2017–2018 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

6-30-2019

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Table of Contents

Specific AMD project entry forms used for report 2018 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'.

ACKNOWLEDGMENTS

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. We would like to thank and acknowledge the following people for their input and contributions towards this project:

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Monday Creek: Nate Schlater and Tim Ferrell
Sunday Creek: Michelle Shively
Huff Run: Marissa Lautzenheiser
Leading Creek: Jim Freeman

We 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.

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Voinovich School – Elkan Kim (watersheddata.com), Lindsey Siegrist (graphic design), Kyoung Lim (assistant programmer), and Natalie Kruse (research).

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, Mud Run, Yellow Creek, 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) and ODNR-DMRM acid mine drainage restoration and reclamation efforts. 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 targets based on their fish and macroinvertebrate index scores are recorded. As of 2016, approximately 46 additional stream miles of the 142 miles assessed for biology suggest they meet full attainment of the Warmwater Habitat Status. In the headwaters of Raccoon Creek from East Branch and West Branch confluence to Lake Hope dam, 20 stream miles were improved to meeting targets for both macroinvertebrates and fish. Along Raccoon Creek mainstem from Elk Fork tributary to Flat Run tributary, 20.3 miles improved to meet targets. OEPA TMDL data was collected in Raccoon Creek during 2016, results of this report will be available on OEPA's website in 2019, and preliminary results are shown in Figure 1. 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. 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 199 miles of the 210 miles monitored met the pH 6.5 water quality standard in 2017-2018. Since baseline conditions established approximately in 2000, a total of 93.2 miles are now suggestive of meeting Warmwater habitat, 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, biennial 2017-2018. Incremental changes from year to year can be tracked using these indicators. Net alkalinity and pH values have improved from 2006 to 2018. The family-level biological indicator, Macroinvertebrate Aggregated Index for Streams (MAIS), were measured annually from 2006 to 2016, biennial 2017-2018. Macroinvertebrate communities across the watersheds generally remained the same in 2017-2018 or showed continued improvement. Most notable improvements were in the West Branch of Sunday Creek, where all sites scored above the target of 12. On the Sunday Creek mainstem, there were several new high scores and the most downstream site near the mouth met the restoration target of 12 for the first time in monitoring history. Continued biological recovery occurred in Thomas Fork, where a second site (TF0050) met criteria for statistical improvement (P-value = 0.019) and in Huff Run, where a third site (HRR04 at RM 4.8) met criteria for statistical improvement (P-value =0.039).

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 online reporting system, www.watersheddata.com, has been created to track environmental changes in seven watersheds: Raccoon Creek, Monday Creek, Sunday Creek, Huff Run, Mud Run, Yellow Creek, and Leading Creek. These watersheds represent where active AMD reclamation projects have been 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 report is available online at watershedata.com.

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. For the time period 2017-2018 the following projects were added to the AMD project collection: Daniels Reclamation in Raccoon Creek Watershed, Holmes AMD wetland in Mud Run, and Jensie AMD Phase II in Yellow Creek Watershed.

The "Biennial 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 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.

Ohio EPA surveyed Raccoon Creek in 2016, concluding that the entire mainstem of Raccoon Creek meets warm water habitat (WWH), with the exception of one site (MSBC100) in the headwaters which met only one of the two required metrics for full attainment. In fact, waters from Raccoon Creek mouth near Gallipolis, to the town or Vinton, nearly 40 river miles, meet exceptional warm water habitat (EWH), the highest quality to be expected in Raccoon Creek (Figure 1). Biological fish data collected from 2010 to 2016 suggest that 6.2 miles in Sunday Creek, shown in green in Figure 2, meet warm water habitat.

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: Raccoon Creek Recovery Status to 2018

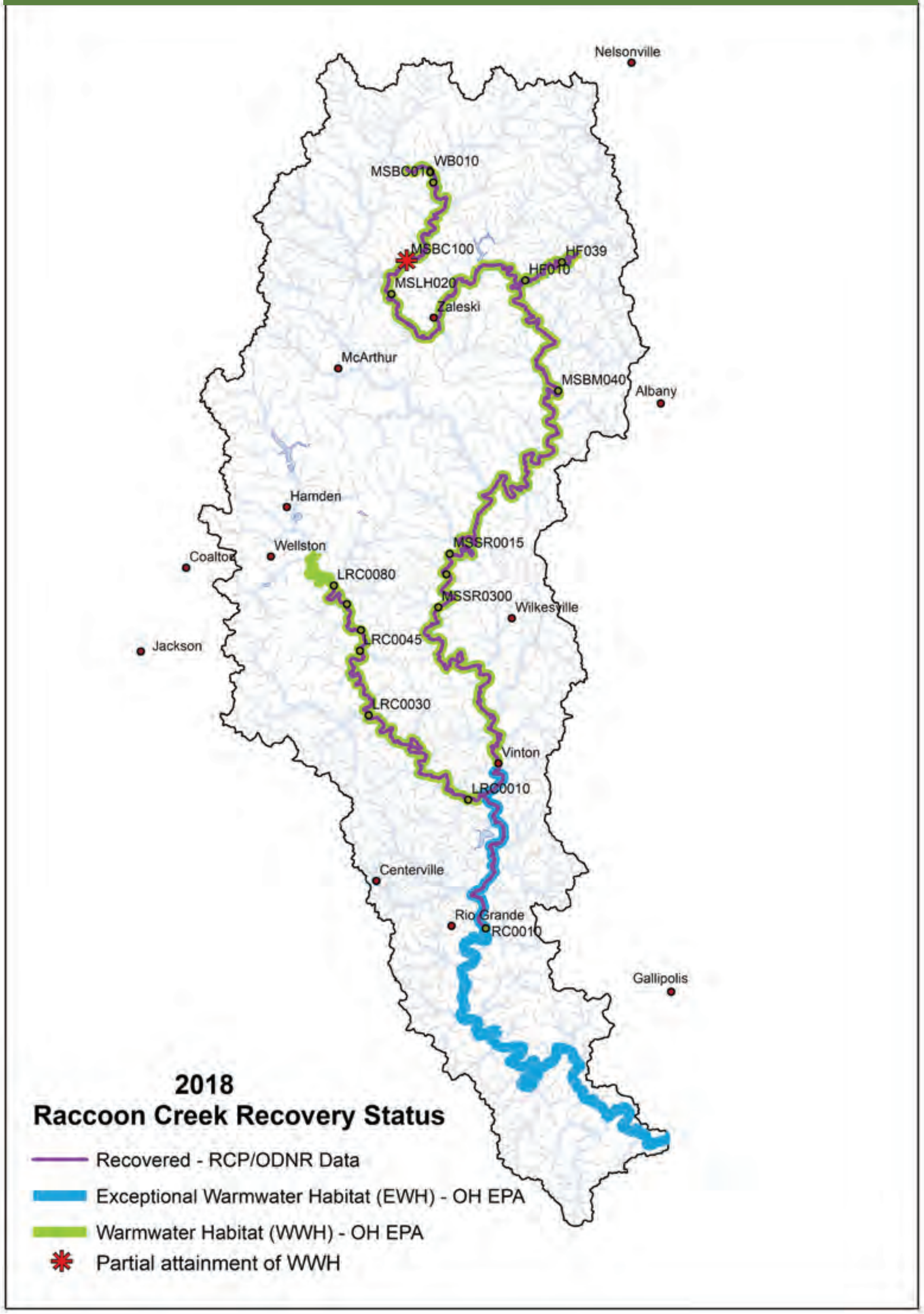


Figure 2: Biological health improvement in Sunday Creek West Branch from 2005 to 2018.

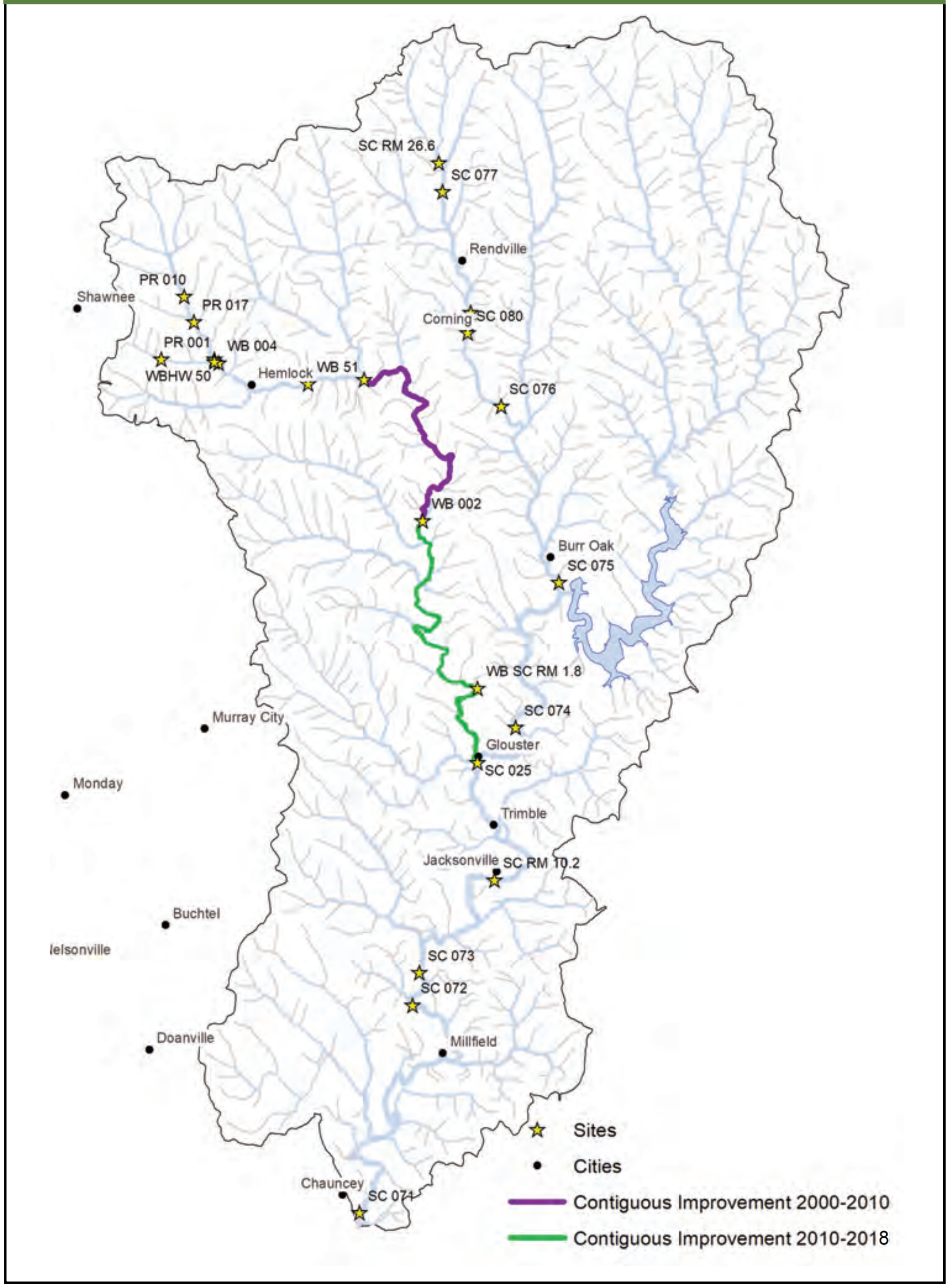


Table 1. Summary of results for each of the five watersheds evaluated from 2005 to 2018: Raccoon Creek, Monday Creek, Sunday Creek, Huff Run, and Leading Creek.

Watershed	Total number of completed projects	Total costs	Total acid load reduction lbs/day 2017–2018	Total metal load reduction lbs/day 2017–2018	Stream miles meeting pH target/ Stream miles monitored
Raccoon Creek	21	$15,222,655	2,645	573	110/116
Monday Creek	18 (plus 5 subsidence projects, costs are not included)	$7,496,369	4,006	393	27.5/33
Sunday Creek	12 (7 of 10 are subsidence projects)	$2,718,273	Insufficient data for calculation in 2017-2018 sampling period	1.25	42.8/43
Huff Run	14	$5,644,950	Insufficient data for calculation in 2017-2018 sampling period	Insufficient data for calculation in 2017-2018 sampling period	9.3/10
Leading Creek	2	$728,481	663	234	9/9
Total	**67**	**$31,810,728**	**7,314**	**2,101**	**198.6/210**

Reductions

Acid Load Reductions 2017-2018 = 7,314 lbs/day

Metal Load Reductions 2017-2018 = 2,101 lbs/day

Costs

Total to date reclamation costs = $31,810,728

RACCOON CREEK WATERSHED REPORT

2017–2018 NPS Report - Raccoon Creek Watershed

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

Reductions

Total acid load reduction = 2,645 lbs/day
Total metal load reduction = 573 lbs/day

