal load reduction using the Stoertz Water Quality Evaluation Method (Kruse et al., 2014) for each year (or group of years) during post-reclamation from the project effluent. From these graphs the rate of decline (and/or improvement) with time of the treatment system is implied. Knowing the rate of decline will aid in the implementation of operation and maintenance plans.

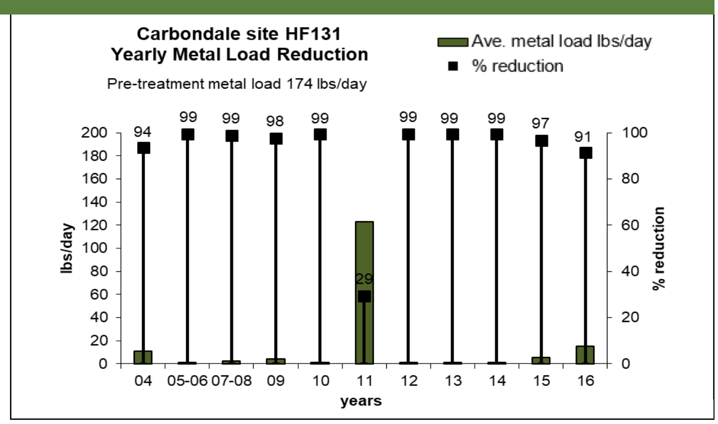
State Route 124 seep site OTF0010



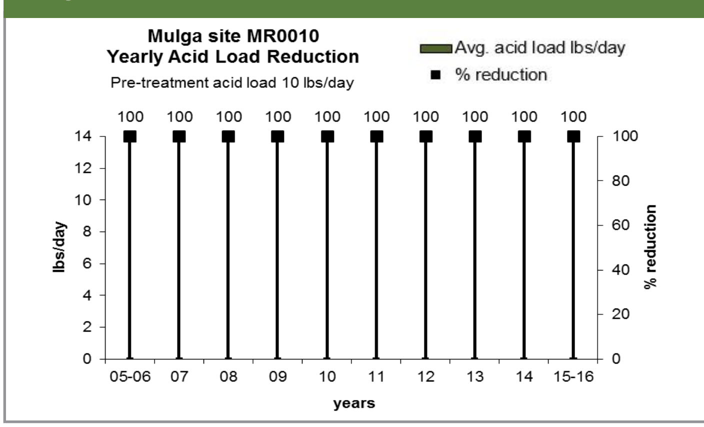


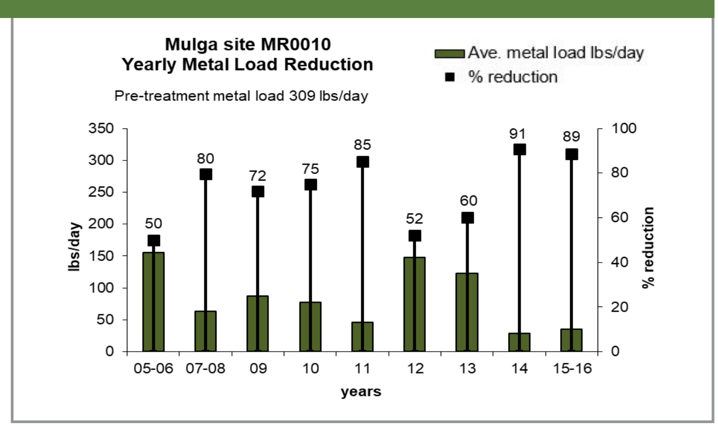
Carbondale site HF131





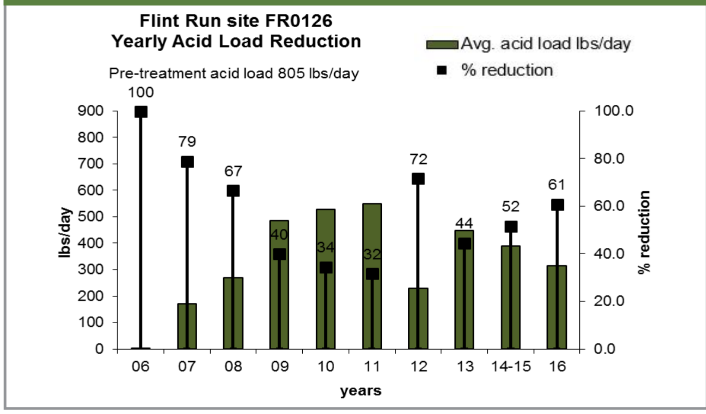
Mulga site MR0010

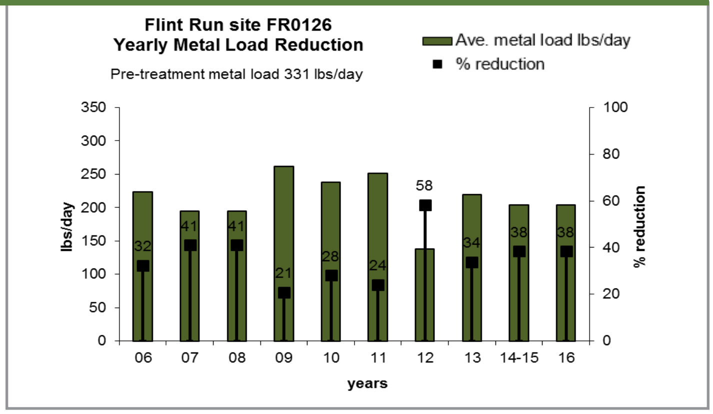




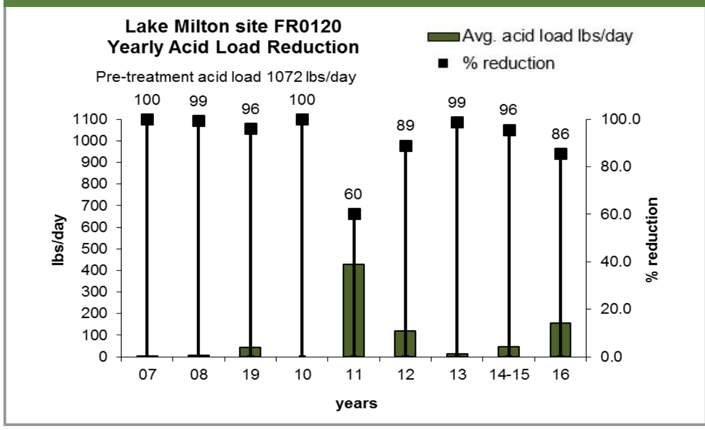
Yearly acid and metal load reduction trends per project

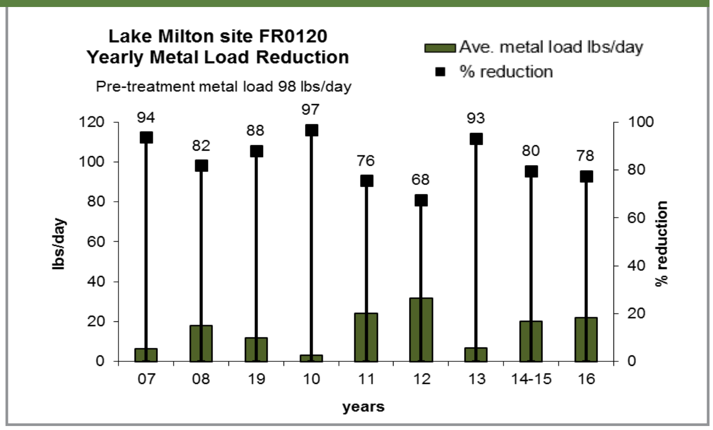
Flint Run site FR0126



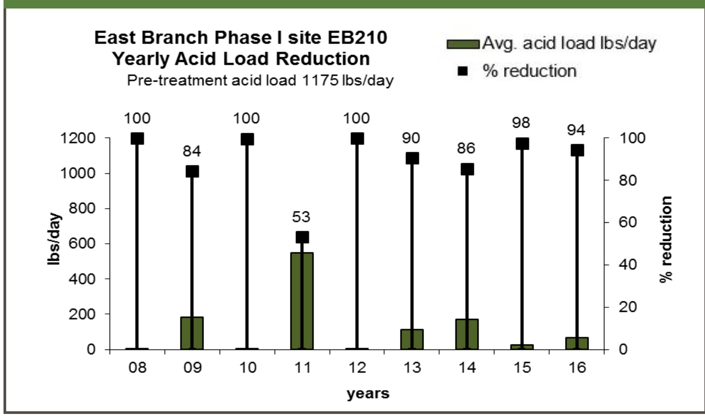


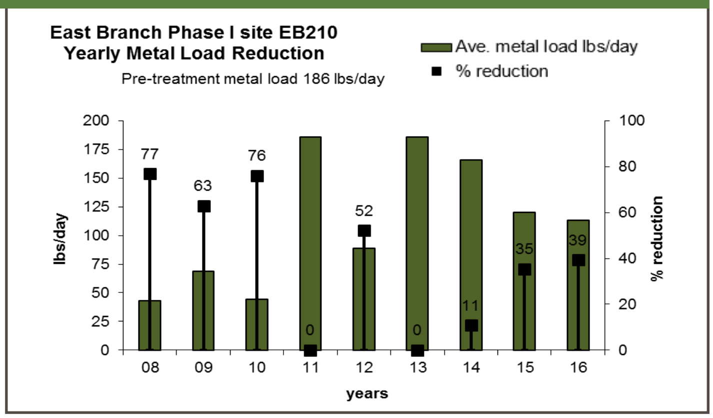
Lake Milton site FR0120





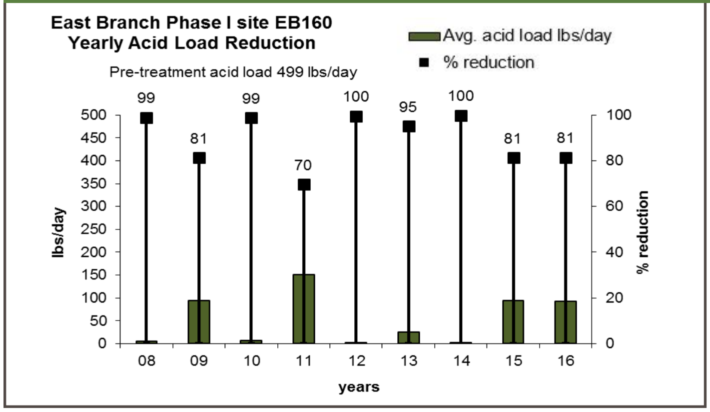
East Branch Phase I site EB210

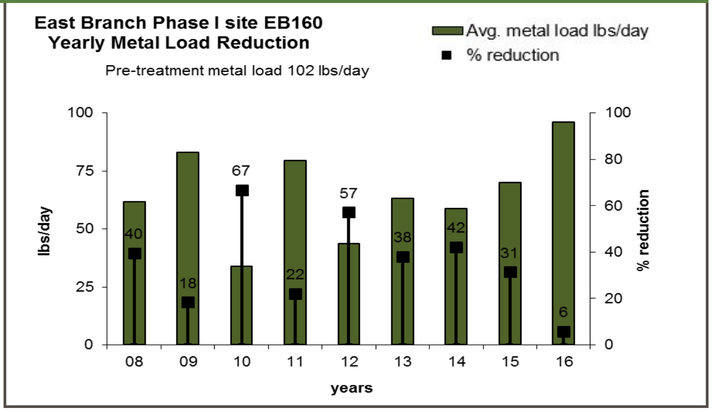




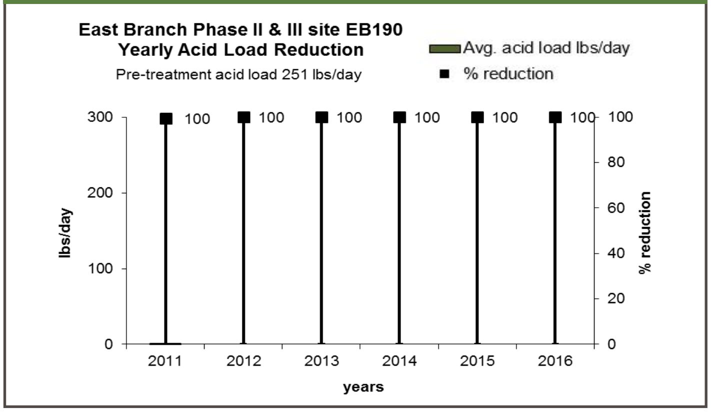
Yearly acid and metal load reduction trends per project

East Branch Phase I site EB160

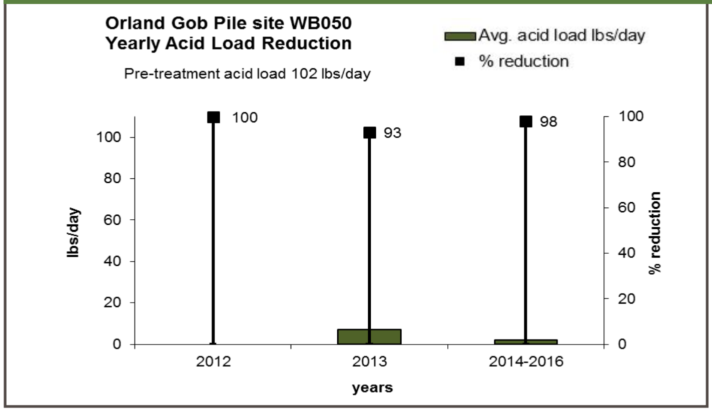


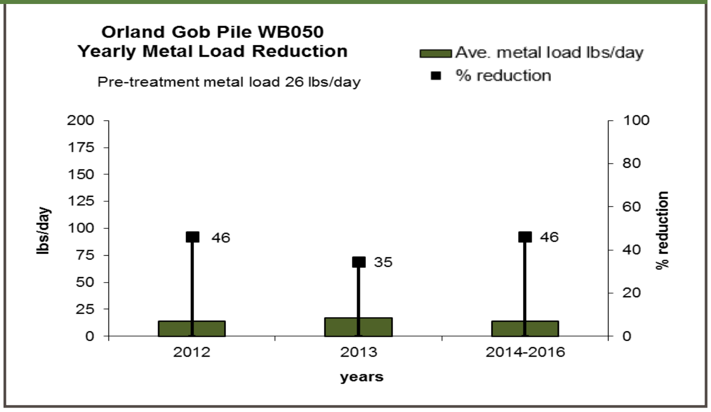


East Branch Phase II & III site EB190



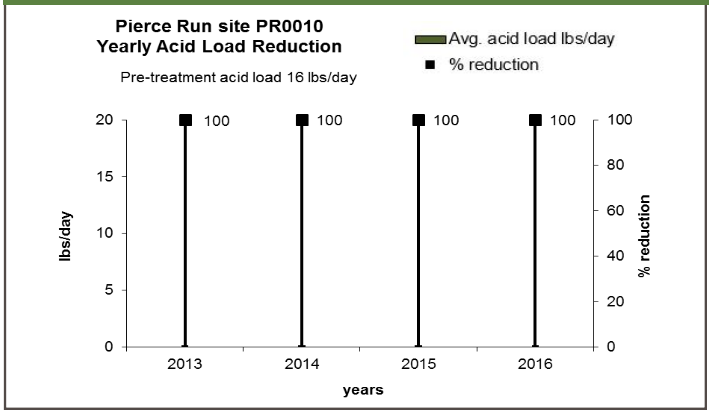
Orland Gob Pile site WB050

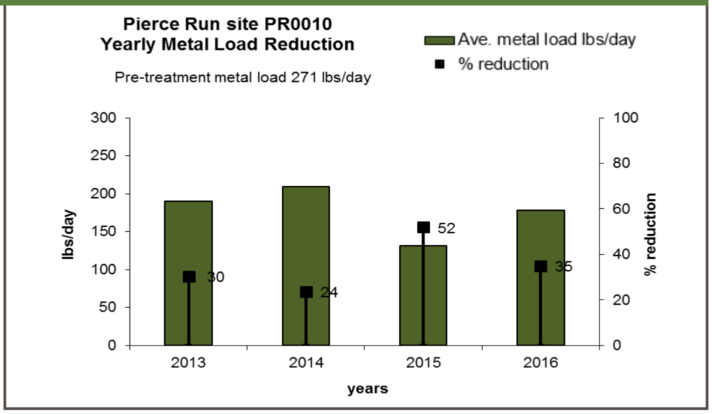




Yearly acid and metal load reduction trends per project

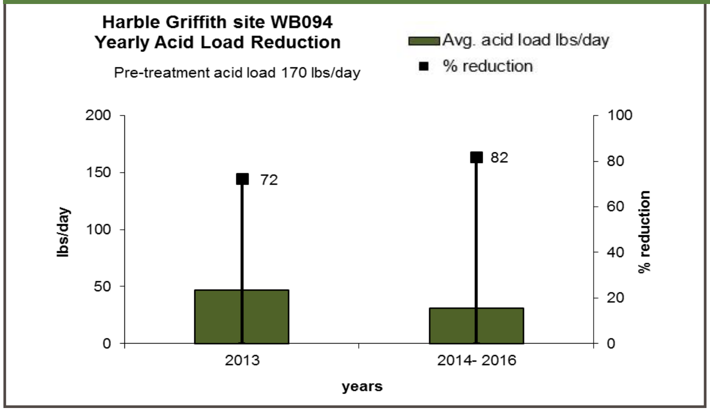
Pierce Run site PR0010*

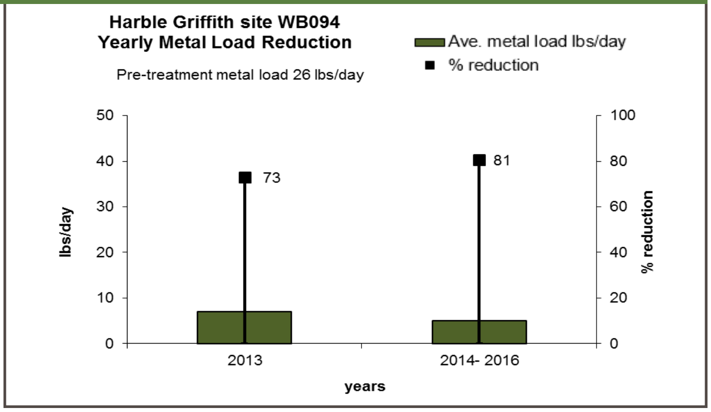




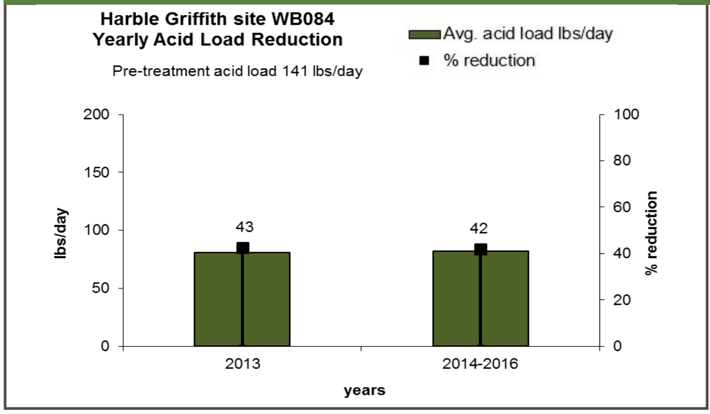
* Waterloo draining alkaline water into Pierce Run, Pierce Run slag bed is clogged

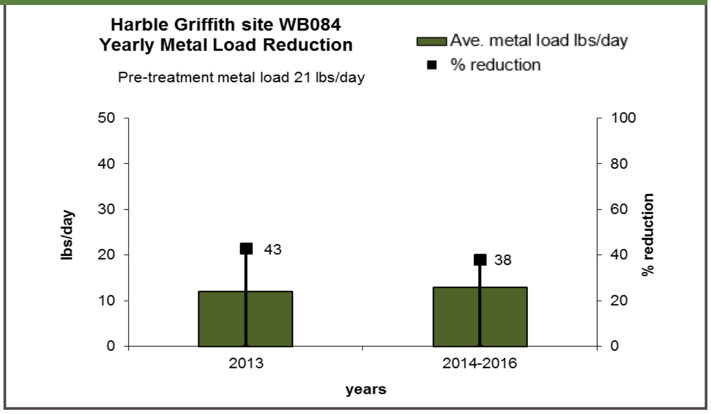
Harble Griffith site WB094





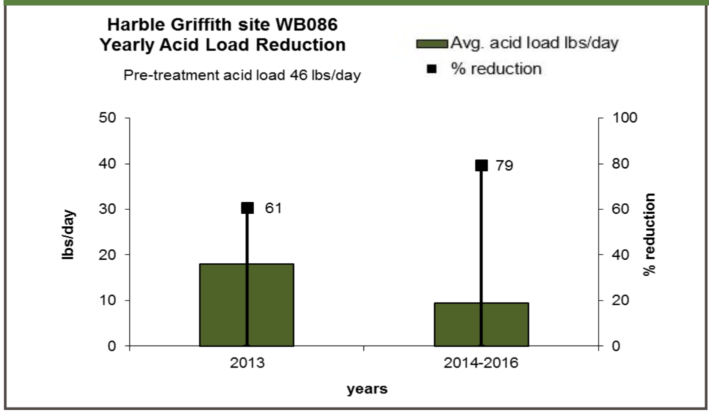
Harble Griffith site WB084

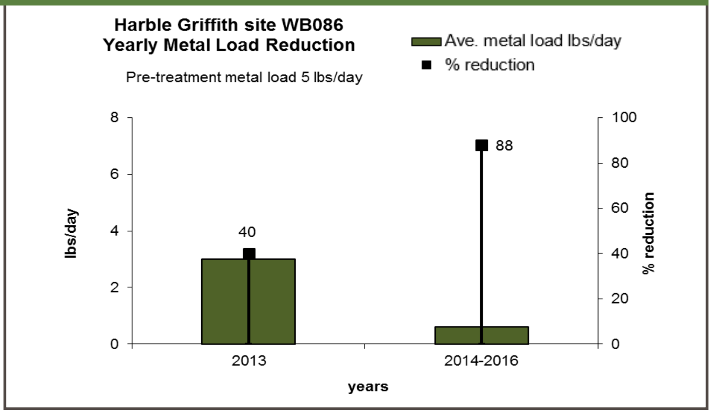




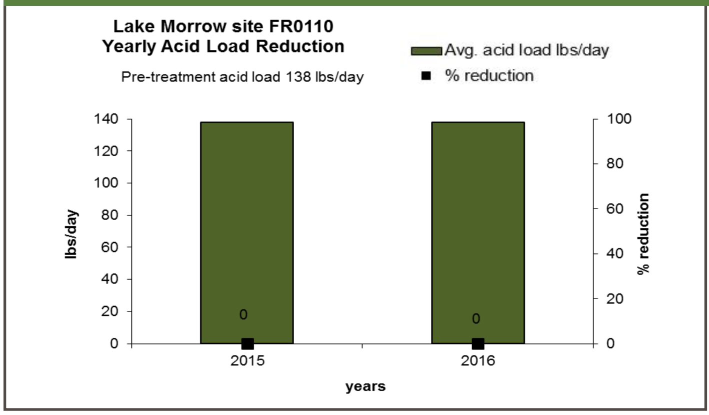
Yearly acid and metal load reduction trends per project

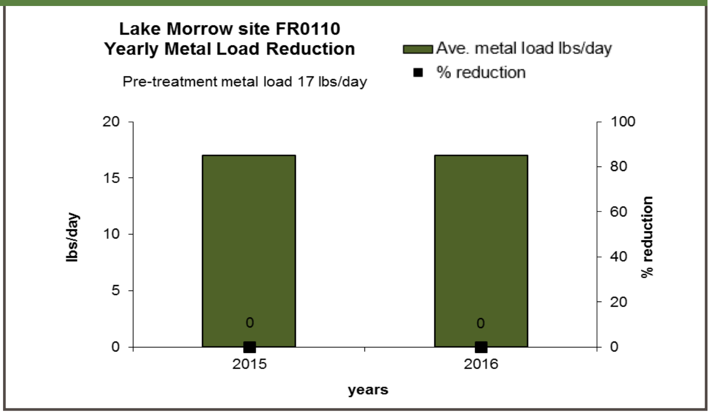
Harble Griffith site WB086



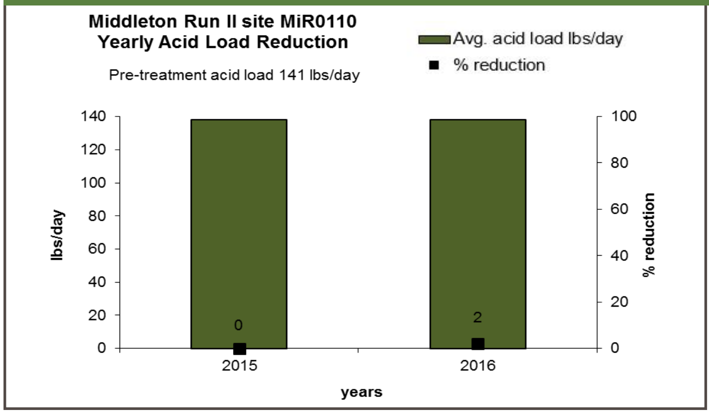


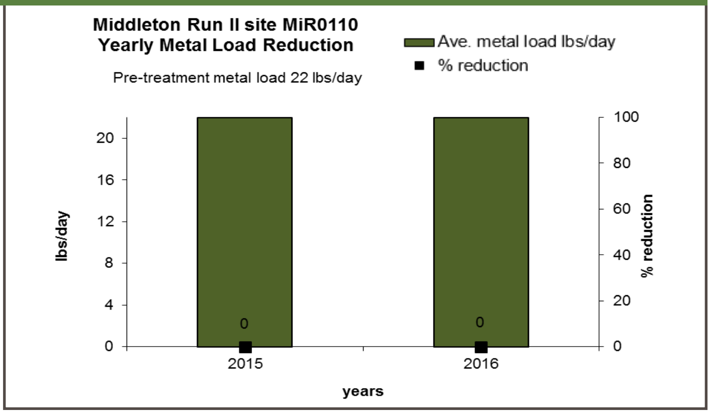
Lake Morrow site FR0110





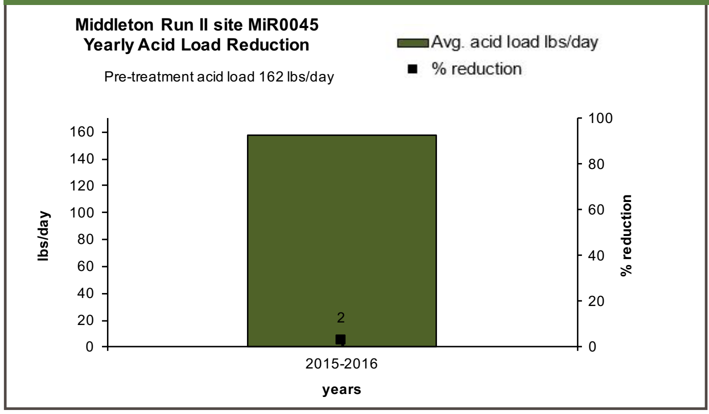
Middleton Run II site MiR0110

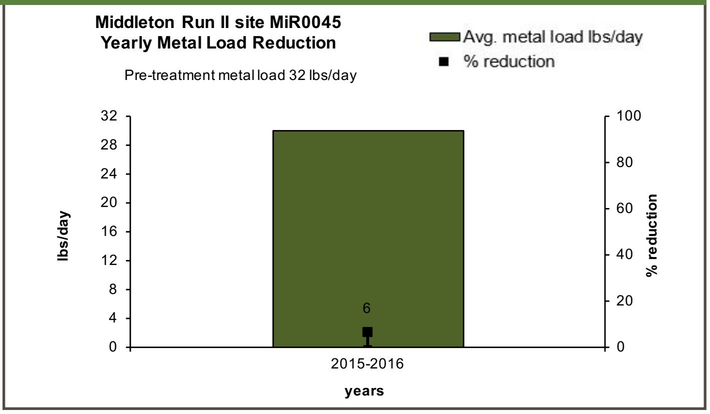




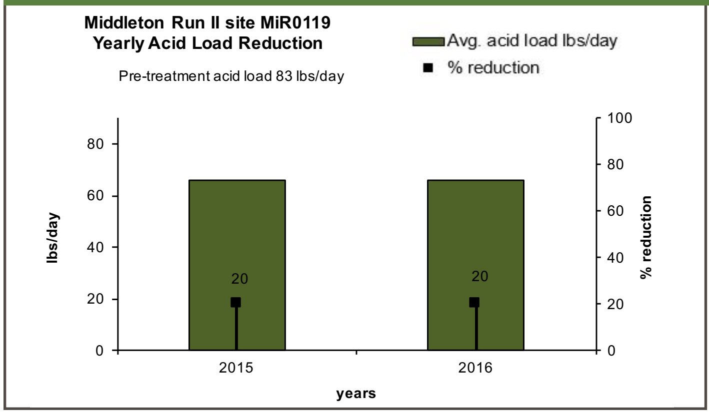
Yearly acid and metal load reduction trends per project

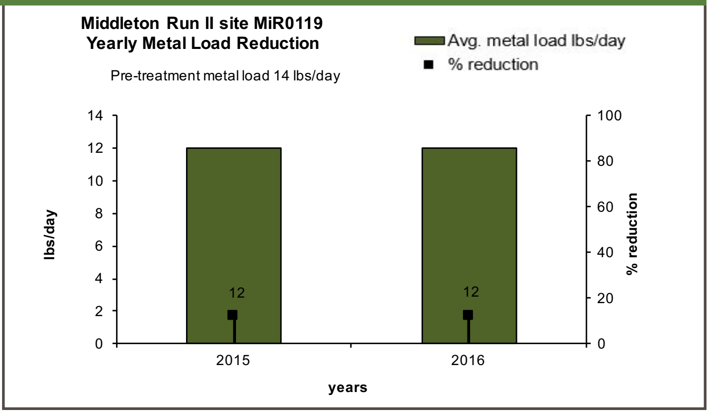
Middleton Run II site MiR0045





Middleton Run II site MiR0119



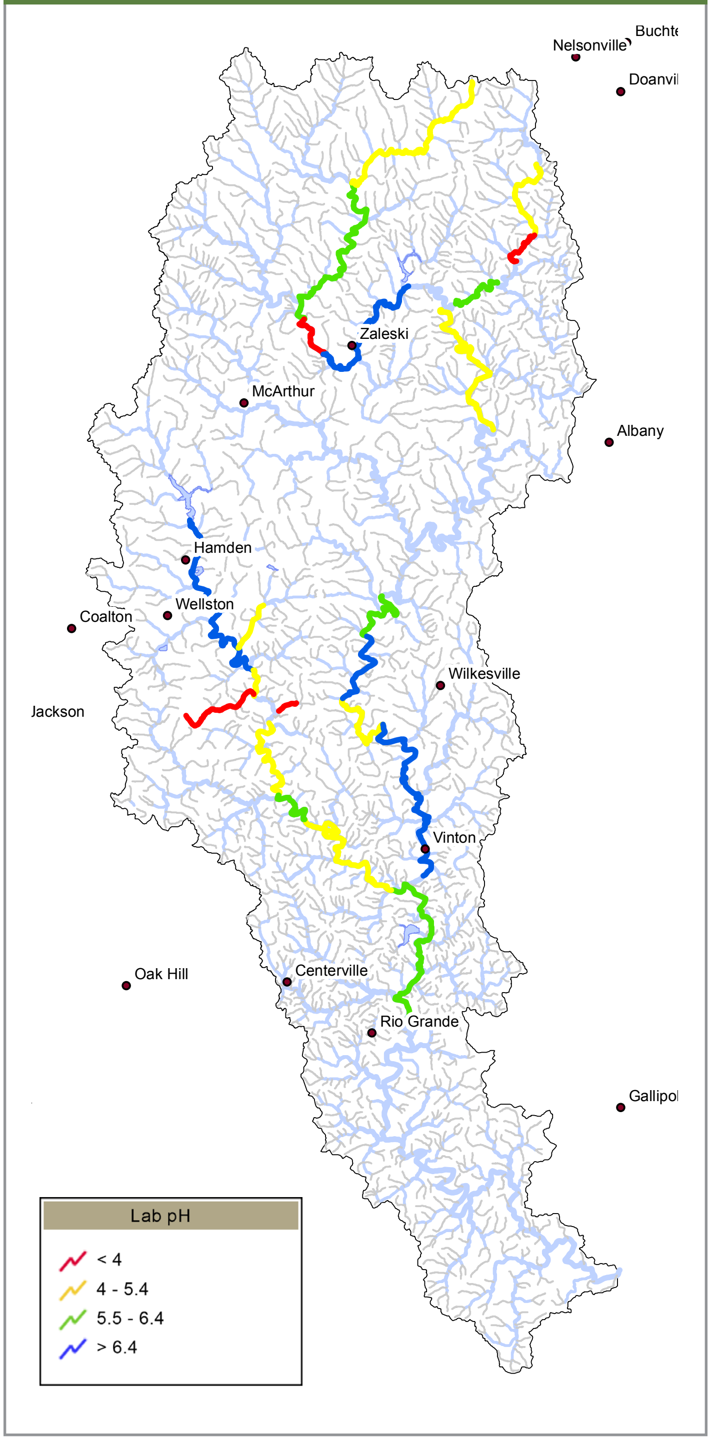


2015 NPS Report - Raccoon Creek Watershed

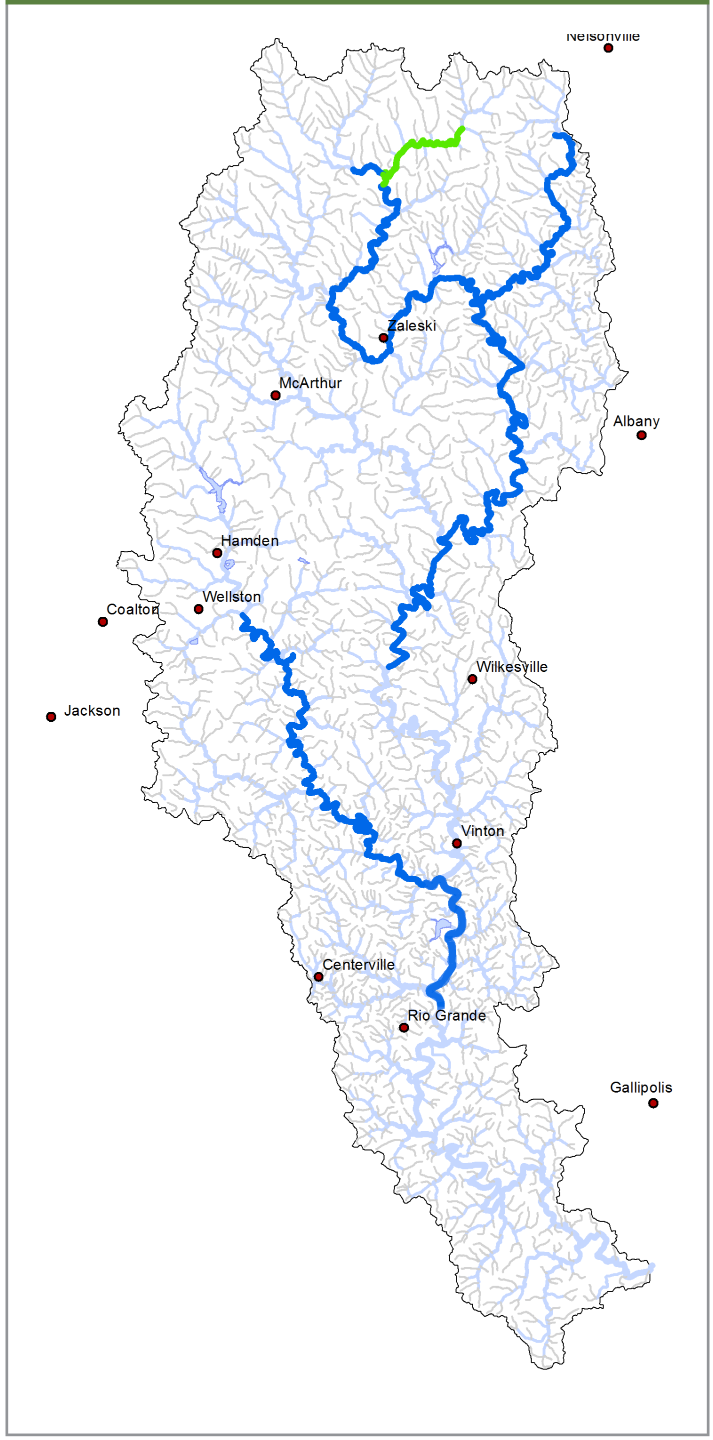
Generated by Non-Point Source Monitoring System
www.watersheddata.com

Chemical Water Quality

Raccoon Creek baseline pH



Raccoon Creek 2016 pH

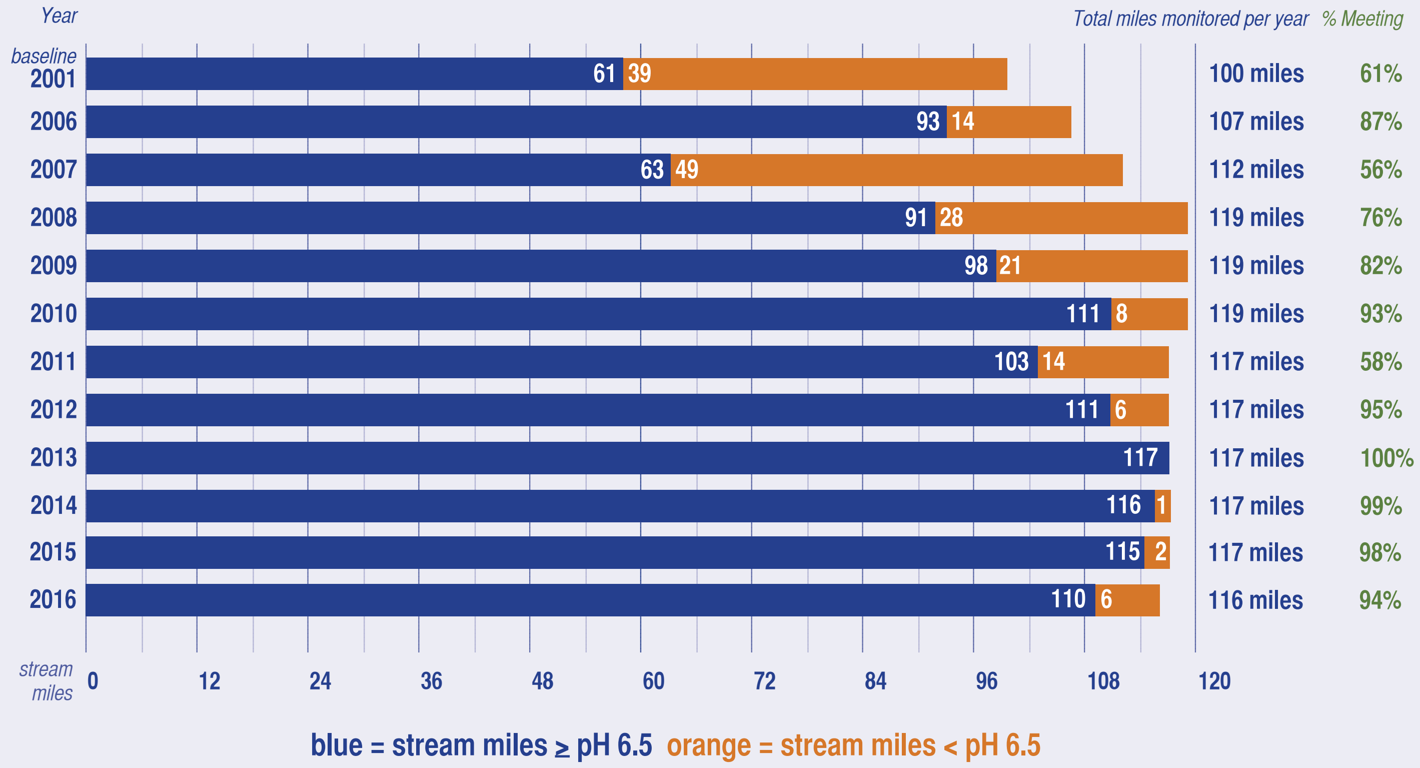


In Raccoon Creek pH values have improved throughout the watershed from baseline conditions (1994-2001) to 2016. Raccoon Creek mainstem, Hewett Fork and Little Raccoon Creek average pH values have increased from a range of 4.0- 5.4 during baseline to all meeting the pH target of 6.5 in 2016, except for a 6.0 stream mile section at the mouth of East Branch. Of the miles of stream monitored in 2016, 14.8 river miles in Hewett Fork, 1.6 miles in West Branch, all 27 river miles in Little Raccoon Creek (LRC), and 68 miles along the mainstem of Raccoon Creek met the pH standard (pH >6.5).

Chemical Water Quality

There are approximately 117 stream miles monitored each year along the mainstem of Raccoon Creek (downstream to Rio Grande), Little Raccoon Crteek, Hewett Fork, and East and West Branch. Each year the number of miles that meet this target fluctuates. Currently in 2016, all but 6.0 of 117 miles of stream miles monitored met the pH target (pH > 6.5).