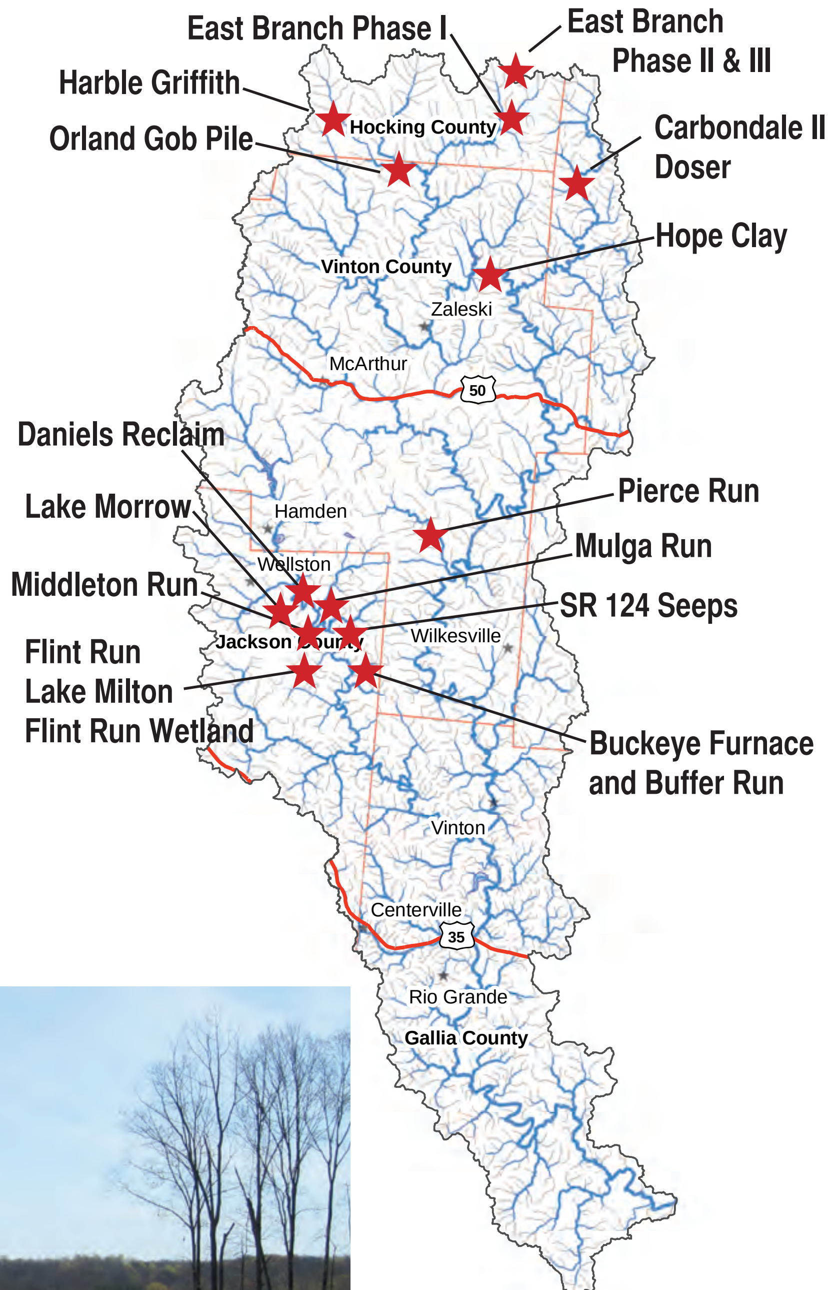
Data derived using the Stoertz Water Quality Evaluation Method (Kruse et al., 2014)

Acid and metal load reductions based on projects monitored during 2018 listed here: Carbondale Doser, Mulga Run, Flint Run, Lake Milton, East Branch I, II, & III, and Middleton Run II.

Cost

Design = $1,905,243
Construction = $13,317,412

Total Costs through 2018 = $15,222,655



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
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
2017	• 2017 Lake Milton, Flint Run, and Carbondale, maintenance projects completed
2018	• Daniels Reclamation Project completed

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 (FR0210) – 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*

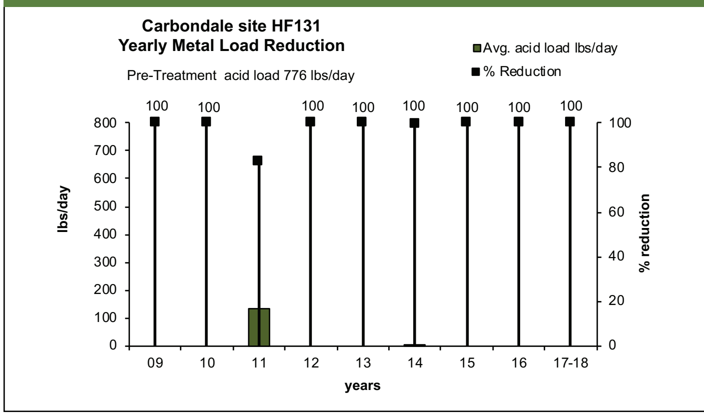
2018 Daniels Reclaimation Project (DaR0051, DaR0052, DaR0053, DaR0054, DaR0055, DaR0056) - Drained and filled strip pits on 10 acre spoil, reconnected positive drainage, mitigated toxic spoil, resoiled and revegetated.

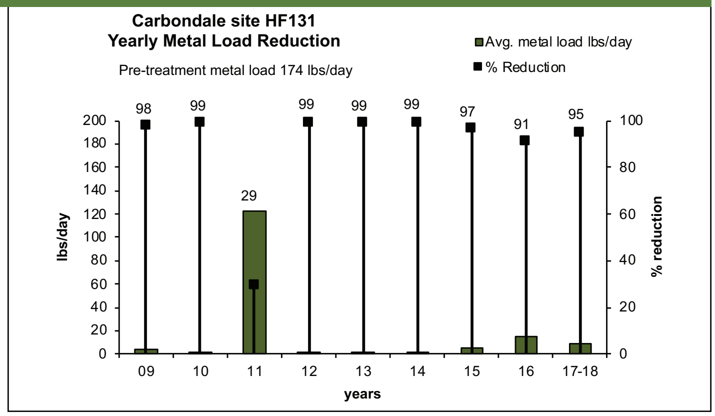
Italicized indicated projects are not actively monitored for acid mine drainage and metal load reduction purposes

Yearly acid and metal load reduction trends per project

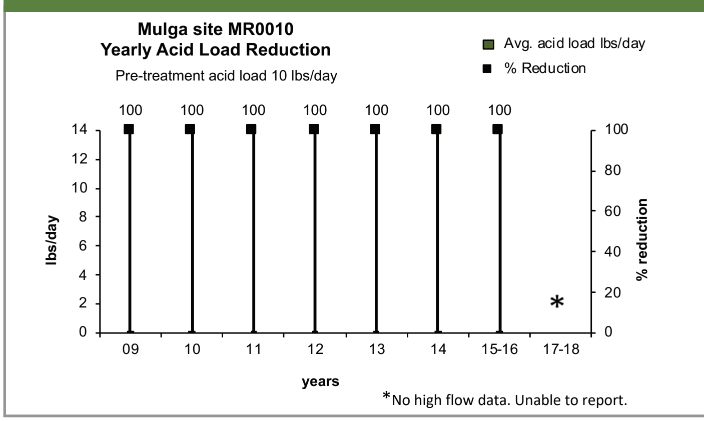
Similar to other environmental best management practices (BMPs), performance of passive acid mine drainage reclamation projects are also expected to decline with time. Active treatment systems are not expected to decline with time but sometimes need to be maintained to perform adequately. Operation and 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.

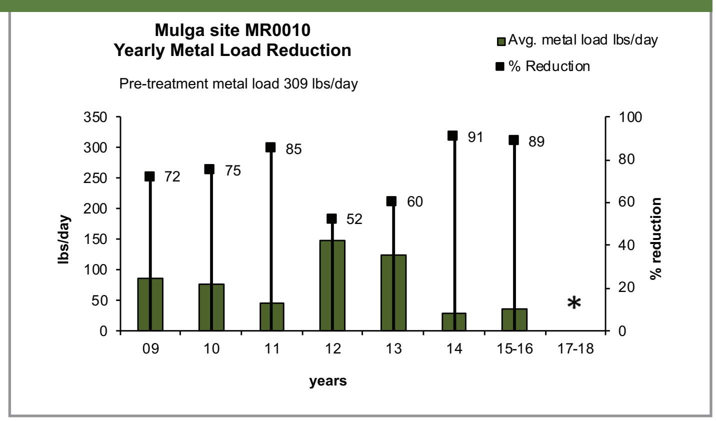
Carbondale site HF131



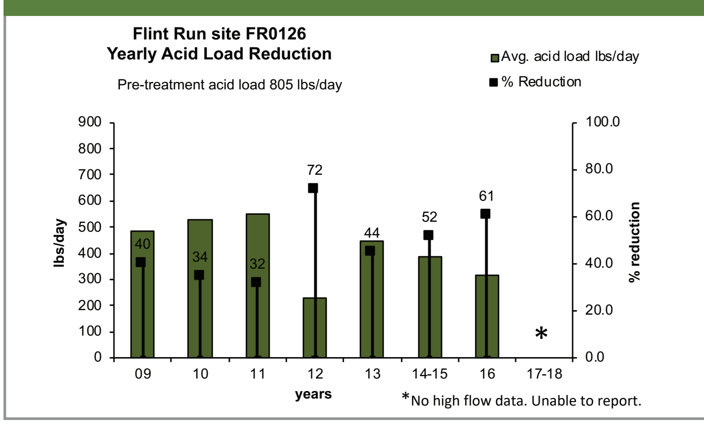


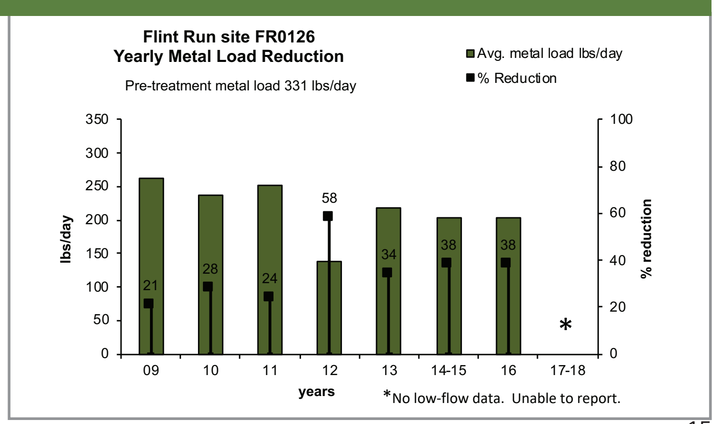
Mulga site MR0010





Flint Run site FR0126





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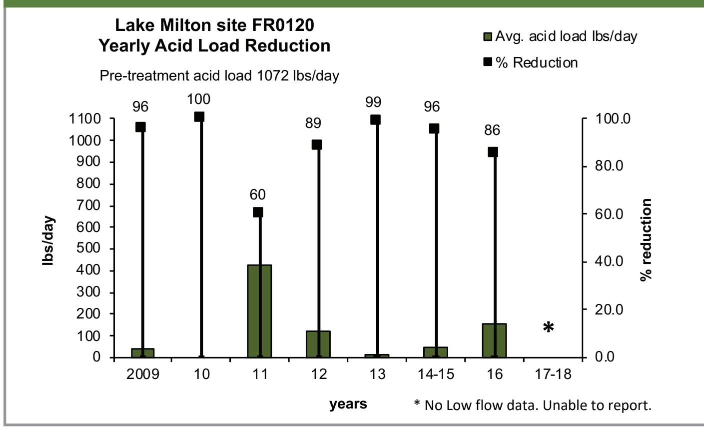
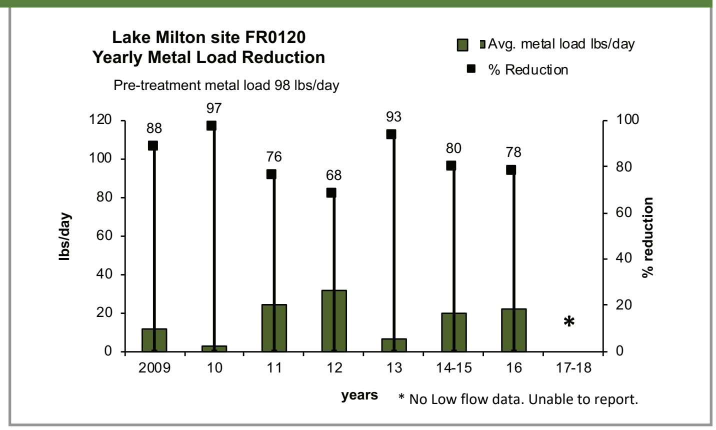
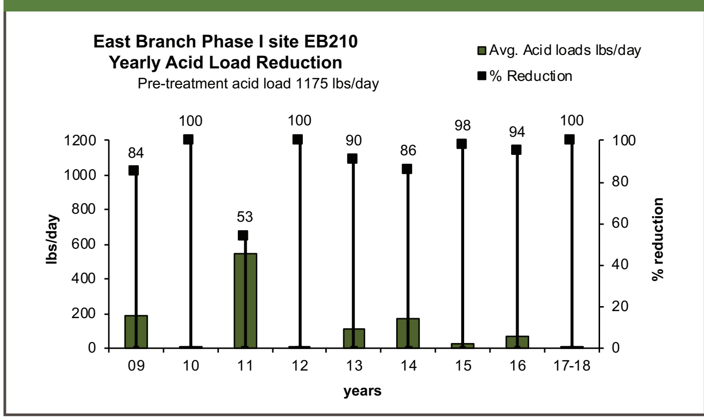
Yearly acid and metal load reduction trends per project