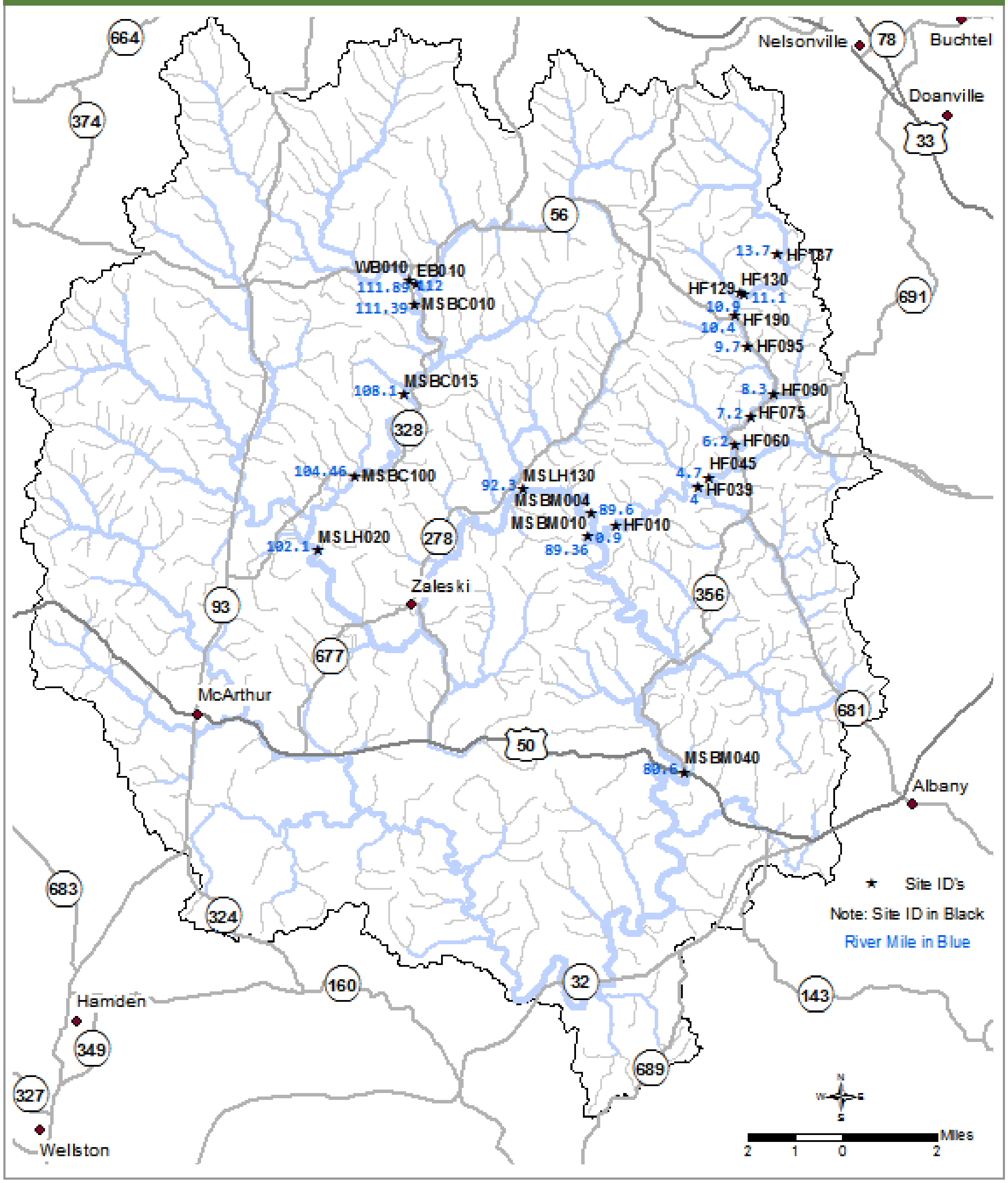
Raccoon Creek total stream miles monitored for pH through time from 2001-2013.



Chemical water quality analysis per stream reach

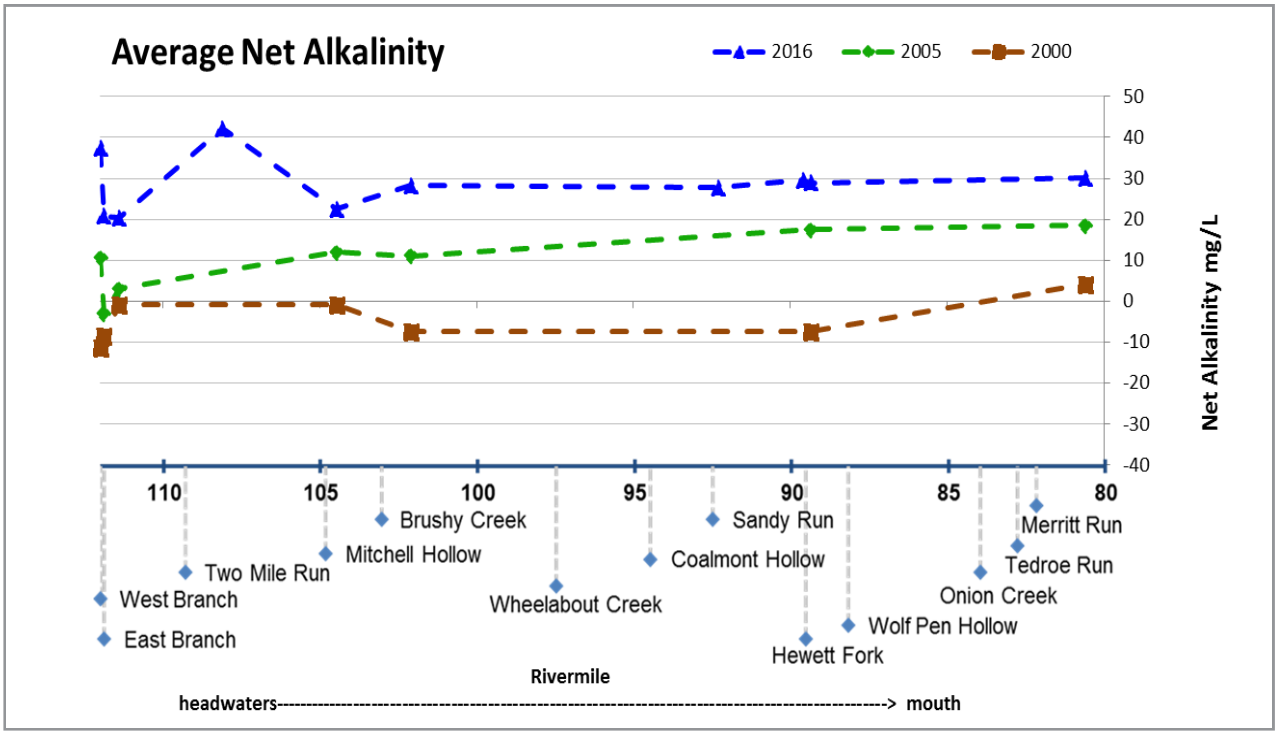
For purposes of analyzing chemical water quality changes along the mainstem of receiving stream where AMD reclamation projects have been completed, Raccoon Creek has been divided into the following stream segments: Raccoon Creek Mainstem, Little Raccoon Creek, and Hewett Fork. Within these stream reaches, chemical long-term monitoring data is utilized to generate line graphs along the stream gradient from headwaters to the mouth. Along the x-axis named tributaries are shown to illustrate new sources of water entering the mainstem. A list of long-term monitoring sites utilized to generate the graphs with their river miles are shown before each set of stream reach graphs.

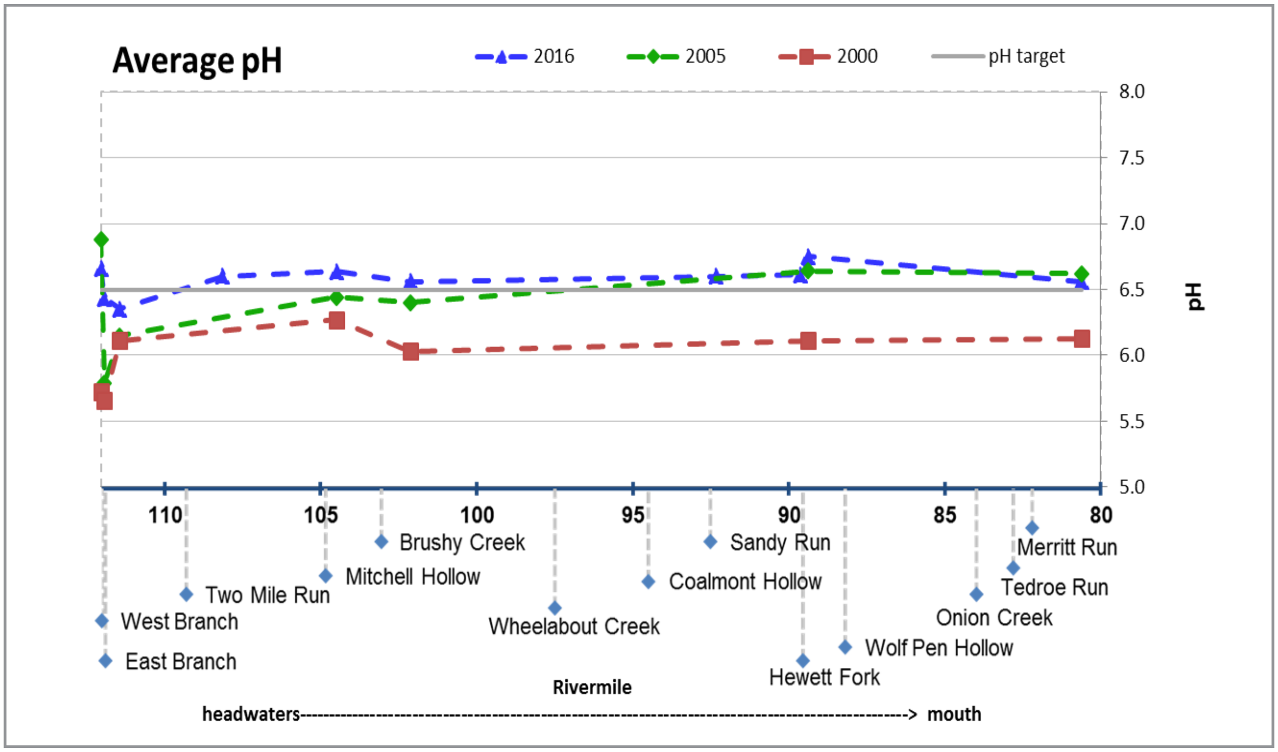
Raccoon Creek Mainstem



Chemical water quality analysis per stream reach

Raccoon Creek Mainstem										
Site ID	WB010	EB010	MSBC010	MSBC015	MSBC100	MSLH020	MSLH130	MSBM004	MSBM010	MSBM040
Rivermile	112	111.89	111.39	108.1	104.46	102.1	92.3	89.6	89.36	80.6

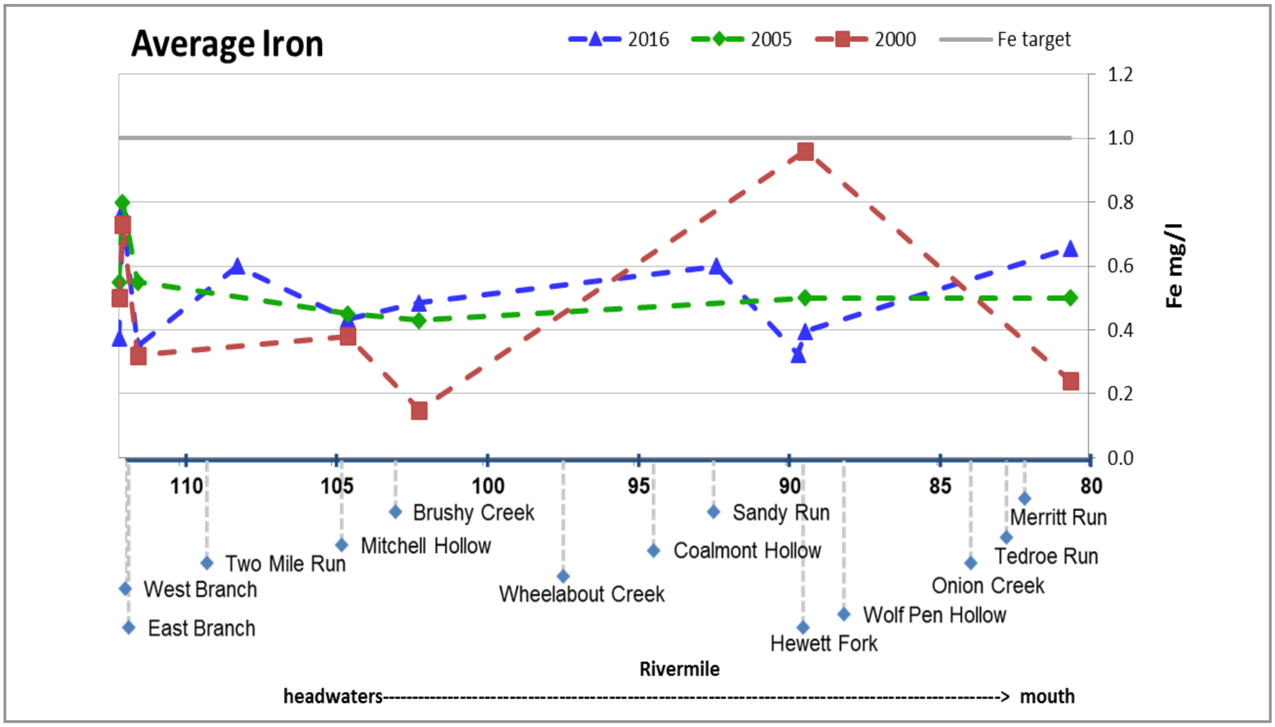


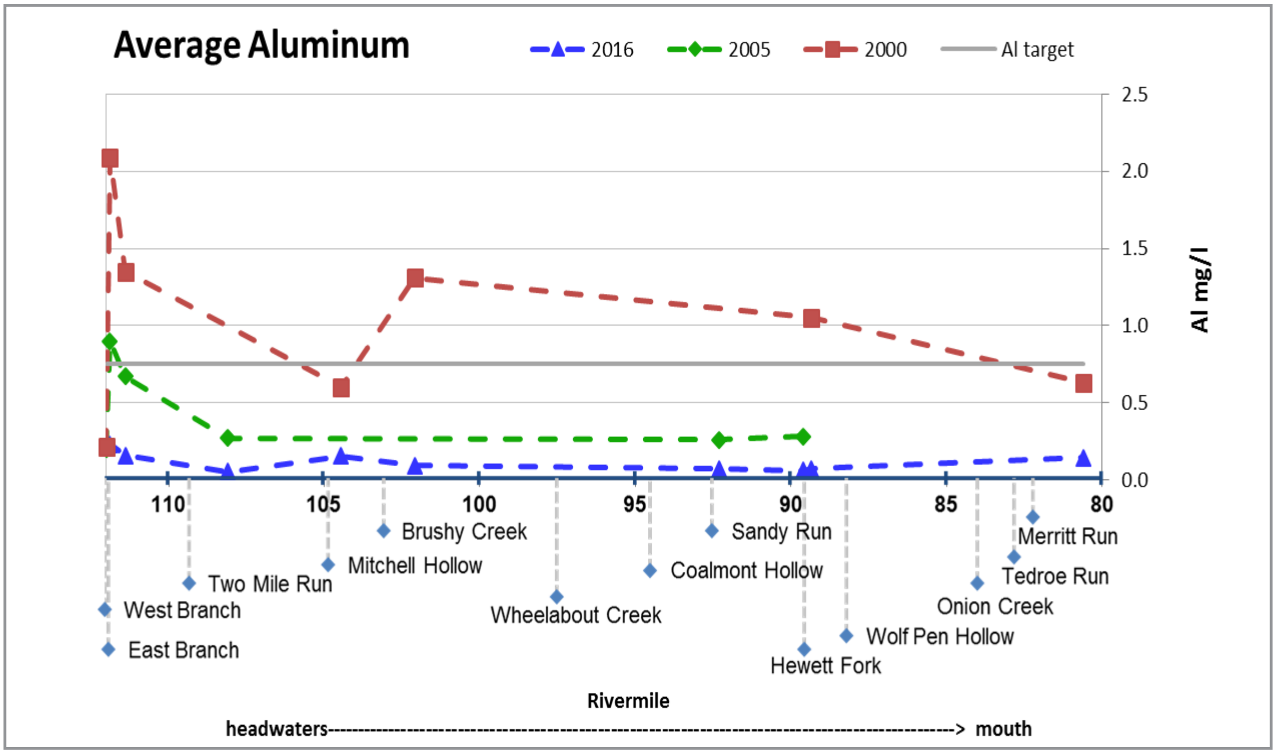


Chemical water quality analysis per stream reach

Raccoon Creek Mainstem

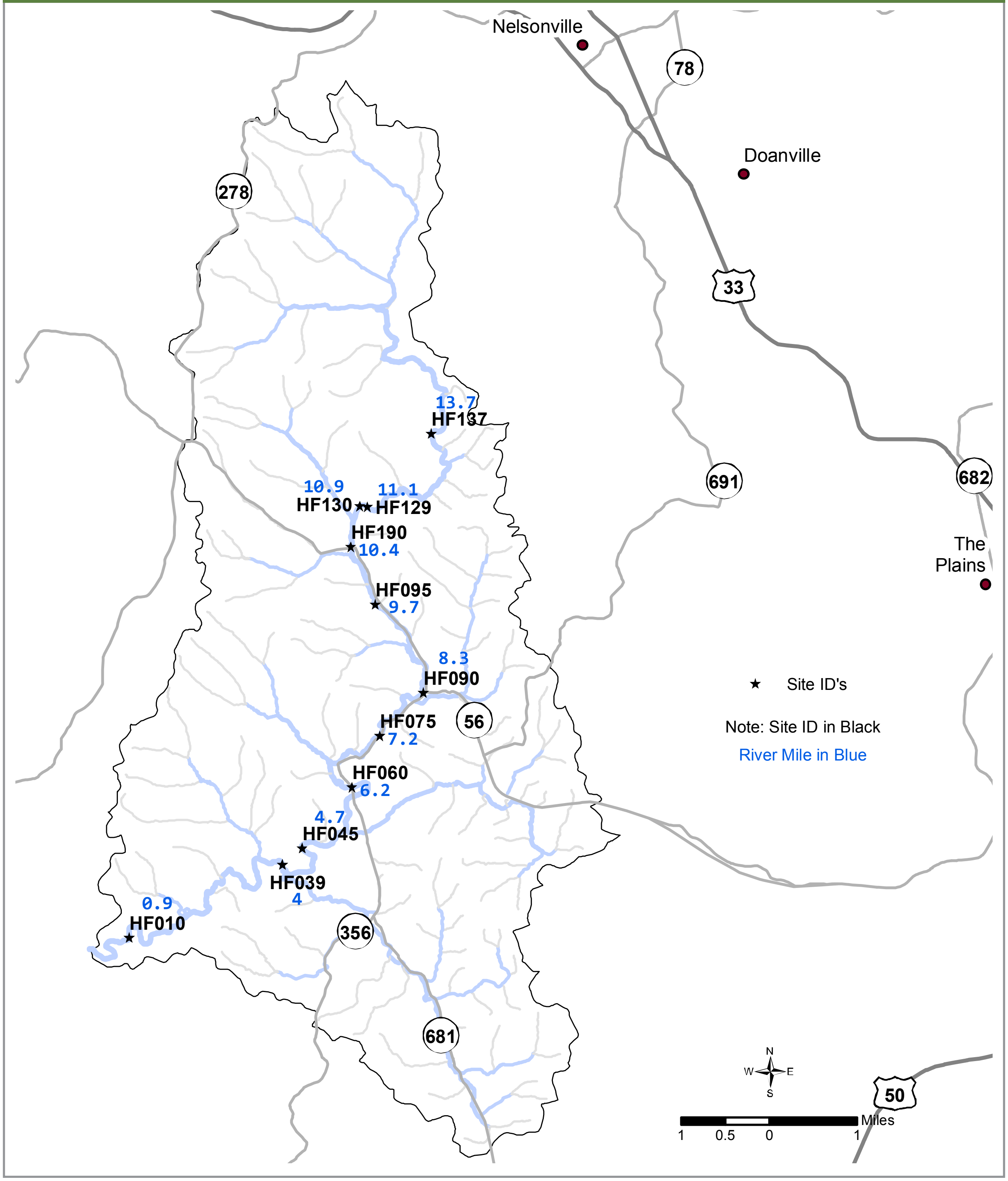
Site ID	WB010	EB010	MSBC010	MSBC015	MSBC100	MSLH020	MSLH130	MSBM004	MSBM010	MSBM040
Rivermile	112	111.89	111.39	108.1	104.46	102.1	92.3	89.6	89.36	80.6





Chemical water quality analysis per stream reach

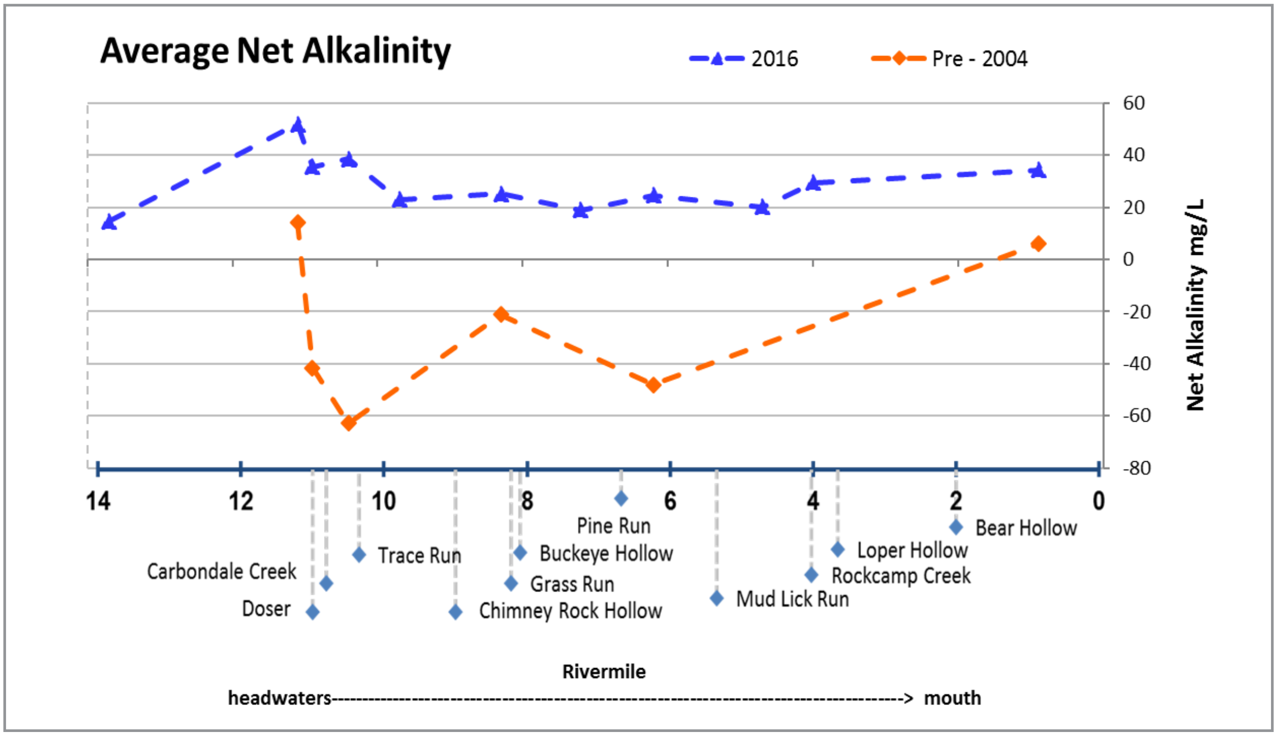
Hewett Fork

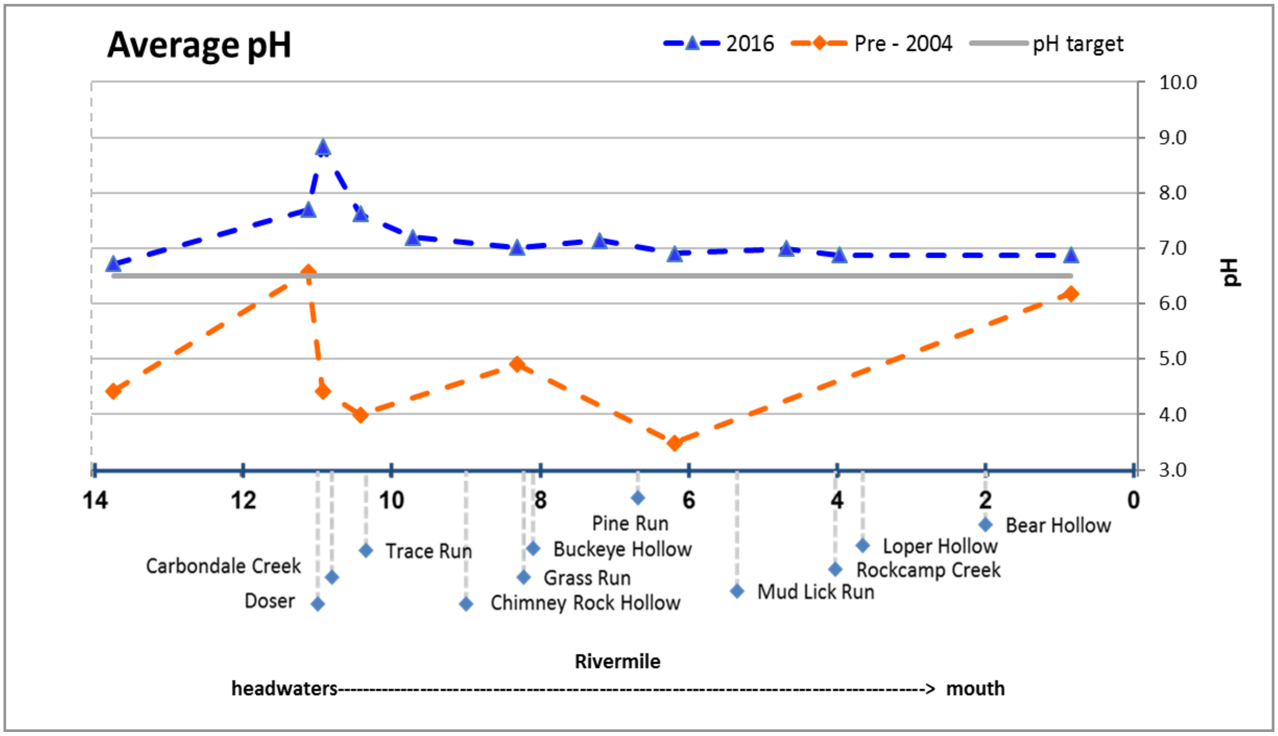


Chemical water quality analysis per stream reach

Hewett Fork											
Site ID	HF137	HF129	HF130	HF190	HF095	HF090	HF075	HF060	HF045	HF039	HF010
Rivermile	13.7	11.1	10.9	10.4	9.7	8.3	7.2	6.2	4.7	4	0.9

Note: Lime Doser installed in 2004 at RM 11



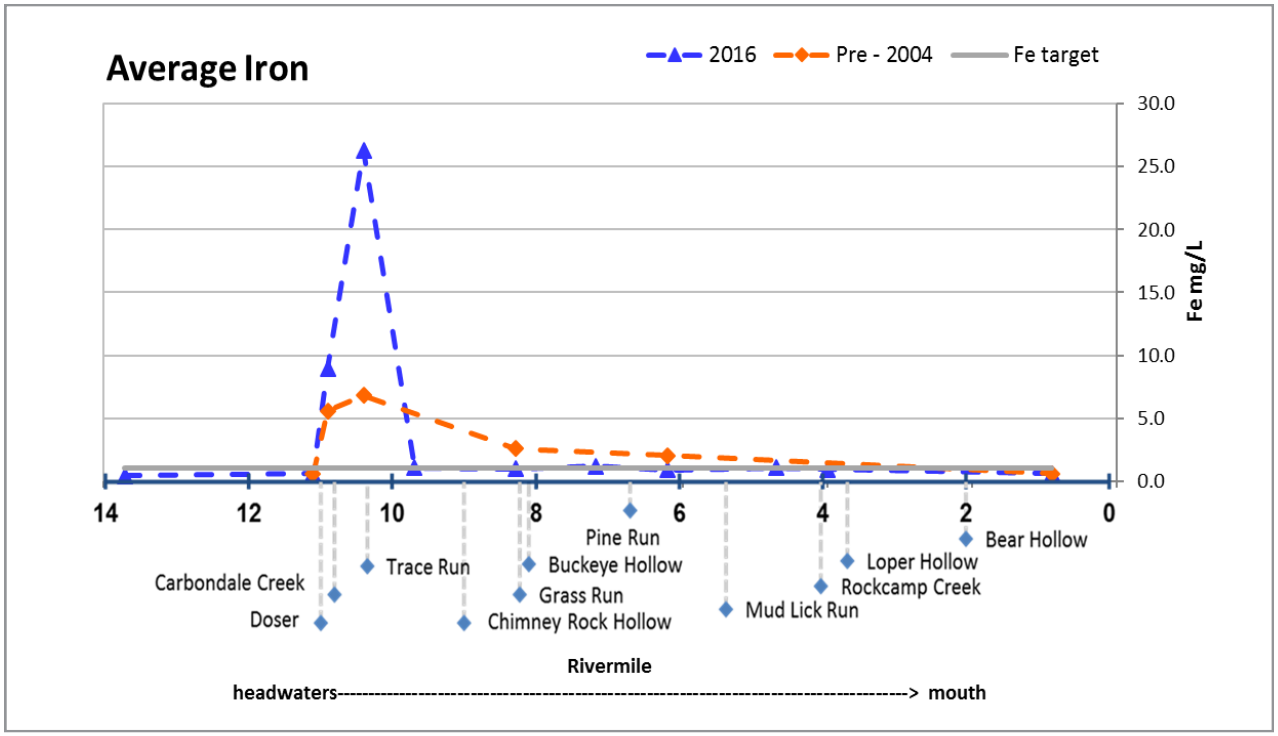


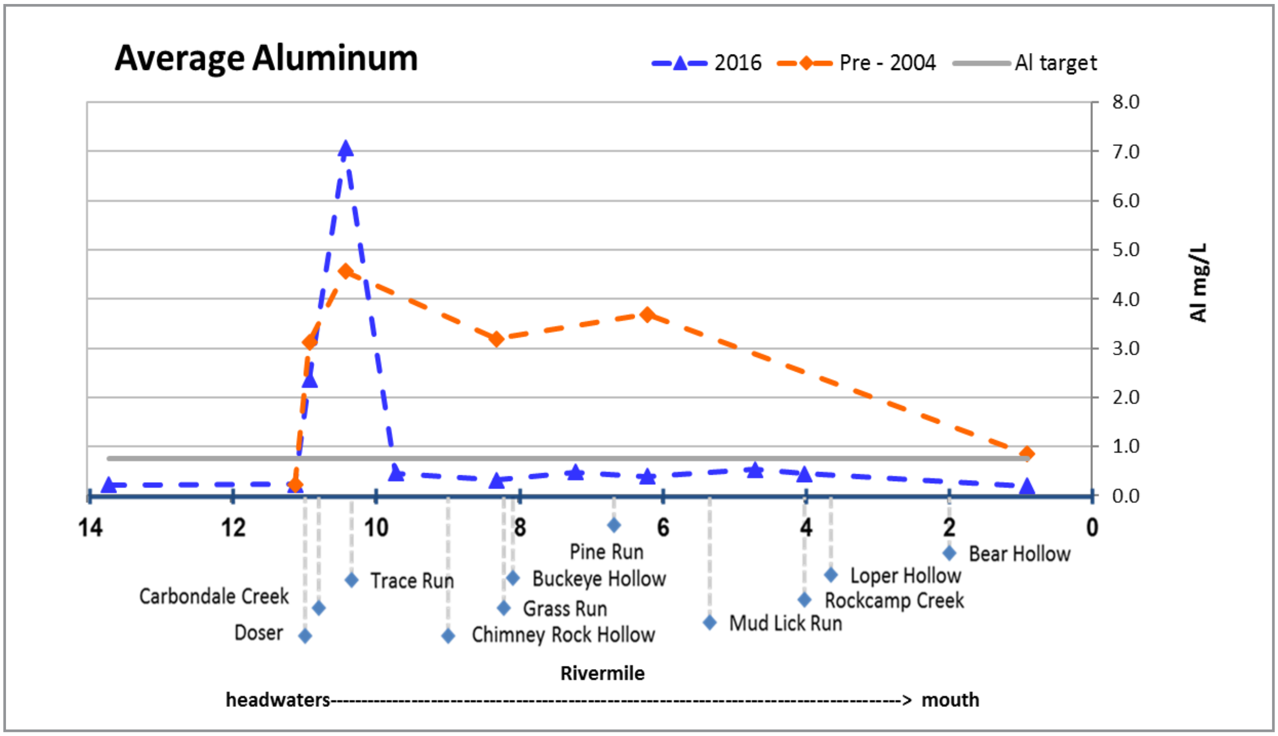
Chemical water quality analysis per stream reach

Hewett Fork

Site ID	HF137	HF129	HF130	HF190	HF095	HF090	HF075	HF060	HF045	HF039	HF010
Rivermile	13.7	11.1	10.9	10.4	9.7	8.3	7.2	6.2	4.7	4	0.9

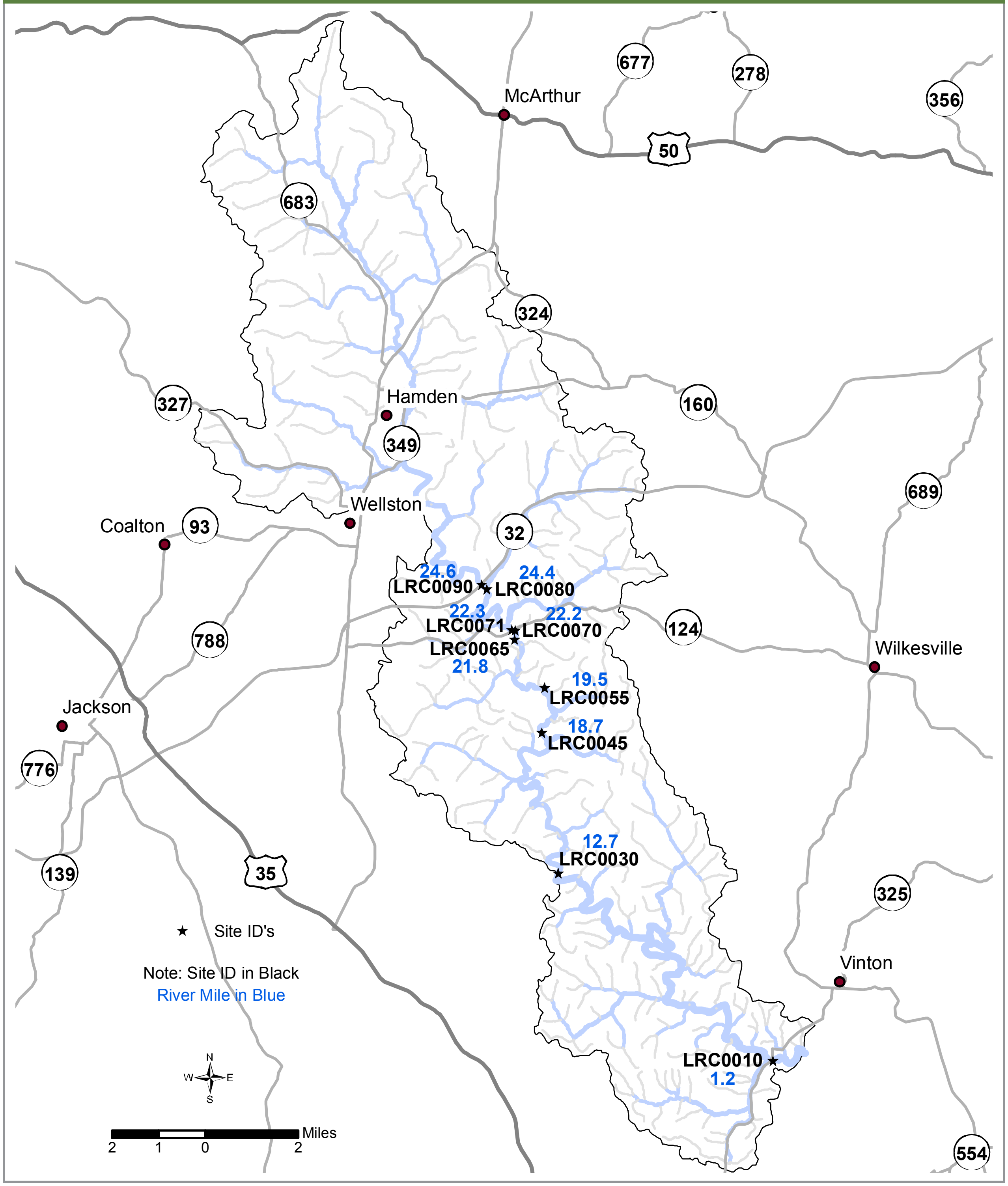
Note: Lime Doser installed in 2004 at RM 11





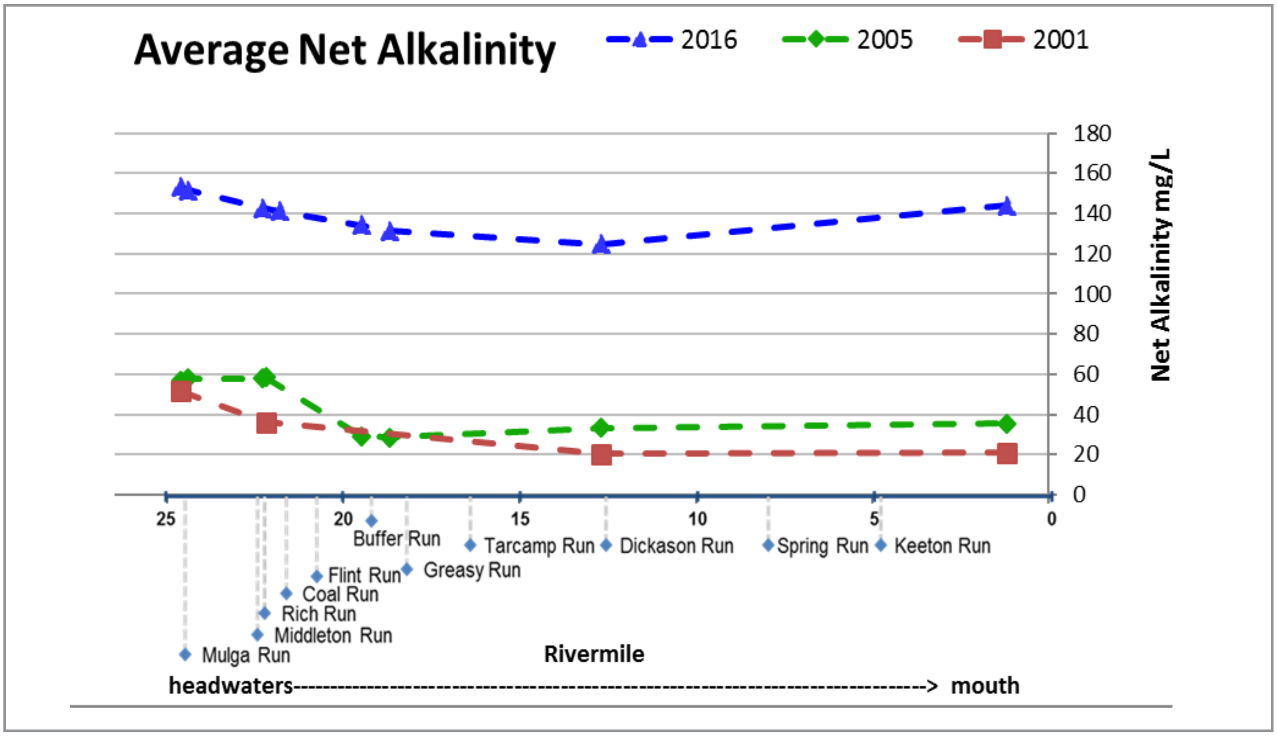
Chemical water quality analysis per stream reach

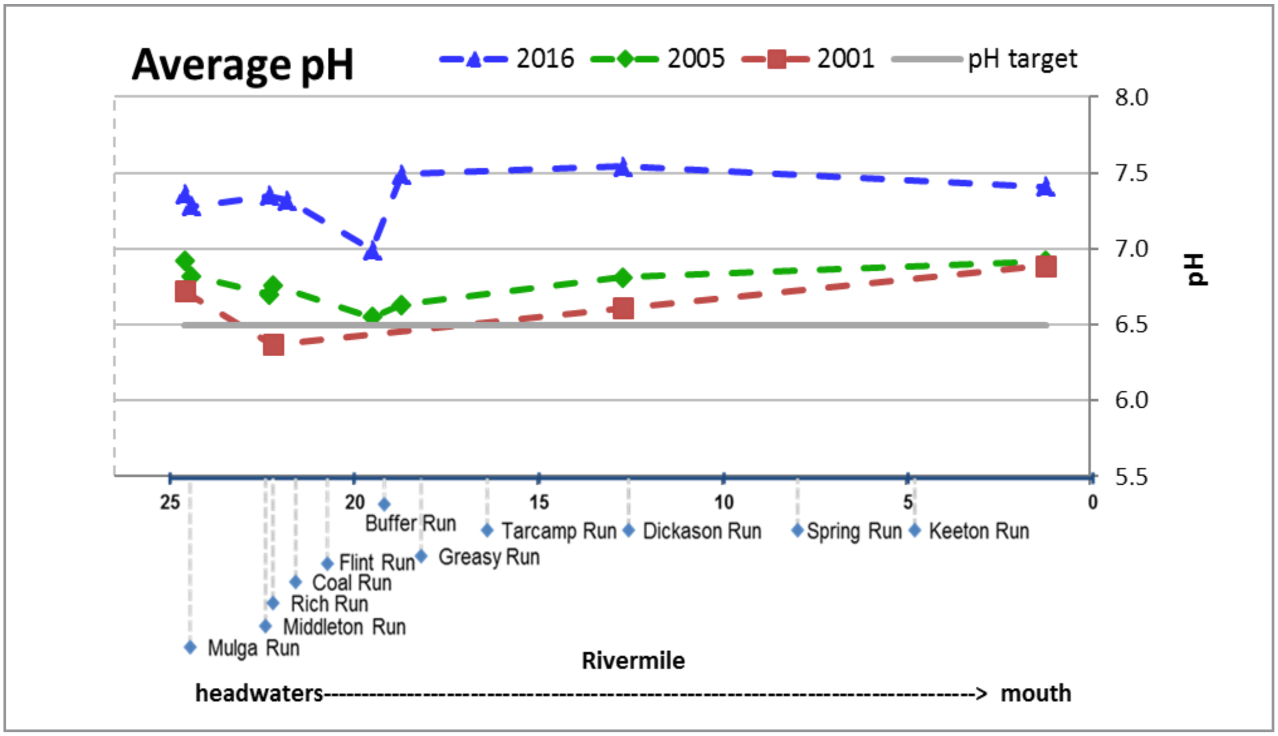
Little Raccoon Creek



Chemical water quality analysis per stream reach

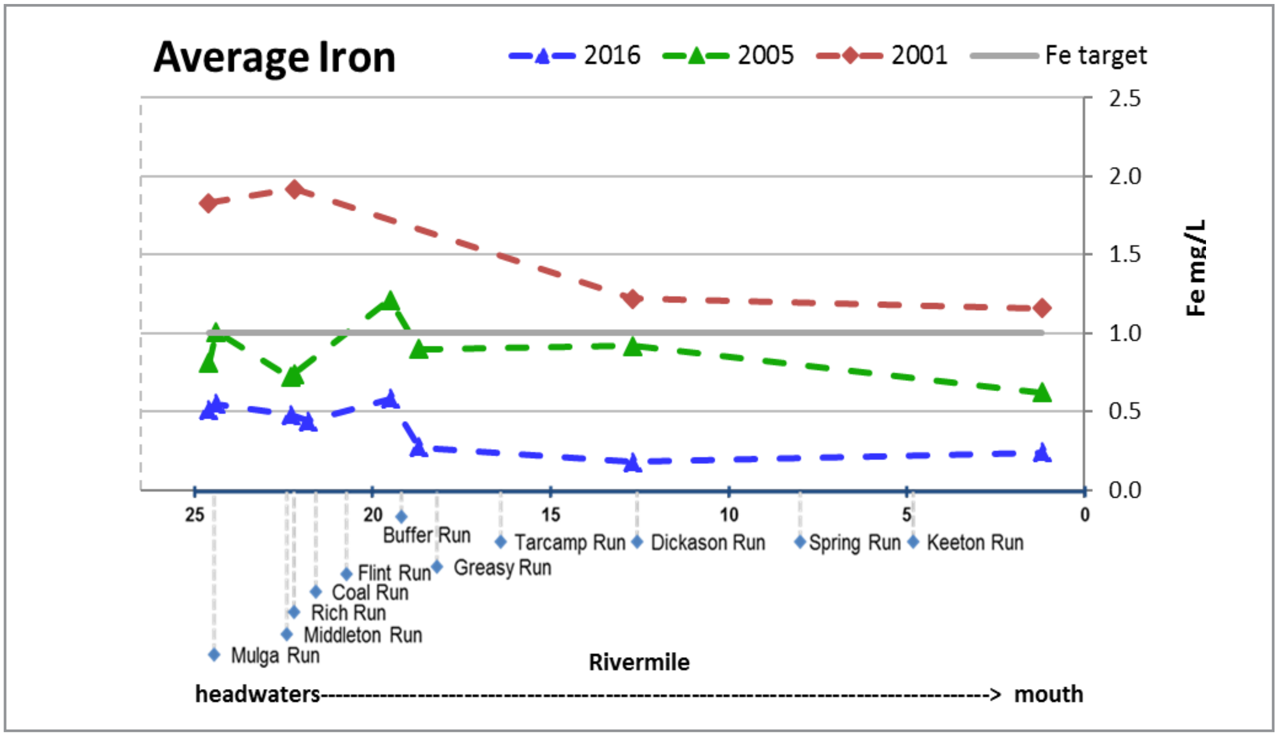
Little Raccoon Creek									
Site ID	LRC0090	LRC0080	LRC0071	LRC0070	LRC0065	LRC0055	LRC0045	LRC0030	LRC0010
Rivermile	24.6	24.4	22.3	22.2	21.8	19.5	18.7	12.7	1.2

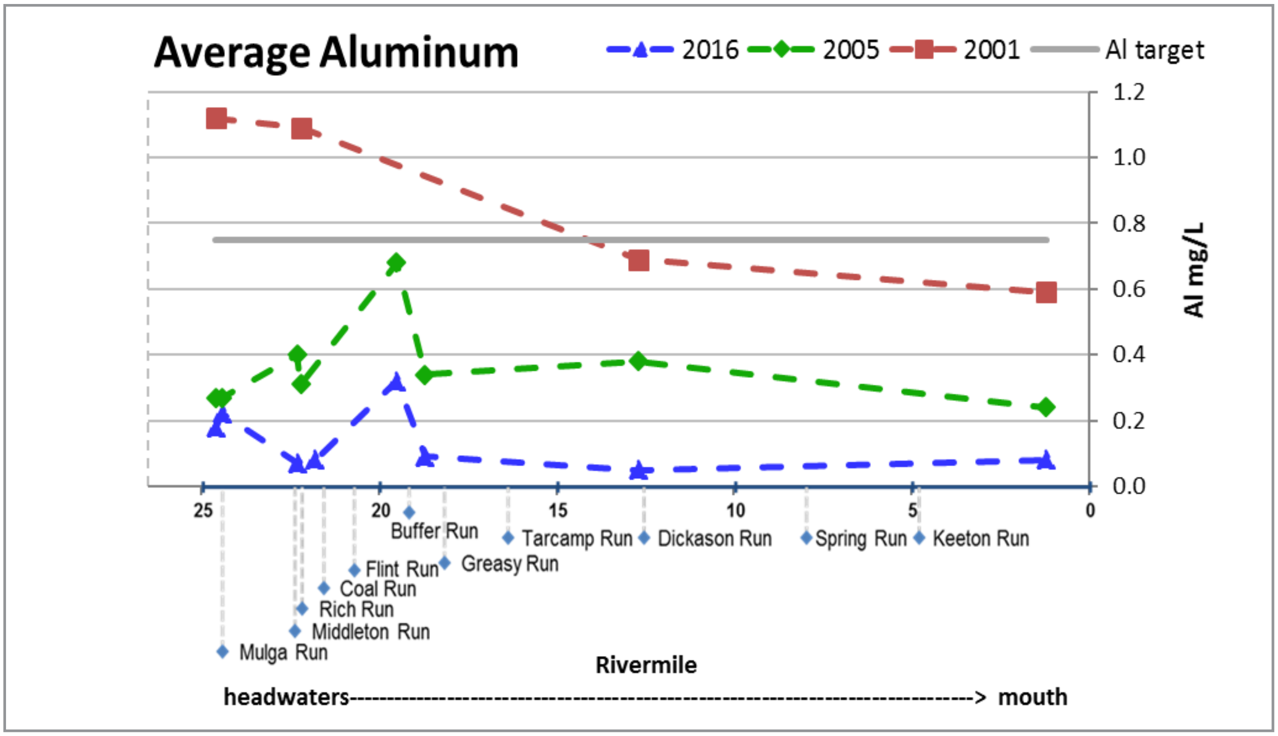




Chemical water quality analysis per stream reach

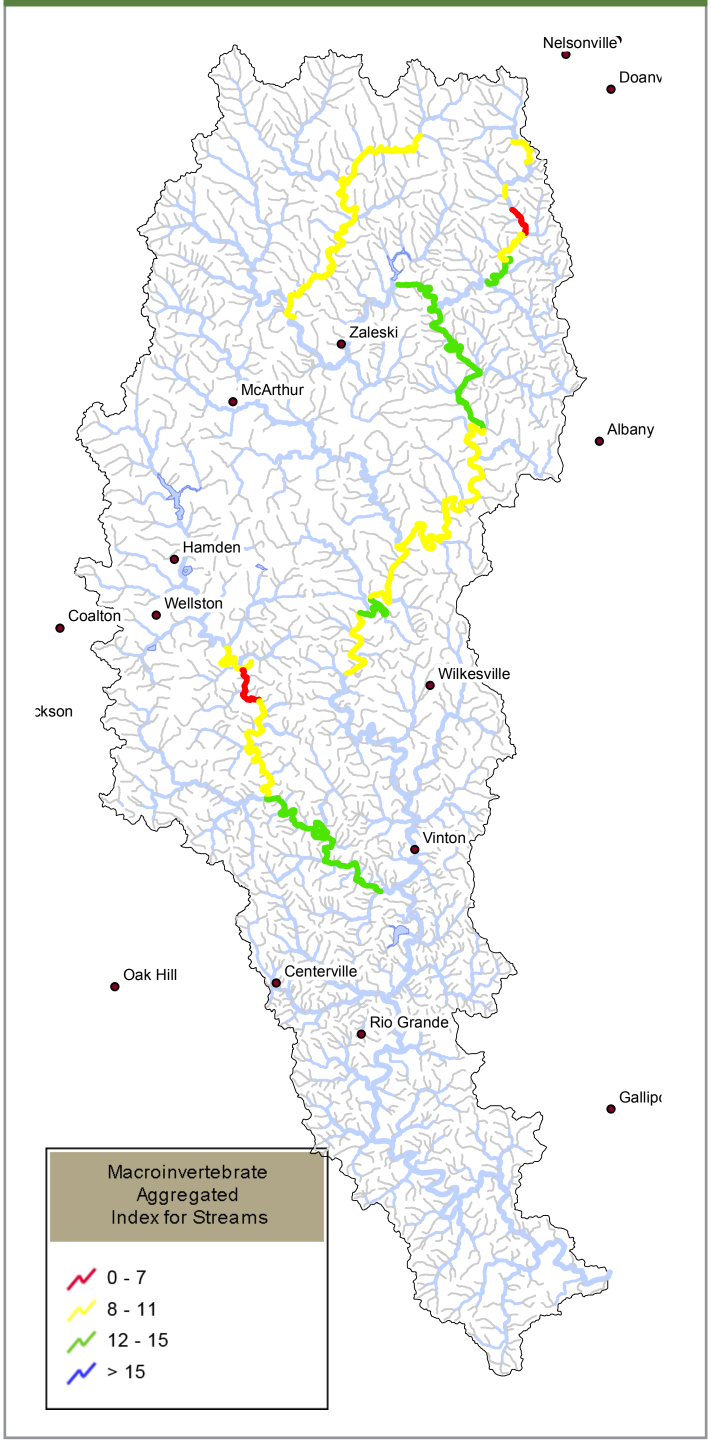
Little Raccoon Creek									
Site ID	LRC0090	LRC0080	LRC0071	LRC0070	LRC0065	LRC0055	LRC0045	LRC0030	LRC0010
Rivermile	24.6	24.4	22.3	22.2	21.8	19.5	18.7	12.7	1.2



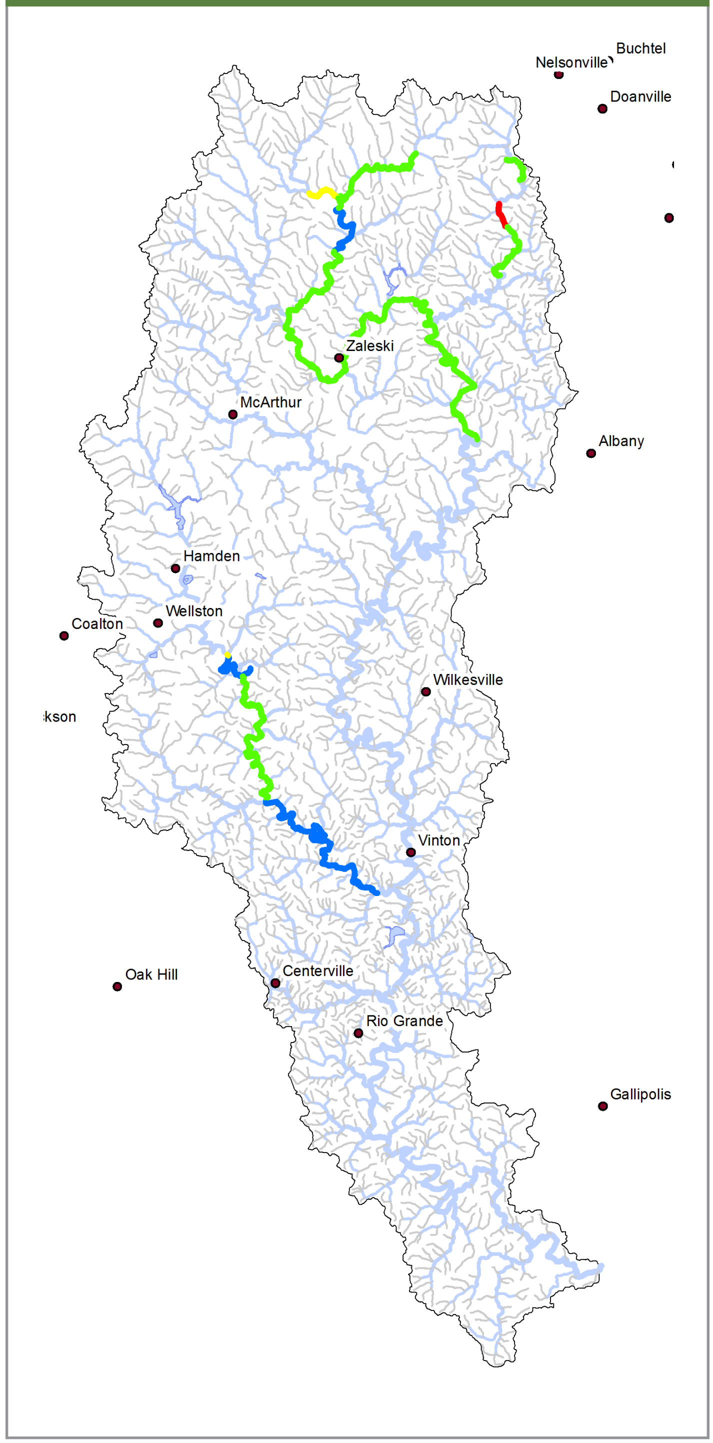


Biological Water Quality

Raccoon Creek baseline MAIS



Raccoon Creek 2016 MAIS

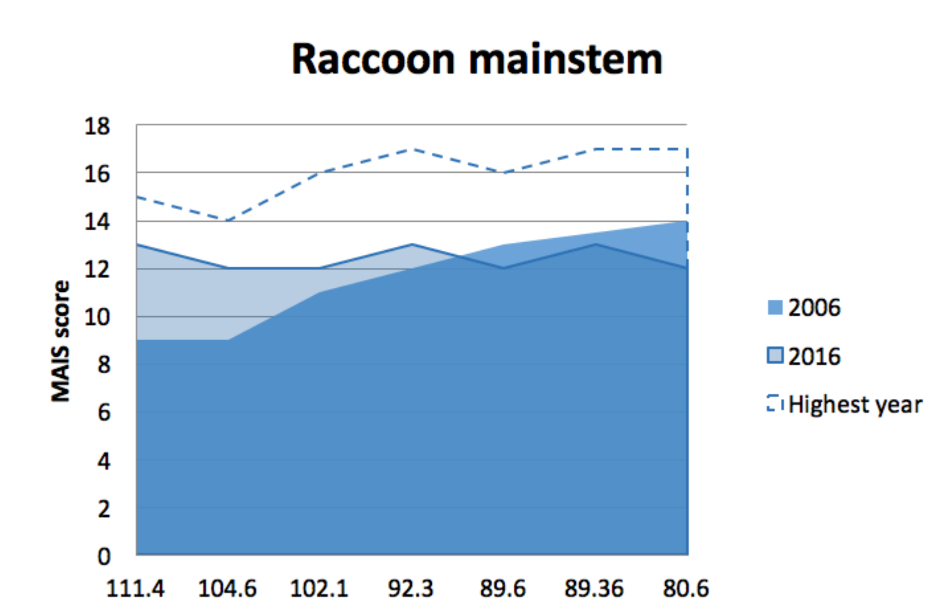


MAIS samples were collected throughout Raccoon Creek in 2016 (excluding Middle Basin sites). These stations have been established as annual monitoring stations for macroinvertebrates. The sites are used to track incremental changes each year.

Raccoon Creek - Mainstem

The roughly thirty river miles of mainstem of Raccoon Creek are generally of high biological quality, with all sites typically meeting or exceeding the target MAIS score of ‘12’. The upstream sites were historically the worst impaired and thus are the sites that have shown statistical improvement over the past ten years or so. In 2016, MAIS scores across most sites were lower than usual. Field observations suggested that flow conditions were not ideal for sampling.

Biological Recovery



The blue dashed line identifies the highest MAIS score achieved at that site throughout the monitoring time period.

Raccoon Creek - Mainstem - MAIS Regressions

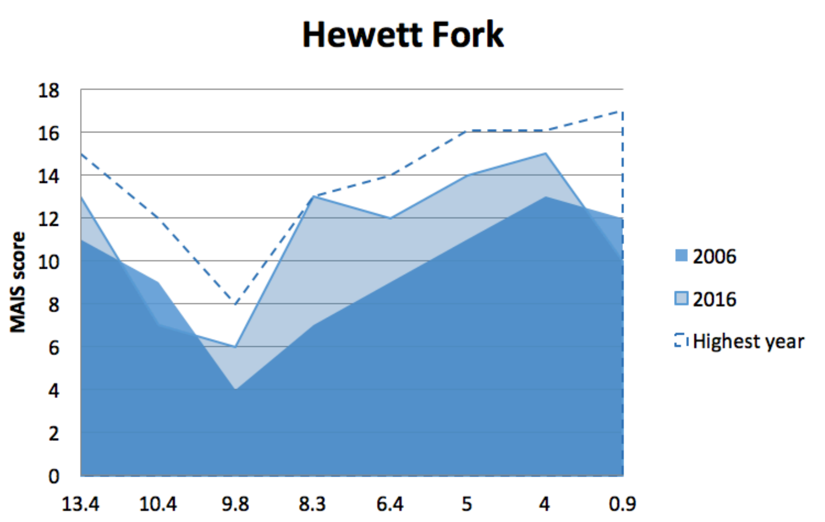
Raccoon Mainstem	RM	‘06	‘07	‘08	‘09	‘10	‘11	‘12	‘13	‘14	‘15	‘16	Linear trends	R square	P-value	Years
MSBC010	111.4	9	12	9	10	12	13	12	13	13	15	13	improved	0.731	0.0004	11
MSBC100	104.6	9	11	12	9	11	10	14	14	13	13	12	improved	0.425	0.029	11
MSLH020	102.1	11	11	10	13	10	11	12	15	15	16	12	improved	0.432	0.028	11
MSLH130	92.3	*	*	10	10	17	11	14	13	14	11	13	no change	0.048	0.572	9
MSBM004	89.6	13	14	11	16	12	16	15	14	13	16	12	no change	0.018	0.691	11
MSBM010	89.36	*	12	16	14	17	13	13	13	10	14	13	no change	0.120	0.326	10
MSBM040	80.6	14	14	17	16	12	14	15	14	14	16	12	no change	0.053	0.494	11
MSPR0085	63			16	16	14	14	*	*	15	*	*	no change	0.189	0.465	7
EB010	0.1	8	12	6	12	11	9	13	10	14	13	13	**improved**	0.381	0.043	11
EB047	2.25				11	13	8	12	15	14	14	13	no change	0.389	0.098	8
WB010	0.1						14	9	12	10	15	11	no change	0.0005	0.965	5

**Indicates a score graphed as the mean of sites immediately upstream and downstream that year*

Raccoon Creek - Hewett Fork

The biological quality of the eleven mile reach below the Carbondale doser has stabilized for several years after steady improvements to sites downstream of the treatment area (biological data shown below is all post treatment, doser installed 2004). A well-defined 2.5 mile 'mixing zone' downstream of the doser remains impaired in most years, but sites further downstream sites show increasing MAIS scores with increasing distance from the doser and mixing zone. In 2016 for the first time, HF090 (RM 8.3) at the lower end of the mixing zone exceeded the target MAIS score of '12' and effectively extended the recovered length of the creek to over 8 river miles. The MAIS score at the lowermost site, HF010 (RM 0.9) was unusually low this year. This site typically supports more EPT taxa but riffle habitat is limited to manmade structure around the railroad crossing and this year no mayflies were found there.

Biological Recovery



The blue dashed line identifies the highest MAIS score achieved at that site throughout the monitoring time period.

Raccoon Creek - Hewett Fork MAIS Regressions

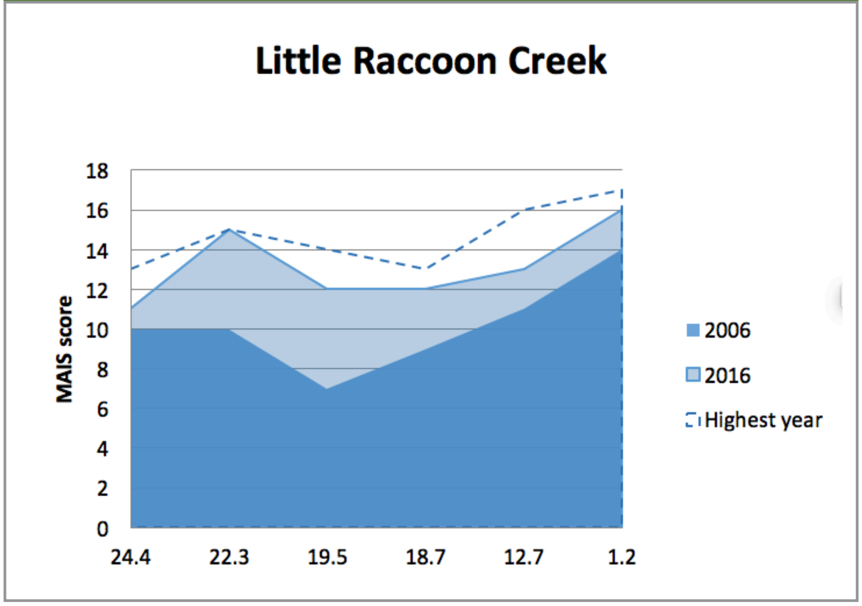
Raccoon Mainstem, RM	'06	'07	'08	'09	'10	'11	'12	'13	'14	'15	'16	Linear trends	R square	P-value	Years
HF 137, RM 13.4	11	8	9	12	13	11	11	11	13	15	13	improved	0.497	0.015	11
HF 190, RM 10.4	9	3	7	6	6	5	8	12	8	9	7	no change	0.156	0.230	11
HF095, RM 9.8	4	3	6	3	3	8	4	4	4	5	6	no change	0.083	0.391	11
HF 090, RM 8.3	7	3	5	6	3	6	9	7	11	11	13	improved	0.649	0.003	11
HF 060, RM 6.4	9	9	8	10	10	13	11	14	13	11	12	improved	0.544	0.009	11
HF045, RM 5.0					14	15	12	13	16	14	14	no change	0.014	0.799	7
HF 039, RM 4.0	13	13	14	13	13	14	14	16	16	15	15	improved	0.641	0.003	11
HF 010, RM 0.9	12	12	15	17	13	16	16	14	16	14	10	no change	0.0008	0.935	10

**Indicates a score graphed as the mean of sites immediately upstream and downstream that year.*

Raccoon Creek - Little Raccoon Creek

Little Raccoon Creek biological quality remains high, with most sites showing stable improvement since 2006, after completion of the six major reclamation projects upstream of RM 19.5 (Mulga Run, Salem Road/Middleton Run, State Rte. 124 seeps, Flint Run East, Lake Milton, and Buckeye Furnace). This year a new high score of '15' was recorded at RM 22.3, and this year all but the uppermost site (RM 24.4) achieved target macroinvertebrate scores of '12'or higher, indicating that the macroinvertebrate community is probably at or near attainment of WWH status for most of the sampled length (more than 22 river miles).

Biological Recovery



The blue dashed line identifies the highest MAIS score achieved at that site throughout the monitoring time period.

Little Raccoon Creek - MAIS Regressions

RM	'05	'06	'07	'08	'09	'10	'11	'12	'13	'14	'16	Linear trends	R sq.	P-value	Years
24.4	8	10	11	11	9	9	13	11	11	12	11	improved	0.327	0.052	12
22.3	8	10	10	9	10	10	10	10	13	11	15	no change	0.155	0.206	12
19.5	*	7	*	9	11	12	13	10	11	14	12	improved	0.536	0.038	8
18.7	14	9	12	9	13	11	11	12	11	10	12	no change	0.007	0.832	9
12.7	3	11	13	13	14	14	14	14	15	16	13	improved	0.556	0.021	9
1.2	14	14	13	15	17	16	16	16	14	17	16	no change	0.201	0.226	9

** Missing values were replaced with arithmetic averages of the preceding and following years' scores for graphing.*

MONDAY CREEK
WATERSHED REPORT

Monday Creek Restoration Project

Reductions

Total acid load reduction 2016 = 4360 lbs/day

Total metal load reduction 2016 = 544 lbs/day

Data derived using the Stoertz Water Quality Evaluation Method (Kruse et al. 2014) (excludes Rock Run Gob Pile Project)

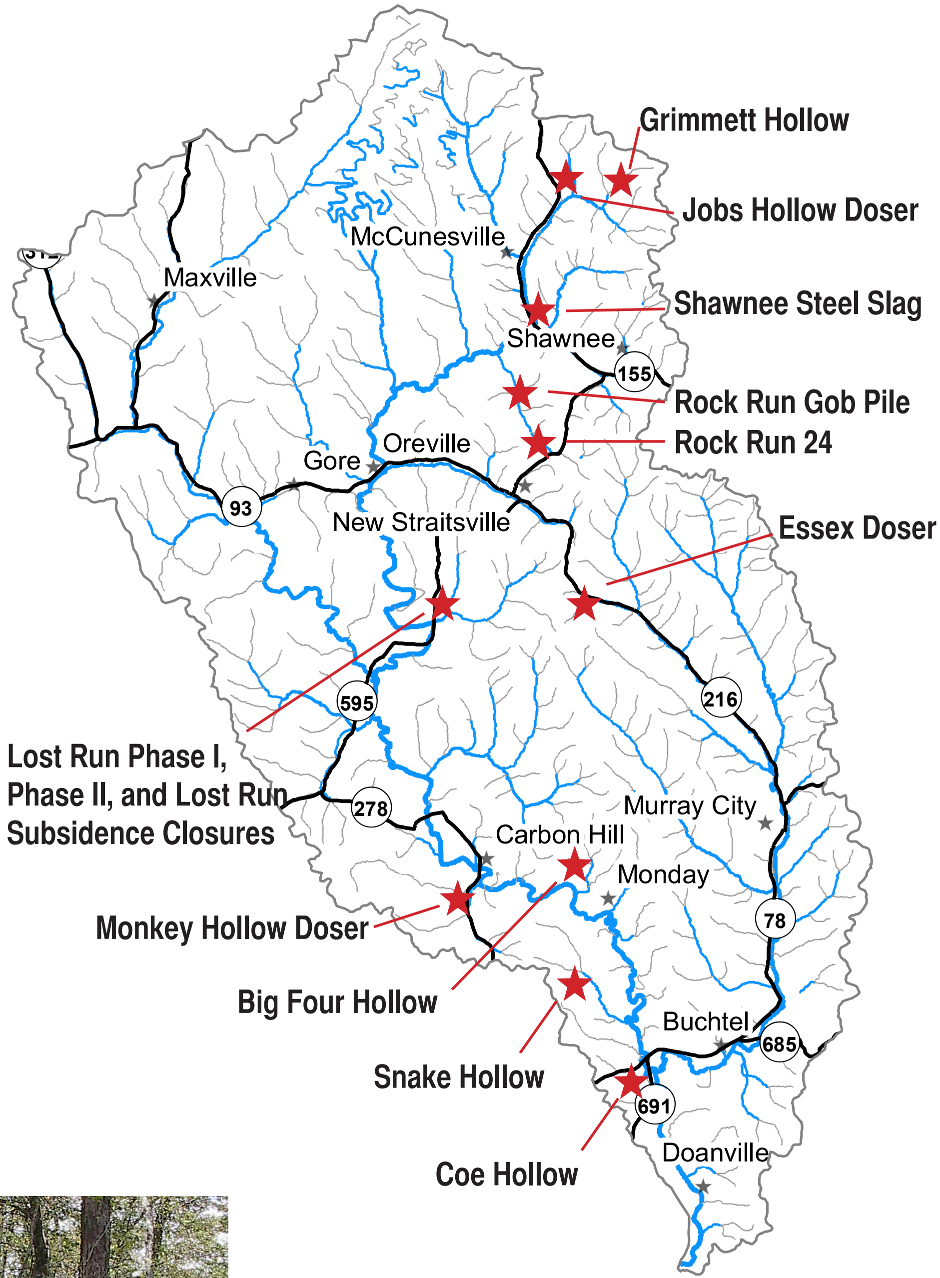
Acid and metal load reductions based on projects monitored during 2016 listed here: Jobs Hollow Doser, Big Four Hollow, Lost Run I, II, & III, Rock Rub Gob pile, Coe Hollow, and Monkey Hollow.

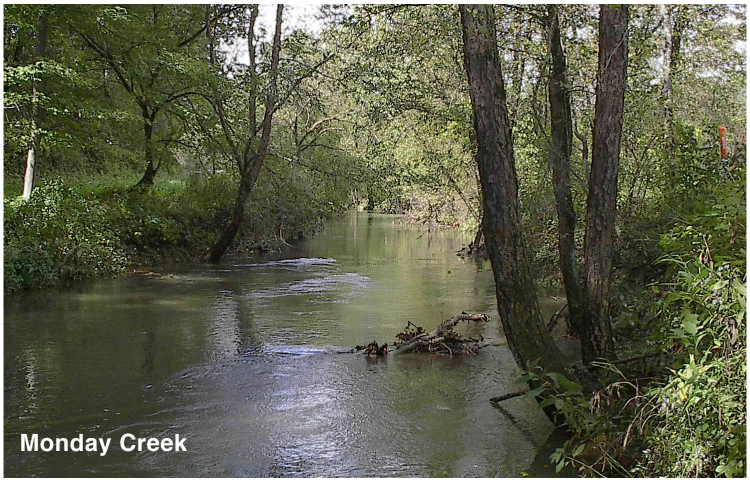
Cost

Design $448,545
(excluding Jobs Doser & Lost Run maintenance and Snake Hollow)

Construction $6,749,264

Total costs through 2016 = $7,197,808




Monday Creek

363,425,000 gallons of stream water per year eliminated from entering into the deep mines as the result of conducting seven stream capture closure projects in Monday creek.

Timeline of the Monday Creek Watershed Project Milestones & AMD Projects

Year	Milestones
1994	• Formation of Monday Creek Restoration Project
1995	• First stream water quality study on Monday Creek (USFS, CURSML, and USGS) • OSM awarded MCRP an Appalachian Clean Stream Initiative (ACSI) grant for Rock Run
1996	• Ohio EPA awards Monday Creek with a 319 grant for Rock Run
1997	• "Monday Creek Watershed AMDAT Acid Mine Drainage Abatement and Treatment Plan I" published • Ohio EPA awards Ohio University with a 319 to treat mine drainage at Rock Run, Brush Fork and seal a subsidence on Goose Run and at Majestic Mine site • Monday Creek video "Silent Waters: The Story of Monday Creek" is produced
1998	• Grant from CURSML for capping Jobs 13 gob pile
1999	• First Management Plan, "A Comprehensive Plan for the Monday Creek Watershed", published • MCRP Office opened in New Straitsville • OSM awarded ACSI grant for Jobs Hollow doser, Snake Hollow, and Salem Hollow • Mitigation funds from ODOT awarded to MCRP for reclamation in Big Four Hollow • "Monday Creek Watershed Acid Mine Drainage Abatement and Treatment Plan II" published • OSM awarded a Cooperative Agreement for treatment at Rock Run 24
2000	• Ohio EPA awarded a 319 grant for work at Jobs Hollow (Grimmett Site) and Monkey Hollow • MCRP receives Watershed Coordinator Grant
2001	• Wayne National Forest closed subsidences at Orbiston North, Long Hollow, and Essex Mine
2002	
2003	• Jobs 13 gob pile capping is underway. • Video about Monday Creek entitled "Cool Waters" is released
2004	• Volunteers planted nearly 7,000 Pine on Sunday Creek Coal Company land • Jobs active alkaline doser installed • U.S. Forest Service constructed a series of limestone leach beds and channels in Snake Hollow • Ohio EPA awarded MCRP a 319 grant for work at Lost Run
2005	• U.S. Army Corps of Engineers Civil Works Review Board approves the Monday Creek Feasibility Study for a favorable Chief of Engineers' Report and inclusion in Water Resources Development Act of 2005 (WRDA '05)

continued on next page

Timeline of the Monday Creek Watershed Project Milestones & AMD Projects (continued)

2006	• Acid Mine Drainage Abatement and Treatment (AMDAT) Plan III approved • Essex Doser (319 grant) is operational • U.S. Forest Service constructed open limestone channels, closed subsidence and established positive drainage at New Straitsville North area, Monkey Hollow, and Elm Rock area • The MCRP Watershed Management Plan was fully endorsed by the Ohio DNR and Ohio EPA • Lost Run Phase I reclamation and OEPA 319 grant was completed
2007	• Ohio EPA awarded MCRP a 319 grant for construction of a steel slag leach bed at Shawnee • U.S. Forest Service closed subsidences near State Route 216 and Snake Hollow • The Water Resources Development Act of 2007 is approved, Congress authorizied $21 million for ecological restoration of Monday Creek
2008	• U.S. Forest Service completes reclamation in Valley Junk area • ODOT mitigation funds in the amount of $200,000 secured for work at Lost Run Phase 2
2009	• ODOT mitigation funds are in place for work in Big Four Hollow and at Rock Run • U.S. Forest Service completed reclamation work along State Route 278, New Straitsville South area, Lost Run headwaters, Brush Fork, and Coe Hollow. • Ohio DNR completes phase II of Shawnee steel slag leach bed
2010	• U.S. Forest Service closed subsidences along Snow Fork, Rock Run, and New Straitsville South
2011	• U.S. Forest Service closed subsidences in the Cawthorn area • Ohio DNR conducted reclamation and needed maintenance at Rock Run • U.S. Forest Service and ODNR completed reclamation in Sand Run • Ohio DNR completes construction to minimize sediment transport at Big Four Hollow
2012	• 3 limestone leach beds installed in Big Four Hollow. • MCRP, Perry Co. Health Department, Village of New Straitsville and watershed residents installed a community garden in New Straitsville. • Major AMD maintenance projects completed in Lost Run and Jobs Hollow
2013	• Five new fish species found in Monday Creek and the first annual Monday Creek Canoe Float with 54 people in 27 boats!
2014	• The Essex Doser moved to Monkey Hollow and two new species of fish found in the Carbon Hill area: Brown Bullhead and the Banded Darter.
2015	• Monkey Hollow Doser began operating August 26, 2015. This project will help improve 6.5 miles of Monday Creek. • The Smallmouth Bass (Micropterus dolemieu) was found for the first time in Monday Creek since restoration project. Two other native species were also found, greenside darter (Etheostoma blennioides) and spotted sucker (Minytrema melanops).
2016	• USFS closed subsidence holes in Salem Hollow and Sand Run • The Longear Sunfish (Lepomis megalotis) was found for the first time in Monday Creek. • Lost Run 3 East steel slag leach bed began operating. • USFS identified the Kitchen Run - Monday Creek 12 digit HUC as a priority watershed and completed a Watershed Restoration Action Plan to identify ways to continue improving the target area.

Monday Creek Projects

Acid mine drainage reclamation projects completed in Monday Creek Watershed:

1999 Rock Run Gob Pile revamped 2011 (RR02100) – Gob pile reclamation

2001 *Rock Run 24 (RR00820) – Limestone channel*

2003 *Grimmett Hollow (JH09020) – Enhanced wetland with lime and limestone channels*

2004 Jobs Hollow Doser (JH00500) – Active calcium oxide doser

Big Four Hollow (BF00100) – 2 limestone beds and limestone channels

Snake Hollow (SH00100) – Close 9 subsidence features, 2 steel slag beds, enhance wetland, and limestone channels

2006 *Essex Doser (SY00706) – Active calcium oxide doser shutdown in 2008*

Lost Run Phase I (LR01020) – limestone leach beds and limestone channels

2007 Lost Run Phase II (LR00020) – Steel slag beds, limestone leach beds, and limestone channels

Lost Run Subsidence and Portal Closures – closed ten subsidence features

2008 *Shawnee Steel Slag Bed (MC00900) – Steel slag bed, limestone channels, and sand filter*

2010 Jobs Hollow Doser Maintenance II – Clean out of source pond, supply lines, and installed safety cage to hatch and ladder

Coe Hollow (CH00100) – Limestone leach ponds, passive wetlands,, steel slag leach bed, and 2 subsidence features closed

2012 Lost Run II Maintenance – New steel slag installed, additional piping in the underdrain, and improve water delivery to SSLB.

Big Four Hollow LLB (BF00400) – 3 limestone leach beds

2015 Monkey Hollow Doser (MH00100) – Active calcium oxide doser

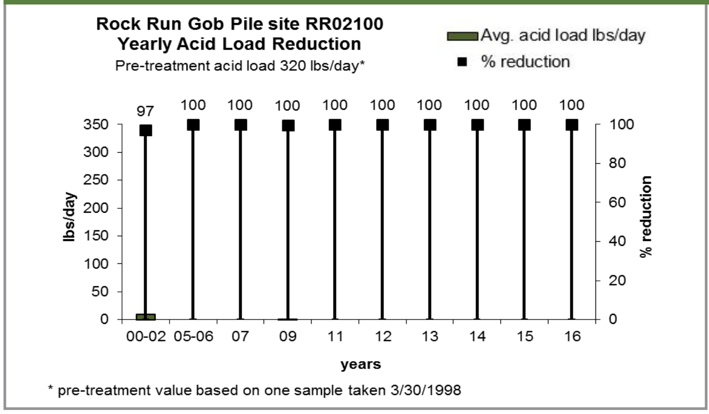
Big Four Wetland Enhancement (BF00100) - Three wetlands installed for metal retention

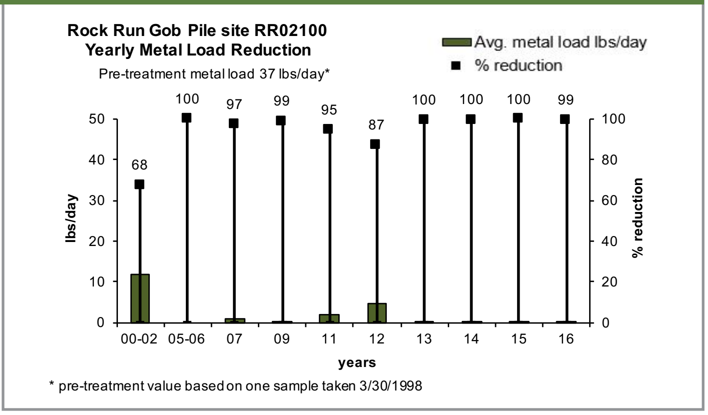
Italicized indicated projects are not actively monitored for acid mine drainage and metal load reduction purposes

Yearly acid and metal load reduction trends per project

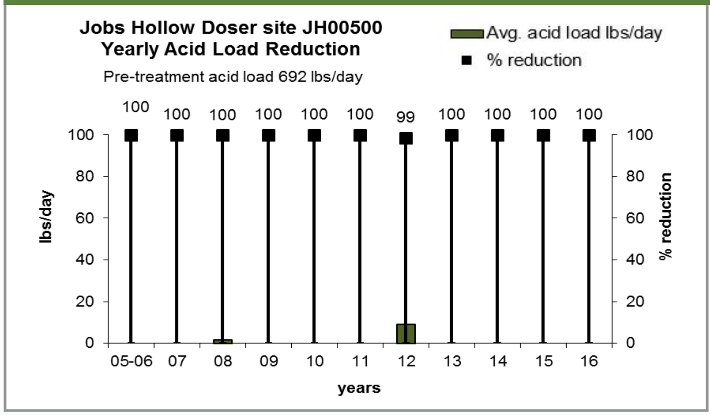
Similar to other environmental best management practices (BMPs), performance of passive acid mine drainage reclamation projects are also expected to decline with time. Active treatment systems are not expected to decline with time but sometimes need to be maintained to perform adequately. Currently, operation and maintenance plans are being designed for each existing system and are planned for future projects. The graphs below show the mean annual acid and metal load reduction using the Stoertz Water Quality Evaluation Method (Kruse et al., 2014) for each year (or group of years) during post-reclamation from the project effluent. From these graphs the rate of decline (and/or improvement) with time of the treatment system is implied. Knowing the rate of decline will aid in the implementation of operation and maintenance plans.