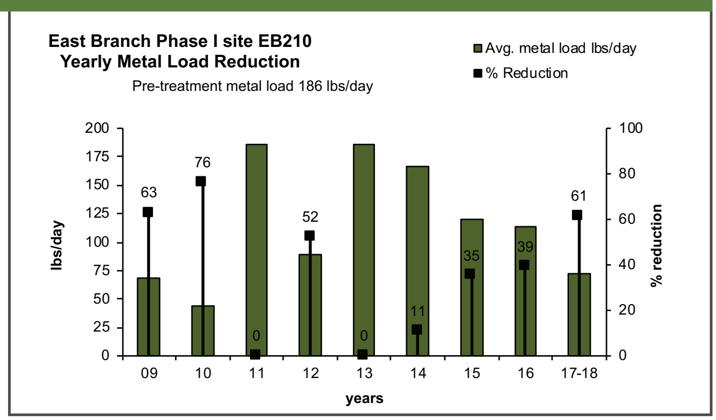
Lake Milton site FR0120



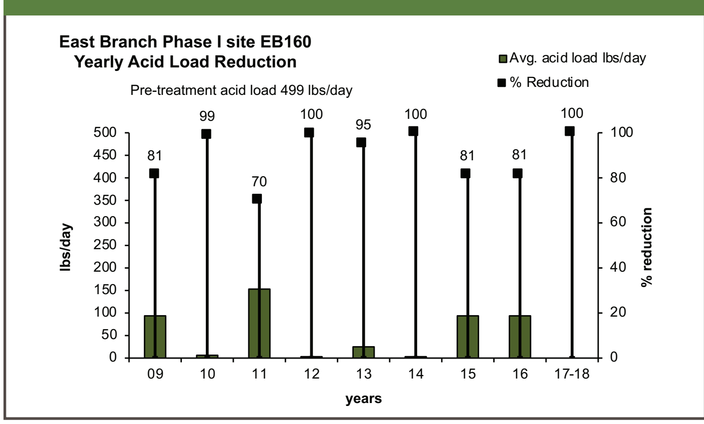


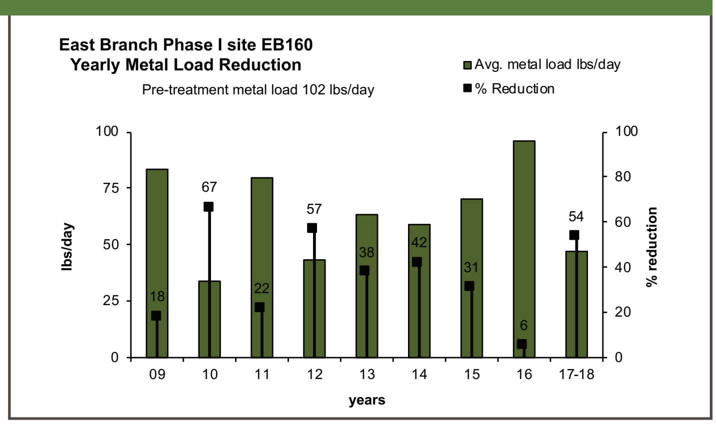
East Branch Phase I site EB210





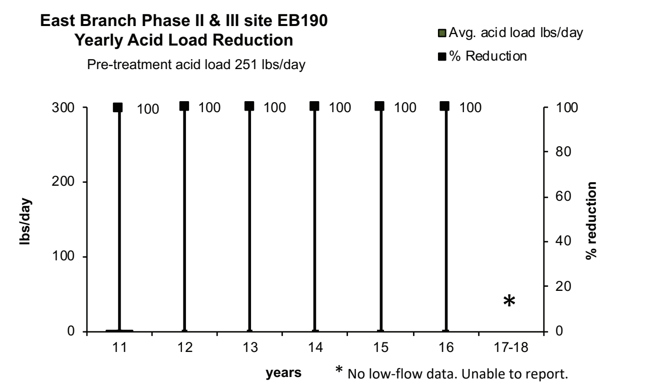
East Branch Phase I site EB160



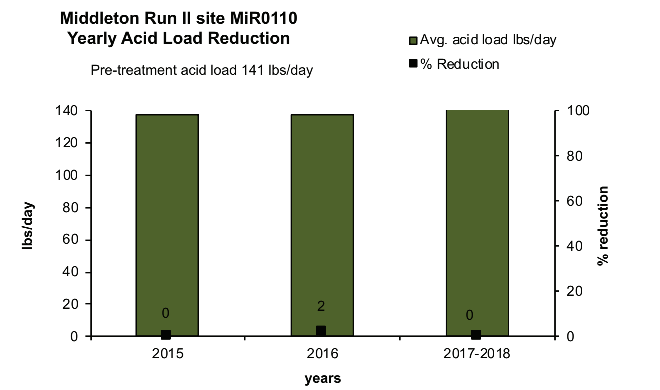


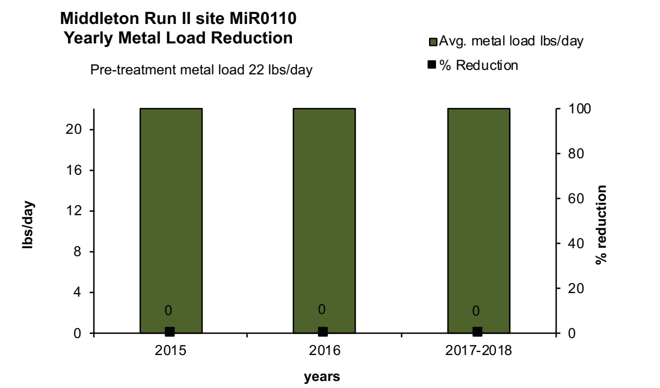
Yearly acid and metal load reduction trends per project

East Branch Phase II & III site EB190

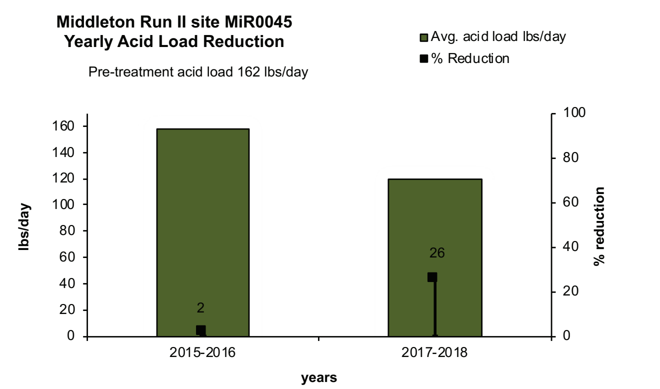


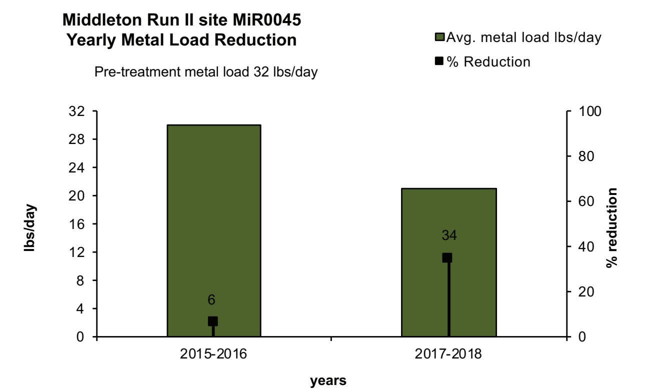
Middleton Run II site MiR0110





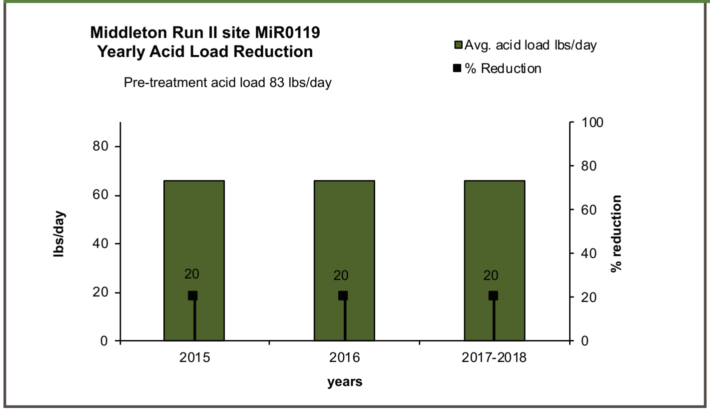
Middleton Run II site MiR0045

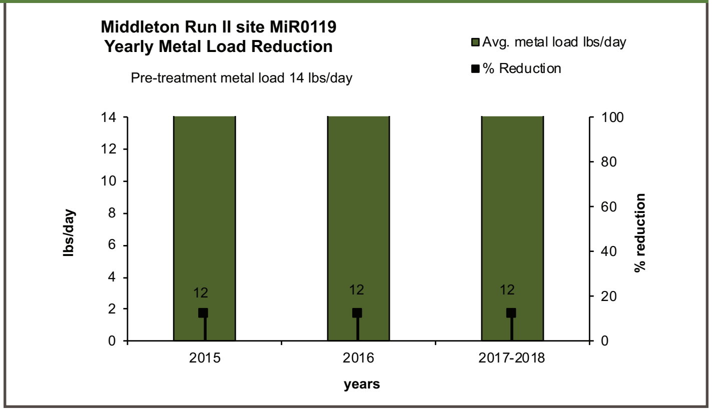




Yearly acid and metal load reduction trends per project

Middleton Run II site MiR0119





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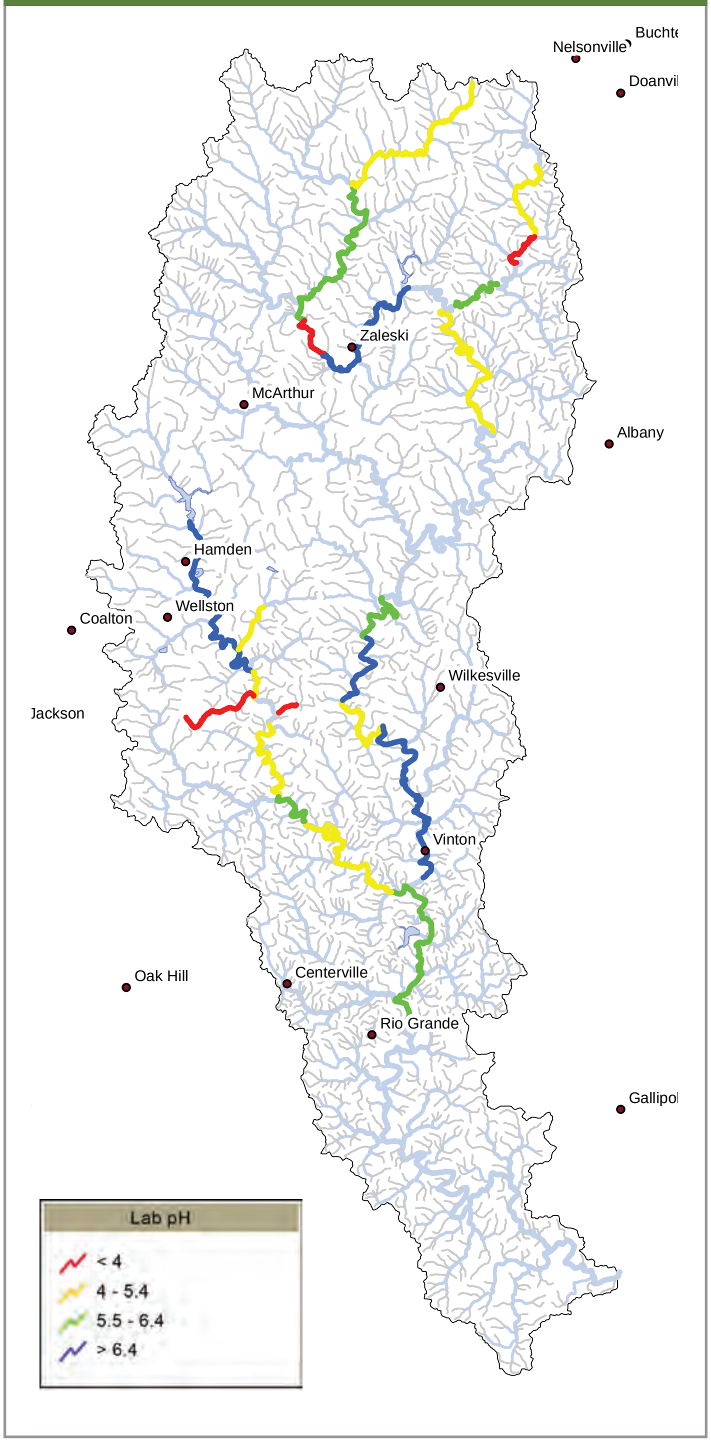
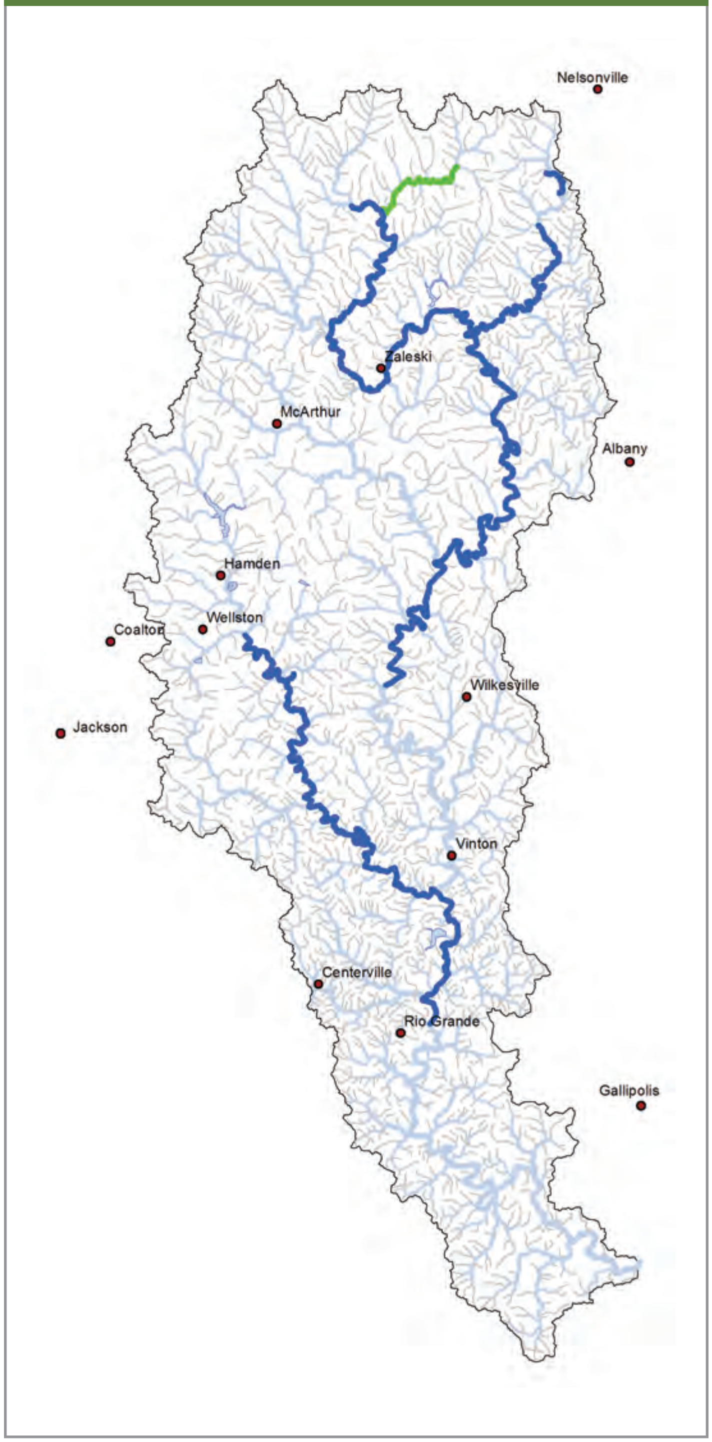
Chemical Water Quality