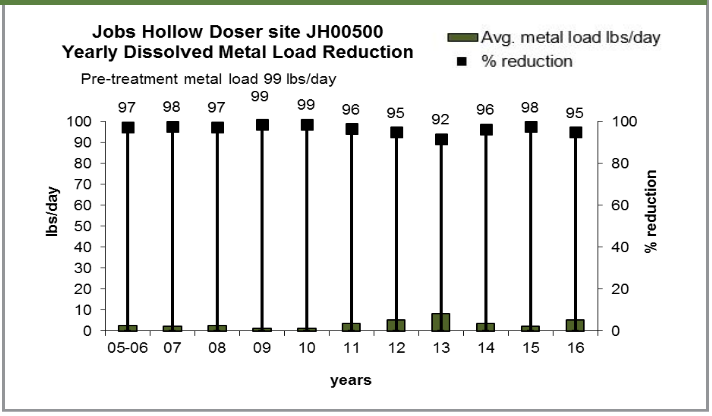
Rock Run Gob Pile site RR02100



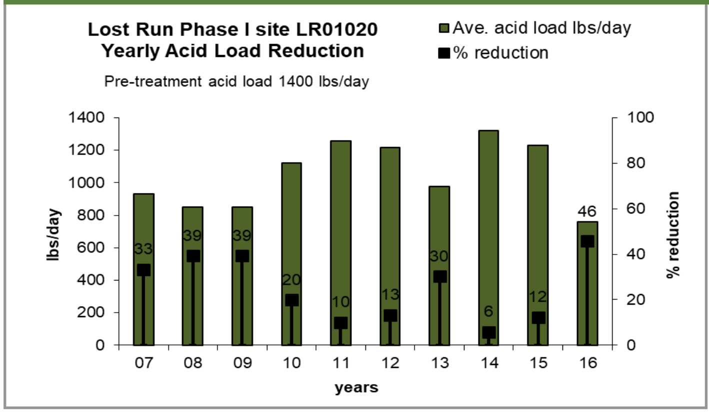


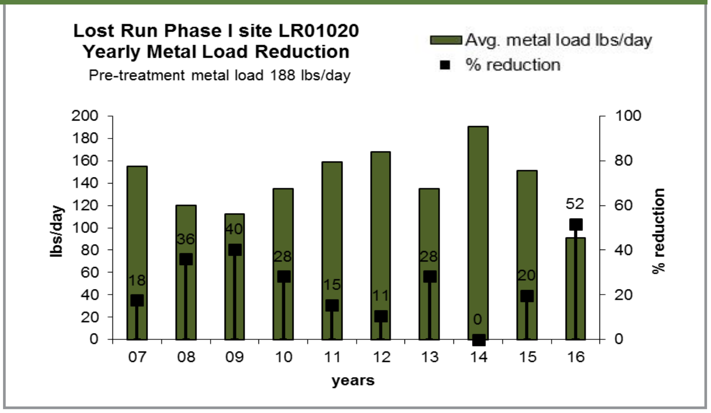
Jobs Hollow Doser site JH00500





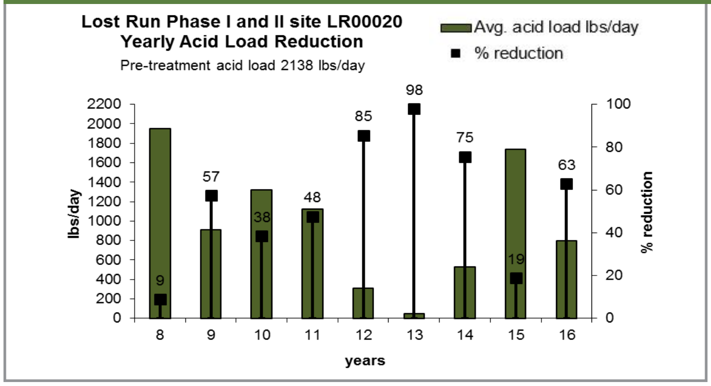
Lost Run Phase I site LR01020

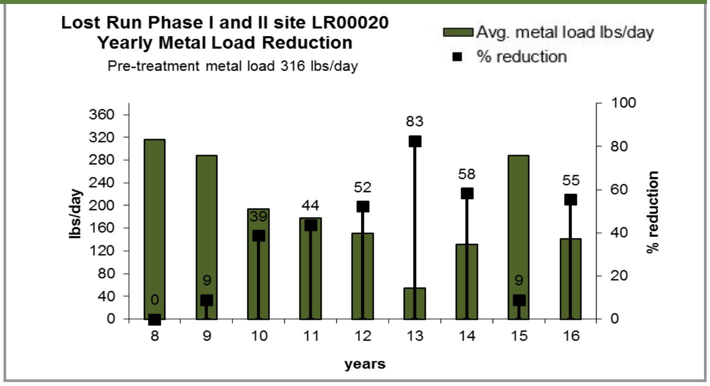




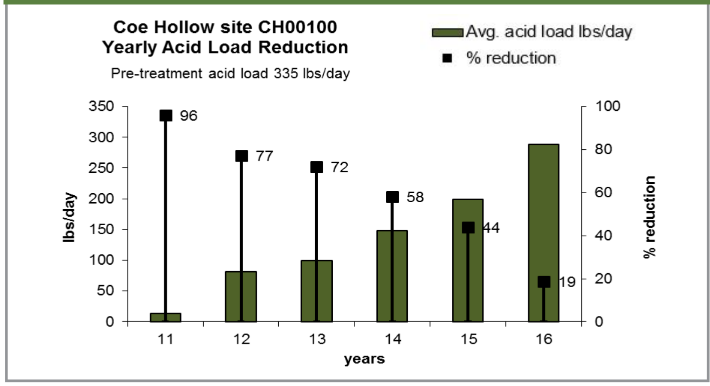
Yearly acid and metal load reduction trends per project

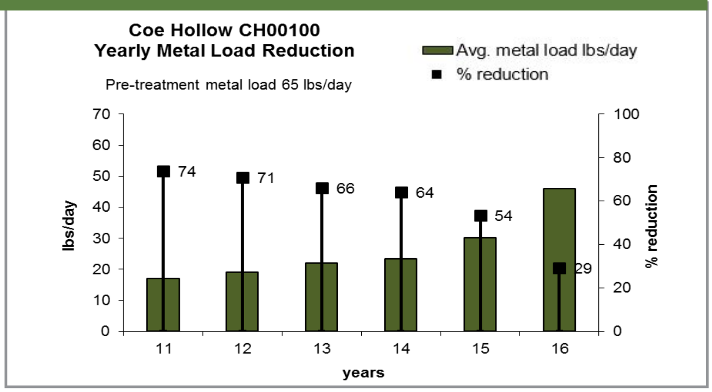
Lost Run Phase I and II site LR00020



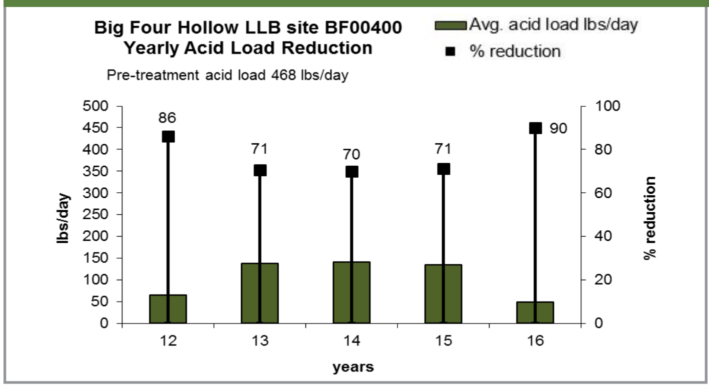


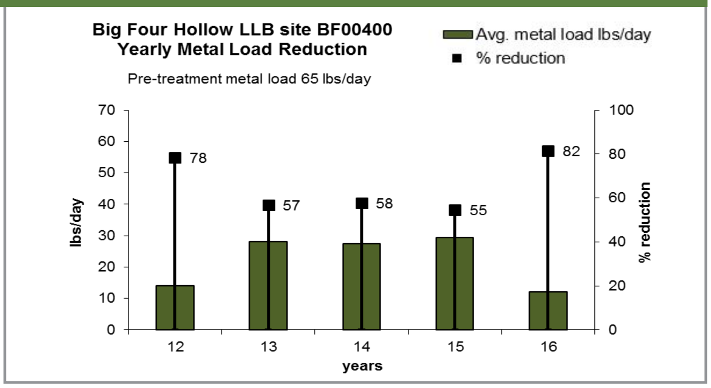
Coe Hollow site CH00100





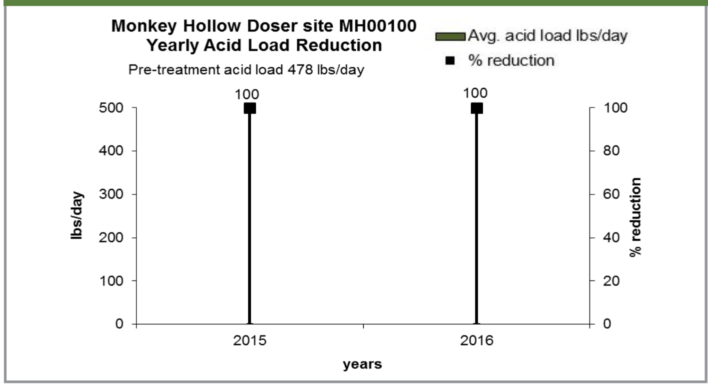
Big Four Hollow LLB site BF00400

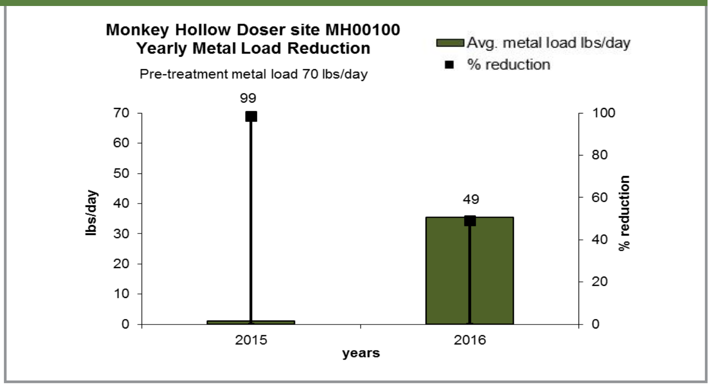




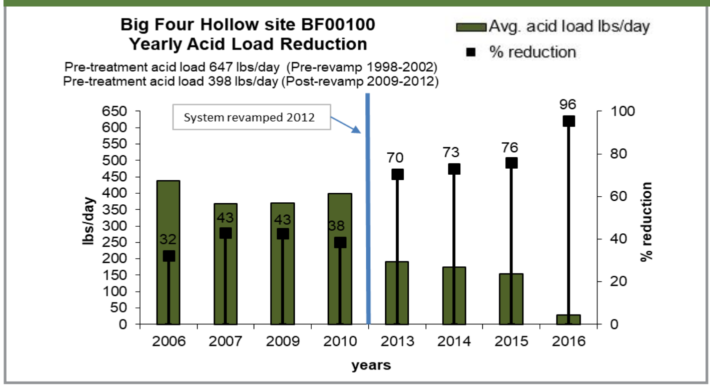
Yearly acid and metal load reduction trends per project

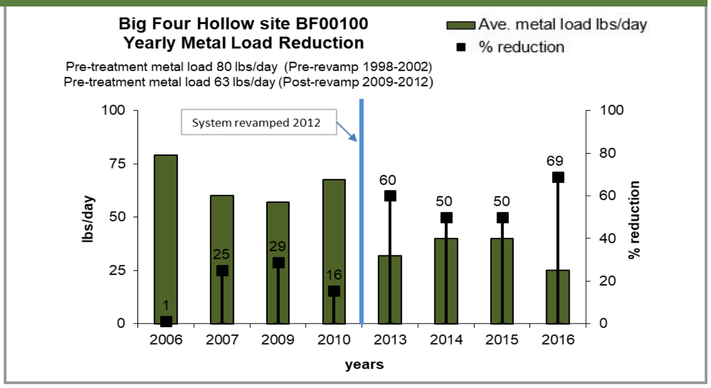
Monkey Hollow doser site MH0010





Big Four Hollow site BF00100



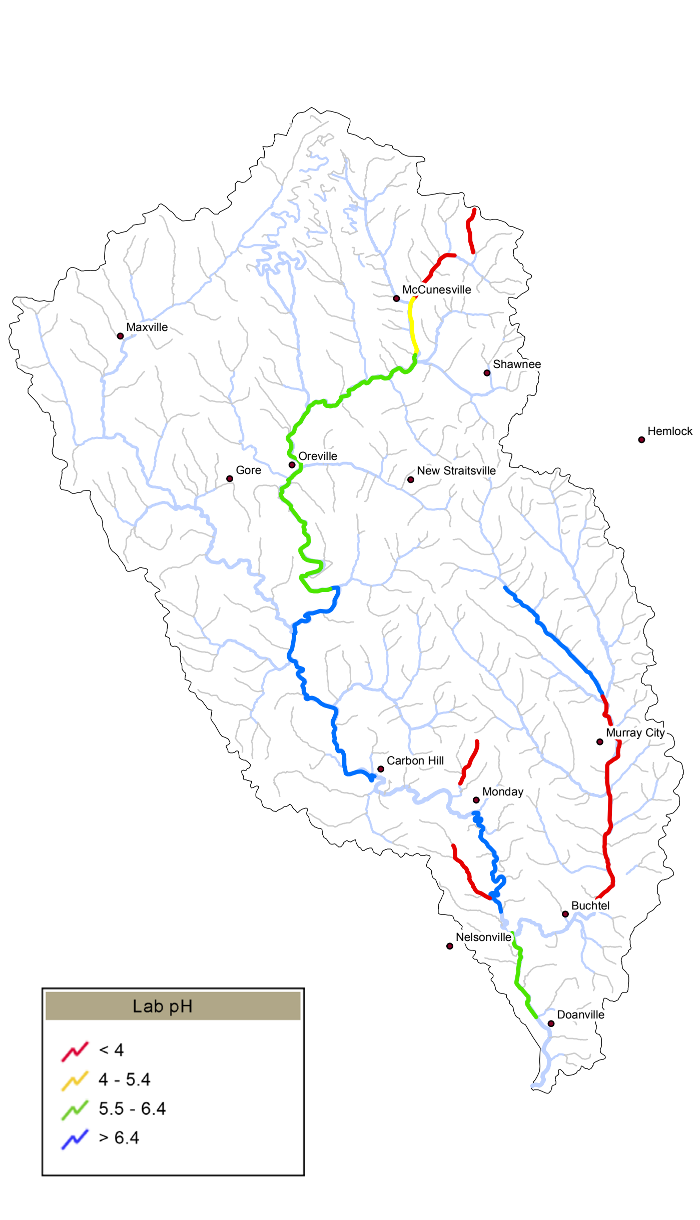


2016 NPS Report - Monday Creek Watershed

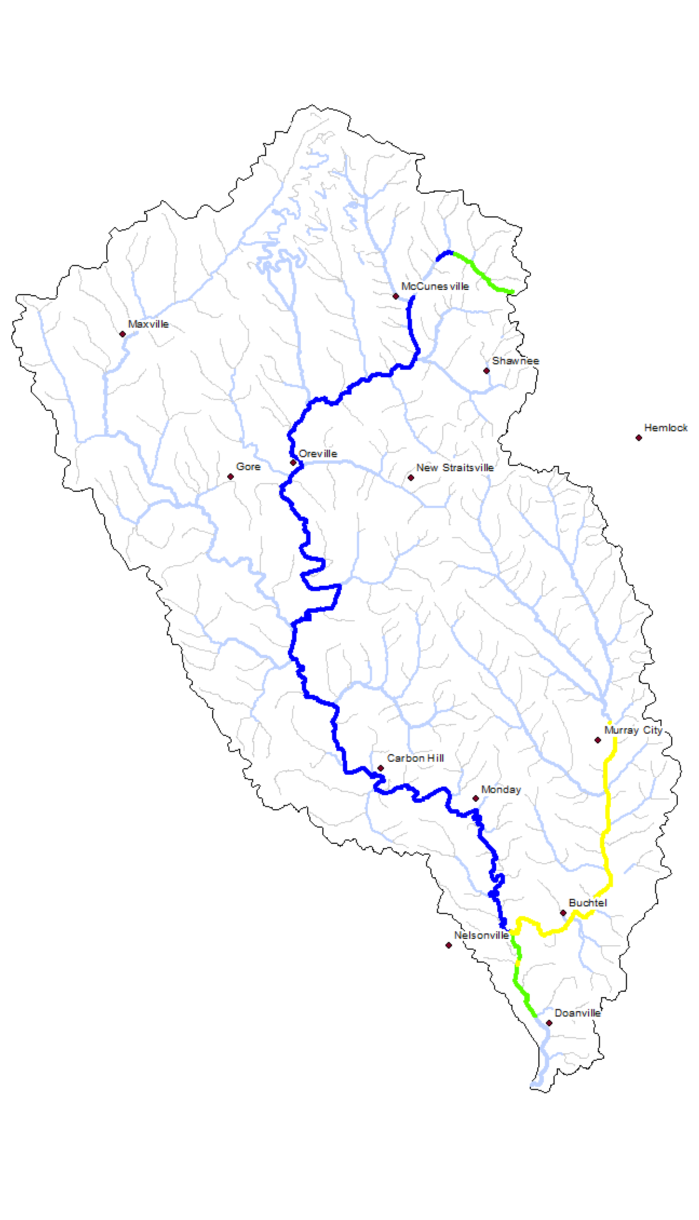
Generated by Non-Point Source Monitoring System
www.watersheddata.com

Chemical Water Quality

Monday Creek baseline pH



Monday Creek 2016 pH

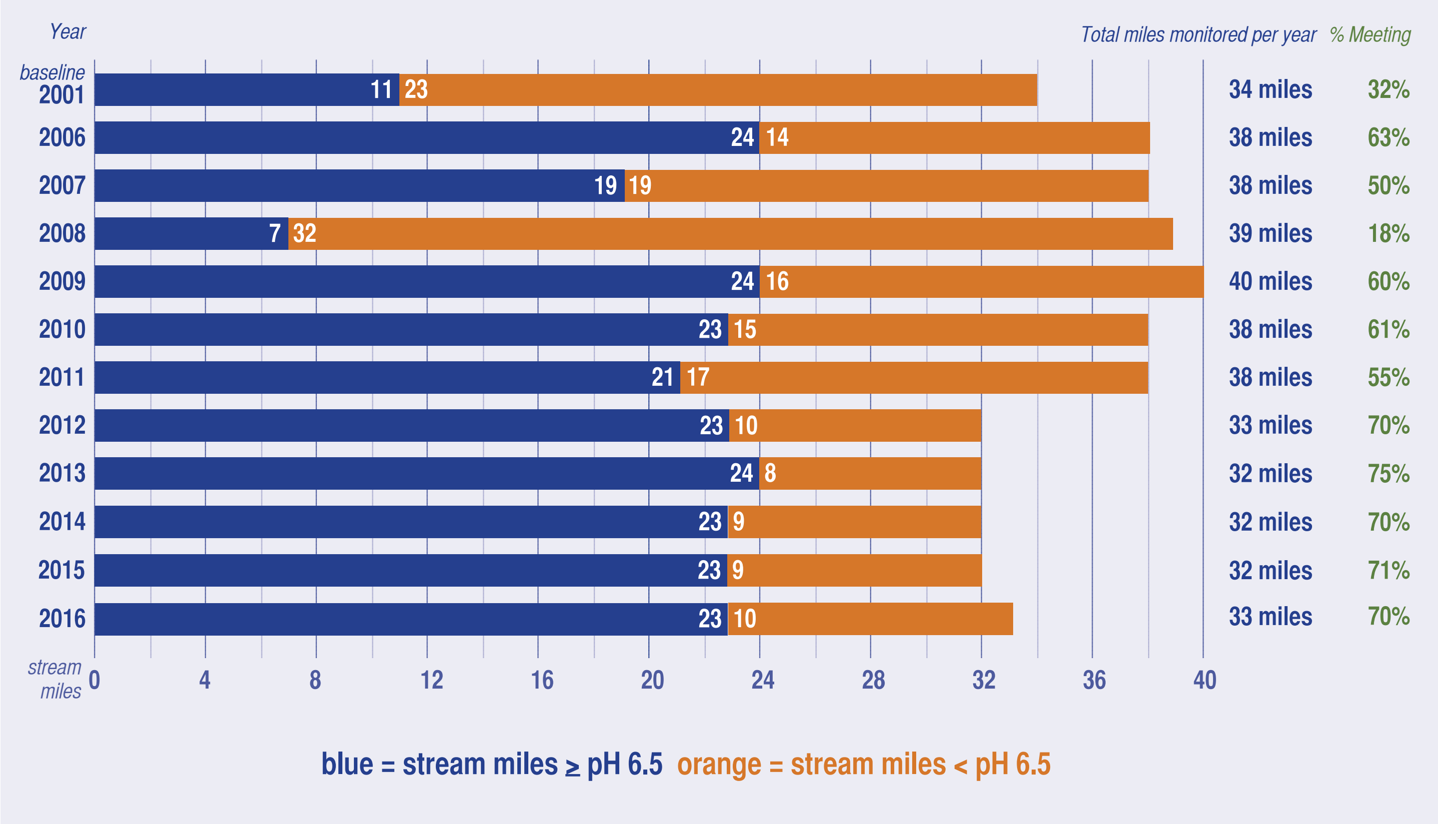


In Monday Creek pH values have improved throughout the watershed from baseline conditions (2001) to 2016. In 2016, stream miles meeting pH target of 6.5 is approximately 23 miles of the 33 miles monitored (72%).

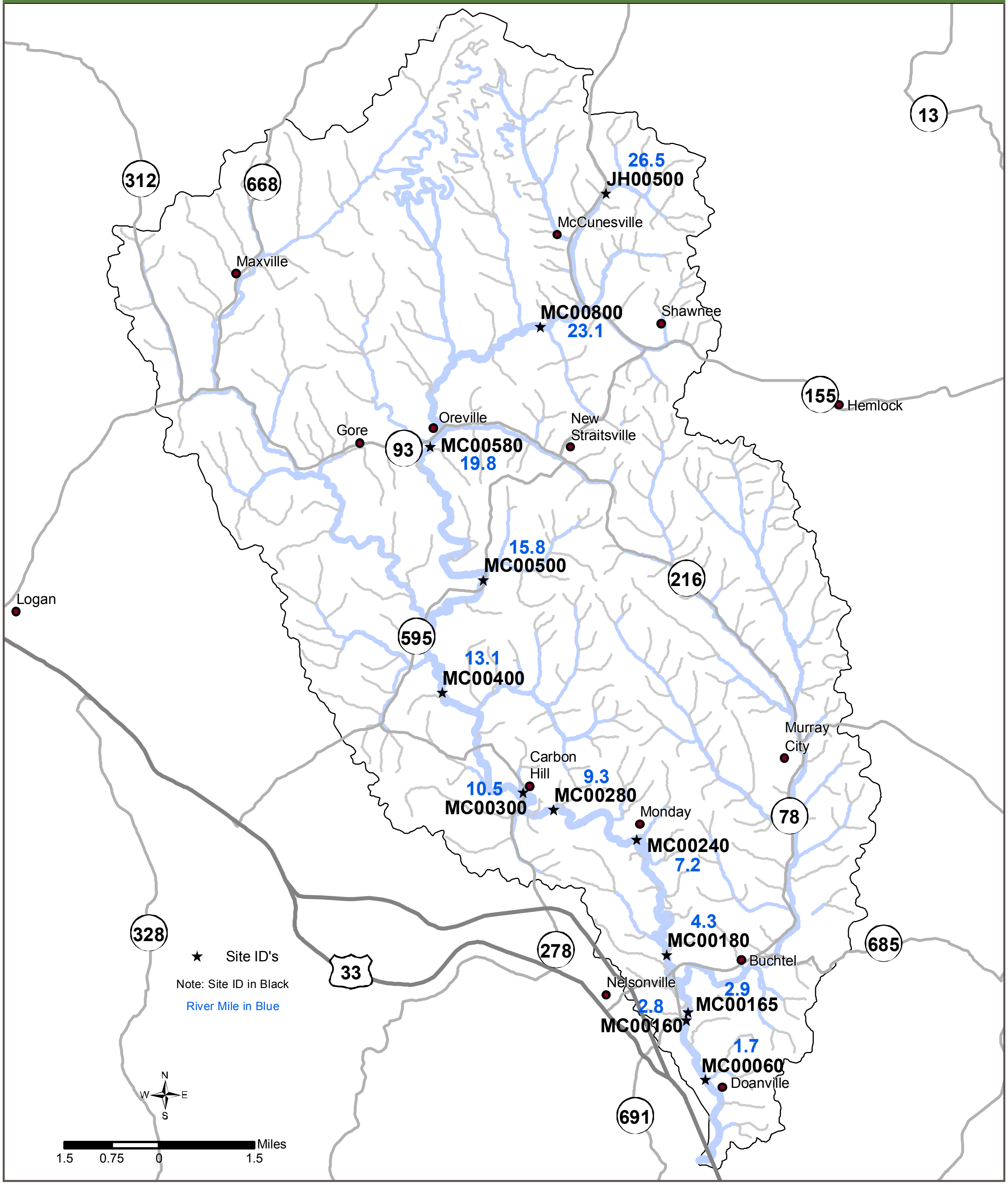
Chemical Water Quality

There are approximately 32 stream miles monitored each year along the mainstem of Monday Creek, 38 miles when major tributary Snow Fork is included. The restoration target for pH is 6.5. In 2007, 19 stream miles of the 38 monitored met the pH target of 6.5. However in 2008 only 7 miles of the 39 miles monitored met this target. In 2009 and 2010 data shows an increase again with approximately 24 of the 39 miles monitored meeting the pH target. In 2011, the site near Lost Run MC00500 dropped below the pH target with an average pH value of 6.24. From 2012 -2016, stream miles meeting the pH target have remained constant. The mainstem of Snow Fork, downstream of Essex Doser has been discontinued for monitoring. Site SF00940 represents the five miles missing from the total miles monitored in past years 38 down to 33 (Figure 1). Snow Fork (SF00100) fails to meet the pH target of 6.5 and treatment in this basin is unlikely.

Figure 1. Monday Creek pH



Monday Creek

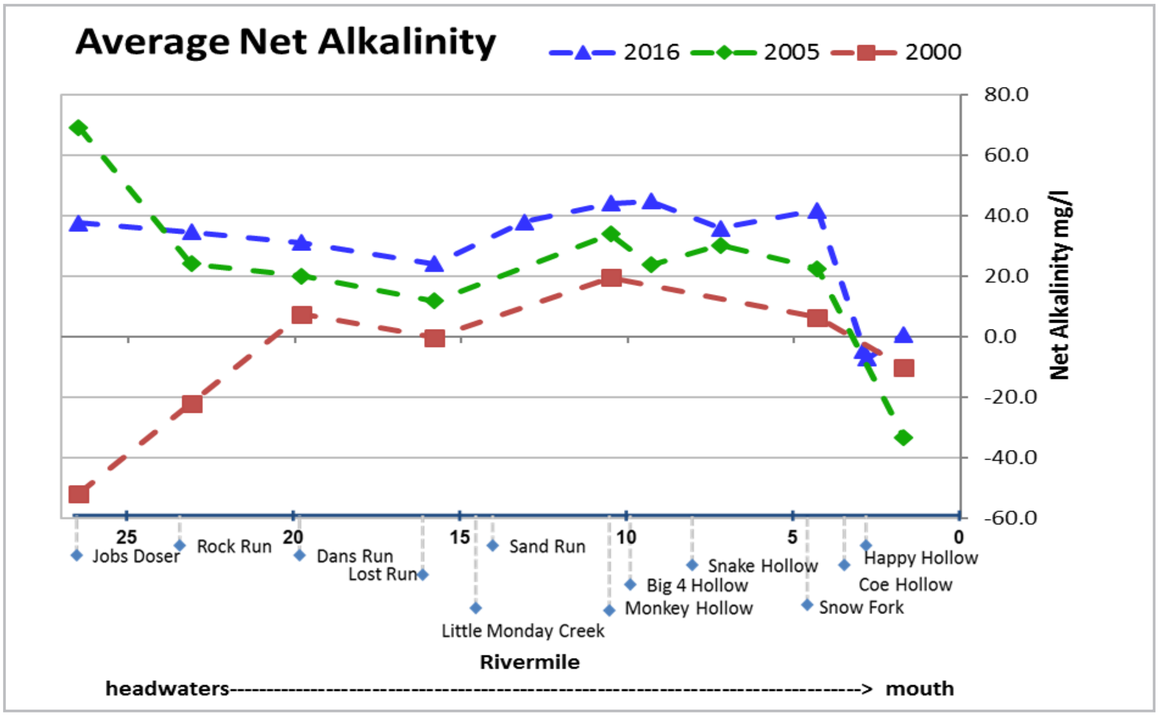


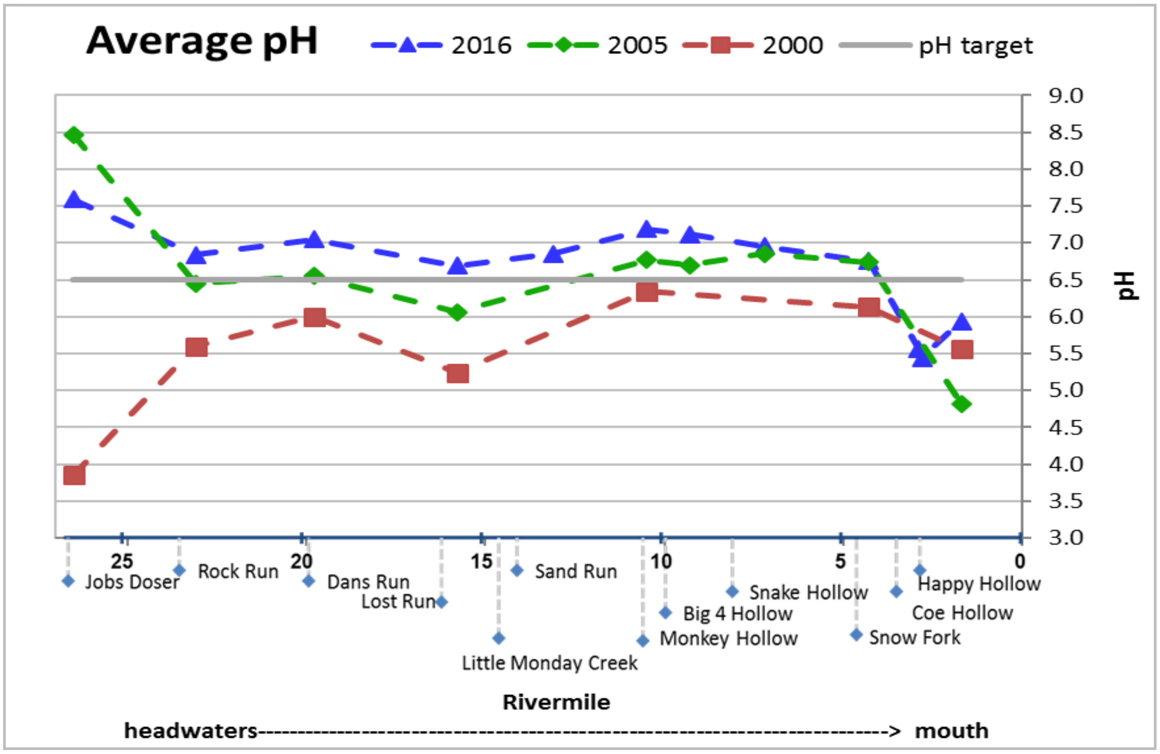
Chemical water quality analysis per stream reach

Chemical water quality changes along the mainstem of Monday Creek are shown in the stream reach graphs below. Chemical long-term monitoring data is utilized to generate line graphs along the stream gradient from headwaters to the mouth. Along the x-axis named tributaries are shown to illustrate sources of water entering the mainstem. A list of long-term monitoring sites utilized to generate the graphs with their river miles are shown below.

Monday Creek Mainstem

Site ID	JH00500	MC00800	MC00580	MC00500	MC00400	MC00300	MC00280	MC00240	MC00180	MC00165	MC00160	MC00060
Rivermile	26.5	23.1	19.8	15.8	13.1	10.5	9.3	7.2	4.3	2.9	2.8	1.7

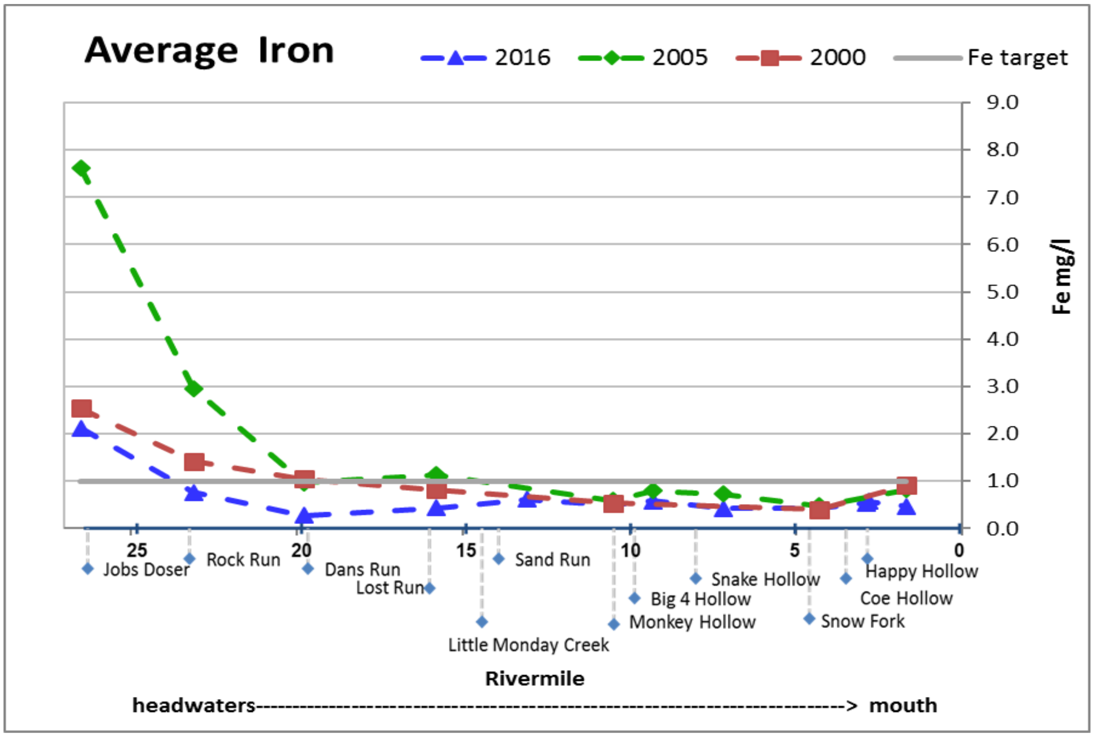


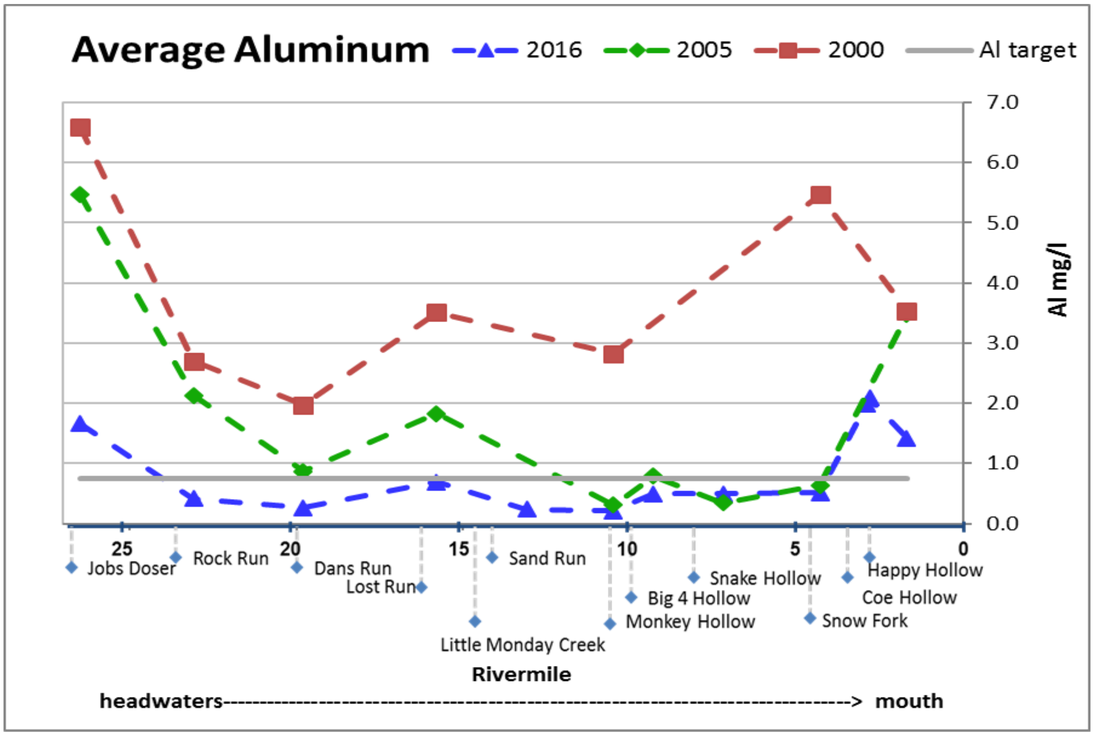


Chemical water quality analysis per stream reach

Monday Creek Mainstem

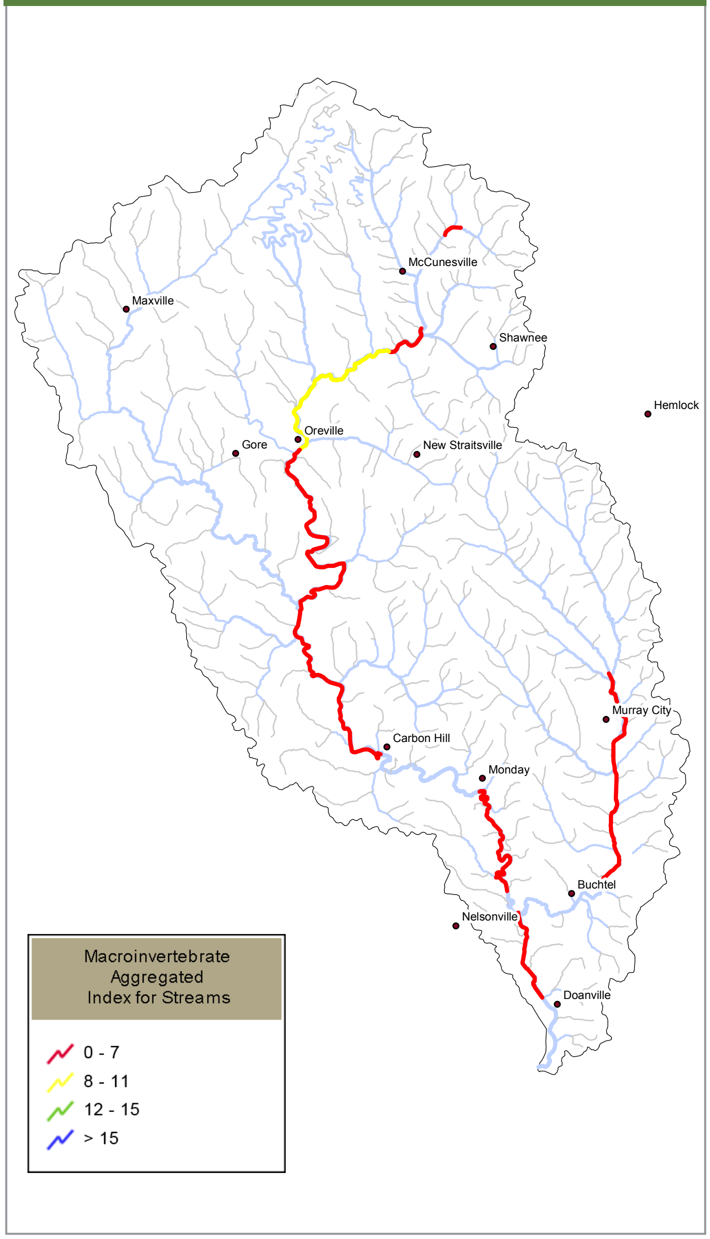
Site ID	JH00500	MC00800	MC00580	MC00500	MC00400	MC00300	MC00280	MC00240	MC00180	MC00165	MC00160	MC00060
Rivermile	26.5	23.1	19.8	15.8	13.1	10.5	9.3	7.2	4.3	2.9	2.8	1.7



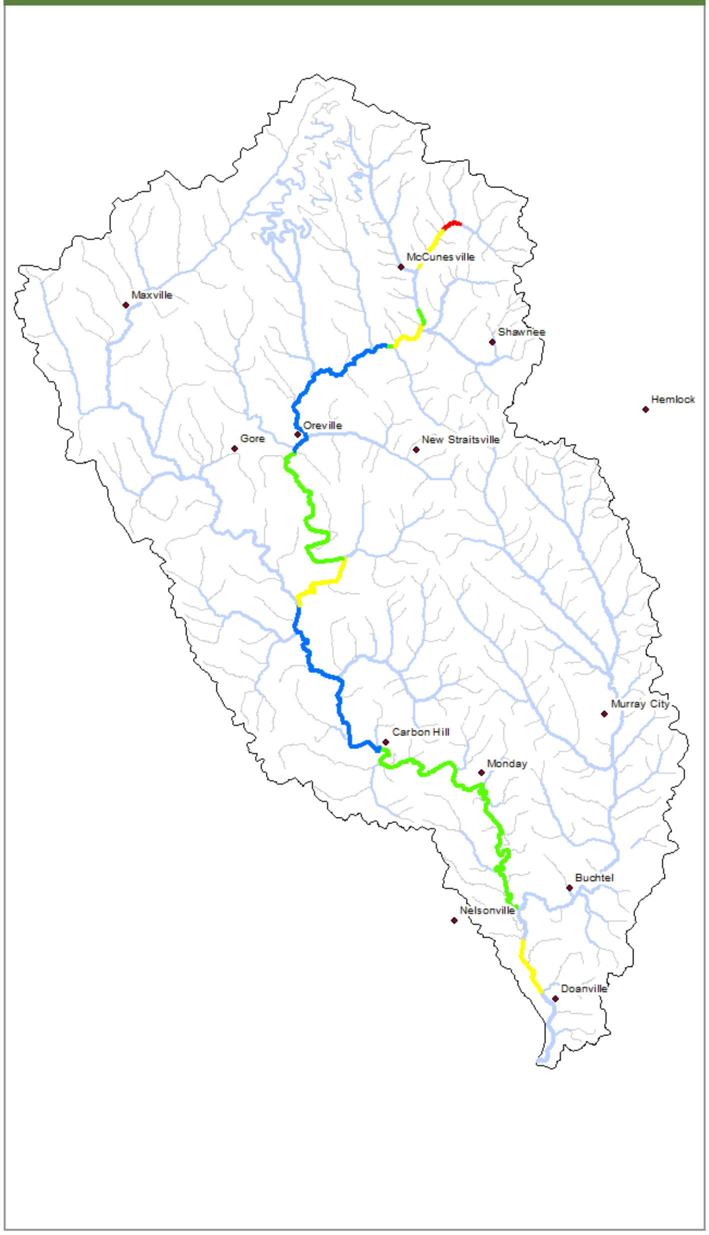


Biological Water Quality

Monday Creek baseline MAIS



Monday Creek 2016 MAIS

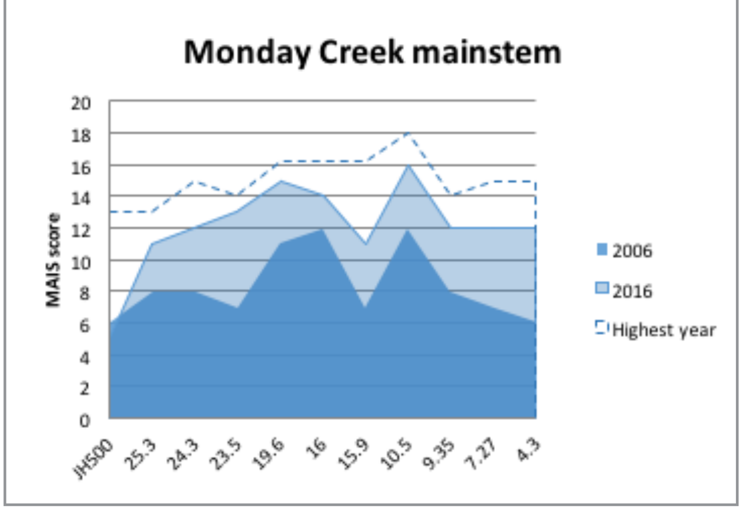


MAIS samples were collected throughout Monday Creek at established annual monitoring stations from 2001 through 2016.

Biological Water Quality

The Monday Creek mainstem has shown steady improvements in biological quality over the last ten years. All long term sites are now categorized as 'improved' and only one site, JH0500 consistently scores below the MAIS target of '12'. MC00500 at RM 15.9 also scored below '12' this year, even though it has improved from the past. The high scores of '15' and 16' at this site in 2012 and 2013 indicate that it has potential for recovery, yet in 2016 and other years the macroinvertebrate scores are much lower, suggesting that the site's potential is not consistently achieved. In 2016, scores in general were a little lower than in previous years but a similar longitudinal pattern was evident.

Area of Degradation



The blue dashed line identifies the highest MAIS score ever a chieved at that site throughout the monitoring time period.

Monday Creek MAIS Regressions

Site ID Rivermile	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Linear trend	R square	P-value	Years
JH00500 RM 26.5	6	5	4	7	8	9	11	10	13	8	5	no change	0.217	0.1492	**11**
MC00950 RM 25.3	8	7	4	9	6	10	10	10	12	13	11	improved	0.610	0.0045	**11**
MC00900 RM 24.3	8	12	12	11	11	12	12	14	12	15	12	improved	0.447	0.0244	**11**
MC00800 RM 23.5	7	9	12	7	13	11	13	12	14	14	13	improved	0.595	0.0054	**11**
MC00580 RM 19.6	11	12	12	13	16	14	16	15	14	16	15	improved	0.601	0.0050	**11**
MC00510 RM 16	12	11	10	10	10	*	14	14	14	14	14	improved	0.598	0.0053	**11**
MC00500 RM 15.9	7	8	*	5	*	*	15	16	9	13	11	improved	0.407	0.0346	**11**
MC00300 RM 10.5	12	14	*	12	16	16	15	16	16	18	16	improved	0.666	0.0022	**11**
MC00280 RM 9.4	8	9	10	9	14	12	10	15	11	14	12	improved	0.436	0.0269	**11**
MC00240 RM 7.3	7	7	8	10	14	10	8	11	13	11	12	improved	0.432	0.0280	**11**
MC00180 RM 4.3	6	9	7	4	13	9	9	15	11	13	12	improved	0.470	0.0198	**11**

* Missing values were replaced with arithmetic averages of preceding and following years for graphing.

SUNDAY CREEK
WATERSHED REPORT

Reductions

Total acid load reduction 2016 = 22 lbs/day

Total metal load reduction 2016 = 31 lbs/day

Data derived using the Stoertz Water Quality Evaluation Method (Kruse et al. 2014)

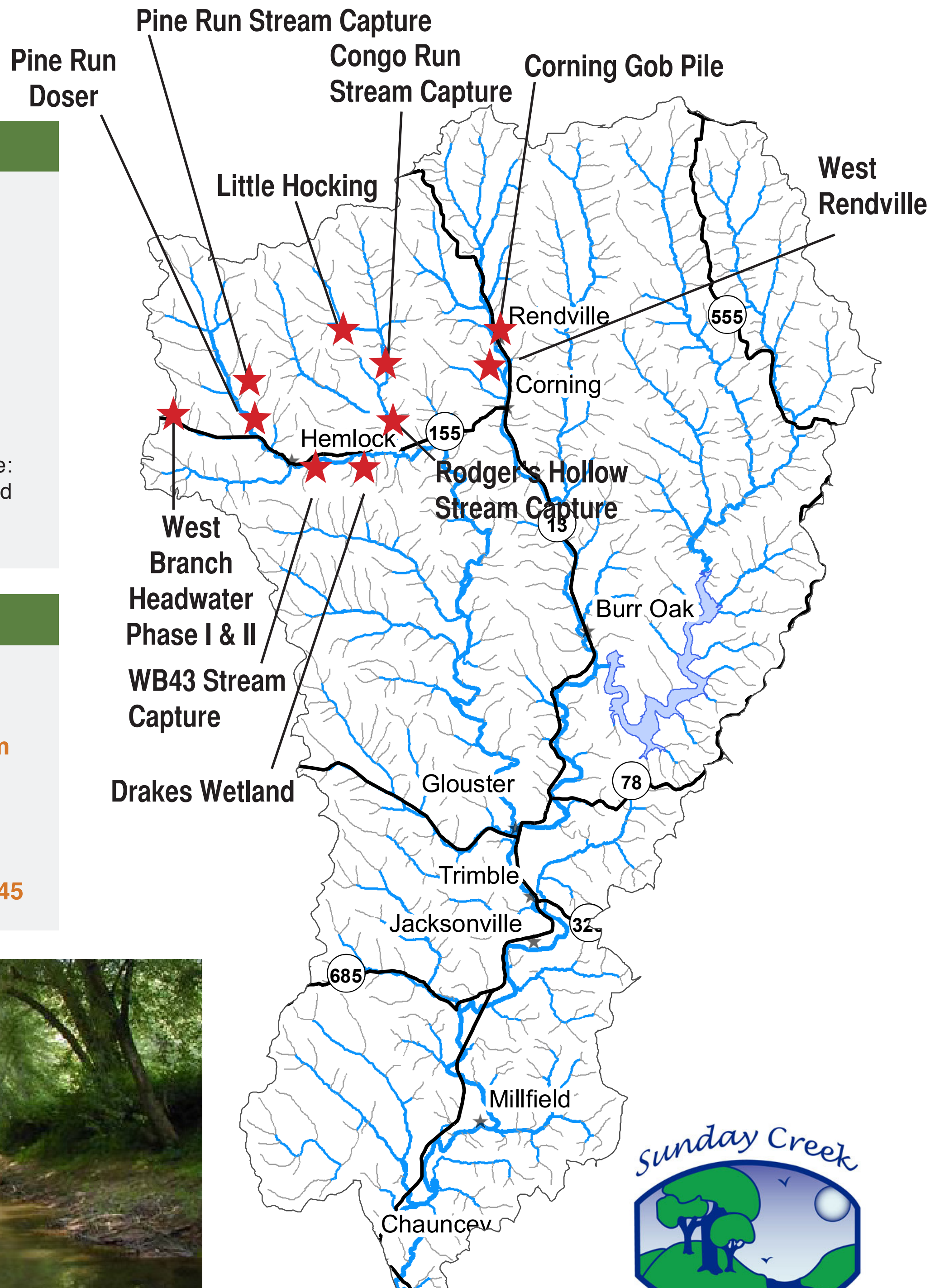
Acid and metal load reductions based on projects monitored during 2016 listed here: West Branch Headwaters Phase I & II, and Drakes Wetland.

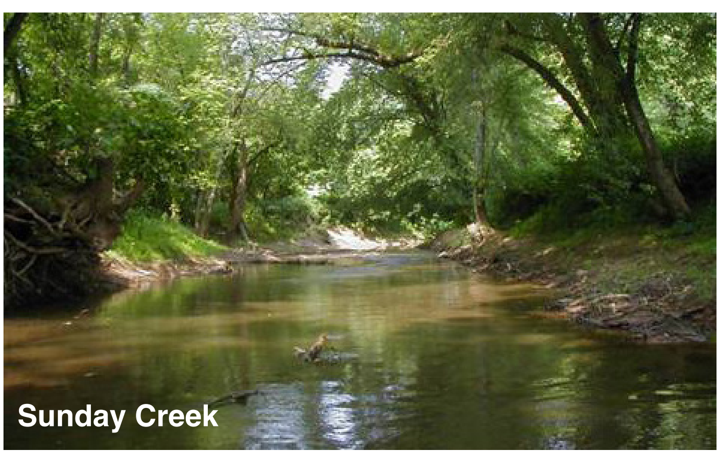
Costs

Design = $491,759 (excluding Congo Run CR-15, Drakes Wetland & Pine Run Stream Capture maintenance)

Construction = $2,091,186

Total costs through 2016 = $2,582,945





Sunday Creek Watershed Group

Six stream captures located in the Sunday Creek Watershed were closed and completed from 2004-2011. A total of 2,401 acres surface drainage area drained year round into the deep mines and, as a result of closing these subsidence holes, 884,021,000 gallons per year were diverted from entering into the deep mine, thus abating the generation of acid mine drainage. Expected additional alkaline loading from these closures returning clean water to the receiving streams is 986 lbs/day. As result of the Rodgers Hollow Subsidence closure, the deep mine discharge in Drakes has seen a reduction in acidity load by 18 lbs/day.

Timeline of the Sunday Creek Watershed Project Milestones and AMD Projects

Year	Milestones
1999	• Sunday Creek Watershed Group (SCWG) Founded
2000	
2001	• Rural Action adds VISTA volunteer to SCWG staff
2002	• SCWG Hired First Watershed Coordinator, funded for six years
2003	• Sunday Creek Watershed AMDAT Completed • SCWG Watershed Action Plan Conditionally Endorsed by the State of Ohio
2004	• Congo Subsidence/ Stream Capture Project Completed
2005	• Sunday Creek Watershed TMDL Study Completed
2006	• SCWG Coordinator funded three more years
2007	• Pine Run Stream Capture Project Completed • Rodger’s Hollow Stream Capture Project Completed • Corning Gob Pile Reclamation Project Completed
2008	
2009	• Congo Run (CR-11/ Little Hocking) Stream Capture Project Completed • SCWG Coordinator funded for three more years • Rural Action adds AmeriCorps member to SCWG staff
2010	• West Branch Headwaters Phase I Project Completed • West Branch 43 Stream Capture Project Completed
2011	• SCWG Watershed Action Plan Officially Endorsed by the State of Ohio • West Branch Headwaters Phase II Project Completed • West Rendville Stream Capture Project Completed
2012	
2013	• Pine Run Doser installed
2014	• Drakes Wetland project in the West Branch of Sunday Creek completed

Sunday Creek Projects

Acid mine drainage reclamation projects completed in Sunday Creek Watershed:

2004 *Congo Stream Capture (CR-15) –Fill subsidence feature*

2007 *Pine Run Stream Capture (PR-20 and PR-21) – Fill subsidence feature and restore positive drainage in stream*

Corning Gob Floodplain (CG 02) – Remove gob from floodplain, gob pile reclamation on hillslope

Rodger's Hollow Stream Capture (RH 001) – Close multiple subsidence features and install natural channel

2009 *Little Hocking Stream Capture (CR 11) – Close subsidence feature and reconnect stream channel*

2010 *West Branch 43 Stream Capture (WB 43) – Close subsidence feature and create positive drainage*

Pine Run Stream Capture Maintenance – installed 4 limestone berms in channel

West Branch Sunday Creek Headwaters Phase I & II (WBHW 03) – Limestone channels, closed 4 subsidence features, reclaimed gob pile, surface reclamation, limestone leach bed, and passive wetland

2011 *West Rendville Stream Capture – Close 2 subsidence features and create positive drainage*

2013 Pine Run Doser (PR001) – Active calcium oxide doser

2014 Drakes Wetland Enhancement (WB 36) – Wetland enhancement, metals removal

Italicized indicates projects are not actively monitored for acid and metal load reductions purposes

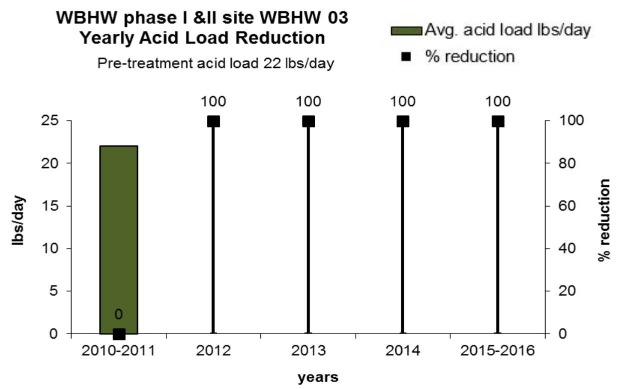
Most of the remediation in Sunday Creek consists of source control (i.e. stream capture, gob pile capping, etc….) and aren't actively monitored for acid and metal load reductions. Therefore target restoration sites along West Branch of Sunday Creek mainstem have been selected to analyze the acid and metal loading reduction as well as loading through time, these sites include:

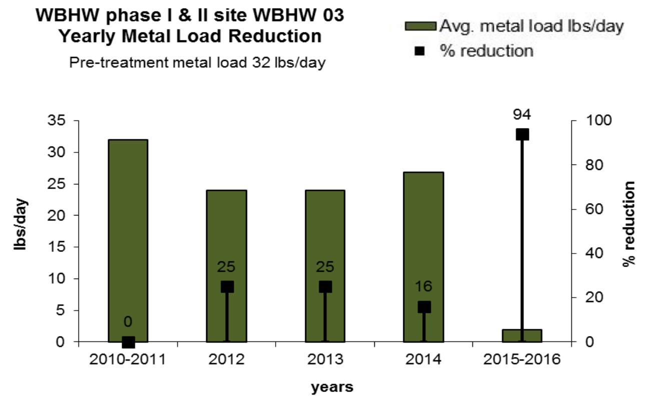
WBHW 03, WB 51, and WB 002. Yearly load reductions for these mainstem sites are shown on the next few pages.

Yearly acid and metal load reduction trends per project

Similar to other environmental best management practices (BMPs), performance of passive acid mine drainage reclamation projects are also expected to decline with time. Active treatment systems are not expected to decline with time but sometimes need to be maintained to perform adequately. Currently, operation and maintenance plans are being designed for each existing system and are planned for future projects. The graphs below show the mean annual acid and metal load reduction using the Stoertz Water Quality Evaluation Method (Kruse et al., 2014) for each year (or group of years) during post-reclamation from the project effluent. From these graphs the rate of decline (and/or improvement) with time of the treatment system is implied. Knowing the rate of decline will aid in the implementation of operation and maintenance plans.

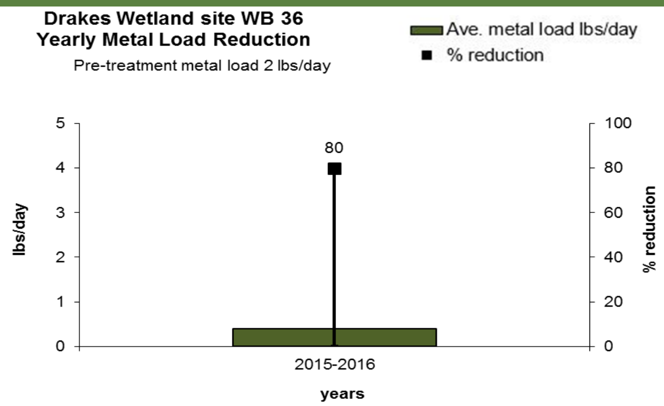
WBHW phase I & II site WBHW 03





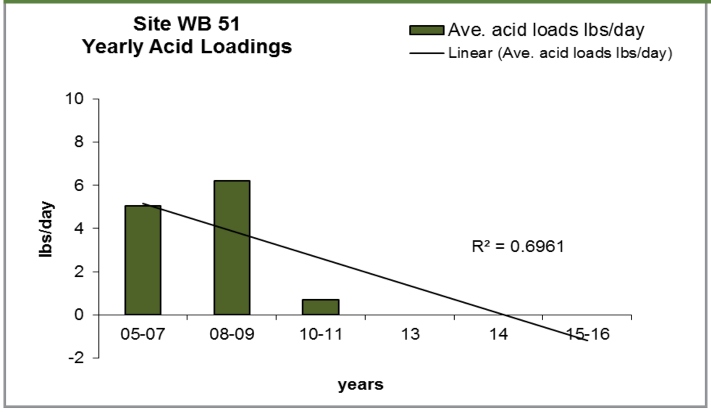
Drakes site WB 36

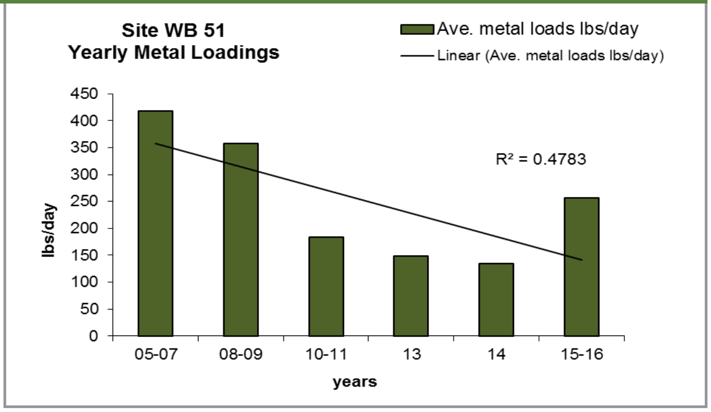
Drakes Wetland site WB 36 is net alkaline pre-treatment, Wetland was enhanced to maintain the longevity of the wetland.



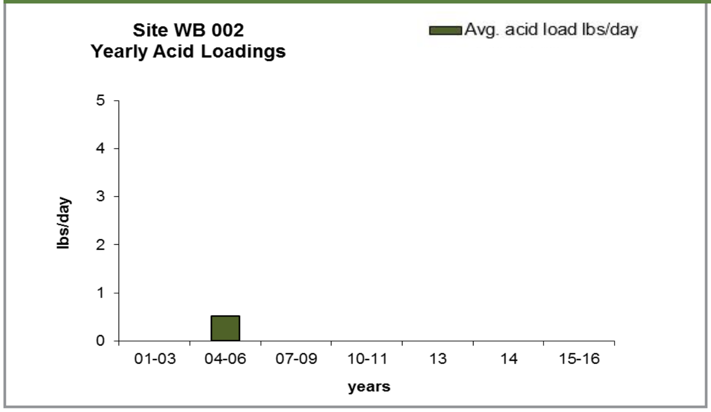
Yearly acid and metal load reduction trends per project

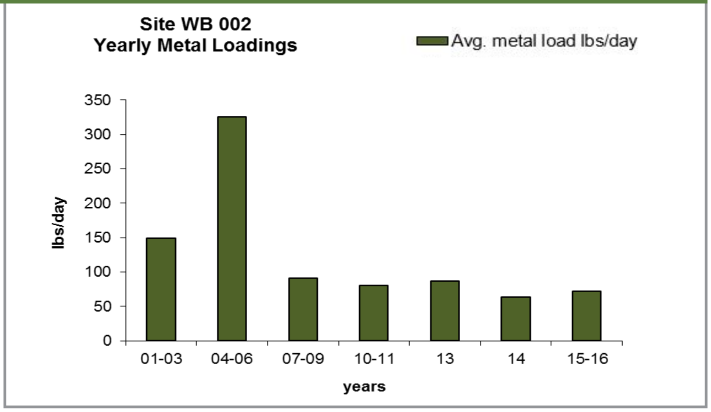
Site WB 51





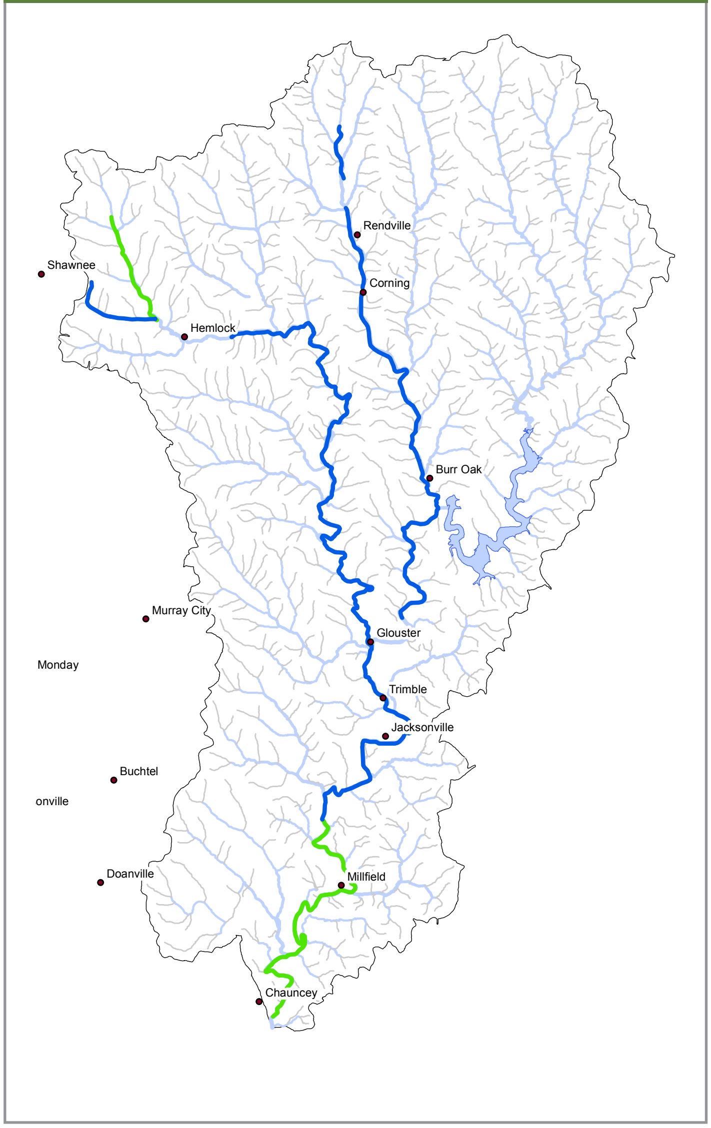
Site WB 002



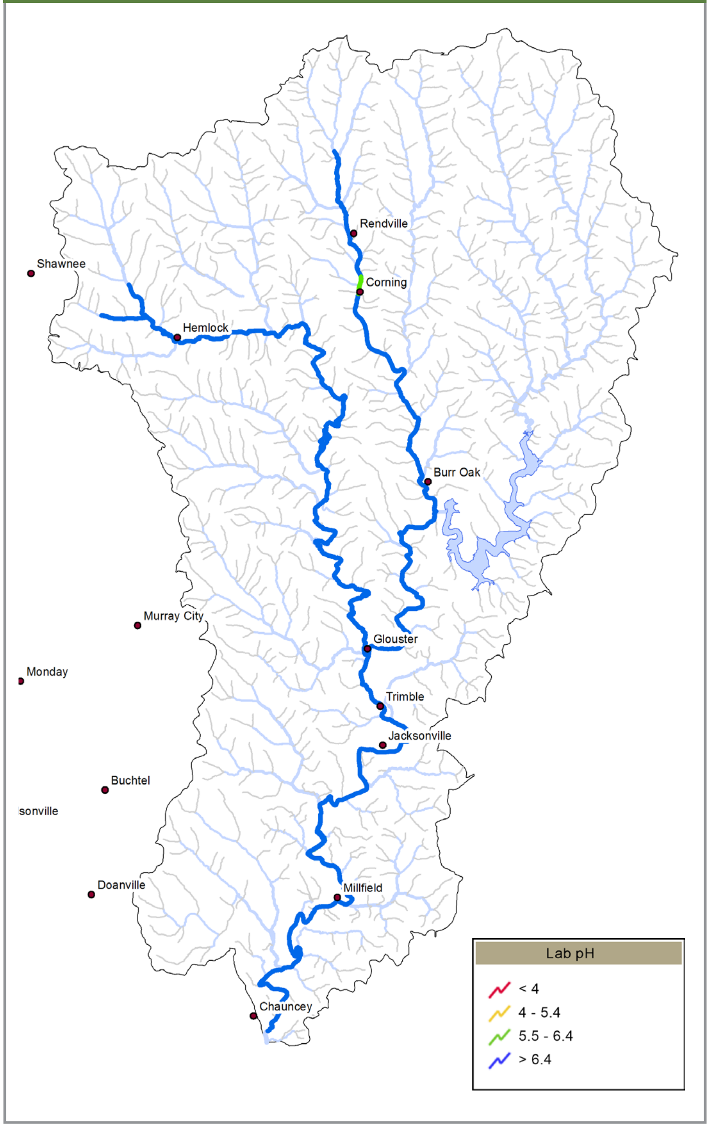


Chemical Water Quality

Sunday Creek baseline pH



Sunday Creek 2016 pH

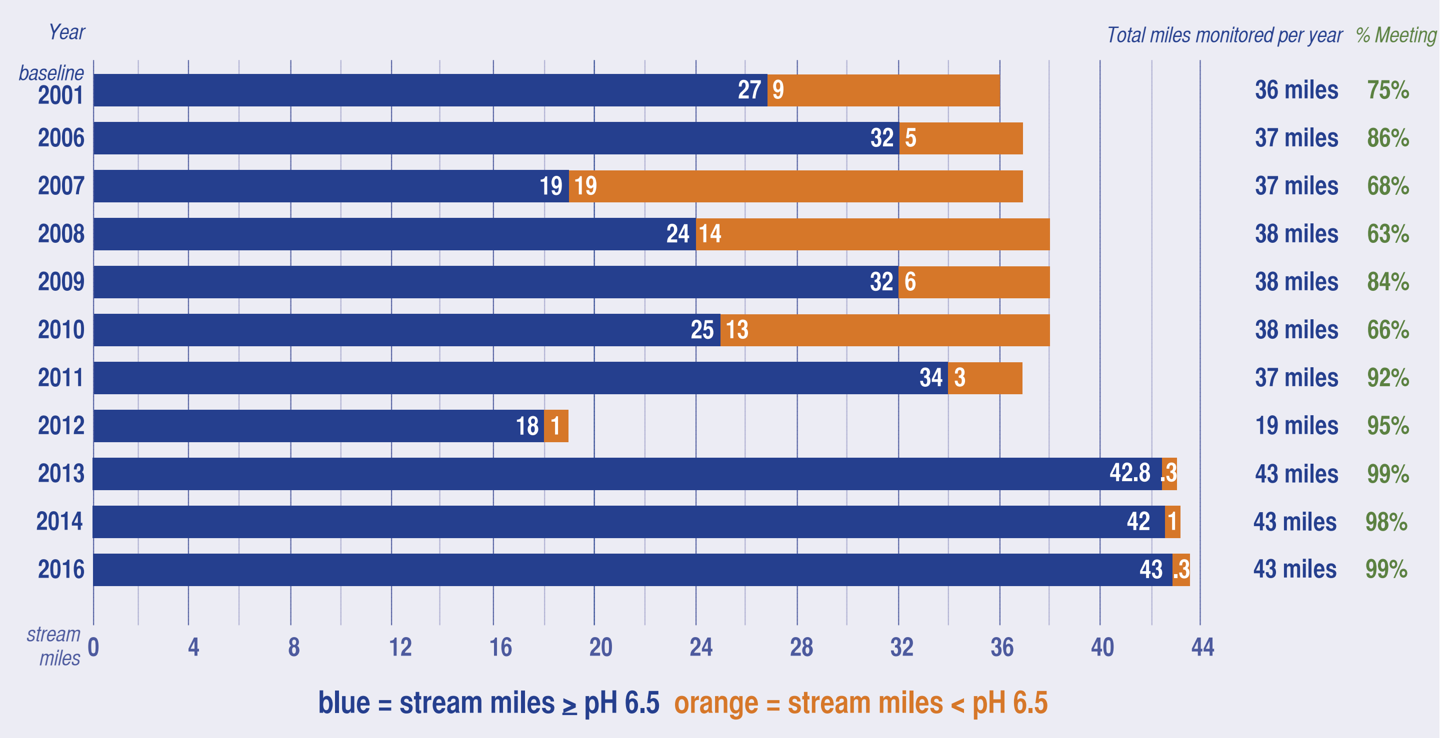


Water quality along the West Branch of Sunday Creek was degraded from baseline conditions in 2001 to 2007. Values of average pH dropped from >6.4 to 4.0-5.4 range in 2005 to 2006 and remained constant in 2007. When the subsidence features increased in Rodger's Hollow, funneling more water into the mine that generated AMD and discharged it into West Branch of Sunday Creek, the water quality decreased. However, after the subsidence closure in Rodger's Hollow in late 2007, in 2008 data for the first time shows an increase in pH along this stream segment. As of 2016 all sites met the pH target of 6.5 except for a small less than half mile section of a stream directly downstream of the Corning discharge of the 43 miles monitored.

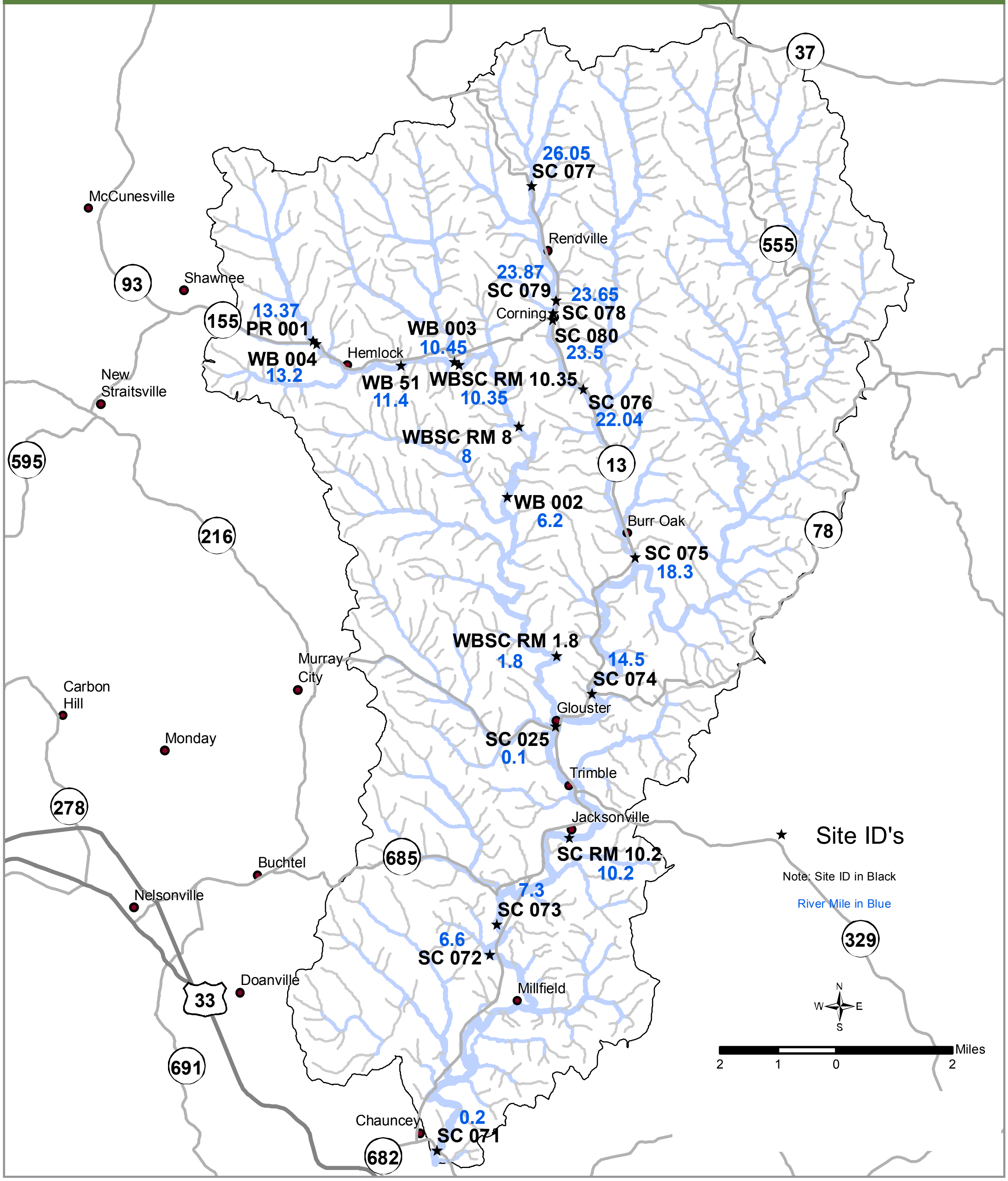
Chemical Water Quality

There are approximately 43 miles monitored for three years along the mainstem of Sunday Creek and major tributary West Branch, up from 38 stream miles monitored in 2010 and early. A restoration target for pH has been set to 6.5. Since 2001 there have been fluctuations in the number of stream miles that meet this target. Currently, in 2016, just under 43 of 43 miles of stream monitored meet the pH target.

Sunday Creek pH

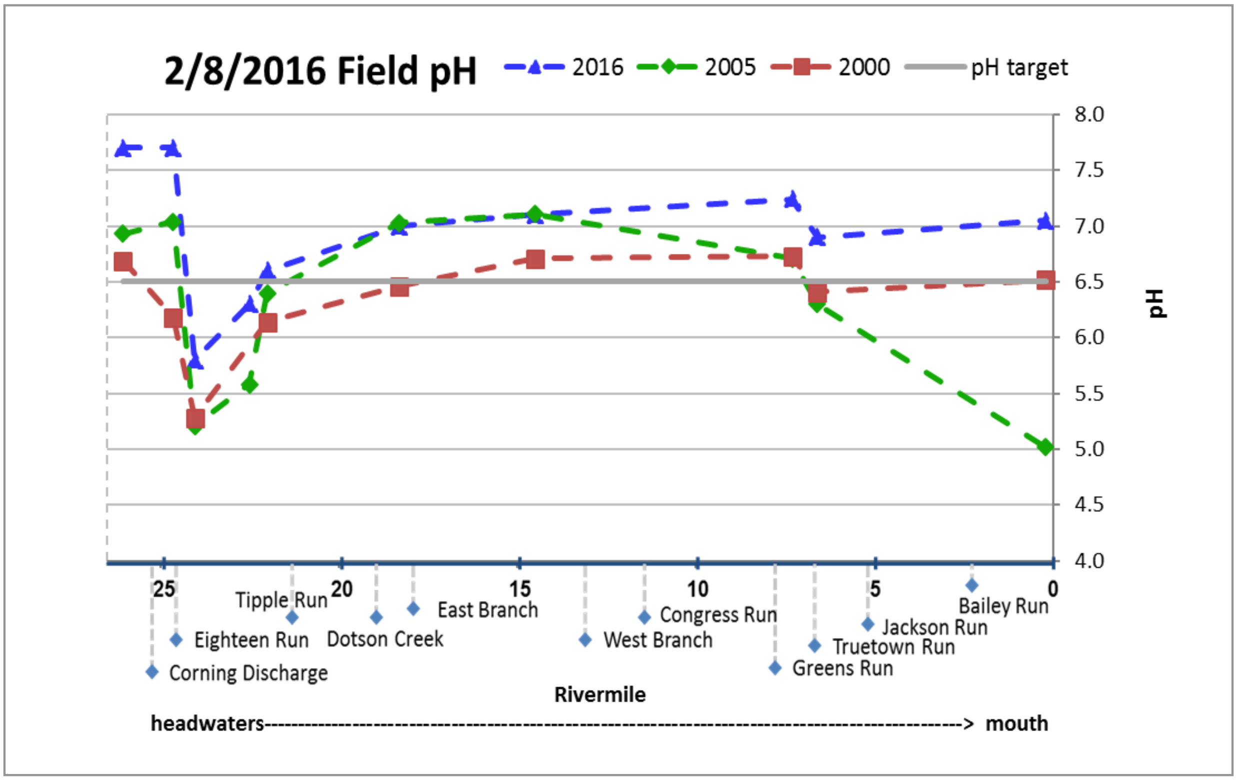


Sunday Creek

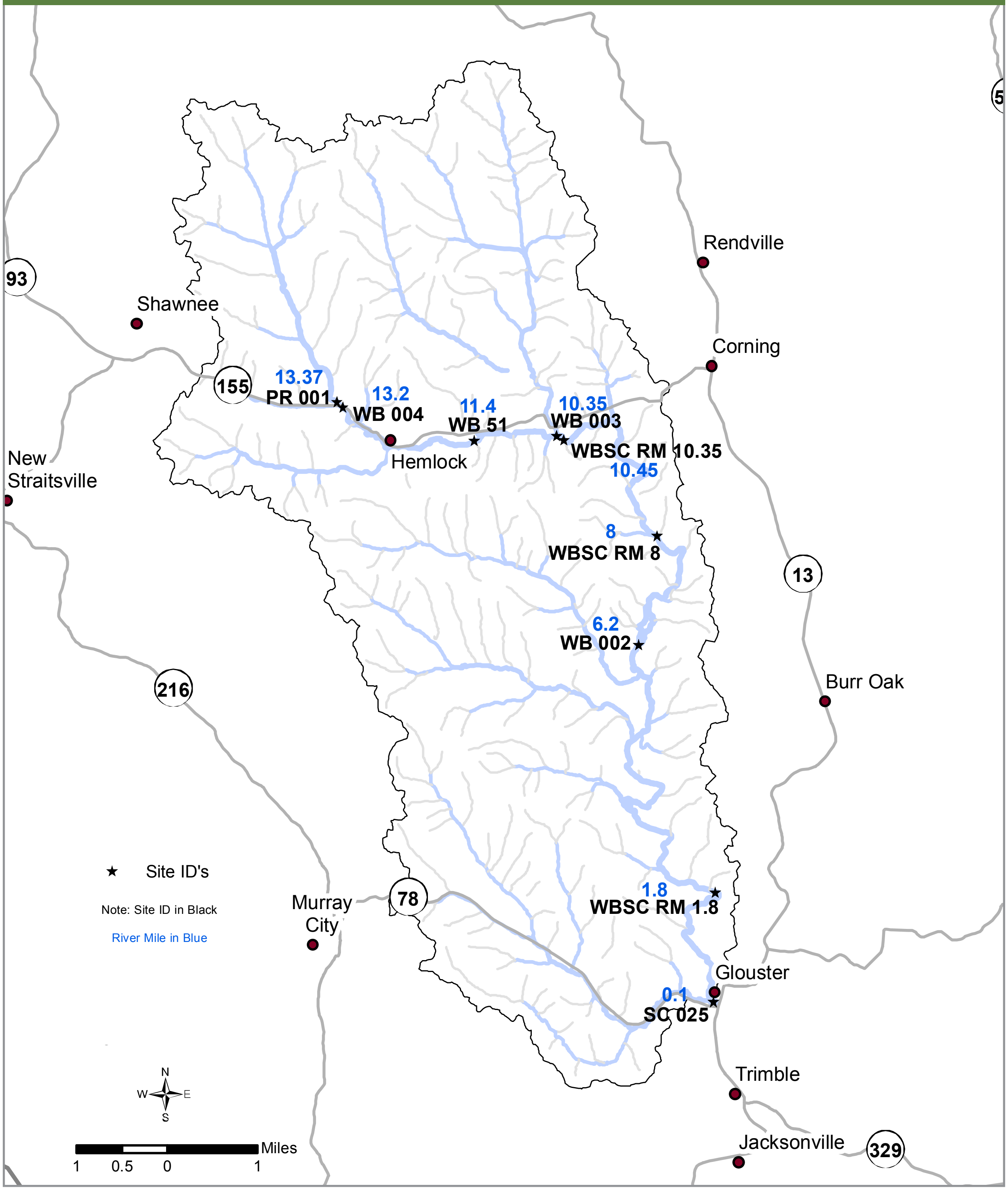


For purposes of analyzing chemical water quality changes along the mainstem of receiving stream where AMD reclamation projects have been completed, Sunday Creek has been divided into the following stream segments: Sunday Creek Mainstem and West Branch of Sunday Creek. Within these stream reaches, chemical long-term monitoring data is utilized to generate line graphs along the stream gradient from headwaters to the mouth. Along the x-axis named tributaries are shown to illustrate sources of water entering the mainstem. A list of long-term monitoring sites utilized to generate the graphs with their river miles are shown before each set of stream reach graphs.