Raccoon Creek baseline pH



Raccoon Creek 2017–2018 pH

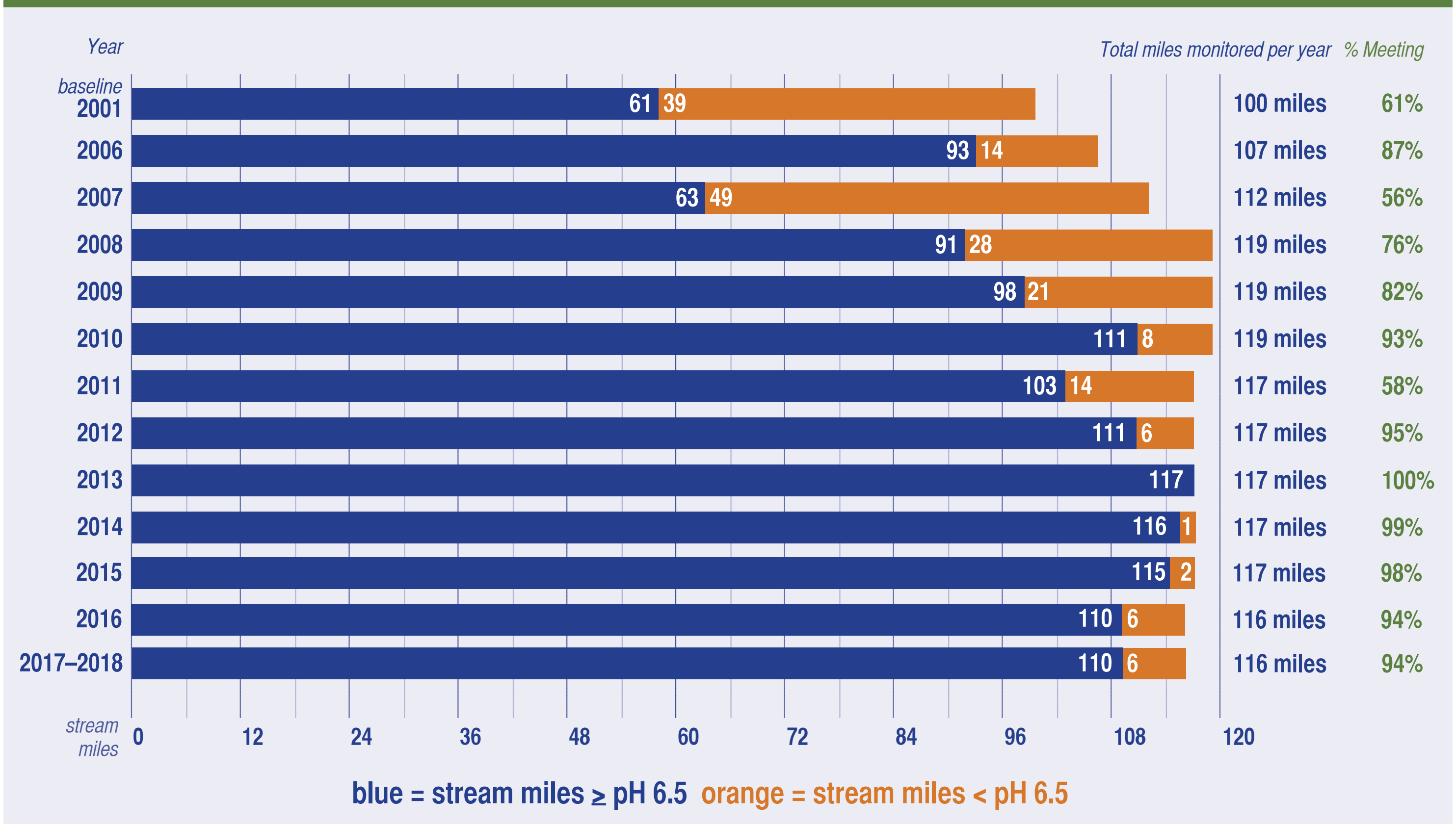


In Raccoon Creek pH values have improved throughout the watershed from baseline conditions (1994-2001) to 2018. Raccoon Creek mainstem, Hewett Fork and Little Raccoon Creek average pH values have increased from a range of 4.0- 5.4 during baseline to all meeting the pH target of 6.5 in 2018, except for a 6.0 stream mile section at the mouth of East Branch. Of the miles of stream monitored in 2017–2018, 14.8 river miles in Hewett Fork (Site HF190 was not monitored during 2017-2018, but field testing in early 2019 indicated the site met pH targets), 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 2018, all but 6.0 of 117 miles of stream miles monitored met the pH target (pH > 6.5).

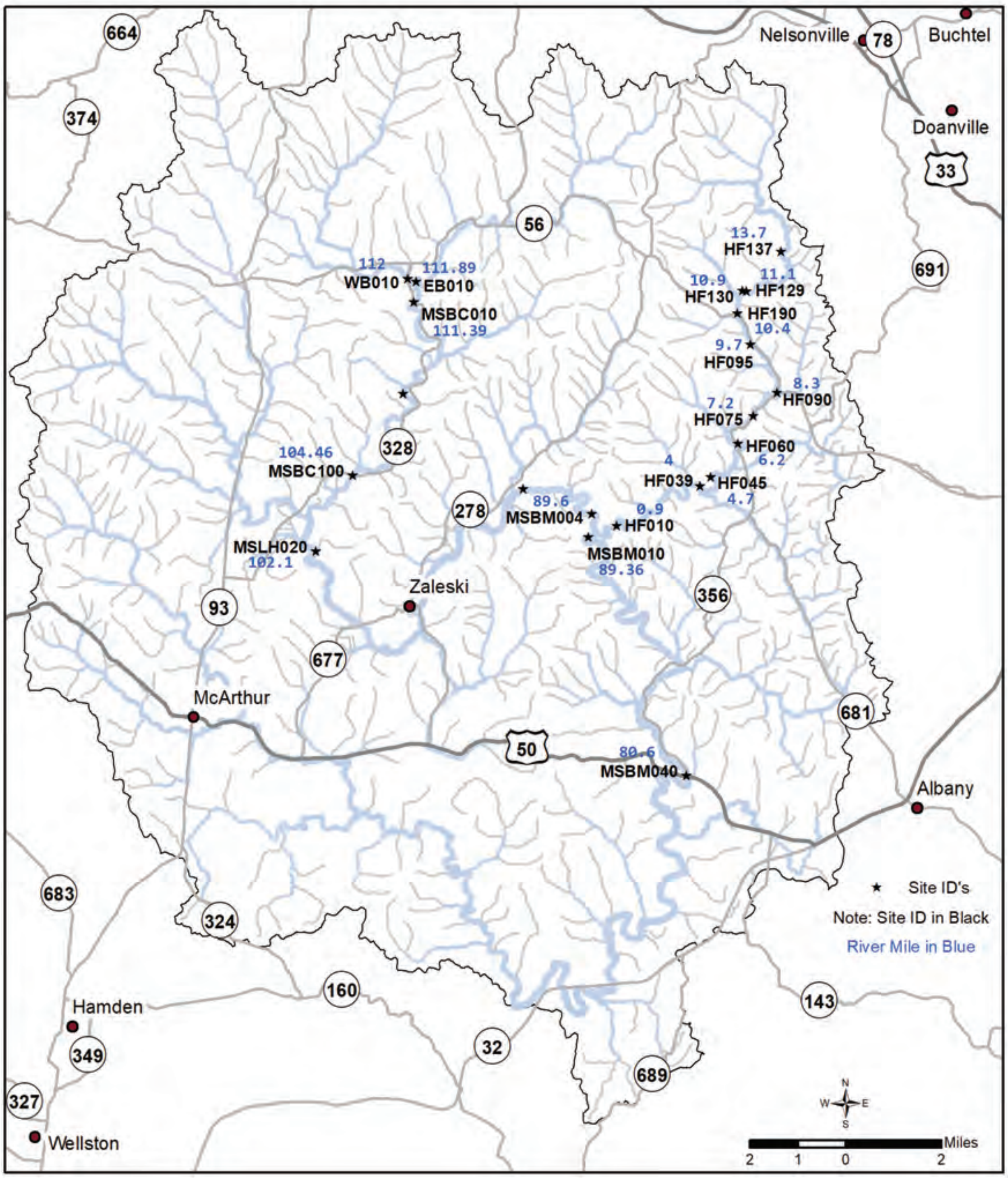
Raccoon Creek total stream miles monitored for pH through time from 2001-2018.



Chemical water quality analysis per stream reach

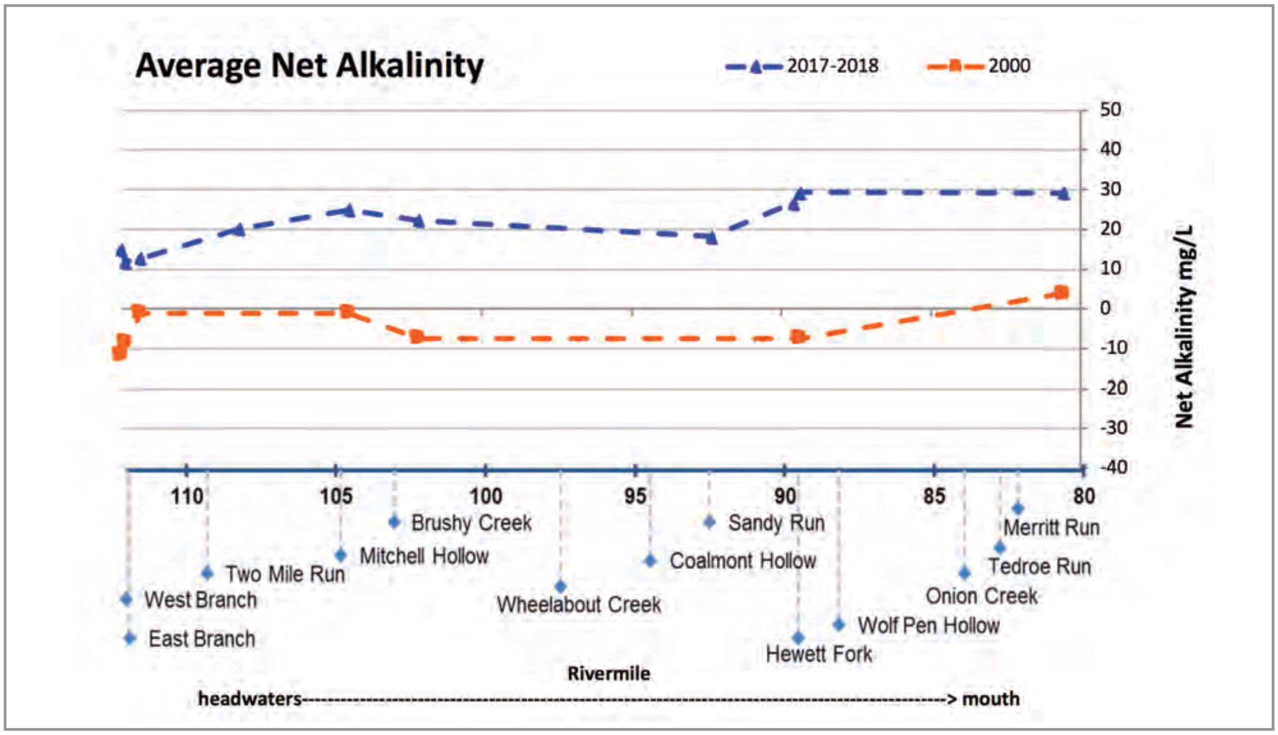
For purposes of analyzing chemical water quality changes along the mainstem of receiving stream where AMD reclamation projects have been completed, Raccoon Creek has been divided into the following stream segments: Raccoon Creek Mainstem, Little Raccoon Creek, and Hewett Fork. Within these stream reaches, 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.