Sunday Creek Mainstem											
Site ID	SC 077	SC 079	SC 078	SC 080	SC 076	SC 075	SC 074	SCRM 10.2	SC 073	SC 072	SC 071
Rivermile	26.05	23.87	23.65	23.5	22.04	18.3	14.5	10.2	7.3	6.6	0.2

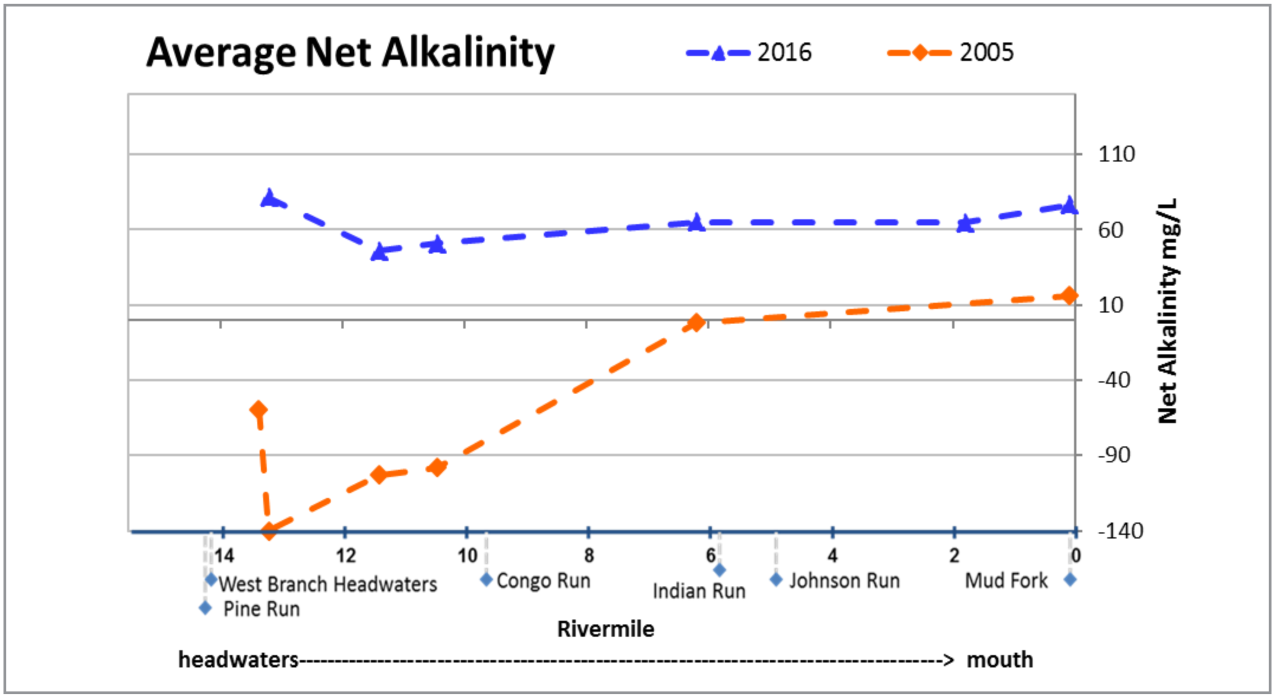


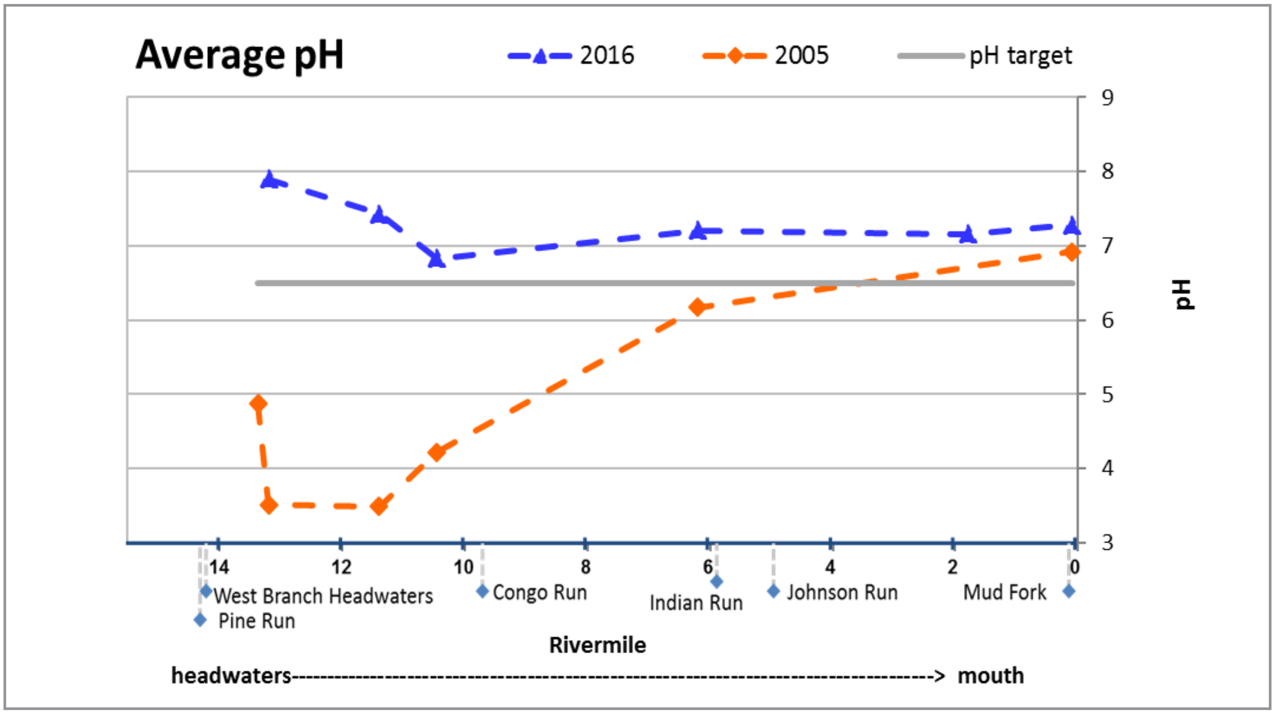
West Branch of Sunday Creek



Chemical water quality analysis per stream reach

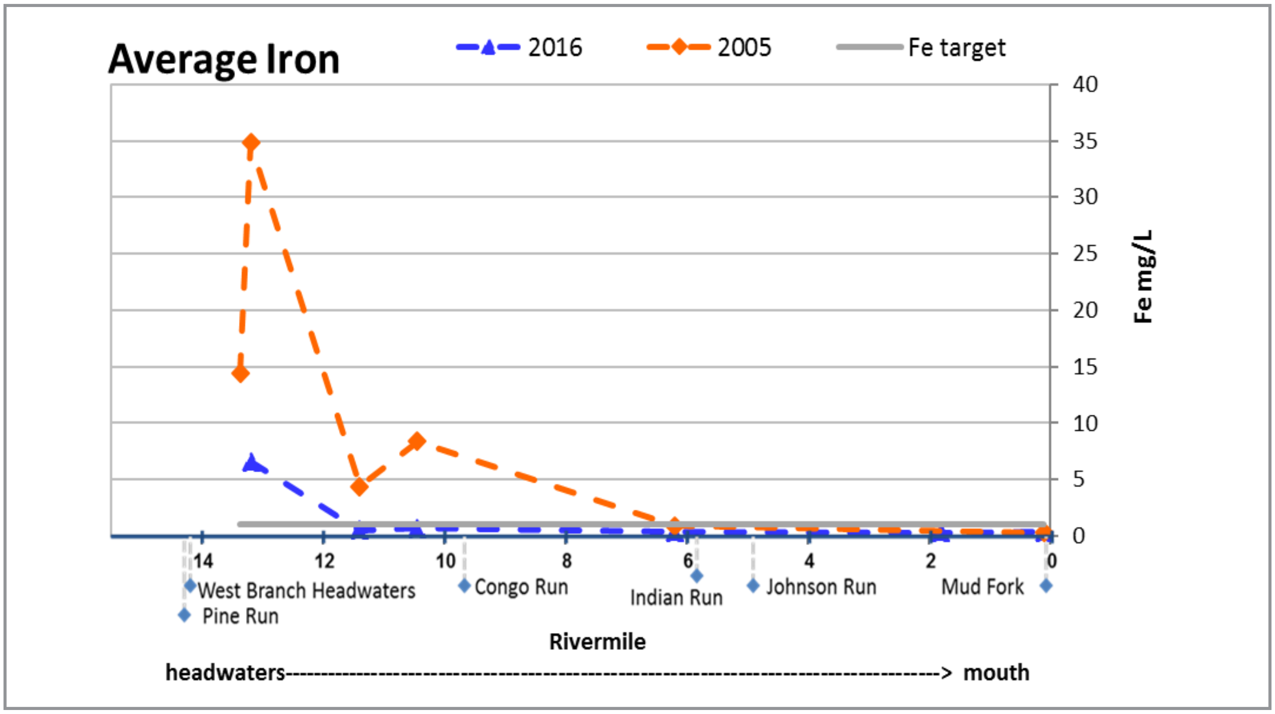
West Branch of Sunday Creek									
Site ID	PR 001	WB 004	WB 51	WB 003	WBSC RM 10.35	WBSC RM 8	WB 002	WBSC RM 1.8	SC 025
Rivermile	13.37	13.2	11.4	10.45	10.35	8	6.2	1.8	0.1

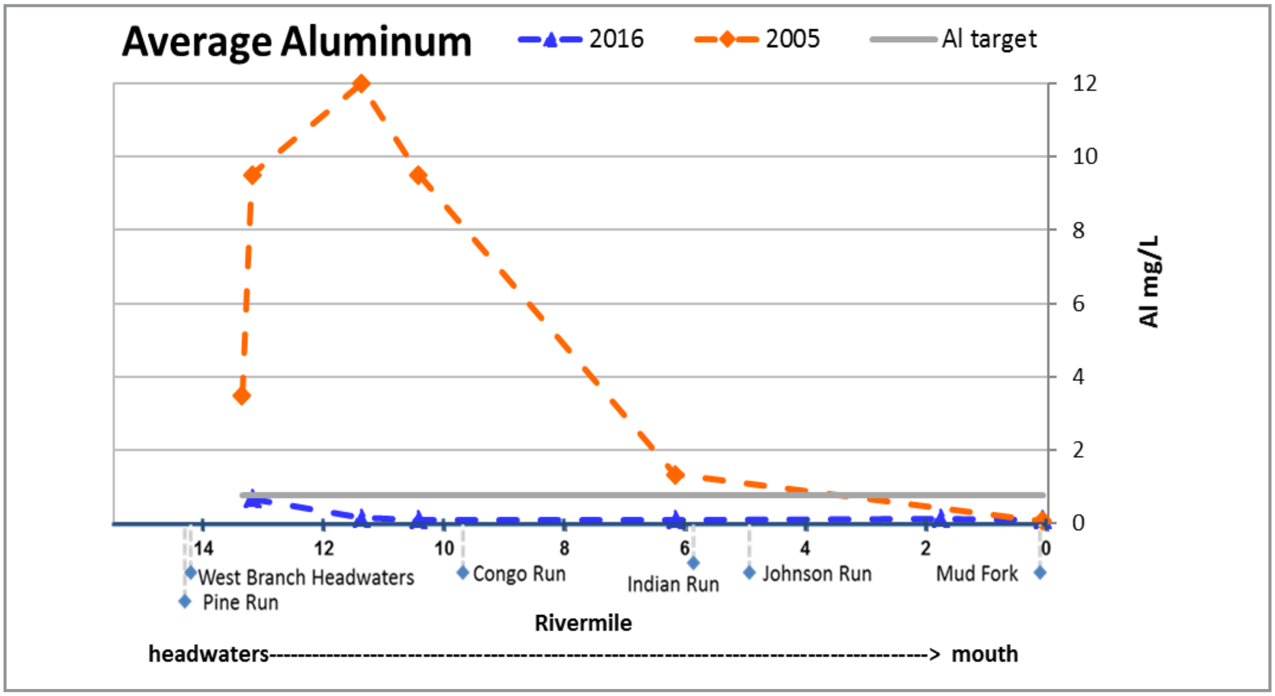




Chemical water quality analysis per stream reach

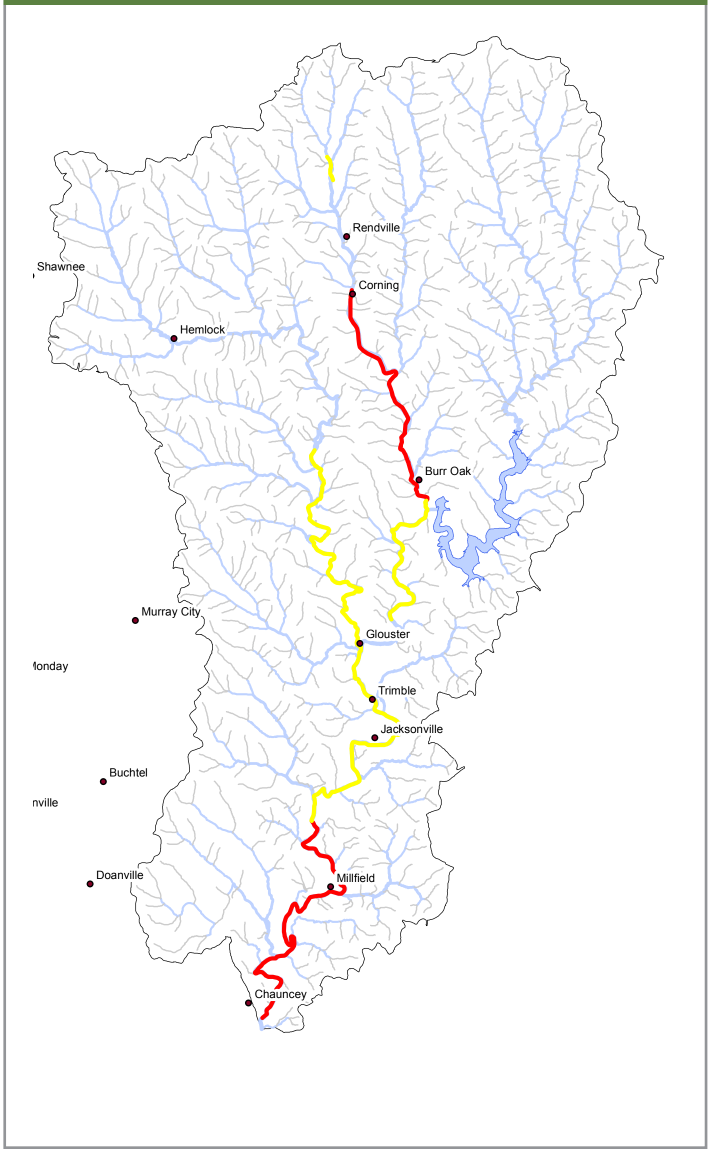
West Branch of Sunday Creek									
Site ID	PR 001	WB 004	WB 51	WB 003	WBSC RM 10.35	WBSC RM 8	WB 002	WBSC RM 1.8	SC 025
Rivermile	13.37	13.2	11.4	10.45	10.35	8	6.2	1.8	0.1



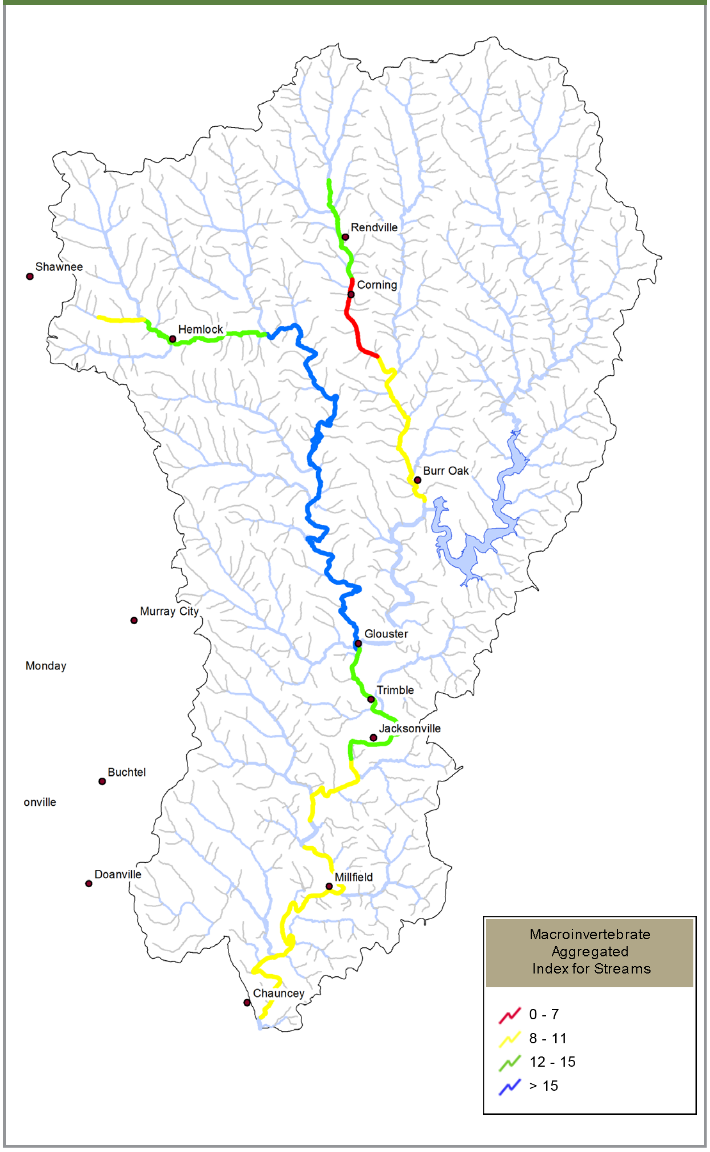


Biological Water Quality

Sunday Creek baseline MAIS



Sunday Creek 2016 MAIS



MAIS samples were collected throughout Sunday Creek at established annual monitoring stations from 2001 through 2016.

Sunday Creek mainstem

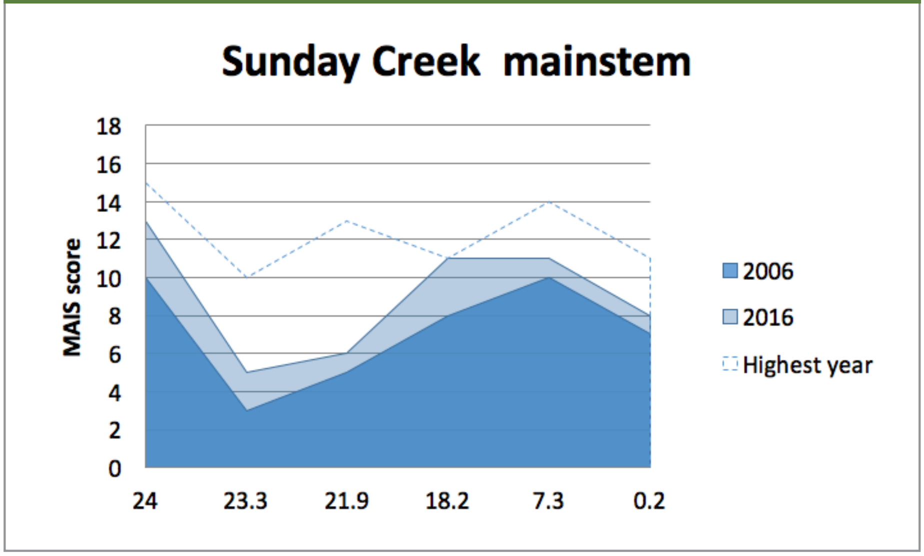
In Sunday Creek, recovery of the mainstem has been slow; improving since 2006 but not gaining statistical significance until this year, when three new sites (one above Corning at RM 24, two sites below the Corning discharge RM 21.9 and 18.2 at the Tom Jenkins dam entrance) met criteria for statistical significance. However, none of the sites immediately below the Corning discharge are yet meeting the MAIS recovery target of '12'. Directly downstream of the Corning discharge (RM 23.3), large amounts of metal precipitates accumulate and these are commonly observed further downstream at RM 21.9, especially during low flow in summer.

Further downstream, at Jacksonville (RM 10.2) and the site just above the Truetown discharge (RM 7.3), the macroinvertebrate community is of moderately high quality and have met or exceeded the target of a MAIS score of '12' over the past three years. The section of Sunday Creek downstream of the Truetown discharge below Chauncey (RM 0.2) was the first mainstem site to show significant improvement in MAIS scores since 2006, but macroinvertebrate scores still fall well below '12'.

West Branch

Improvements in the West Branch are more evident than in the mainstem. The headwater sites continued their trends of significant long-term improvement in macroinvertebrate scores. WB 004 at RM 13.3, which supported almost no macroinvertebrates in 2005 (MAIS score of '1'), earned a new high score of '11' last year and met the MAIS target of '12' for the first time this year. WB 002 (RM 6.2) has shown enough improvement to be considered recovered (MAIS score has exceeded '12' and averages closer to '14' in recent years). Sections of the West Branch further downstream at RM 1.8 and the mouth in Glouster support high quality macroinvertebrate communities. Altogether, in 2016 over 13 miles of the West Branch (from RM 13.3 to the mouth) met restoration targets for macroinvertebrates (MAIS scores of '12' or higher).

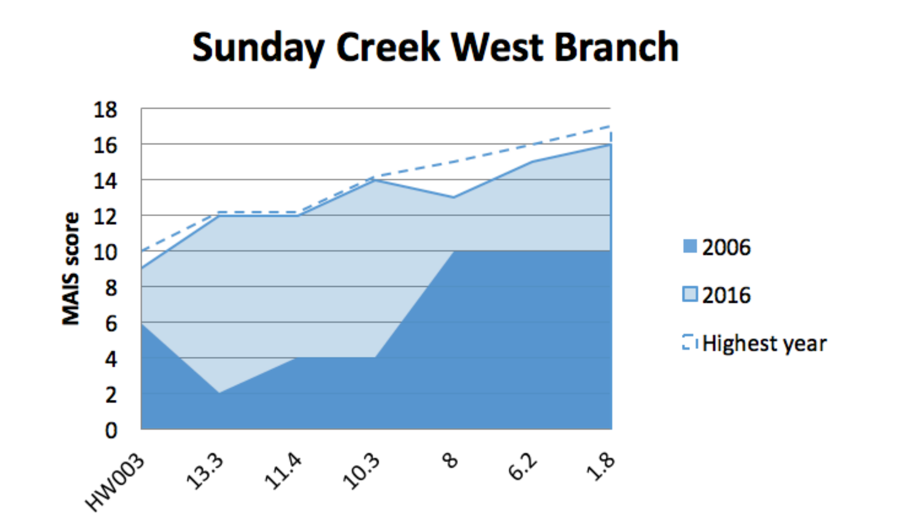
Area of Degradation 2006-2016



The blue dashed line identifies the highest MAIS score ever achieved at that site throughout the monitoring time period.

Biological Water Quality

Area of Degradation 2006-2016

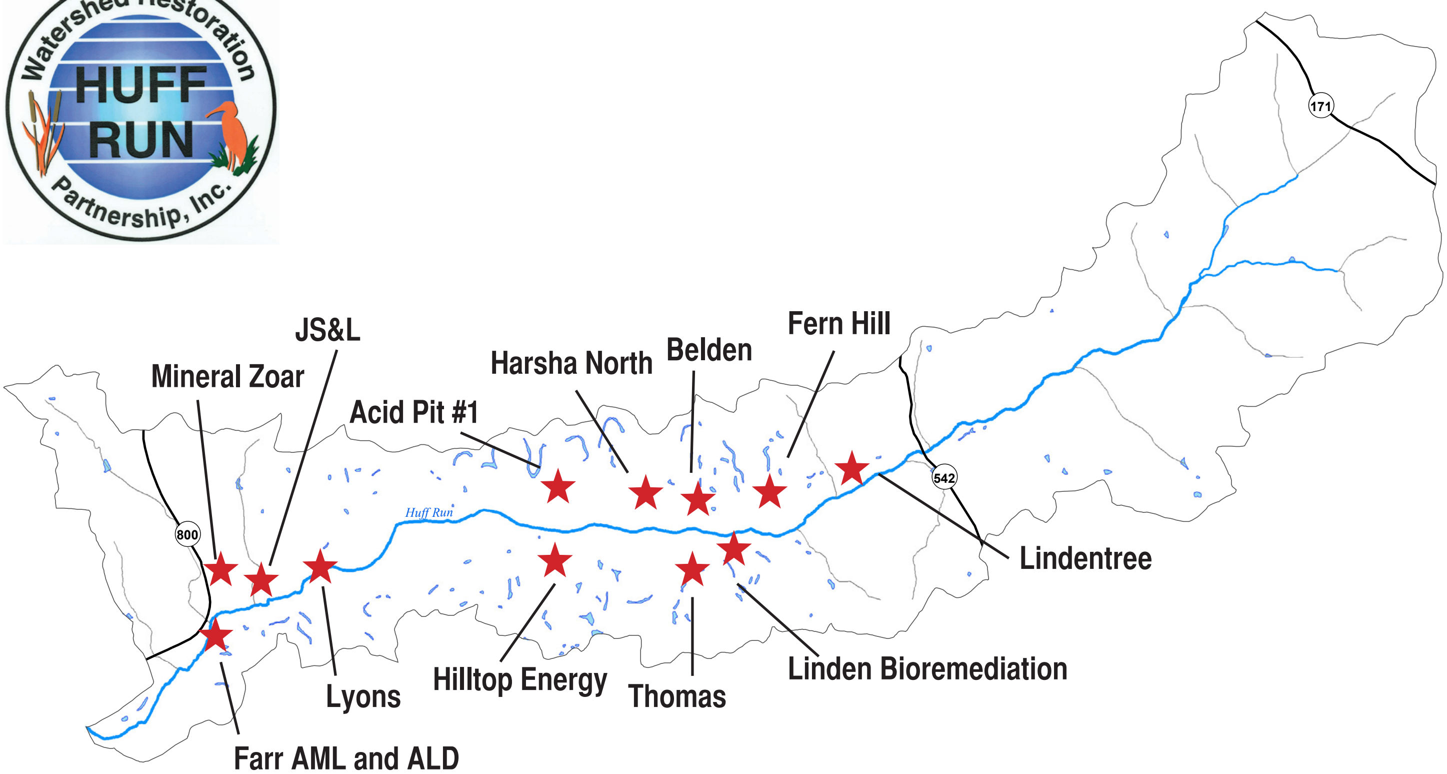


The blue dashed line identifies the highest MAIS score ever achieved at that site throughout the monitoring time period.

Sunday Creek MAIS Regressions

Site ID Rivermile	'05	'06	'07	'08	'09	'10	'11	'12	'13	'14	'16	Linear trend	R square	P-value	Years
Mainstem															
SC RM 26.6						14	14	13	16	15	dry	no change	0.002	0.931	6
SC 079 RM 24	12	10	10	14	12	13	12	11	15	14	13	improved	0.322	0.054	12
SC 080 RM 23.3	5	3	2	7	12	5	10	4	9	4	5	no change	0.057	0.454	12
SC 076 RM 21.9	11	5	5	9	2	3	7	5	8	8	6	improved	0.267	0.048	15
SC 075 RM 18.2	10	8	10	5	7	8	11	10	9	9	11	improved	0.261	0.052	15
SC RM 10.2							17	13	15	16	14	no change	0.160	0.433	6
SC 073 RM 7.3	11	10	10	10	12	11	14	9	11	13	11	no change	0.162	0.137	15
SC 071 RM 0.2	8	7	3	6	11	8	10	7	9	7	8	improved	0.403	0.011	15
West Branch															
WBHW50 RM 14.7		11	10	11	8	12	13	11	11	11		no change	0.072	0.486	9
WBHW03 RM 13.35	5	6	4	8	6	8	10	8	10	8	9	improved	0.557	0.005	12
WB 004 RM 13.3	1	2	2	5	5	7	7	5	11	8	12	improved	0.774	0.0002	12
WB 51 RM 11.4	8	4	2	7	9	5	12	10	7	9	12	improved	0.677	0.0002	15
WB 003 RM 10.3	8	4	3	4	8	4	7	7	7	11	14	no change	0.136	0.177	15
WB SC RM 8.0						14	13	15	14	15		no change	0.009	0.840	7
WB 002 RM 6.2	7	10	8	10	10	13	13	15	16	15	15	improved	0.501	0.003	15
WB SC RM 1.8						12	17	15	16	16	13	no change	0.045	0.649	7
WB SC025 mouth						15	16	17	17	15	15	no change	0.105	0.478	7

HUFF RUN
WATERSHED REPORT



Reductions

Total acid load reduction 2016 = 1,129 lbs/day

Total metal load reduction 2016 = 28 lbs/day

excluding Mineral Zoar and Farr

Acid and metal load reductions based on projects monitored during 2016 listed here: Lyons, Acid Pits, Belden, Fern Hill, Linden, Thomas, Harsha North, Lindentree, and Hilltop Energy.

Costs

Design $724,181
(excluding Linden Bioremediation and Lyons II)

Construction $4,584,172

Total cost through 2016 = $5,308,353

Timeline of the Huff Run Watershed Project Milestones & AMD Projects

Year	Milestones
1985	• Study funded by ODNR conducted by Benatec Associates to identify acid problems in Huff Run Watershed
1988	• First abandoned mine land project, Jobes, completed in the watershed
1996	• Huff Run Watershed Restoration Partnership founded
2000	• Huff Run AMDAT completed • Huff Run Watershed Coordinator funded for six years • First acid mine drainage restoration project, Farr, completed in watershed
2001	• First draft of Huff Run Watershed Plan completed
2002	• Linden Bioremediation Project constructed
2003	• Acid Pit Restoration Project completed
2004	• Lindentree Restoration Project completed
2005	• Rural Action and Huff Run awarded US EPA Targeted Watershed Grant • Rural Action adds VISTA volunteer to Huff Run staff • Second draft of Huff Run Watershed Plan authored, endorsed by the State of Ohio • Lyons Restoration Project constructed
2006	• Harsha North Restoration project completed
2008	• Belden Restoration Project constructed • Fern Hill (HR-42) Phase II Project constructed
2009	• Huff Run Watershed Coordinator funded for three years • Mineral Zoar Project completed • Rural Action adds AmeriCorps member to Huff Run staff
2010	• Thomas Project, Fern Hill Pond A & Belden Gob pile constructed
2011	• Lyons II constructed
2012	• Hilltop Restoration Project started
2013	• Completed Hilltop Restoration Project • MWCD Partners in Watershed Management Grant awarded for environmental education and community outreach
2014	• Project development for JS&L AMD Reclamation Project and the Farr Phase II
2015	• Constructed JS&L AMD Restoration Project, funded by ODNR-DMRM and OEPA • Received $1.7M ODOT Mitigation
2016	• Huff Run Stream Mitigation project completed by Oxbow River & Stream Restoration, funded by ODOT.

Huff Run Projects

Acid mine drainage reclamation projects completed in Huff Run Watershed:

2003 *Farr Project* (FAR01/02) – Surface reclamation, limestone channels, anoxic limestone drains, and passive wetland*
Linden Bioremediation Project (LIN08) – Pyrolusite limestone bioremediation bed

2004 Acid Pit #1 Project (ACP01) – Drain impoundments and surface reclamation

2005 Lyons Project (LYN01) – Steel slag bed, limestone channels, drain impoundments, and surface reclamation
Lindentree Project (LNT01) – Steel slag bed, limestone channels, and fill acid pits

2006 Harsha North Project (HAN05) – Surface reclamation, limestone trenches, and reclaimed gob pile

2008 Fern Hill HR-42 Pits A, B, & C (FRN01) – Surface reclamation, limestone Channels and reclaim 3 acidic pits
Belden and Belden Gob Pile Project (BLD01) – Surface reclamation, steel slag beds, reclaim gob pile, and passive settling ponds

2009 *Mineral Zoar (MZR08) – Reverse alkaline producing systems (RAPS)*

2010 Thomas Project (LIN01/THM06) – Surface reclamation and passive settling ponds

2011 Lyons II maintenance Project (LYN01) – Additional steel slag installed, pipe clean-outs, and added limestone berms to settling pond

2013 Hilltop Energy Project (HRT21/HR37) – Reclaimed gob pile, surface reclamation, limestone channels, and settling pond

2015 JS&L AMD Reclamation (HR25) – Limestone channels, limestone leach bed and precipitation basin.

Italicized indicates projects are not actively monitored for acid and metal load reduction purposes

**Indicates no yearly trend graphs due to lack of pre or post data*

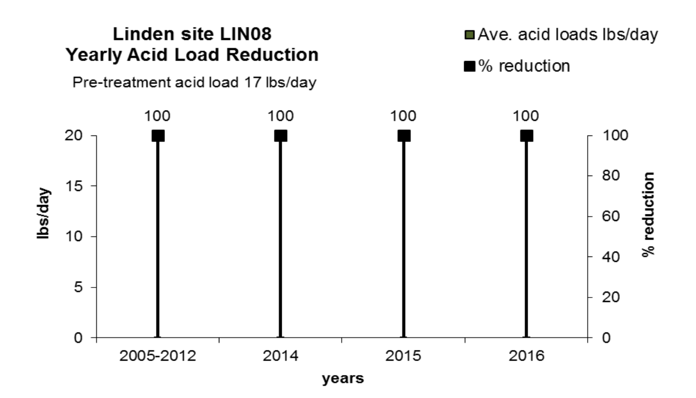
2016 NPS Report - Huff Run Watershed

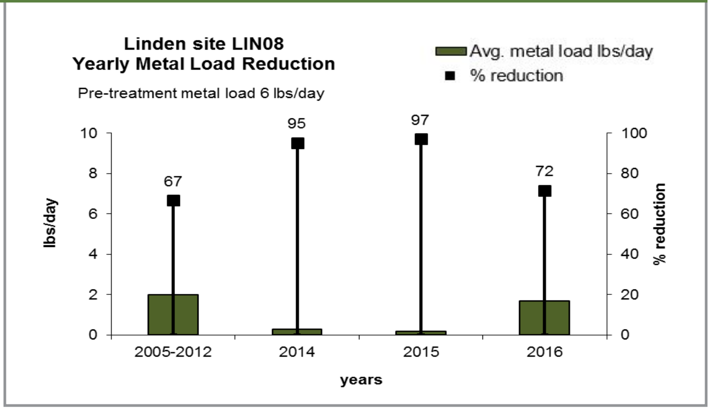
Generated by Non-Point Source Monitoring System
www.watersheddata.com

Yearly acid and metal load reduction trends per project

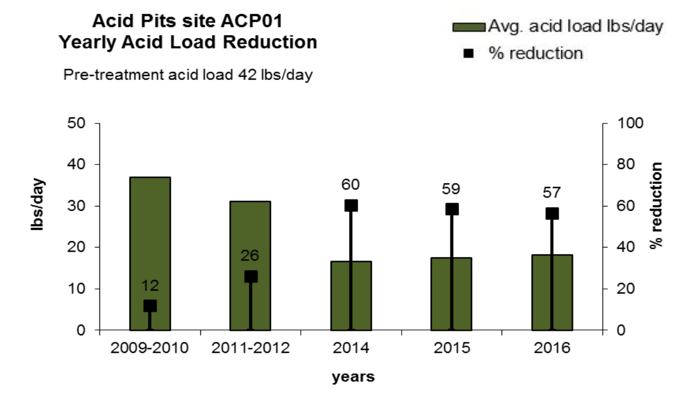
Similar to other environmental best management practices (BMPs), performance of passive acid mine drainage reclamation projects are also expected to decline with time. Active treatment systems are not expected to decline with time but sometimes need to be maintained to perform adequately. Currently, operation and maintenance plans are being designed for each existing system and are planned for future projects. The graphs below show the mean annual acid and metal load reduction using the Stoertz Water Quality Evaluation Method (Kruse et al., 2014) for each year (or group of years) during post-reclamation from the project effluent. From these graphs the rate of decline (and/or improvement) with time of the treatment system is implied. Knowing the rate of decline will aid in the implementation of operation and maintenance plans.

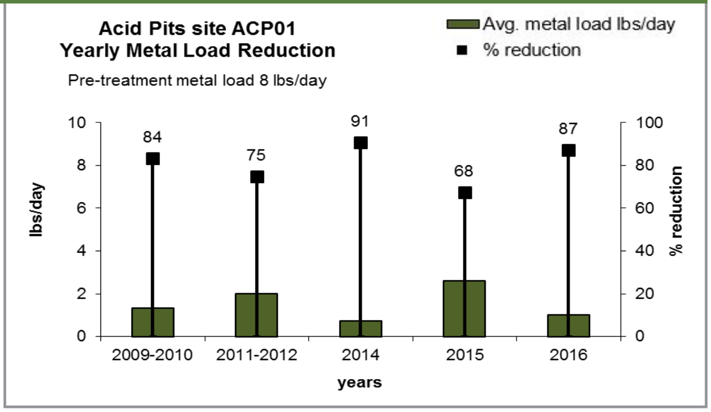
Linden site LIN08



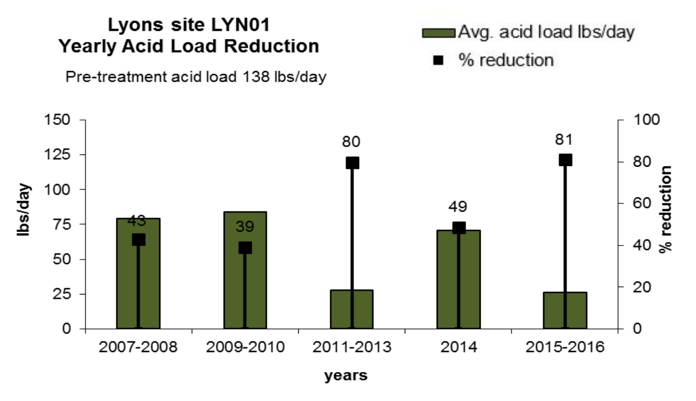


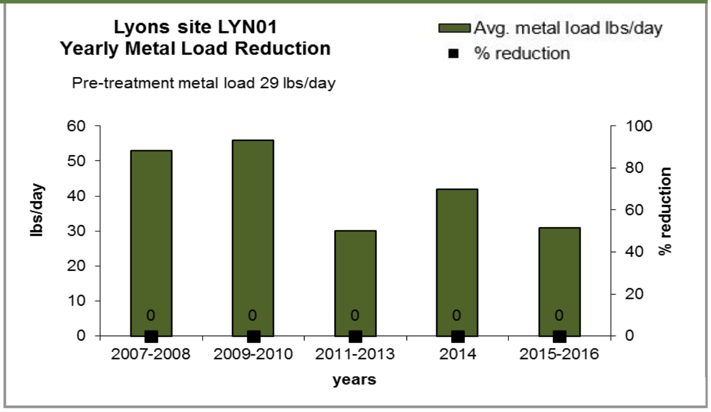
Acid Pits site ACP01





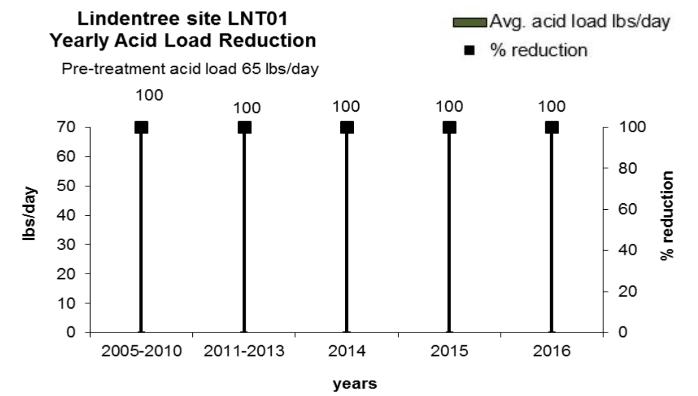
Lyons site LYN01



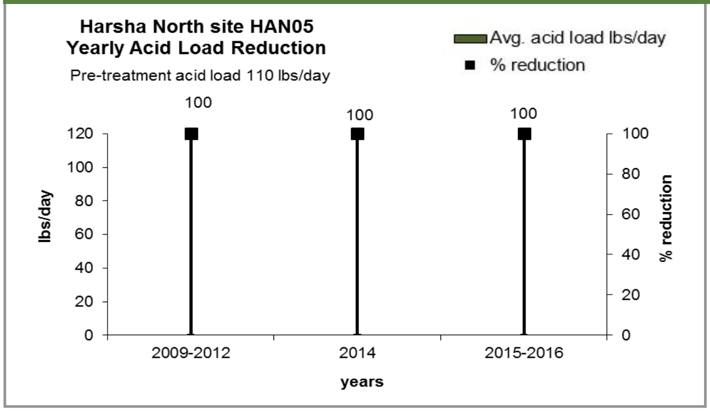


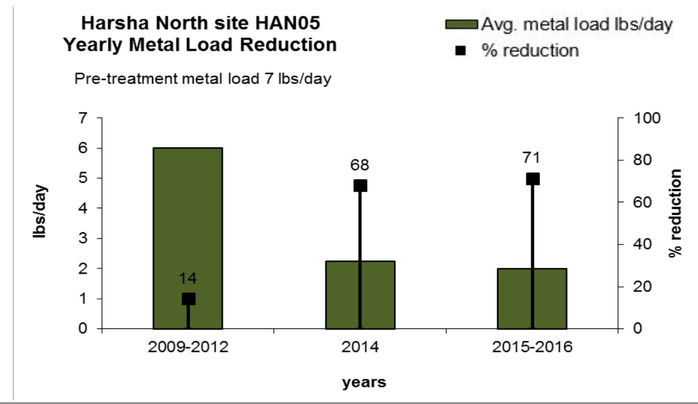
Yearly acid and metal load reduction trends per project

Lindentree site LNT01

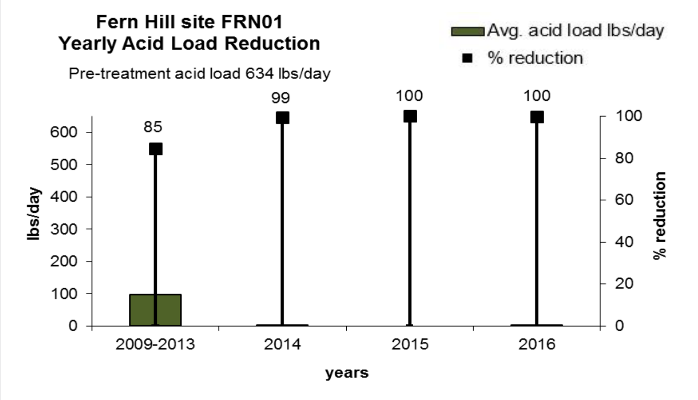


Harsha North site HAN05



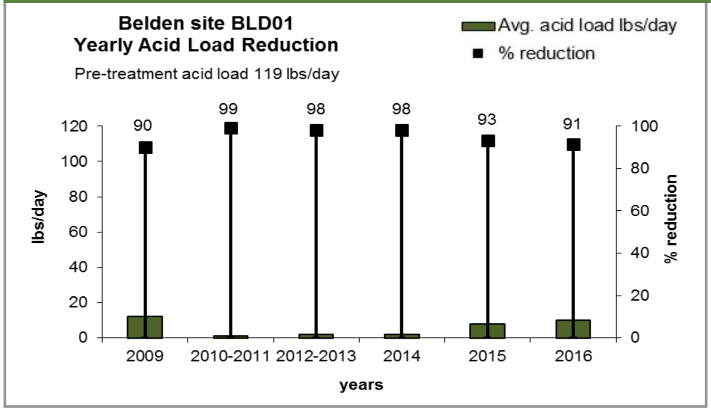


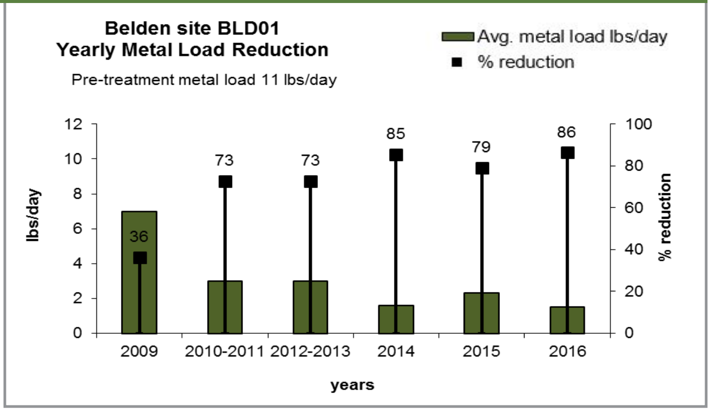
Fern Hill site FRN01



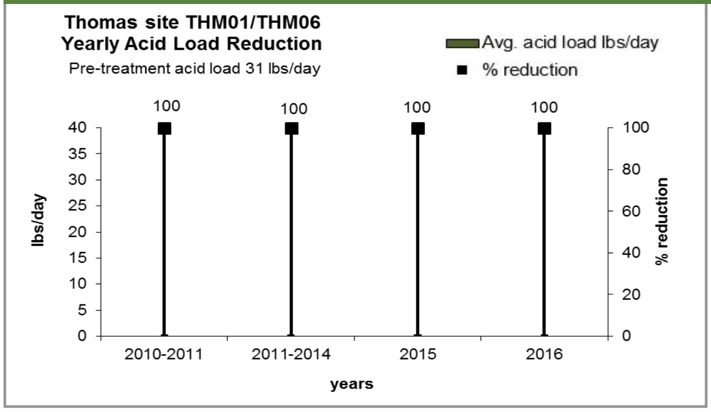
Yearly acid and metal load reduction trends per project

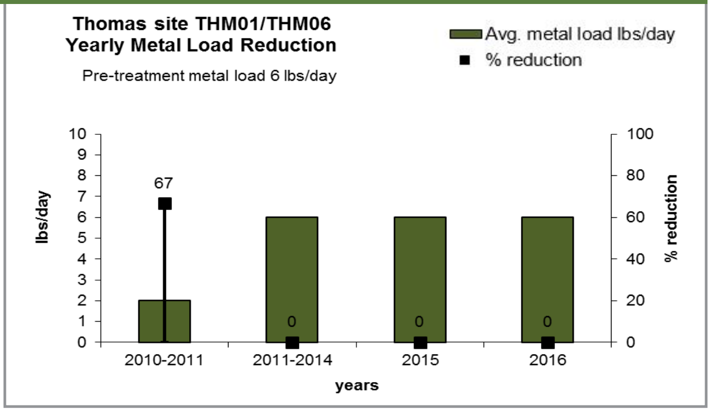
Belden site BLD01



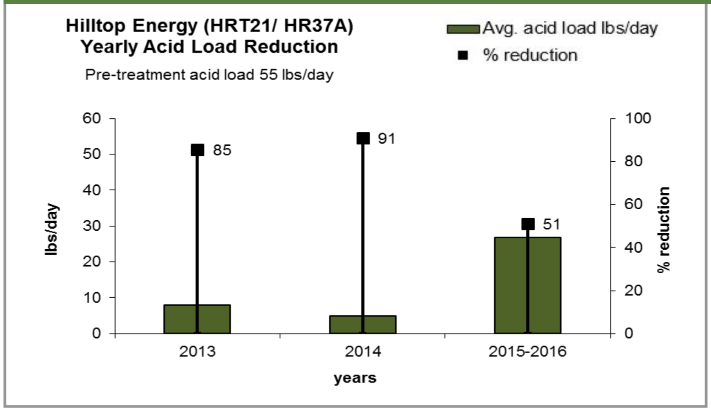


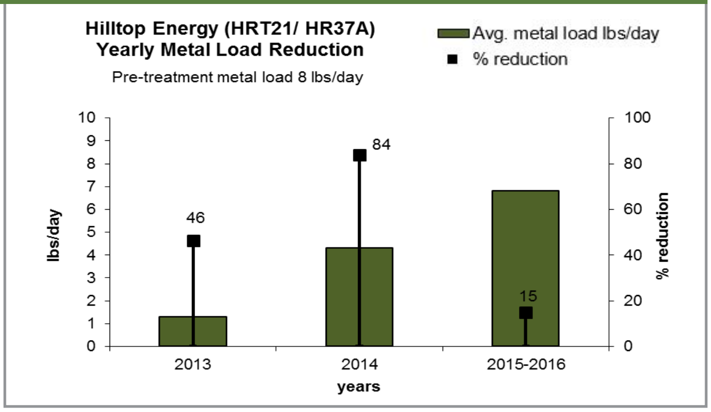
Thomas site THM01/THM06



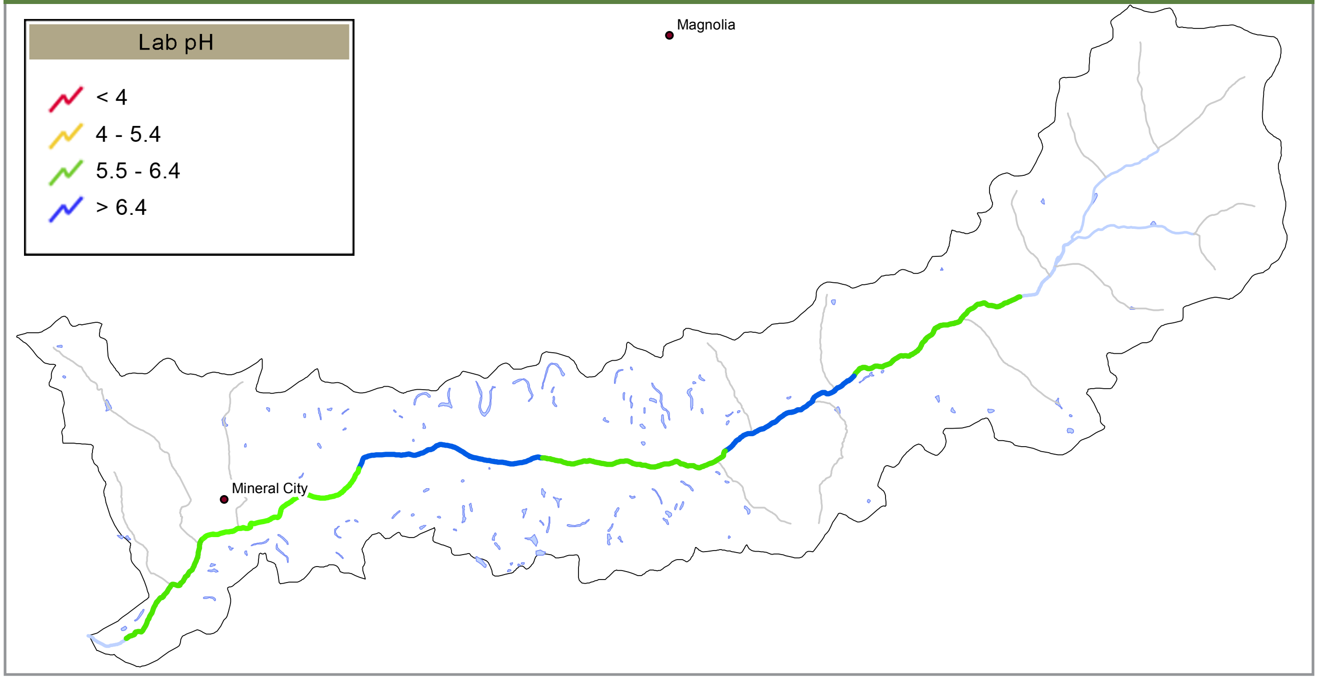


Hilltop Energy (HRT21/HR37A)

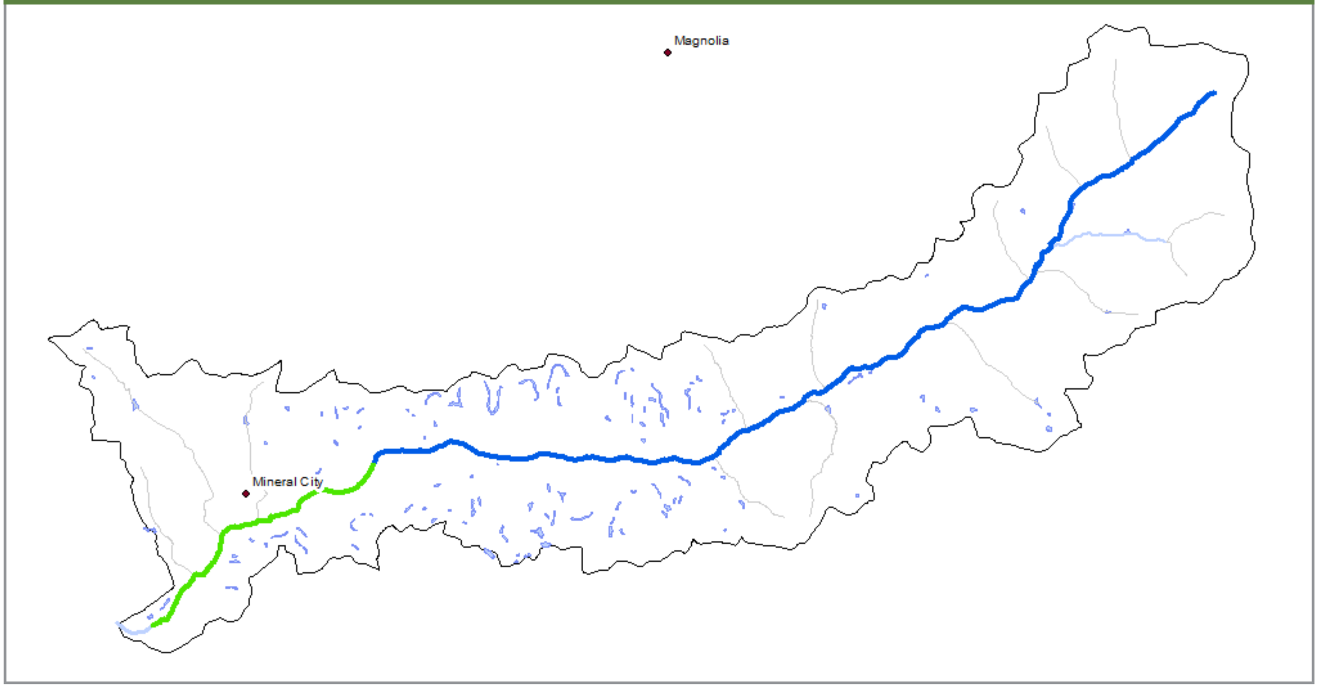




Huff Run baseline pH



Huff Run 2016 pH

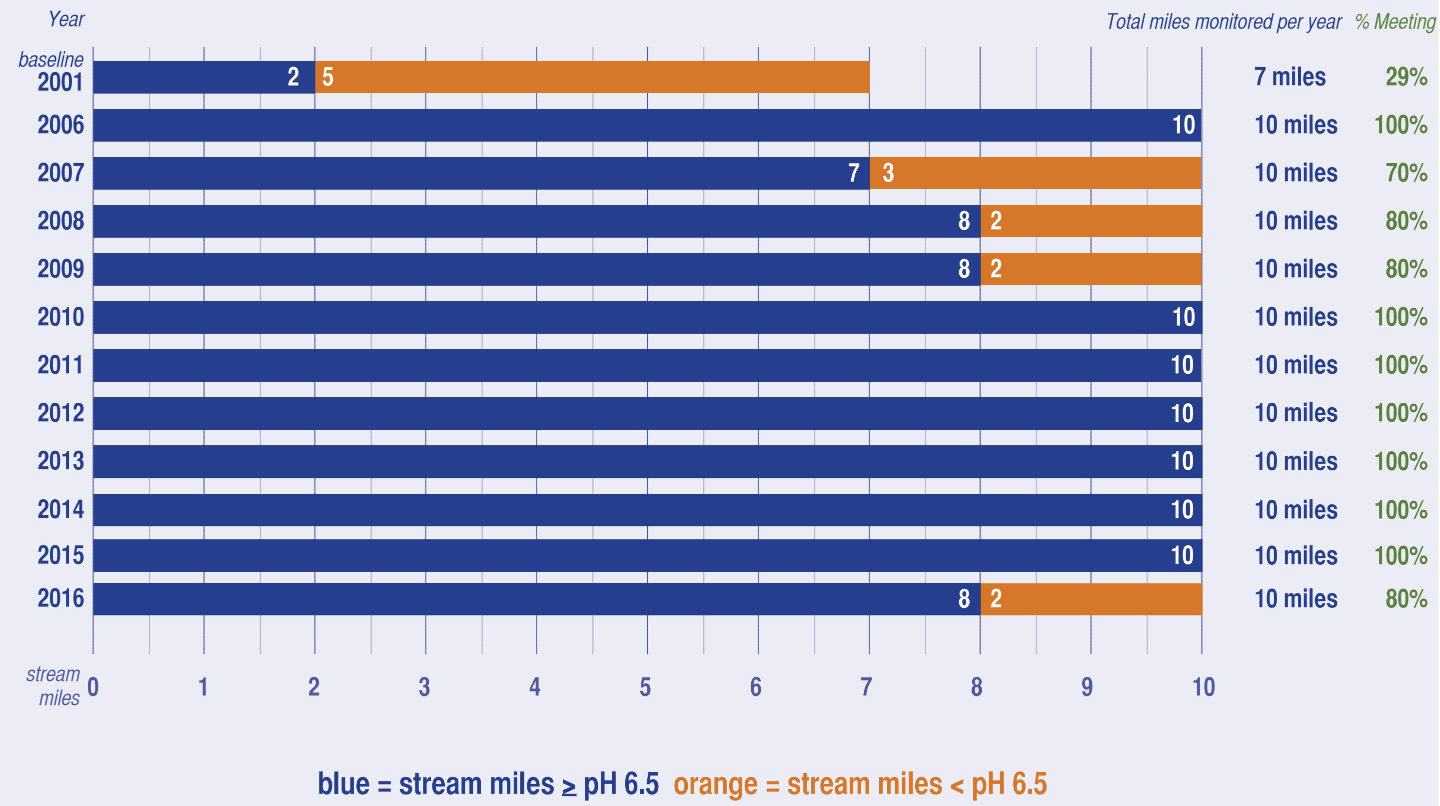


Huff Run pH values have improved from baseline conditions (1985-1998) to 2016. The mouth of Huff Run fell just below the pH target in 2016, leaving 7.8 miles of the upper part of Huff Run meeting the pH target of the 10 miles monitored.

Chemical Water Quality

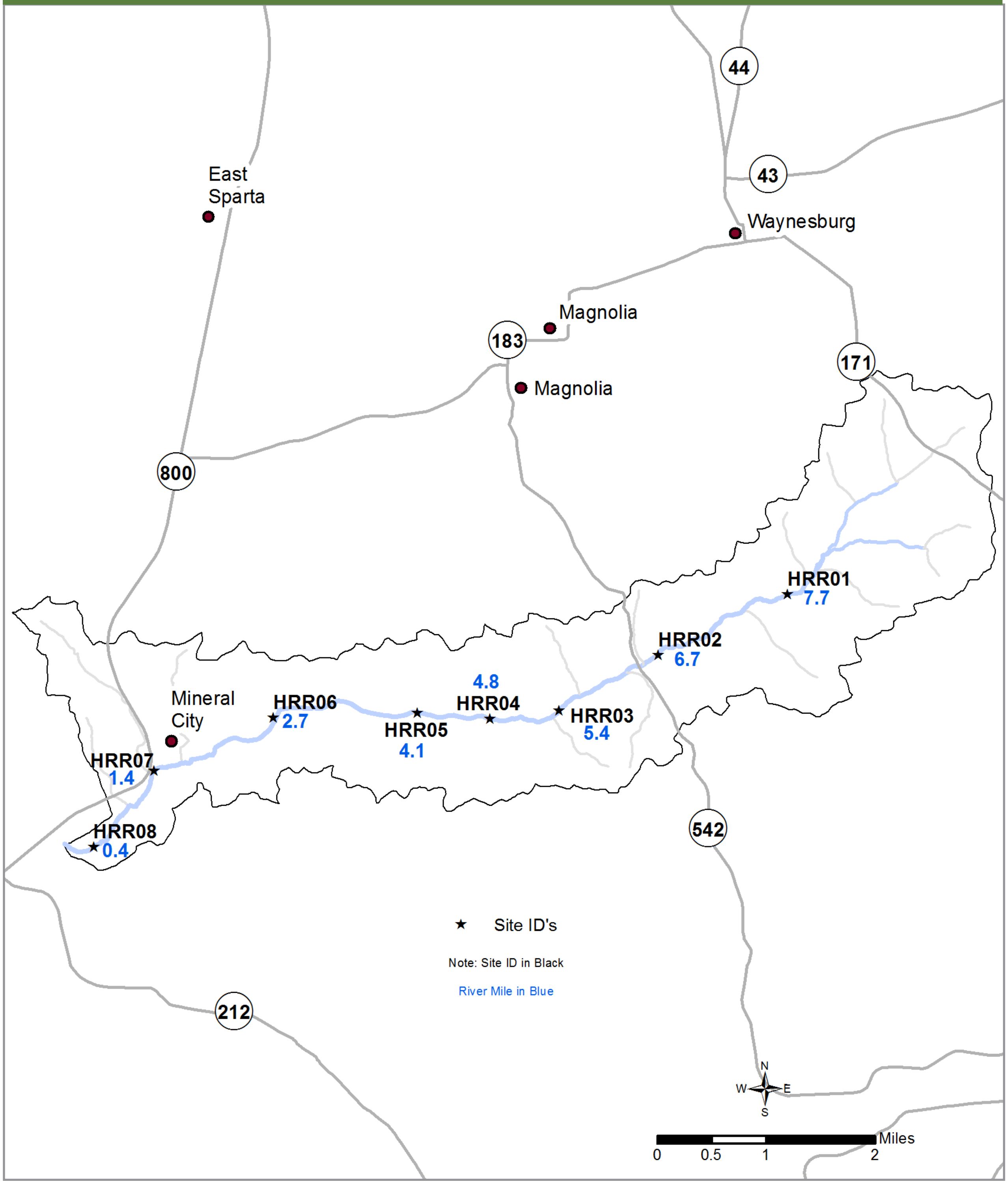
The mainstem of Huff Run is approximately 10 miles in length with monitoring occurring year round. In 2009, 8 miles met the pH target of 6.5 while the two downstream stream reaches (HRR08 and HRR07) fell slightly below the target with an average pH of 6.4. From 2010 to 2015, all 10 miles met the pH target. 2016 is similar to the 2008 and 2009 stream conditions where the mouth of Huff Run fell just below meeting the pH target leaving approximately 8 miles meeting and 2 miles slightly less than pH 6.5.

Huff Run pH



Chemical water quality analysis per stream reach

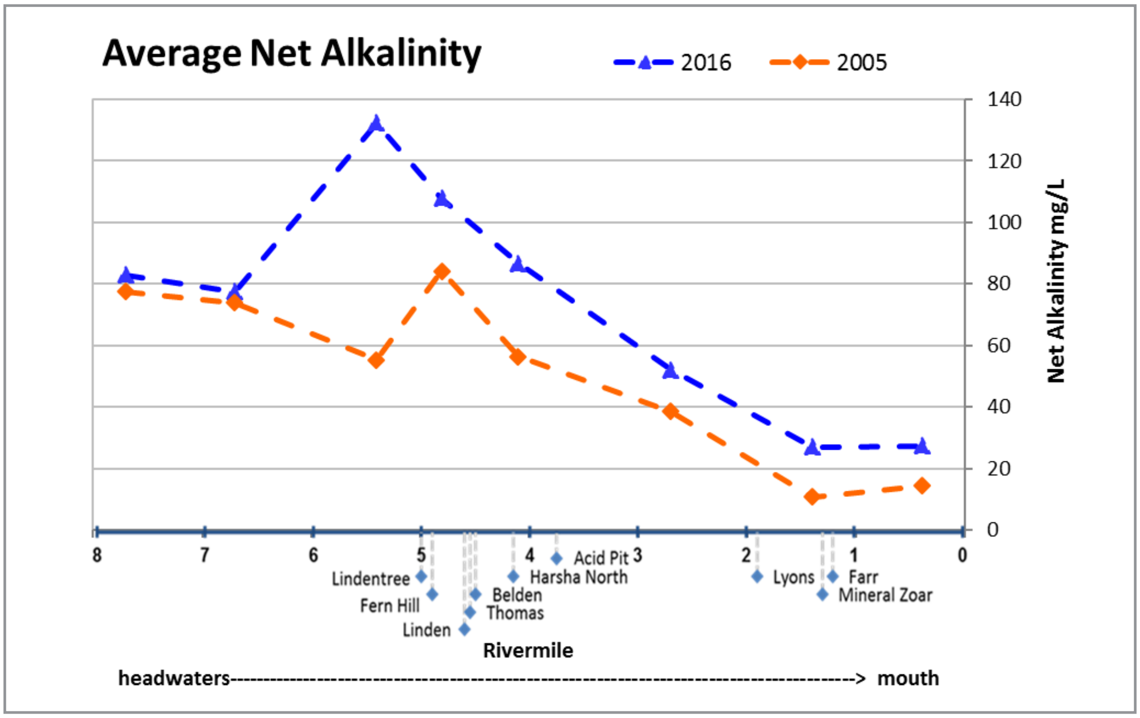
Huff Run

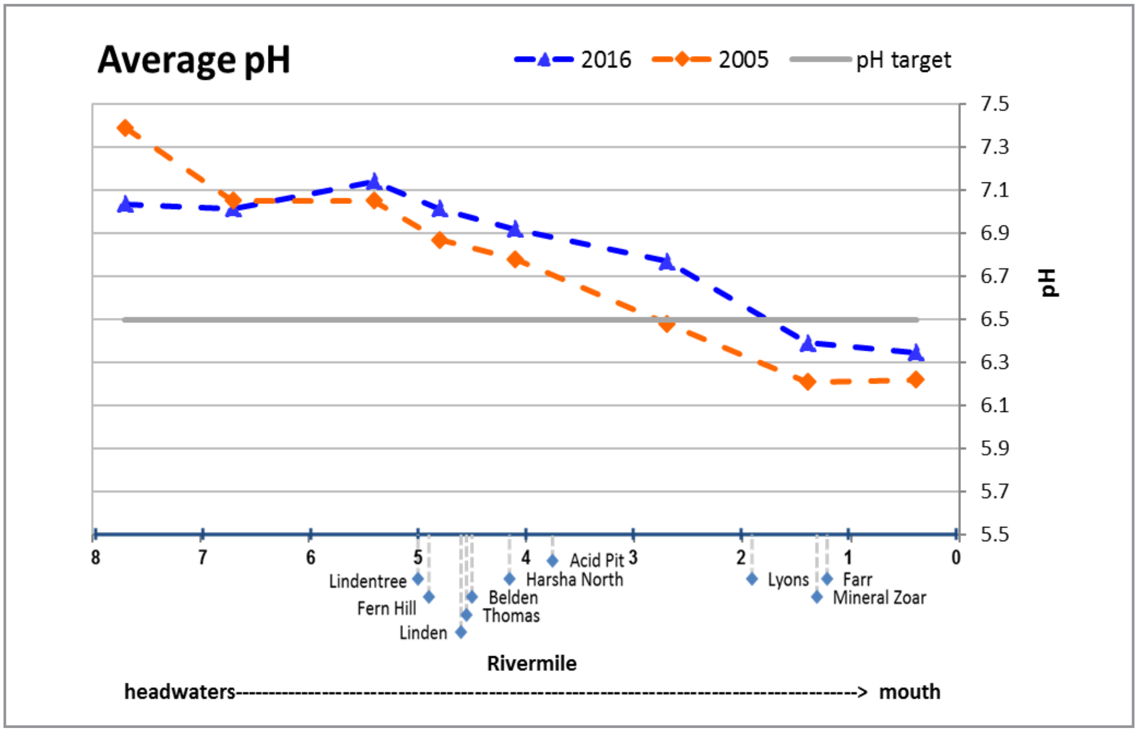


Chemical water quality analysis per stream reach

Chemical water quality changes along the mainstem of Huff Run are shown in the stream reach graphs below. Chemical long-term monitoring data is utilized to generate line graphs along the stream gradient from headwaters to the mouth. Along the x-axis named tributaries are shown to illustrate sources of water entering the mainstem. A list of long-term monitoring sites utilized to generate the graphs with their river miles are shown below.

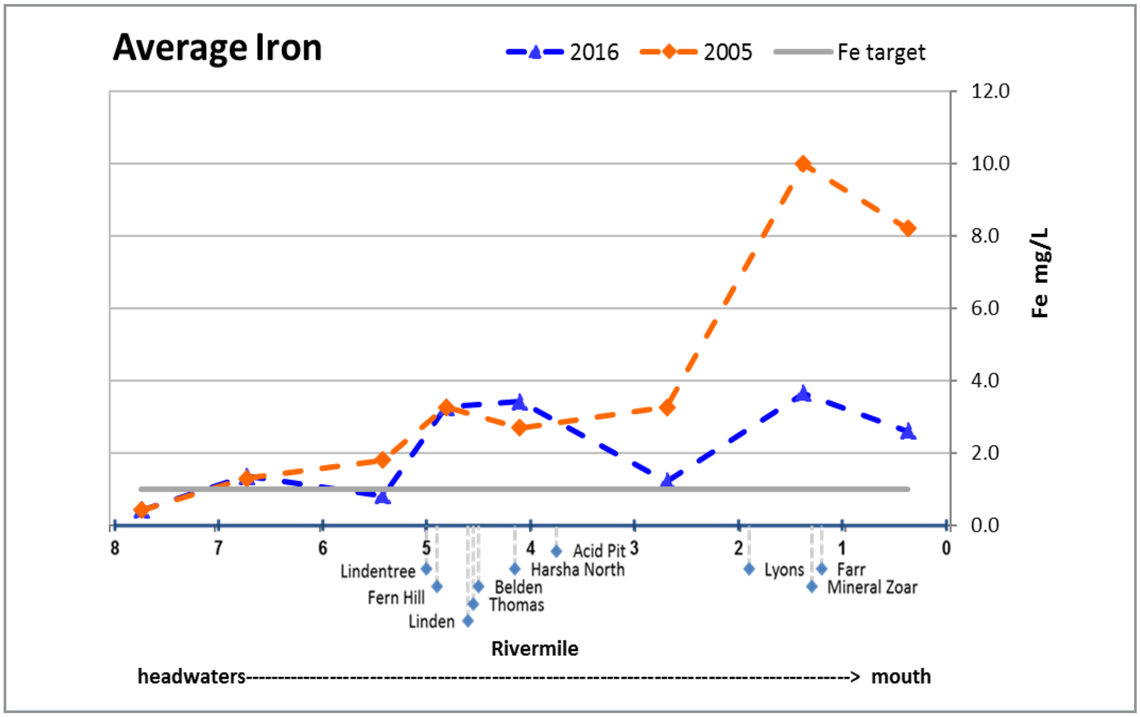
Huff Run								
Site ID	HRR01	HRR02	HRR03	HRR04	HRR05	HRR06	HRR07	HRR08
Rivermile	7.7	6.7	5.4	4.8	4.1	2.7	1.4	0.4

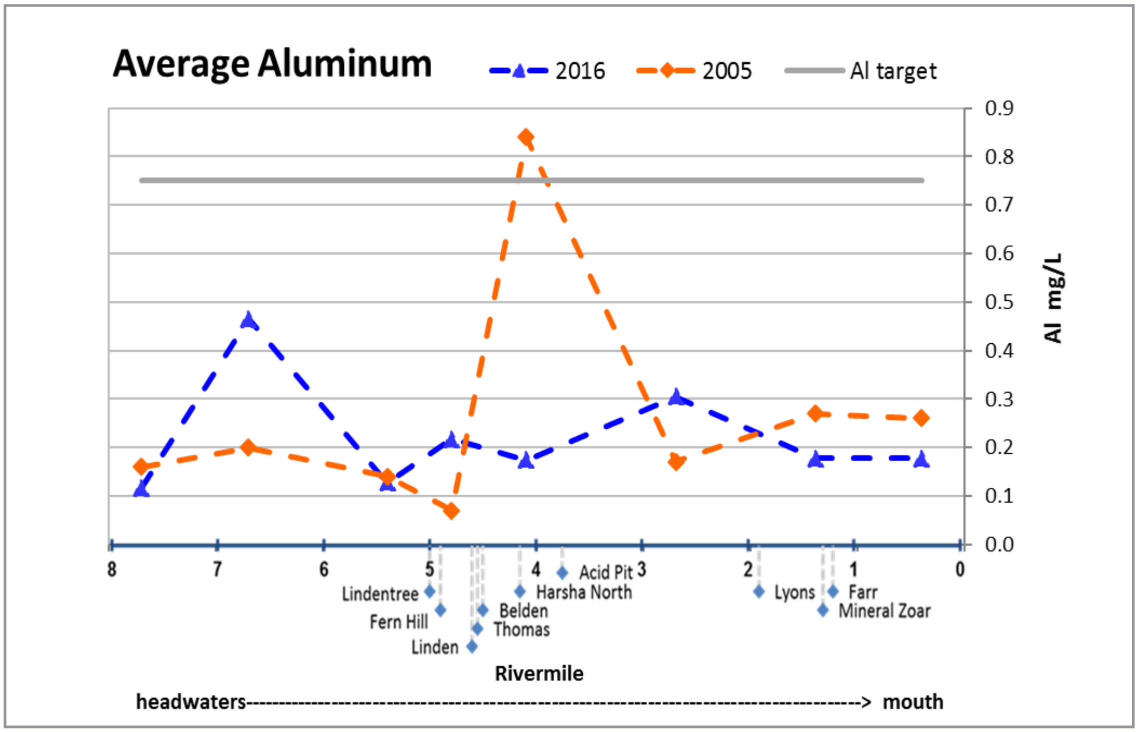




Chemical water quality analysis per stream reach

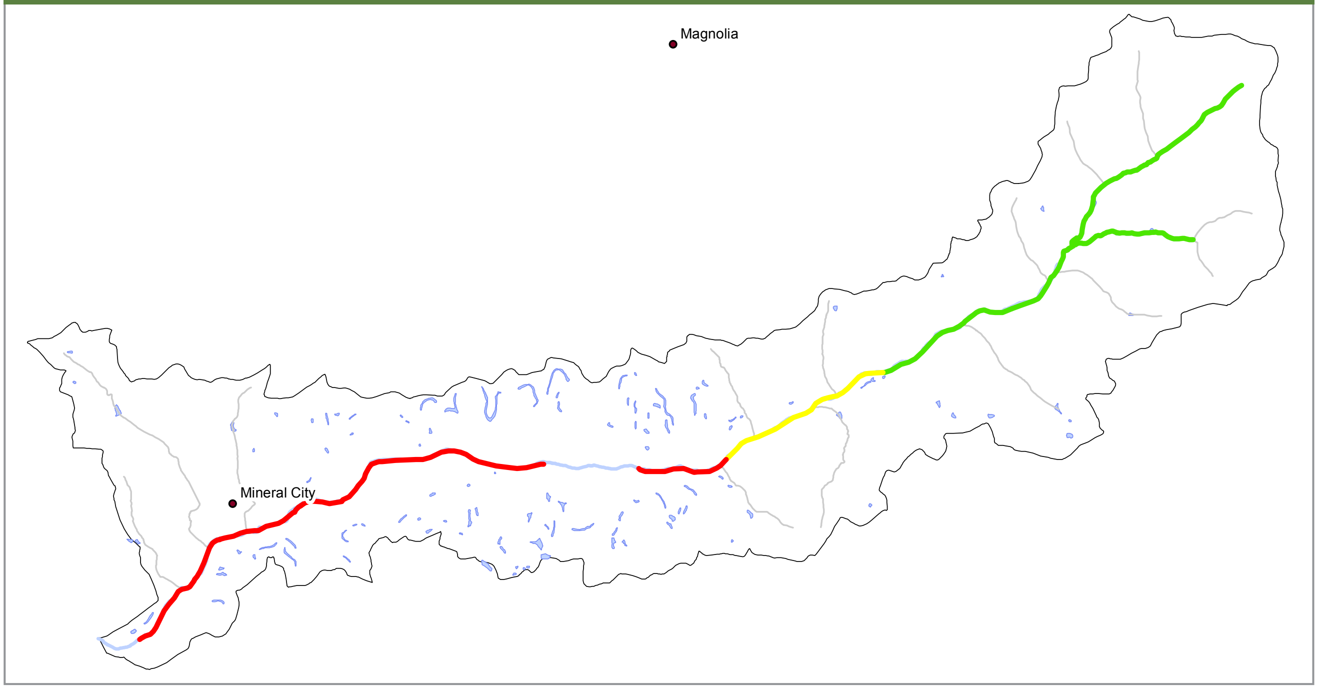
Huff Run								
Site ID	HRR01	HRR02	HRR03	HRR04	HRR05	HRR06	HRR07	HRR08
Rivermile	7.7	6.7	5.4	4.8	4.1	2.7	1.4	0.4



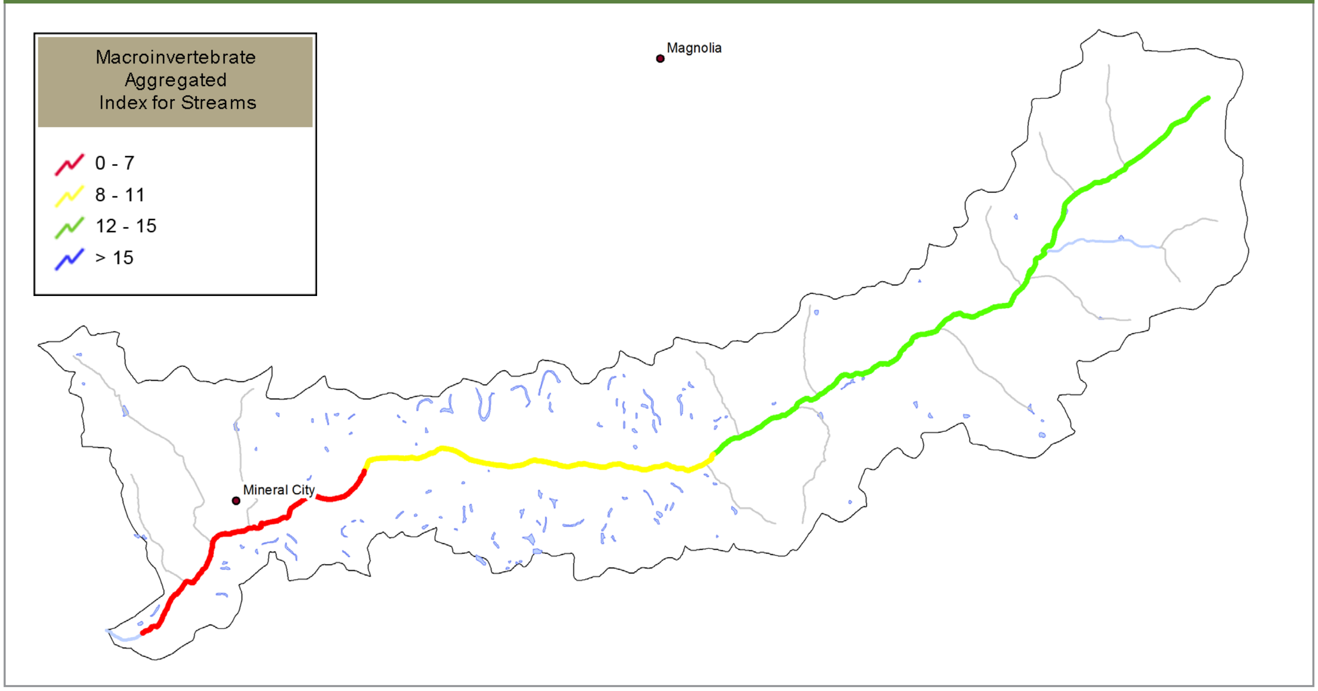


Biological Water Quality

Huff Run baseline MAIS



Huff Run 2016 MAIS

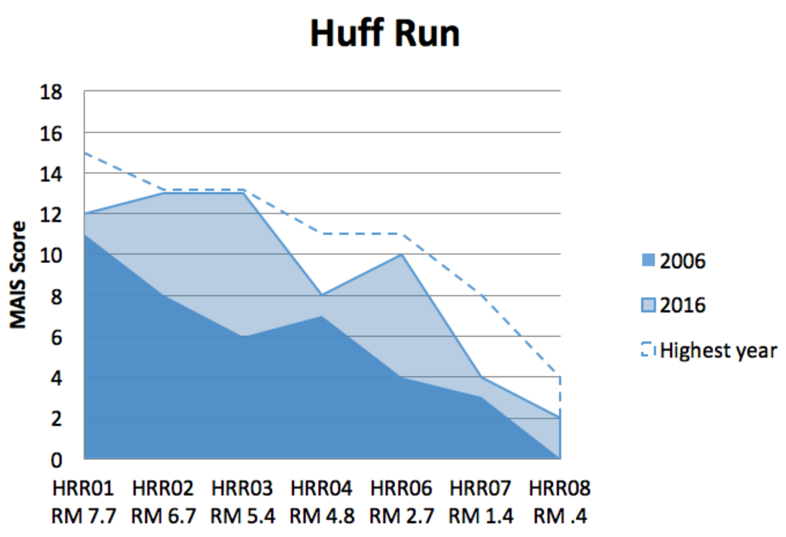


Biological quality in Huff Run decreases from headwaters to the mouth.

Biological Water Quality

Biological quality in Huff Run (based on macroinvertebrate data) improved modestly along the length of the mainstem. In 2014 for the first time since monitoring began in 2005 one of the eight monitoring sites (RM 5.4), improved enough to be categorized as sustained and statistically significant and four sites (RM 7.7, 5.4, 4.8 and 2.7) achieved new high scores that year. In 2015, RM 5.4 became the first site to reach its biological restoration target, earning a MAIS score "13". RM 2.7 also earned a new high score of "11" and became the second site along the mainstem to show sustained biological recovery. These improvements, however, do not extend further downstream; biological quality at the two lowermost sites continues to be relatively poor. Scores at the upper two sites were also unusually low this year.