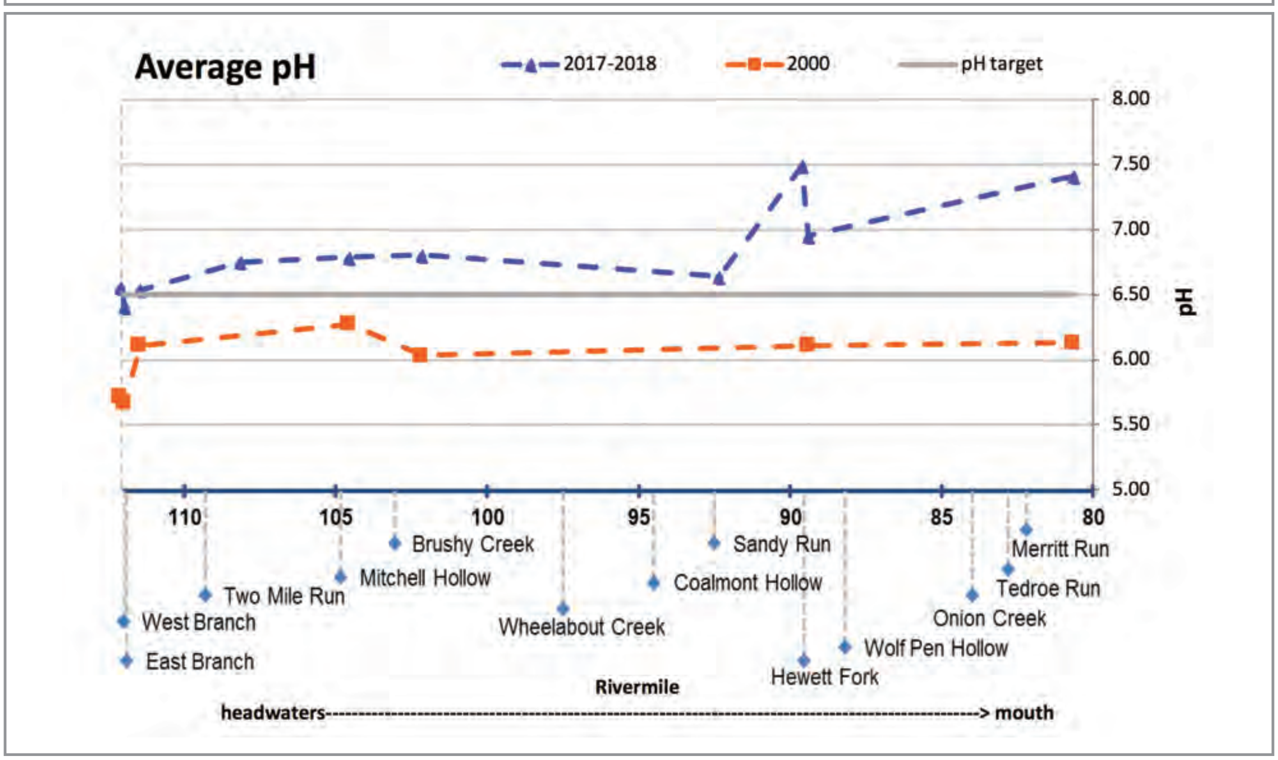
Raccoon Creek Mainstem



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

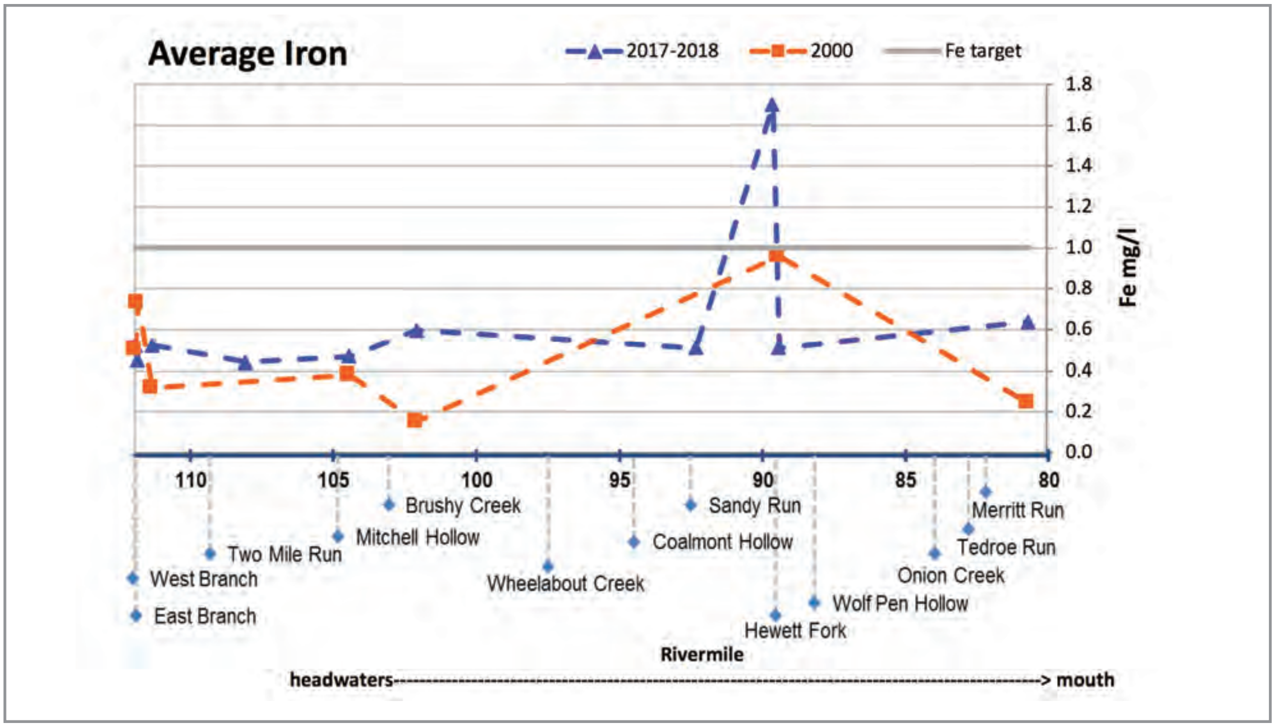


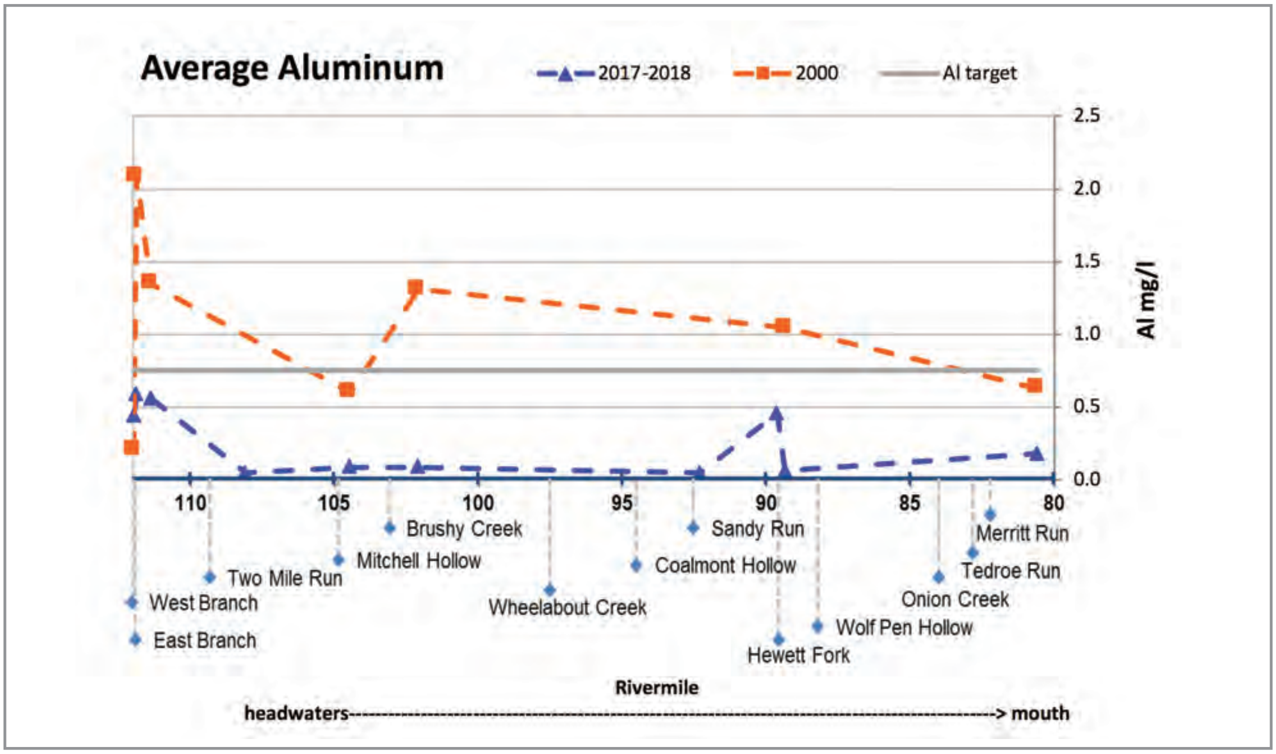


Chemical water quality analysis per stream reach

Raccoon Creek Mainstem

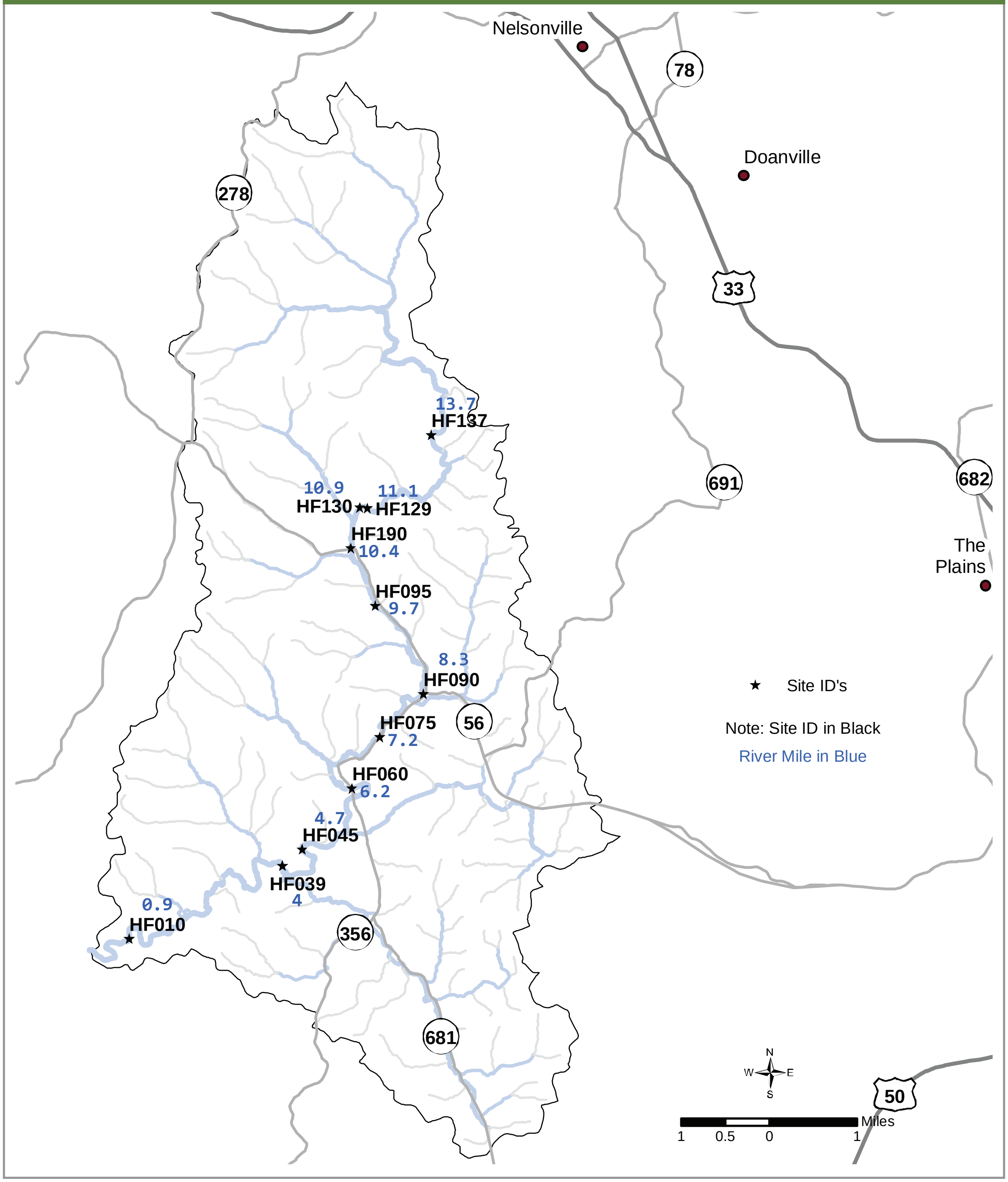
Site ID	WB010	EB010	MSBC010	MSBC015	MSBC100	MSLH020	MSLH130	MSBM004	MSBM010	MSBM040
Rivermile	112	111.89	111.39	108.1	104.46	102.1	92.3	89.6	89.36	80.6





Chemical water quality analysis per stream reach

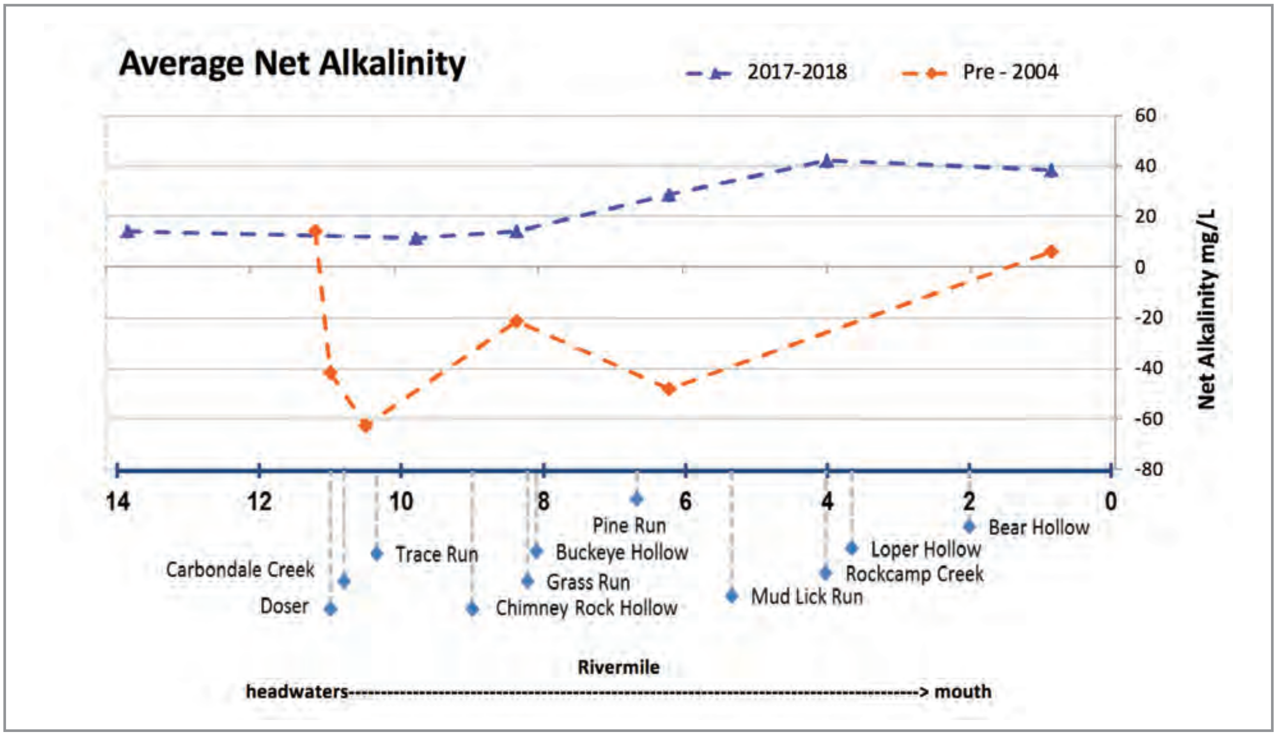
Hewett Fork

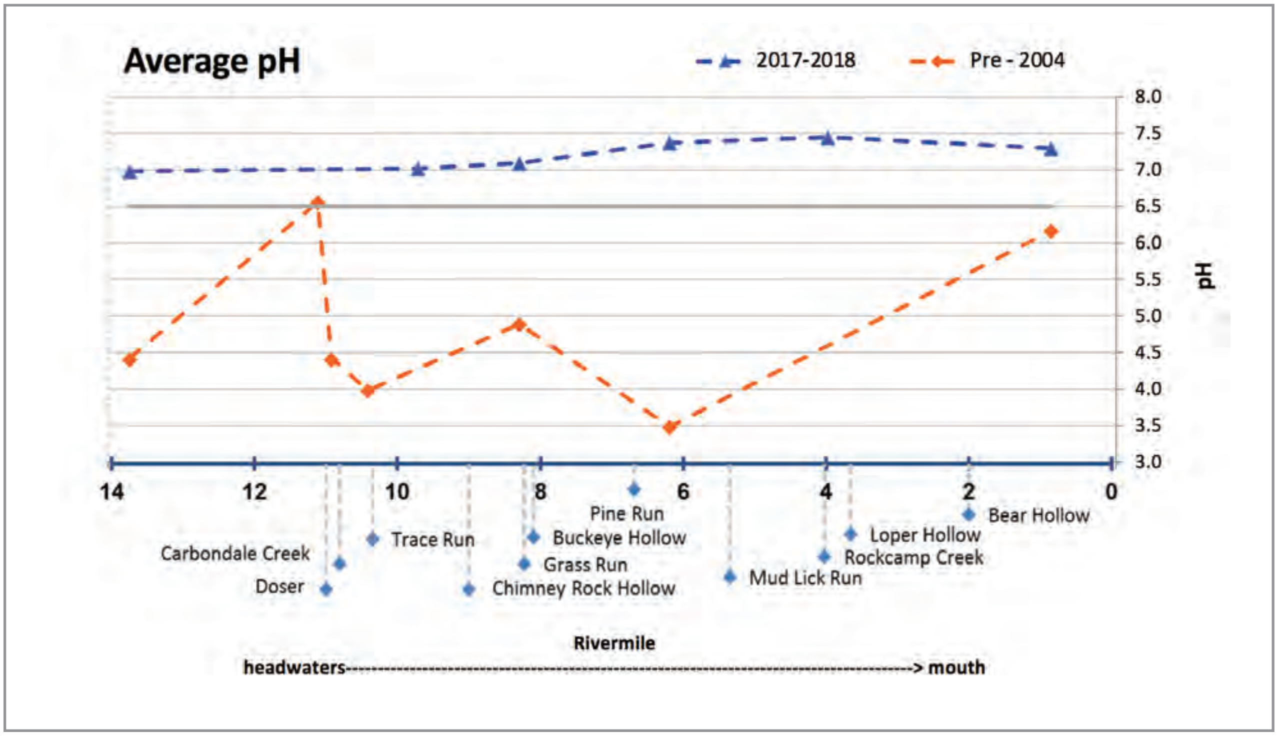


Chemical water quality analysis per stream reach

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



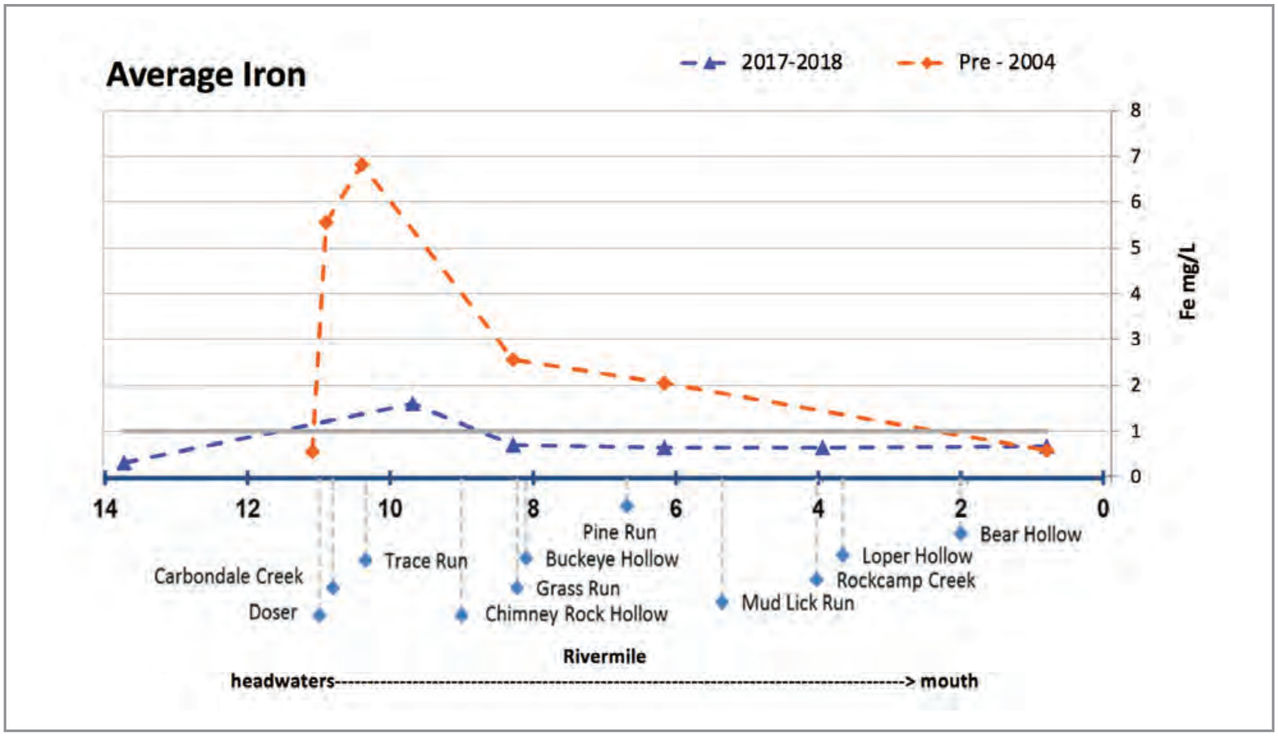


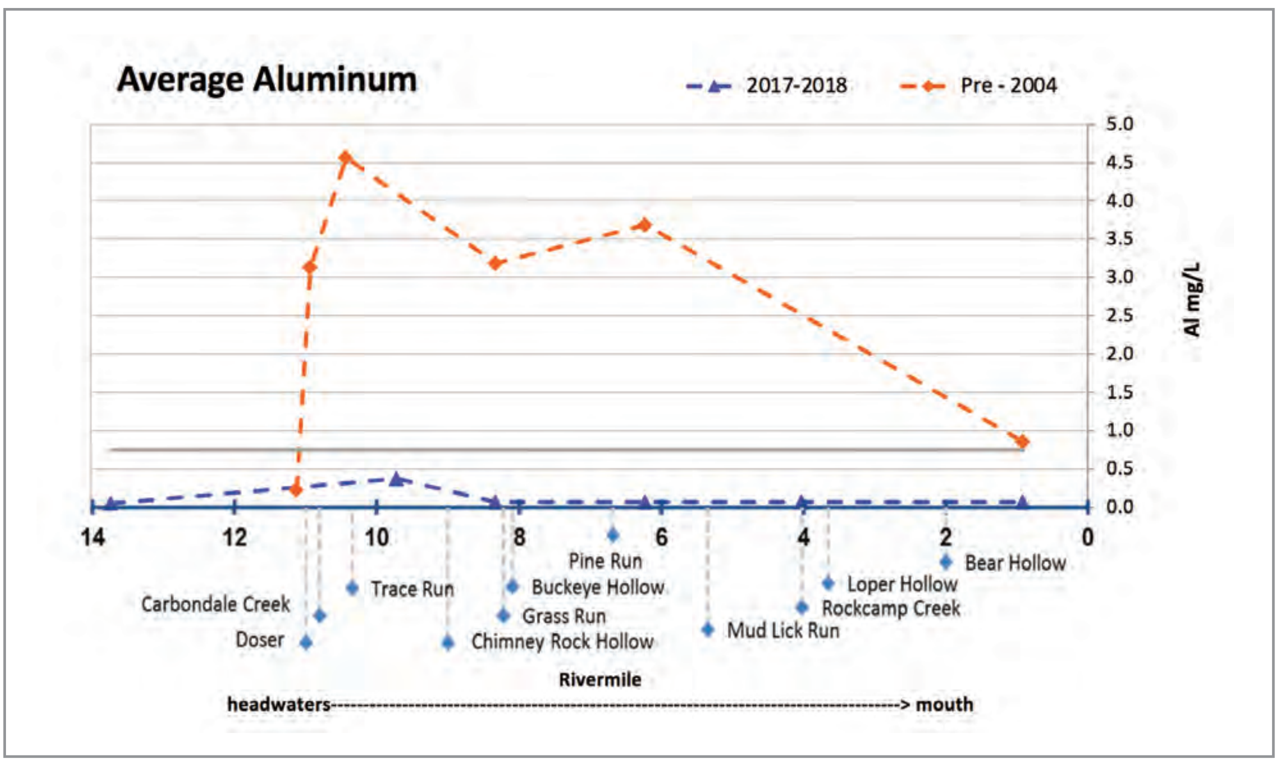
Chemical water quality analysis per stream reach

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

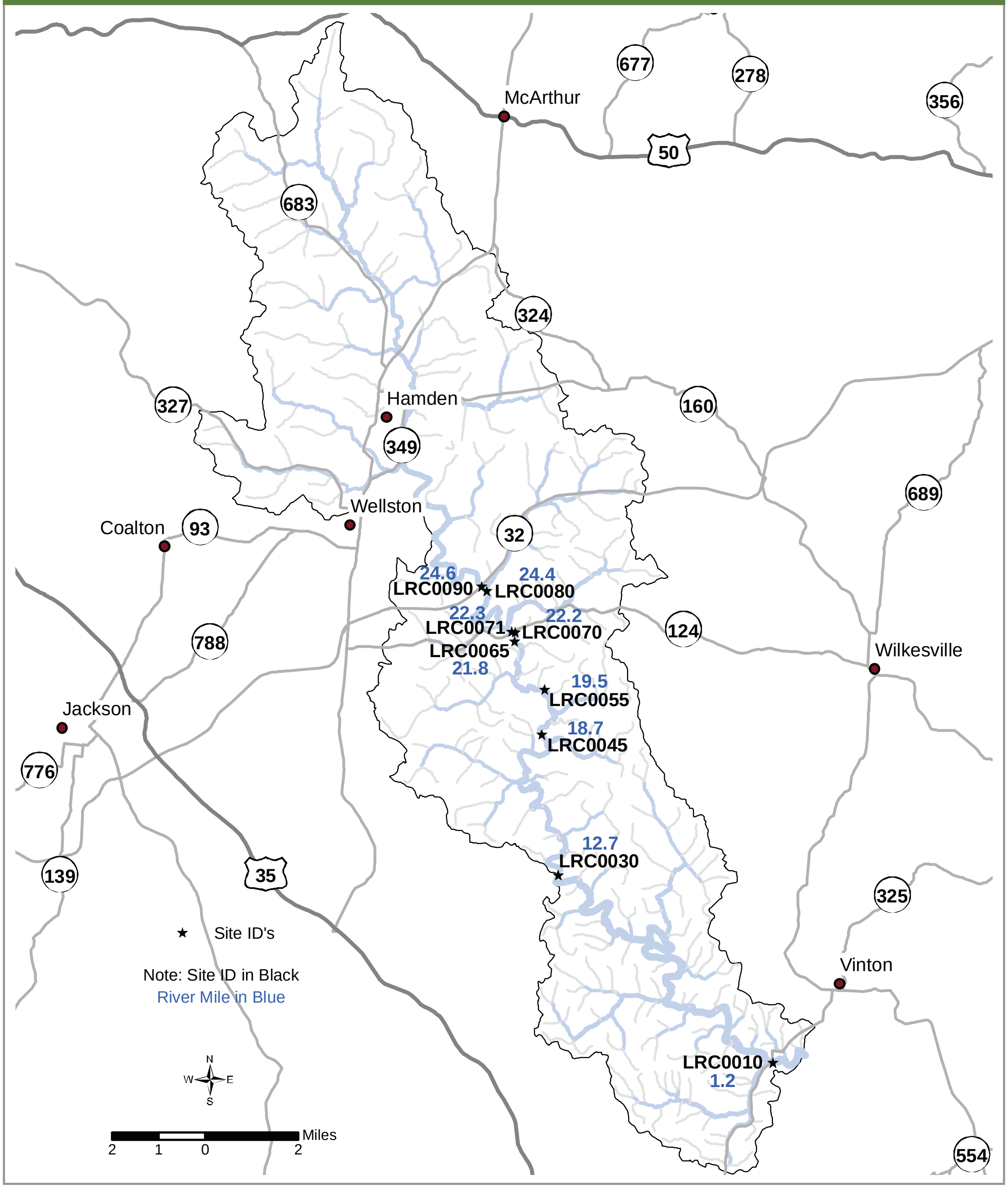
Note: Lime Doser installed in 2004 at RM 11