Area of Degradation 2006-2015



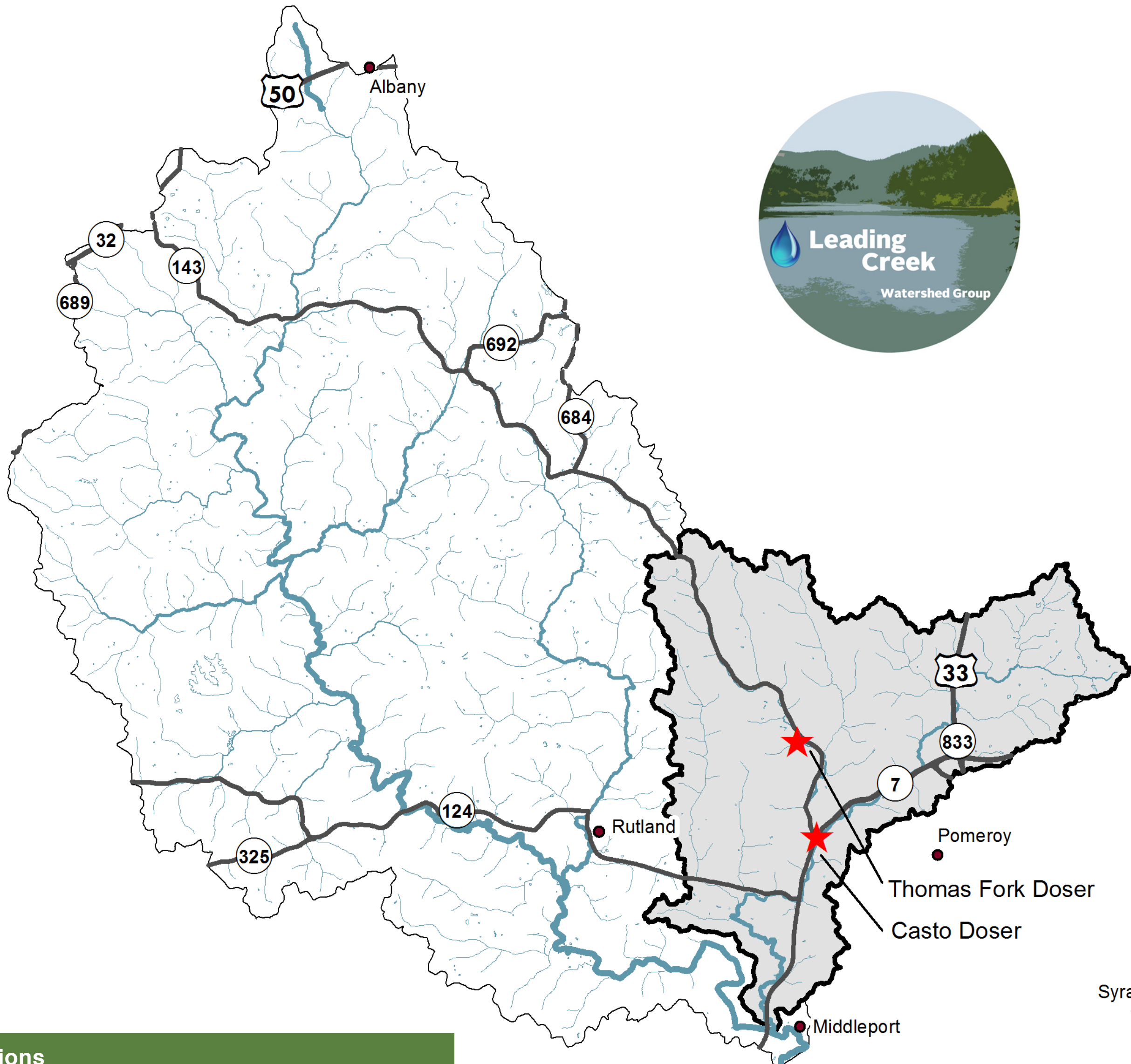
Huff Run MAIS Regressions

	RM	'05	'06	'07	'08	'09	'10	'11	'12	'13	'14	'15	'16	Linear trends	R square	P-value	Years
HRR01	7.7	14	11	12	12	13	9	13	6	10	15	9	12	no change	0.054	0.468	12
HRR02	6.7	12	8	8	8	9	11	11	11	10	9	7	13	no change	0.029	0.599	12
HRR03	5.4	8	6	7	6	8	9	7	9	10	11	13	**13**	improved	0.751	0.0003	12
HRR04	4.8	6	7	9	8	9	9	6	7	9	11	9	8	no change	0.185	0.163	12
HRR06	2.7	5	4	5	3	4	5	3	4	5.5	7	11	**10**	improved	0.488	0.011	12
HRR07	1.4	2	3	3	2	8	2	2	3	5	7	2	4	no change	0.063	0.436	12
HRR08	0.4	3	0	4	3	4	3	3	3	3	4	4	2	no change	0.060	0.441	12

LEADING CREEK
WATERSHED REPORT

2016 NPS Report - Leading Creek Watershed

Generated by Non-Point Source Monitoring System
www.watersheddata.com



Reductions

Total acid load reduction = 663 lbs/day

Total metal load reduction = 233 lbs/day

Acid and metal load reductions based on projects monitored during 2016 listed here: Thomas Fork Doser, and Casto Doser.

Costs

Design $36,132

Construction $692,349

Total Costs through 2016 = $728,481

Timeline of the Leading Creek Watershed Project Milestones & AMD Projects

Year	Milestones
1993	• SOCCO mine release into Leading Creek
1994	
1995	• Mother's Day Flood
1996	
1997	
1998	• Leading Creek Improvement Plan by Dr. Cherry completed
1999	• USFWS began working with Meigs SWCD on watershed projects
2000	
2001	• First Leading Creek Stream Sweep conducted
2002	
2003	• Meigs SWCD Conservation Area purchased along Little Leading Creek • Meigs SWCD obtained first watershed coordinator grant
2004	
2005	• Leading Creek Watershed Management Plan completed
2006	• Pauline Atkins Memorial Trail completed • Leading Creek AMDAT Plan completed
2007	
2008	• Leading Creek TDML Report completed
2009	• Leading Creek Water Trail established • First AmeriCorps member dedicated to the Leading Creek Watershed
2010	• Leading 'From the Past' book completed • Leading Creek Volunteer Monitor Program begun
2011	• Freshwater mussels reintroduced
2012	• Thomas Fork Doser Project completed
2013	• Biological observations along Thomas Fork indicate an increase in diversity of fish and macroinvertebrate species since 2010
2014	• Project development for Casto Doser reclamation scheduled for 2015
2015	• Casto Doser began operating October 2015, adding alkalinity to Thomas Fork to supplement low flow conditions

Leading Creek Projects

Acid mine drainage reclamation projects completed in Leading Creek Watershed:

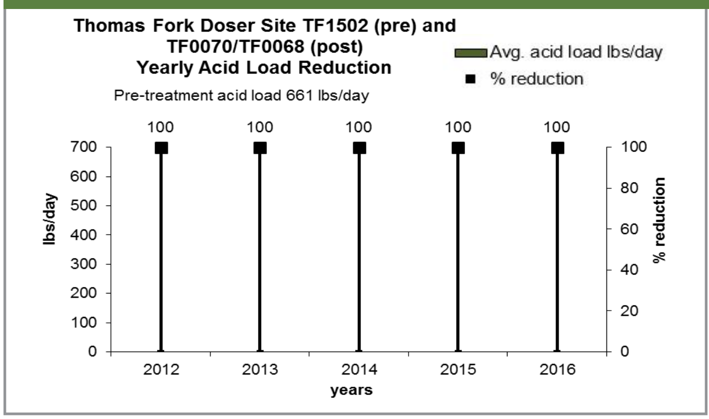
2012 Thomas Fork Doser (TF1502 pre/ TF0070 and TF0068 post) – Active calcium oxide doser

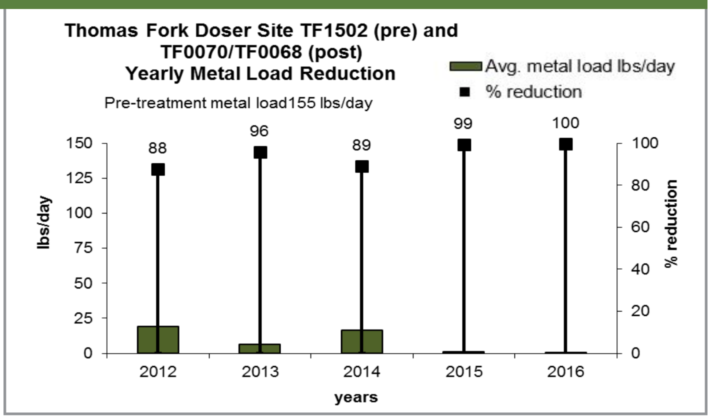
2015 Casto Doser (TF0030) – Super fine lime dust ($CaCO_3$)

Yearly acid and metal load reduction trends per project

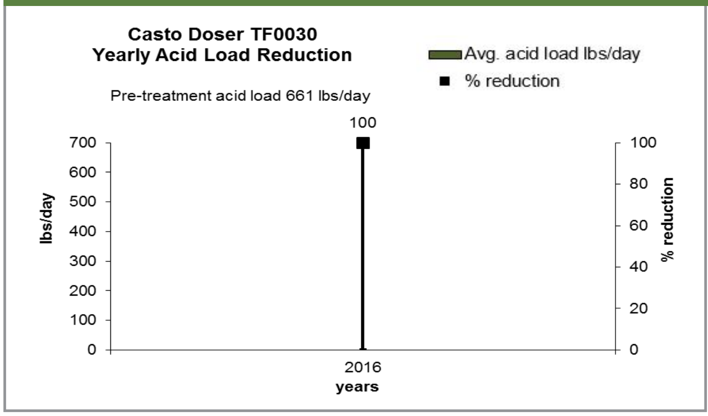
Similar to other environmental best management practices (BMPs), performance of passive acid mine drainage reclamation projects are also expected to decline with time. Active treatment systems are not expected to decline with time but sometimes need to be maintained to perform adequately. Currently, operation and maintenance plans are being designed for each existing system and are planned for future projects. The graphs below show the mean annual acid and metal load reduction using the Stoertz Water Quality Evaluation Method (Kruse et al., 2014) for each year (or group of years) during post-reclamation from the project effluent. From these graphs the rate of decline (and/or improvement) with time of the treatment system is implied. Knowing the rate of decline will aid in the implementation of operation and maintenance plans.

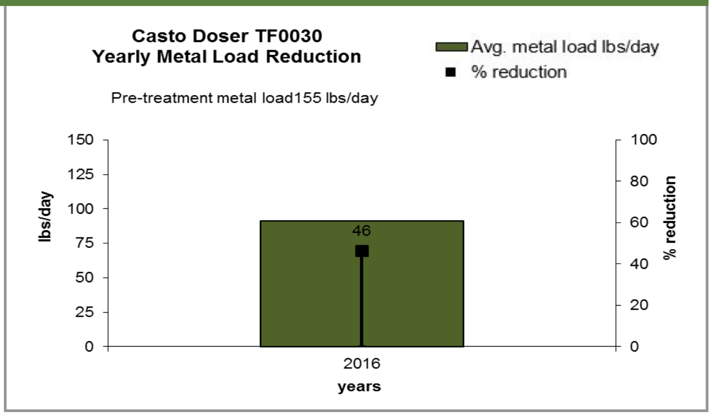
Thomas Fork Doser Site TF1502 and TF0070/TF0068





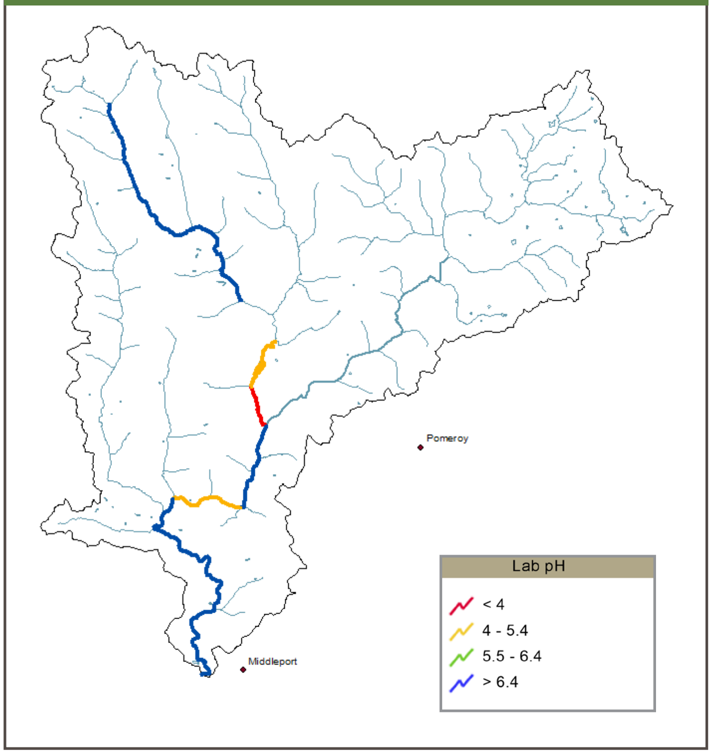
Casto Doser Site TF0030



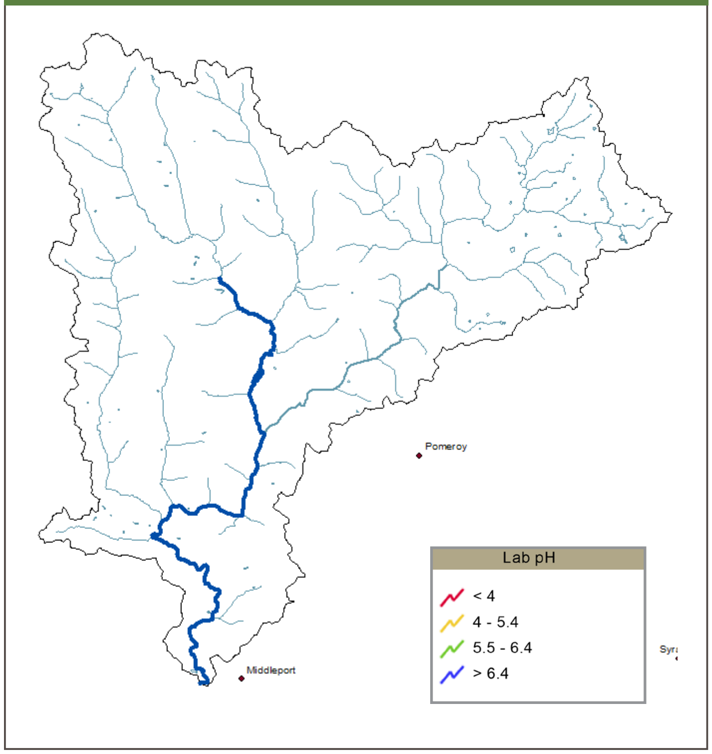


Chemical Water Quality

Thomas Fork baseline (2009) pH

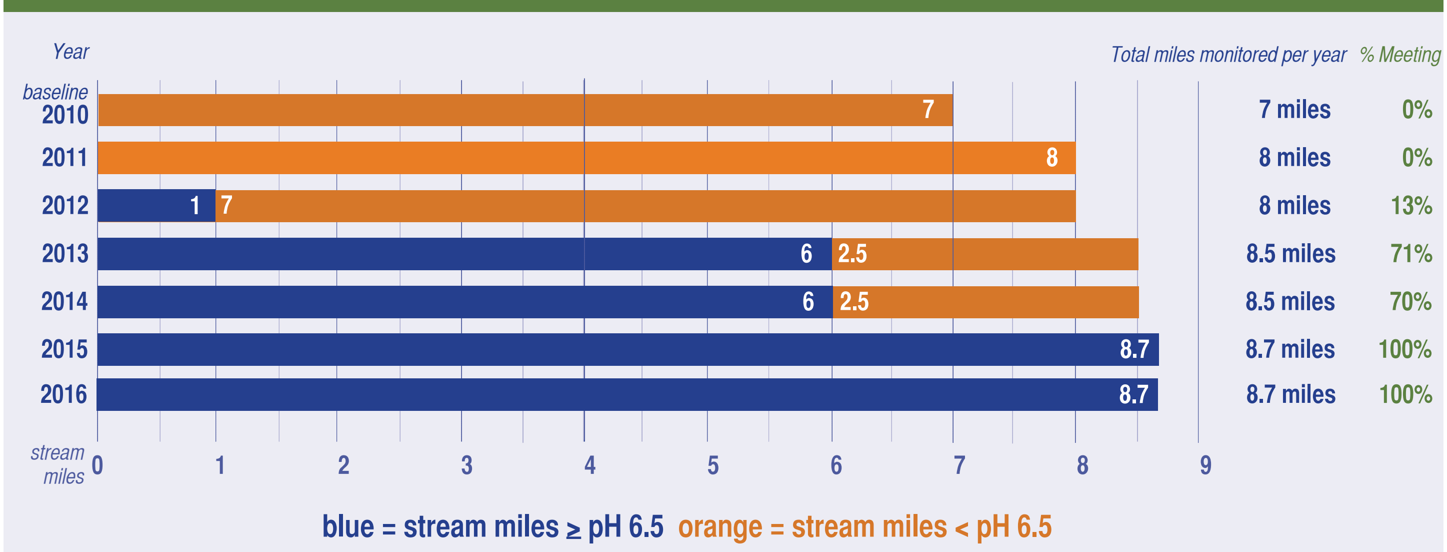


Thomas Fork 2016 pH

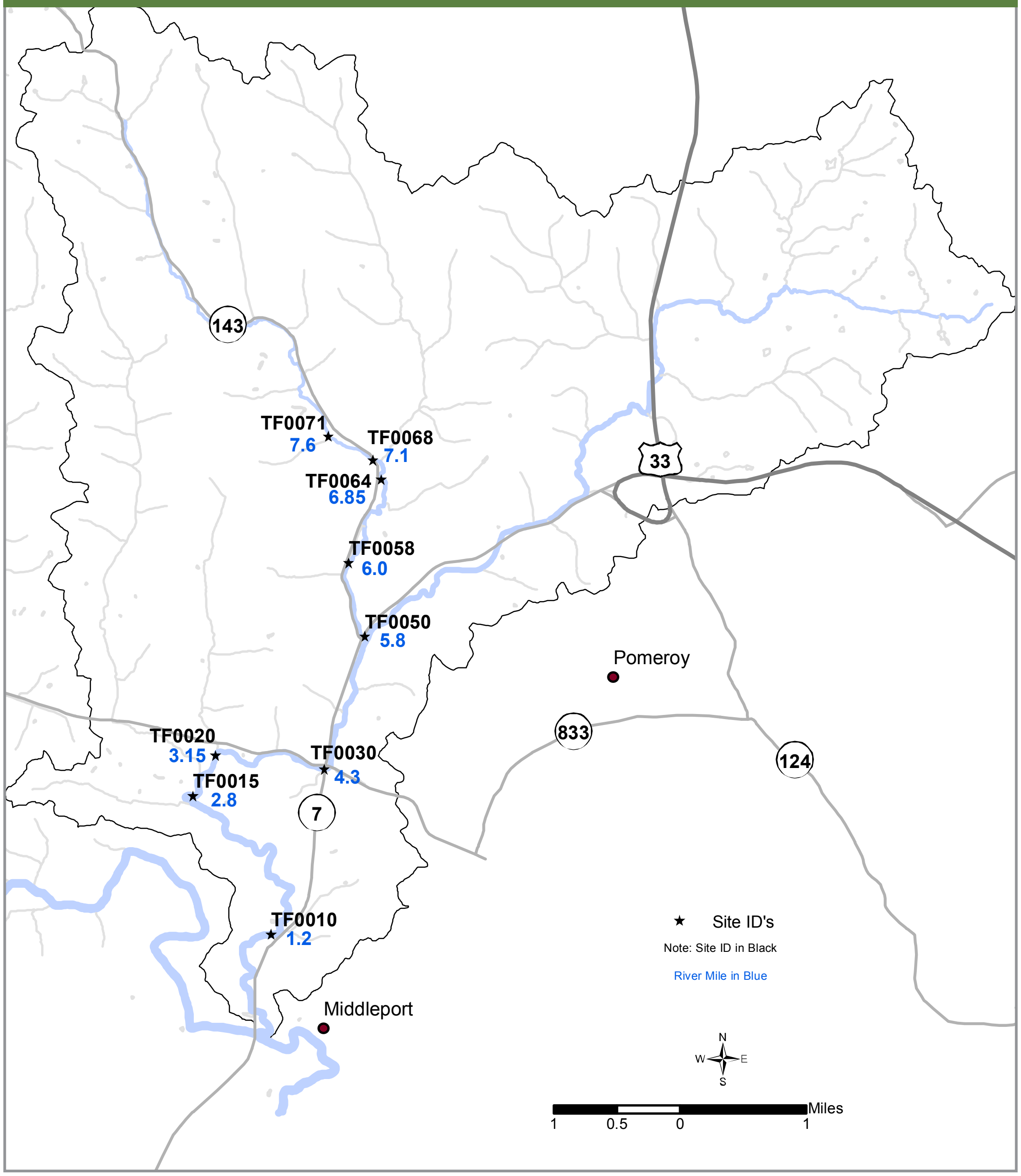


Thomas Fork in 2016, show 8.7 stream miles meeting the pH target of (6.5) of the 8.7 miles monitored (100%). The 2.5 miles of streams that didn't meet the pH target in 2014 are now meeting the pH target for the past two years.

Figure 1. Thomas Fork total stream miles monitored for pH through time



Thomas Fork

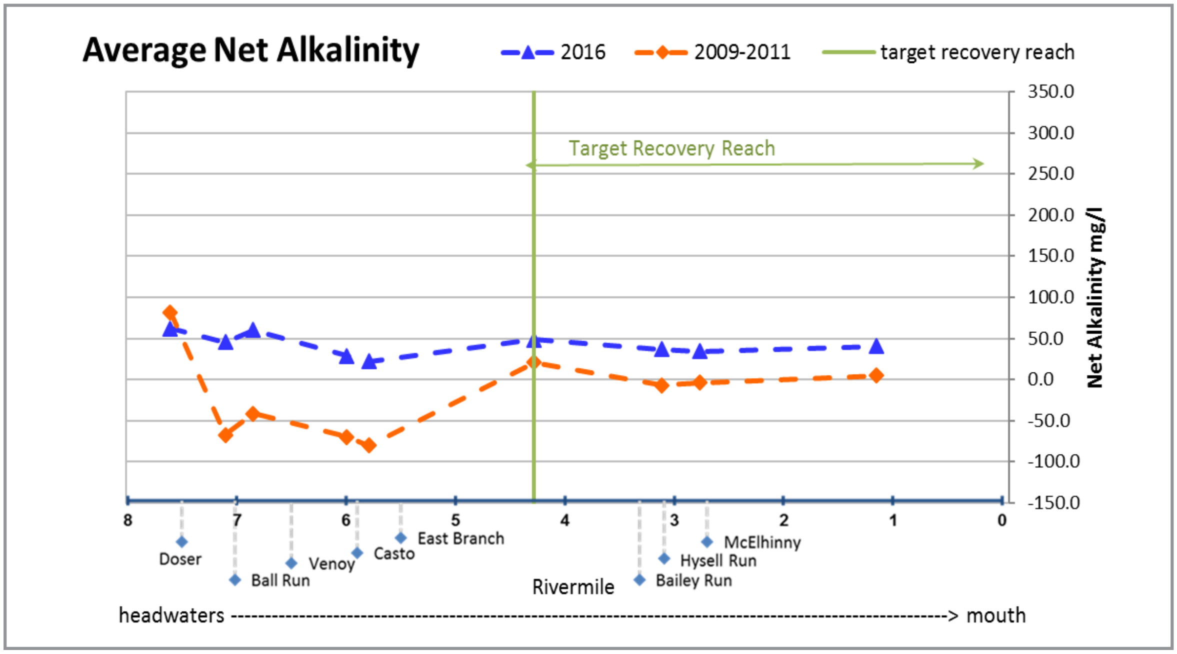


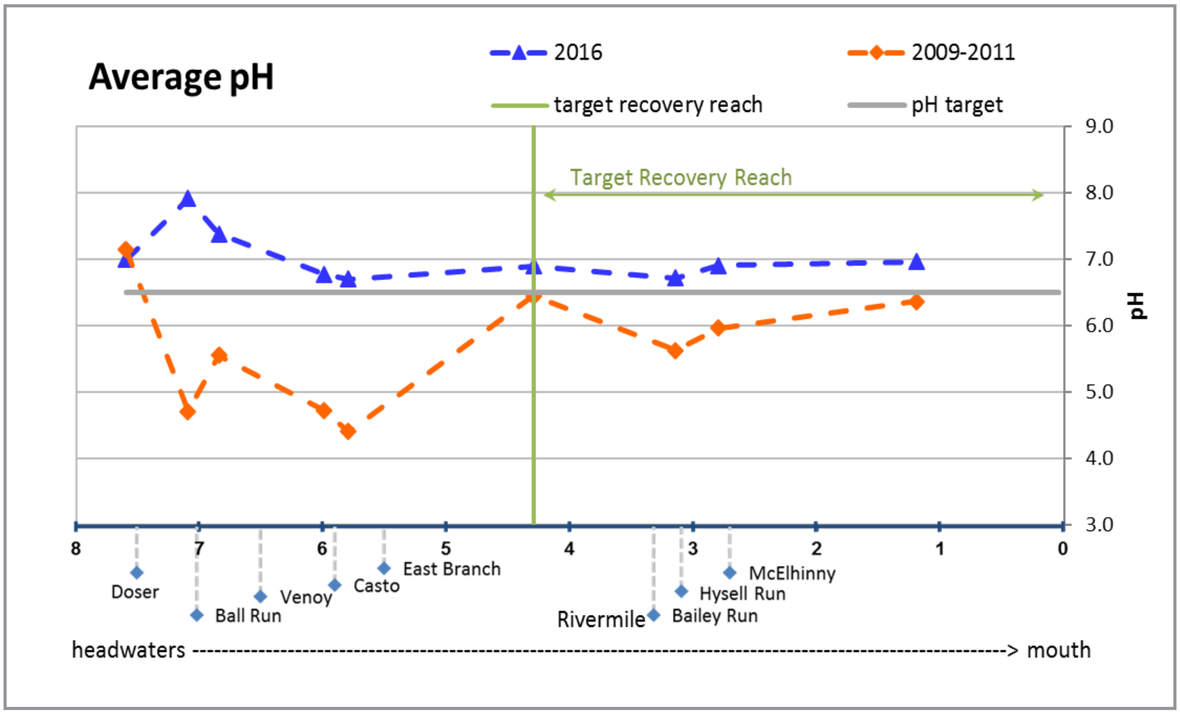
143
TF0071
7.6
TF0068
7.1
TF0064
6.85
33
TF0058
6.0
TF0050
5.8
Pomeroy
833
124
TF0020
3.15
TF0030
4.3
TF0015
2.8
7
TF0010
1.2
Middleport
Site ID's
Note: Site ID in Black
River Mile in Blue
N
W
E
S
1
0.5
0
1
Miles

Chemical Water Quality

Chemical water quality changes along the mainstem of Thomas Fork are shown in the stream reach graphs below. Chemical long-term monitoring data is utilized to generate line graphs along the stream gradient from headwaters to the mouth. Along the x-axis named tributaries are shown to illustrate sources of water entering the mainstem. A list of long-term monitoring sites utilized to generate the graphs with their river miles are shown below.

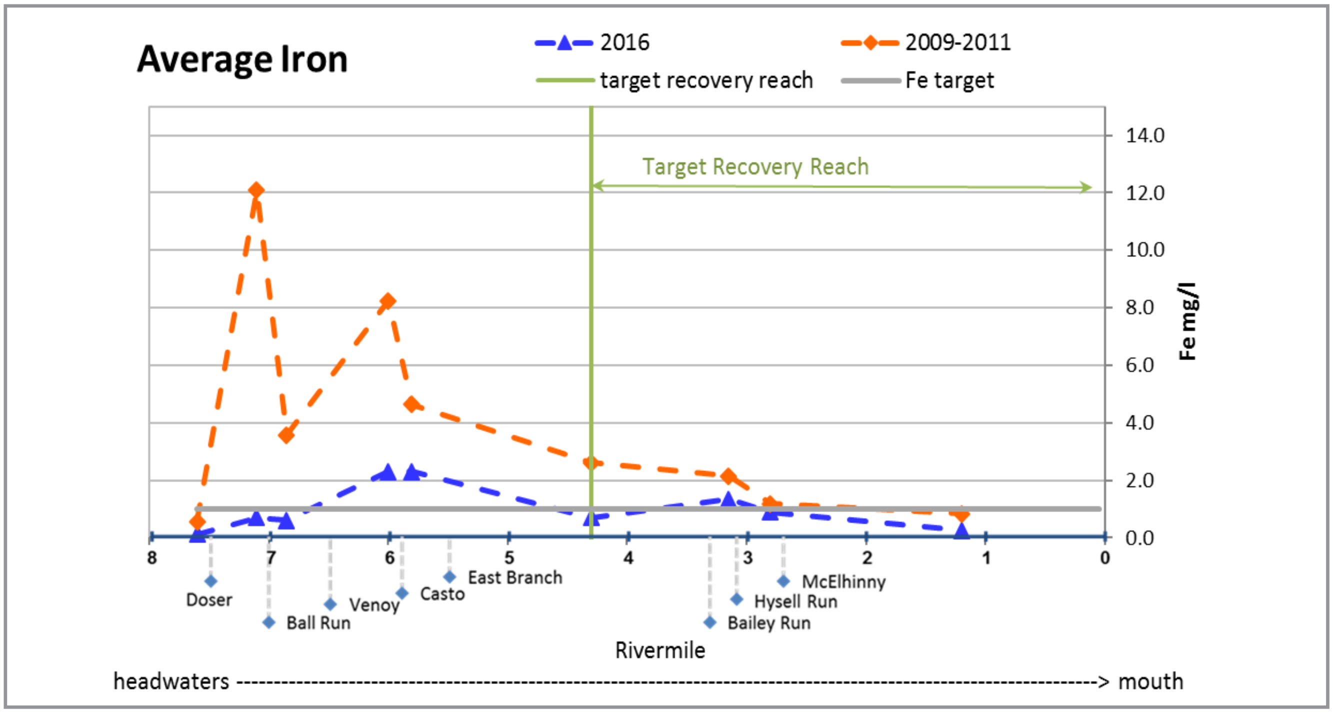
Leading Creek Watershed									
site ID	TF0071	TF0068	TF0064	TF0058	TF0050	TF0030	TF0020	TF0015	TF0010
Rivermile	7.6	7.1	6.85	6	5.8	4.3	3.15	2.8	1.2

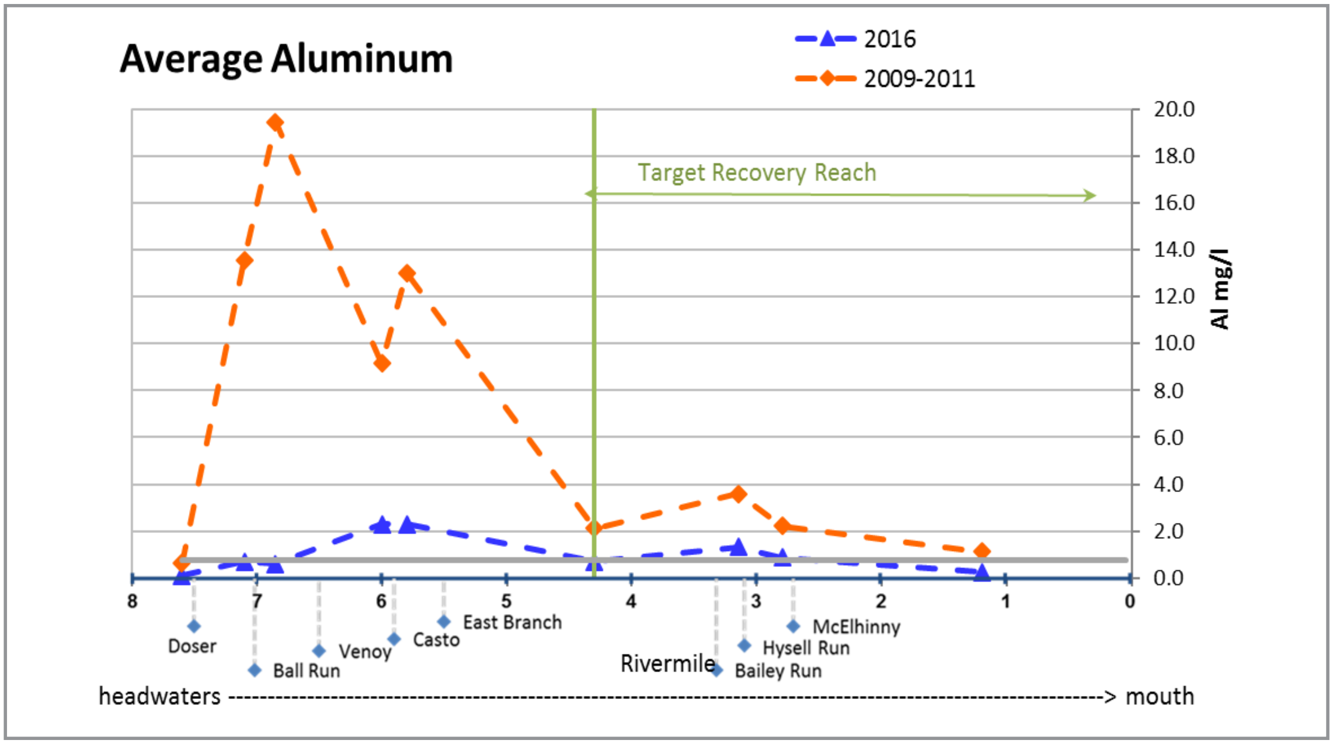




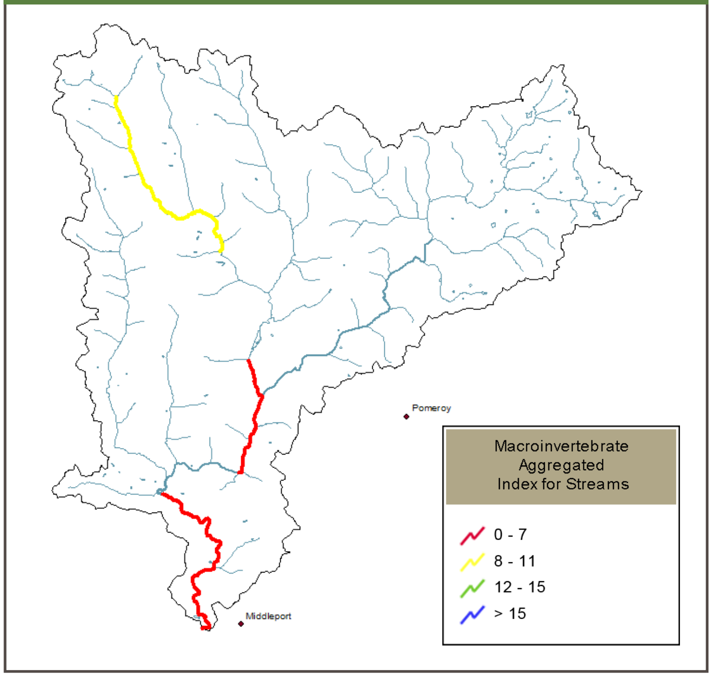
Chemical Water Quality

Leading Creek Watershed									
site ID	TF0071	TF0068	TF0064	TF0058	TF0050	TF0030	TF0020	TF0015	TF0010
Rivermile	7.6	7.1	6.85	6	5.8	4.3	3.15	2.8	1.2

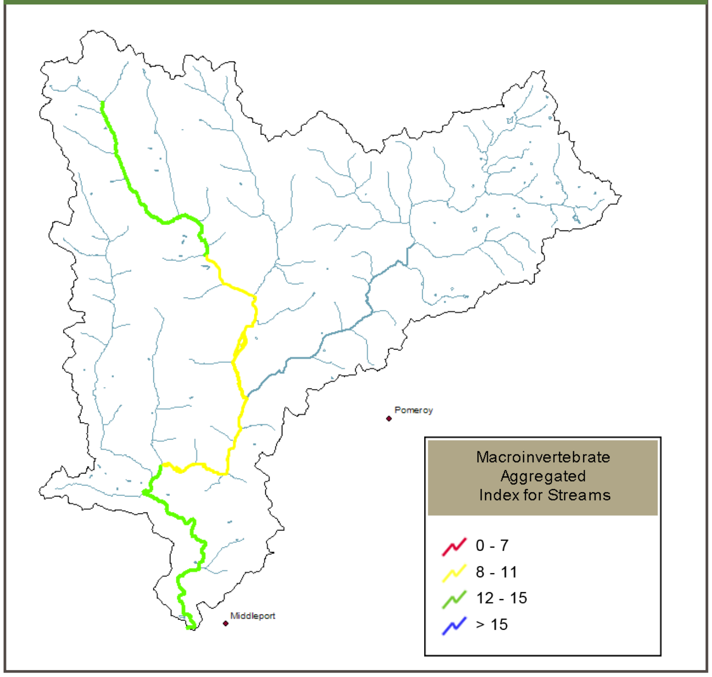




Thomas Fork baseline MAIS



Thomas Fork 2016 MAIS

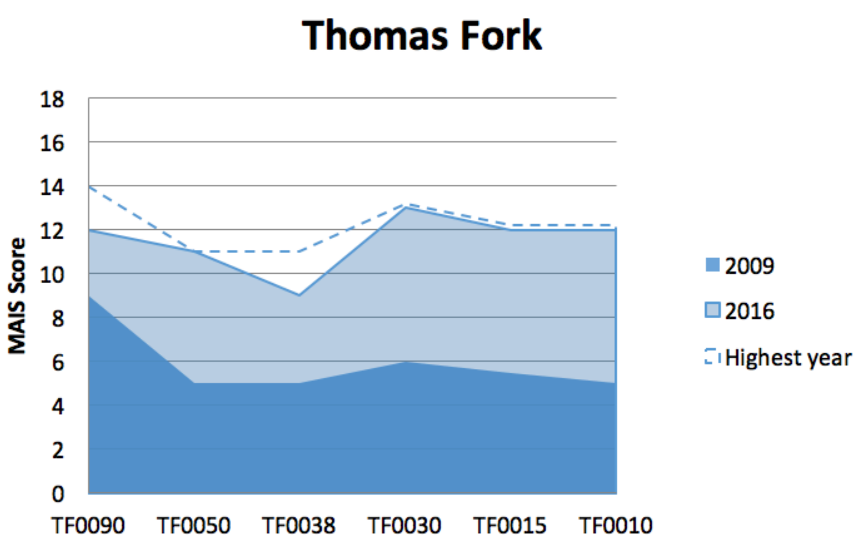


MAIS samples were collected along Thomas Fork a tributary to Leading Creek. These sites are along the mainstem at established long-term monitoring stations, collected from 2009 through 2016.

Thomas Fork

Trends for improvement continued to be evident in Thomas Fork (Leading Creek), at the downstream sites in particular. Overall, biological quality has been higher than the '5's' scored at most of the sites in 2009, 2011 and 2012. Three sites, TF0050, TF0030 and TF0015 earned new high scores of '11', '13' and '12'. This year marked the first statistical improvement in the study reach, at TF0015, and all three downstream sites met the biological target of a MAIS of '12' or higher.

Area of degradation 2009-2016



Thomas Fork MAIS Regressions

	2009	2010	2011	2012	2013	2014	2015	2016	Linear trends	R square	P-value	Years
TF0090	9	13	12	11	14	14	12	12	no change	0.197	0.270	8
TF0050	5	8	3	2	8	6	10	11	no change	0.372	0.109	8
TF0038	5	11	7	5	10	9	10	9	no change	0.183	0.290	8
TF0030	6	12	4	5	10	9	9	13	no change	0.235	0.224	
TF0015	*	8	6	5	9	10	11	12	improved	0.660	0.026	7
TF0010	5	12	5	5	10	9	8	12	no change	0.198	0.269	8

*Missing value was replaced with arithmetic averages of upstream and downstream sites for graphing.

Intentional blank page

References

Johnson, Kelly, 2009. Personal Communications, Ohio University Biological Sciences

Kinney, Chad, 2006. A Comparison of Two Methods of Bioassessment in Streams. Master Thesis at Ohio University.

Kinney, Chad, and Ben McCament, 2010. Screening Guidelines for the Identification of Acid Mine Drainage (AMD) Impaired Watersheds and for Acid Mine Drainage Abatement and Treatment (AMDAT) Plan Selection and Prioritization. Ohio Department of Natural Resources – Division of Mineral Resources Management (ODNR-DMRM) Guidance Document

Kruse, Natalie, Mary W. Stoertz, Douglas H. Green, Jennifer R. Bowman, and Dina L. Lopez, 2014. *Acidity Loading Behavior in Coal-Mined Watersheds.* Mine Water and the Environment 33:177-186.

Stoertz, Mary W. and Douglas H. Green, 2004. Mean Annual Acidity Load: A Performance Measure to Evaluate Acid Mine Drainage Remediation. Ohio Department of Natural Resources Conservation and Restoration Innovations 2004 Applied Research Conference at Ohio University

US Geological Survey (USGS), 2001. *Techniques for estimating selected streamflow characteristics of Rural, unregulated streams in Ohio.* Water-resources investigation report 02-4068. Columbus Ohio.

US Geological Survey (USGS) Stream Stats website – flow characteristics
http://water.usgs.gov/osw/streamstats version 2

LEADING CREEK

	Collection Period	Samples Collected	Duplicates	Blanks
	4/25/16 – 10/24/16	28	3	1
Percent of Samples		-	11%	3.6%

Percent Difference from Lab and Field

Leading Creek	% Difference pH	% Difference Conductivity
Range	0.6-17.2	0-22.0
Median	4%	3.5%

Percent Difference of Duplicate Samples (2)

	% Difference pH	% Difference Conductivity	% Difference Iron	% Difference Aluminum	% Difference Acidity	% Difference Alkalinity
Range	0.43-0.4	0.2-1.2	2.0-7.0	2.3-5.6	2.8-3.8	0.3-1.0
Median	NA	NA	NA	NA	NA	NA

MONDAY CREEK

Monday Creek	Collection Period	Samples Collected	Duplicate Samples	Blanks
	2/22/16 – 12/20/16	250	16	5
Percent of Samples		-	6.4%	2%

Percent Difference from Lab and Field

	% Difference pH	% Difference Conductivity
Range	0-30.0	0-196.0
Median	4.6	1.0

Percent Difference of Duplicate Samples (16)

	% Difference pH	% Difference Conductivity	% Difference Iron	% Difference Aluminum	% Difference Acidity	% Difference Alkalinity
Range	0-6.2	0-1.7	0-51.5	0-51.3	0-13.1	0-21.2
Median	1.7	0.5	2.2	1.9	4.1	4.1

RACCOON CREEK

Raccoon Creek	Collection Period	Samples Collected	Duplicates	Blanks
	3/30/16 – 12/12/16	198	18	14
Percent of Samples			9%	7%

Percent Difference from Lab and Field

	% Difference pH	% Difference Conductivity
Range	0-20.9	0-97.6
Median	4.7	2.0

Percent Difference of Duplicate Samples (18)

	% Difference pH	% Difference Conductivity	% Difference Iron	% Difference Aluminum	% Difference Acidity	% Difference Alkalinity
Range	0-2.5	0-1.3	0-163.6	0-70.3	0-5.8	0-15.1
Median	0.5	0.6	2.4	1.6	1.7	0.5