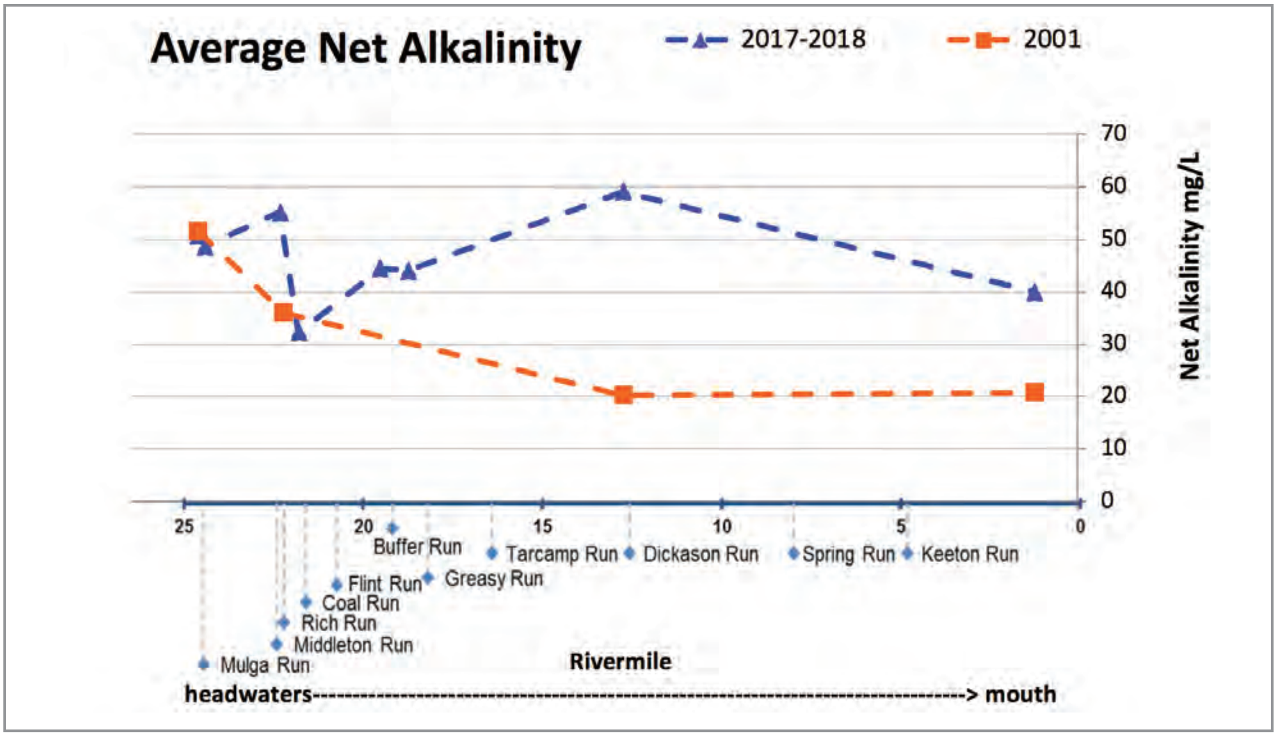
Chemical water quality analysis per stream reach

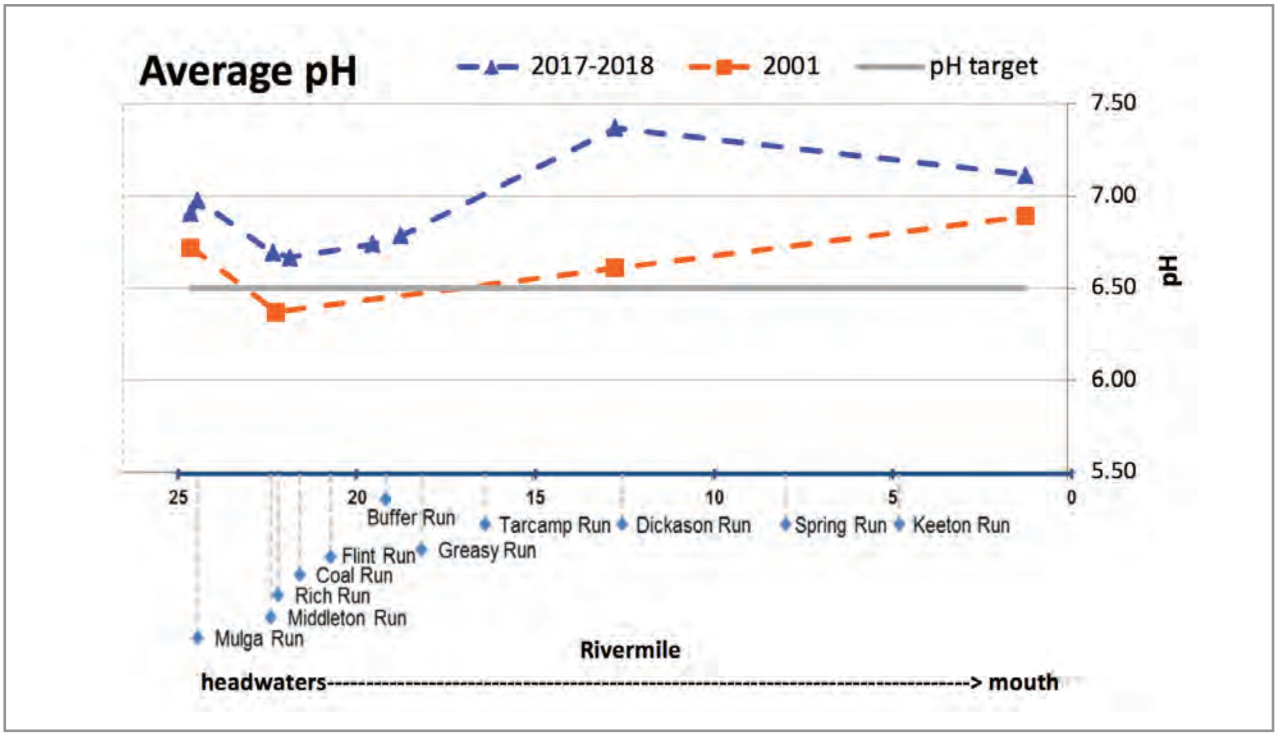
Little Raccoon Creek



Chemical water quality analysis per stream reach

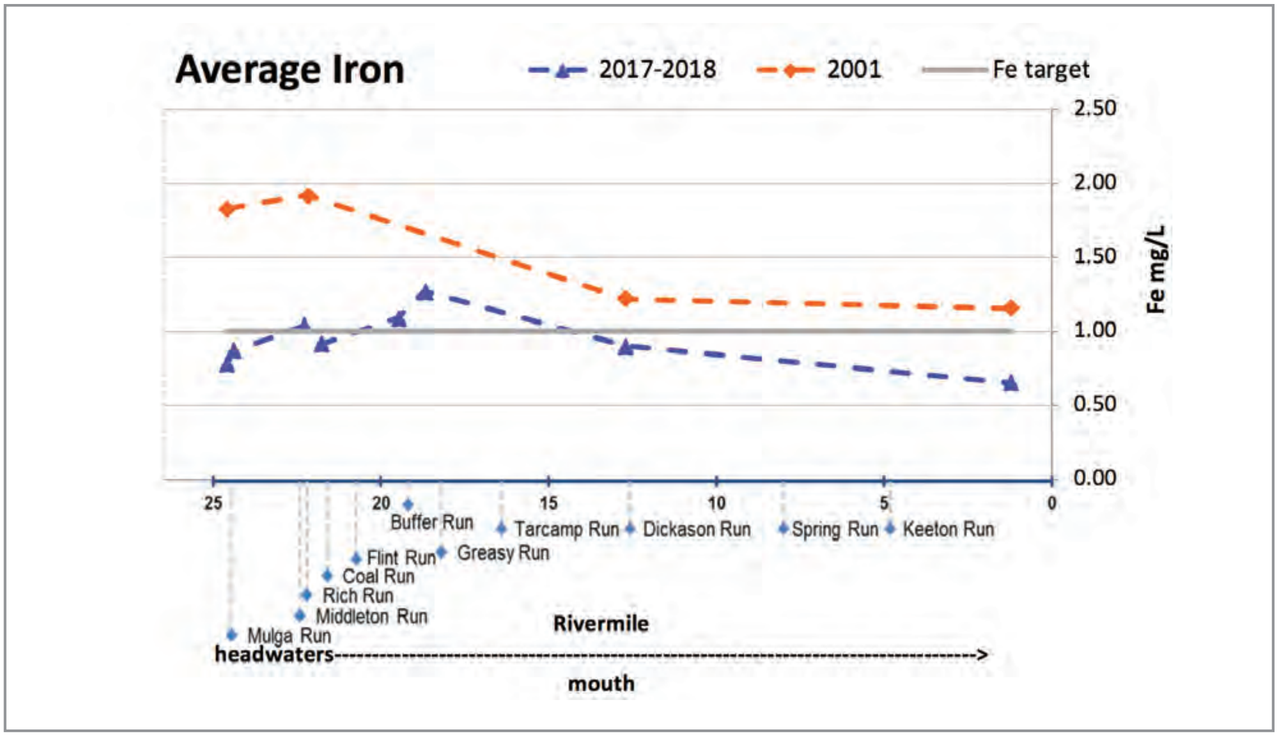
Little Raccoon Creek									
Site ID	LRC0090	LRC0080	LRC0071	LRC0070	LRC0065	LRC0055	LRC0045	LRC0030	LRC0010
Rivermile	24.6	24.4	22.3	22.2	21.8	19.5	18.7	12.7	1.2

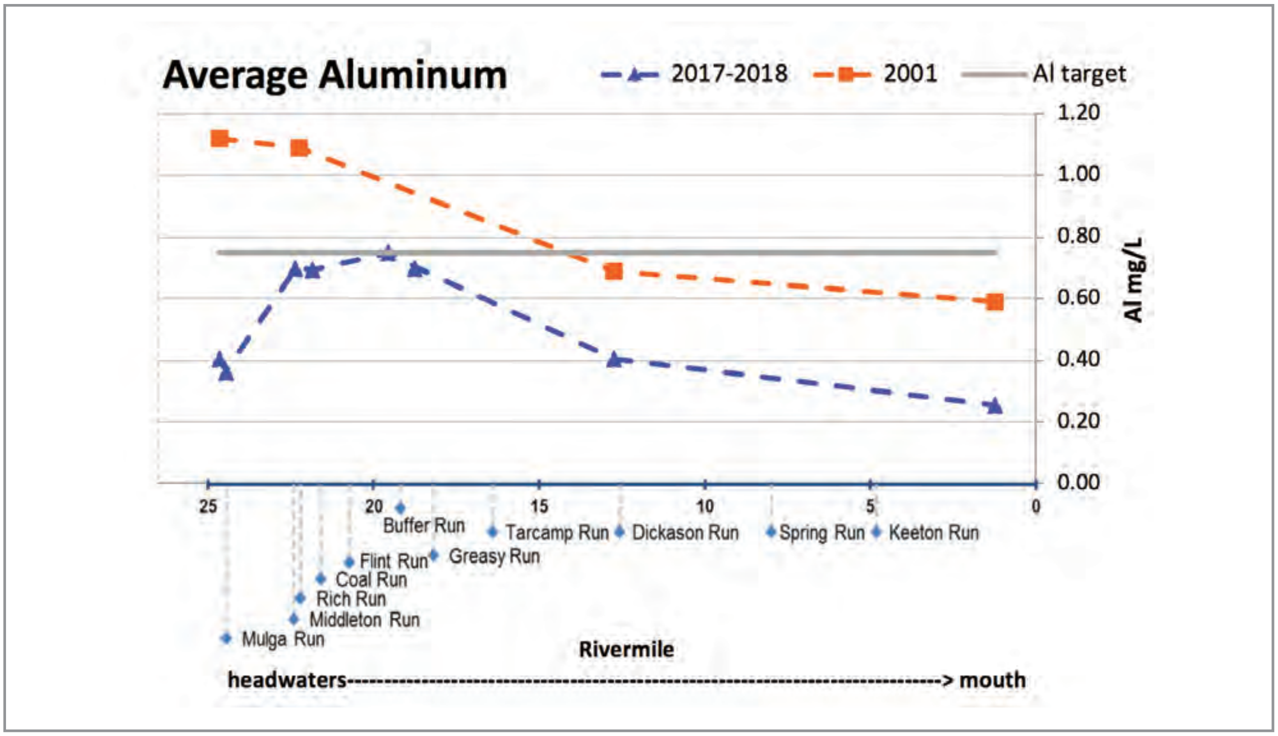




Chemical water quality analysis per stream reach

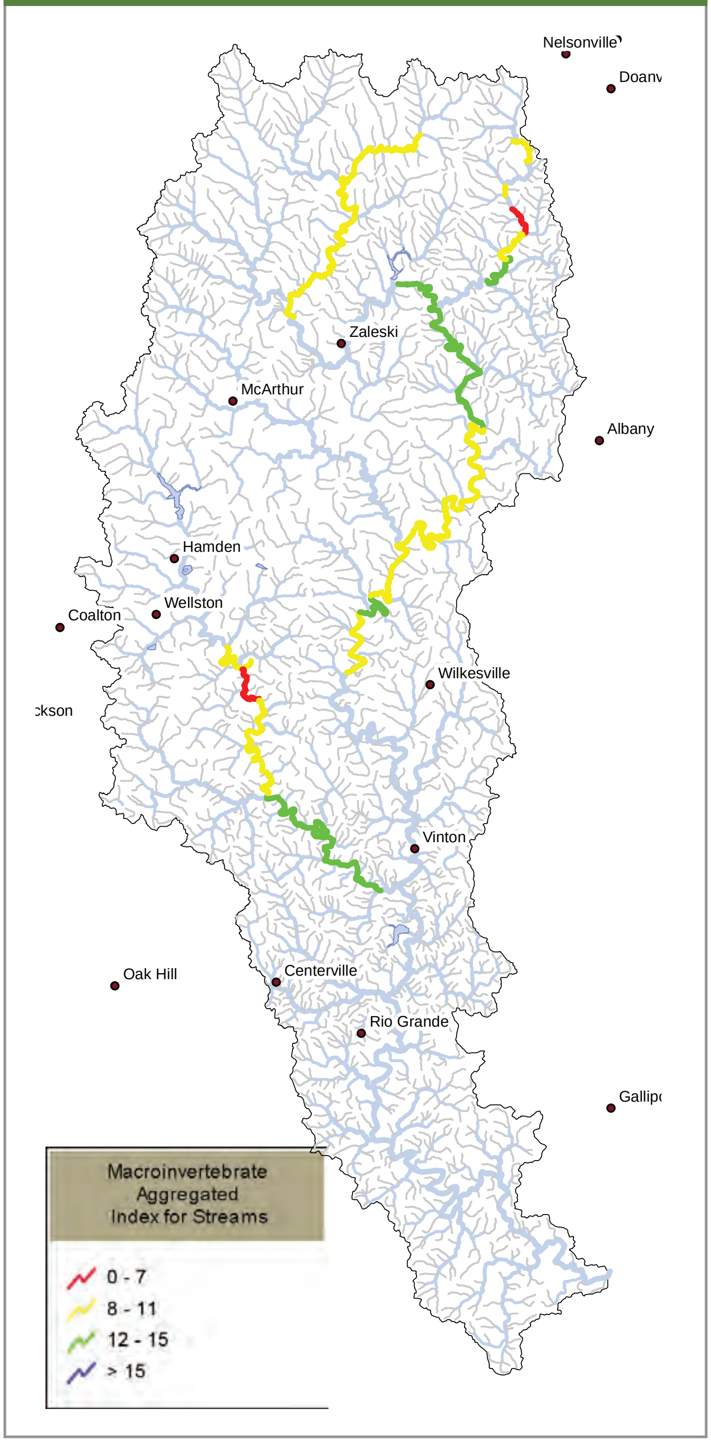
Little Raccoon Creek									
Site ID	LRC0090	LRC0080	LRC0071	LRC0070	LRC0065	LRC0055	LRC0045	LRC0030	LRC0010
Rivermile	24.6	24.4	22.3	22.2	21.8	19.5	18.7	12.7	1.2



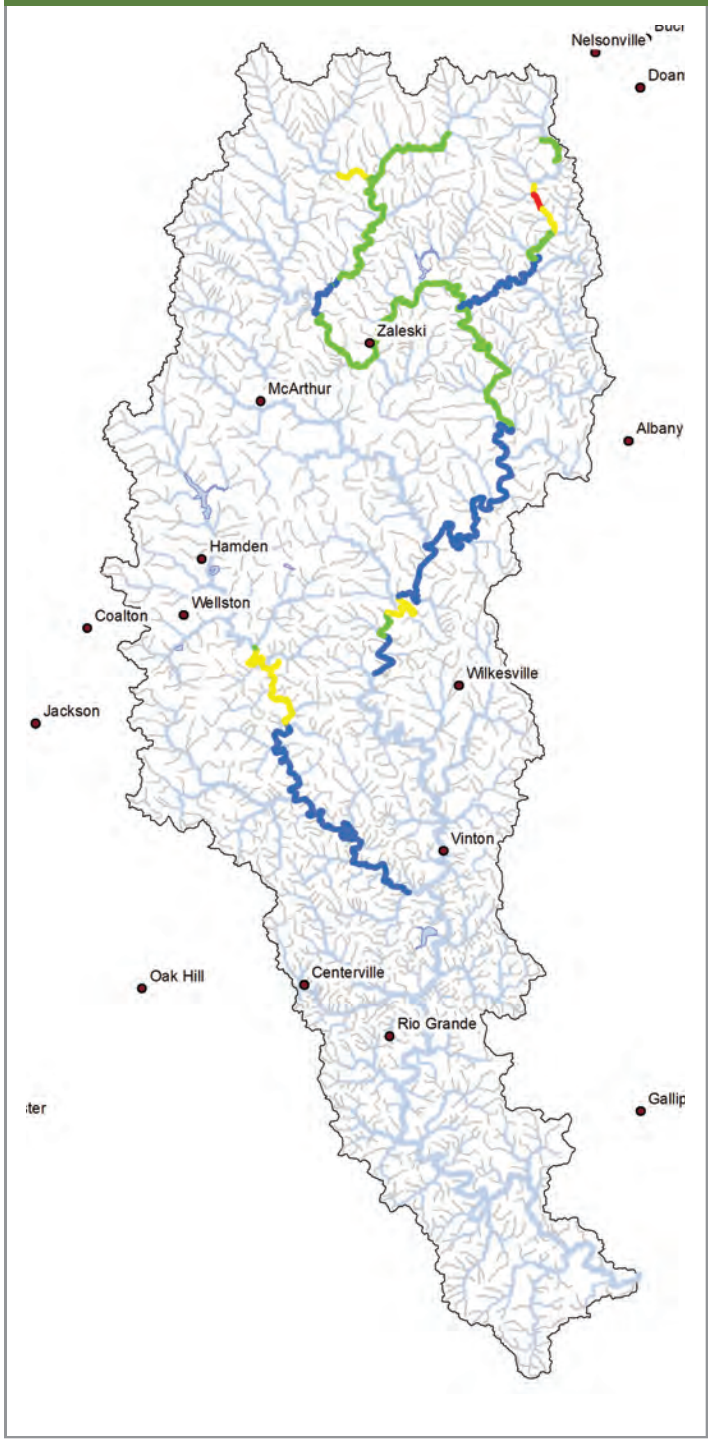


Biological Water Quality

Raccoon Creek baseline MAIS



Raccoon Creek 2017–2018 MAIS

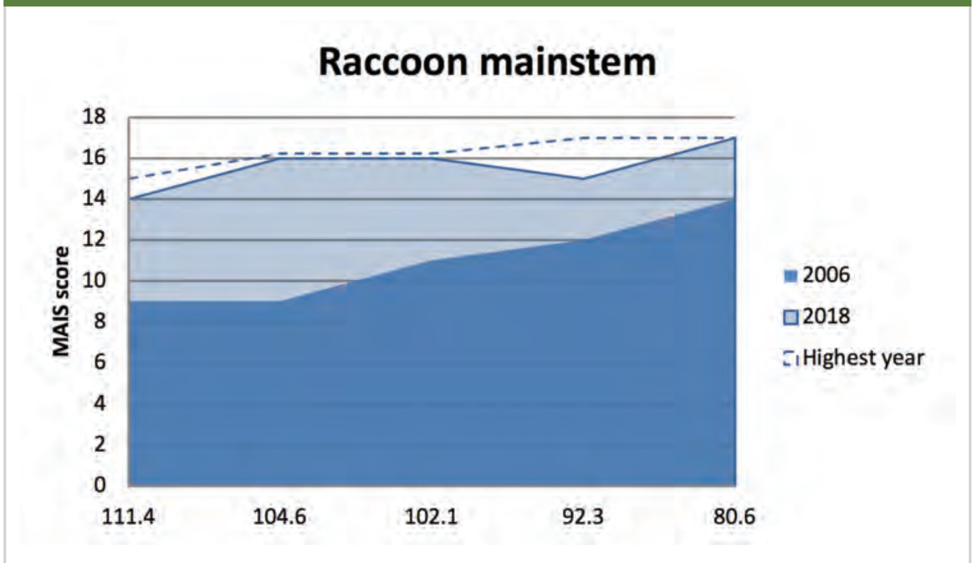


MAIS samples were collected throughout Raccoon Creek in 2017-2018 (excluding Middle Basin sites). These stations have been established as annual monitoring stations for macroinvertebrates. The sites are used to track incremental changes each year.

Raccoon Creek - Mainstem

The mainstem of Raccoon Creek is of high biological quality overall. Most sites are meeting or exceeding the target MAIS score of ‘12’. The sites furthest upstream between RM 111.4 and 102.1 were historically the most impaired in 2006, so the three sites in this nine mile section have shown the greatest improvement since then. By 2012 all three had scores well above ‘12’ and continued to improve. In 2018, MCBC100 at RM104.6 earned a new high score of ‘16’.

Biological Recovery



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

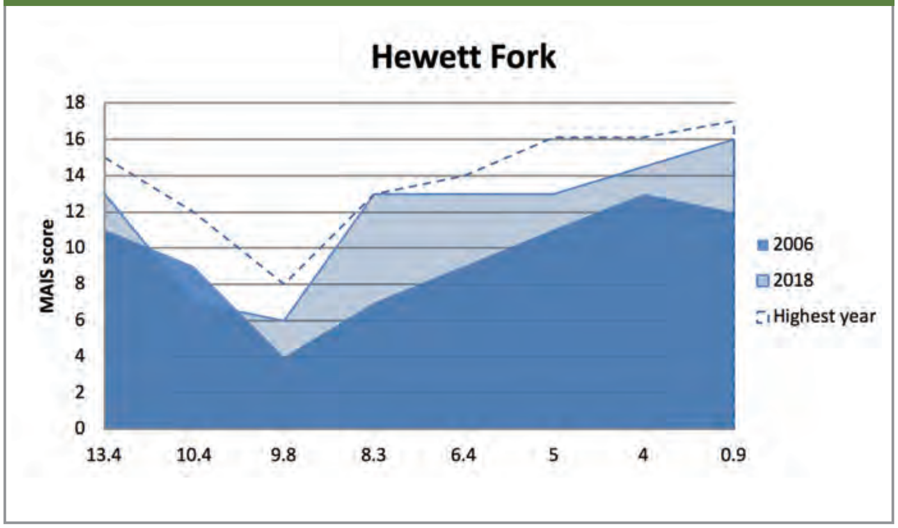
Raccoon Creek - Mainstem - MAIS Regressions

Raccoon Mainstem		2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2018	Linear trends	R square	P-value	No. of observations
MSBC010	111.4	8	9	12	9	10	12	13	12	13	13	15	13	14	**improved**	0.735386	0.000178	13
MSBC100	104.6		9	11	12	9	11	10	14	14	13	13	12	16	**improved**	0.579537	0.004024	12
MSLH020	102.1		11	11	10	13	10	11	12	15	15	16	12	16	**improved**	0.547593	0.005930	12
MSLH130	92.3				10	10	17	11	14	13	14	11	13	15	no change	0.133153	0.299841	10
MSBM004	89.6		13	14	11	16	12	16	15	14	13	16	12					
MSBM010	89.36			12	16	14	17	13	13	13	10	14	13					
MSBM040	80.6		14	14	17	16	12	14	15	14	14	16	12					
MSPR0085	65.8				16	16	14	14			15			17				

Raccoon Creek - Hewett Fork

The biological quality of Hewett Fork downstream of the Carbondale doser continues to be maintained, along with the 2.5 mile ‘mixing zone’ where the water chemistry is still poor and precipitated metals coat the streambed. By 2016, HF090 at the downstream end of the mixing zone exceeded the target MAIS score of ‘12’. In 2018, all sites downstream of HF090 scored above a 12, indicating that over 8 miles of Hewett Fork continue to meet macroinvertebrate targets for Warm Water Habitat, although most were not meeting their highest scores.

Biological Recovery



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

***River miles 10.4 and 9.8 not sampled in 2018. Last known scores (from 2016) used in graph.**

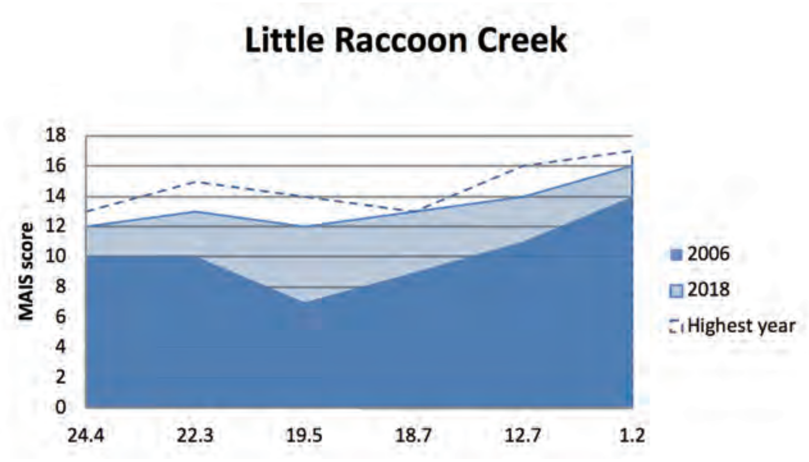
Raccoon Creek - Hewett Fork MAIS Regressions

	RM	‘01	‘02	‘03	‘05	‘06	‘07	‘08	‘09	‘10	‘11	‘12	‘13	‘14	‘15	‘16	‘18	Linear trends	R square	P-value	No. of observations
HF 137	13.4					11	8	9	12	13	11	11	11	13	15	13	13	**improved**	0.541108	0.00987	12
HF 190	10.4					9	3	7	6	6	5	8	12	8	9	7					
HF095	9.8					4	3	6	3	3	8	4	4	4	5	6					
HF 090	8.3	2	3	3	5	7	3	5	6	3	6	9	7	11	11	13	13	**improved**	0.750333	2.96913	16
HF075	7.3									12	11	12	13	11	13						
HF 060	6.4					9	9	8	10	10	13	11	14	13	11	12	13	**improved**	0.520695	0.012183	12
HF045	5									14	15	12	13	16	14	14					
HF 039	4					13	13	14	13	13	14	14	16	16	15	15	16	**improved**	0.670194	0.002060	12
HF 010	0.9					12	12	15	17	13	16	16	14	16	14	10	16	no change	0.002206	0.890911	12

Raccoon Creek - Little Raccoon Creek

Little Raccoon Creek has shown slow but steady improvement in biological quality since monitoring began, especially in the upstream sections between RM 24.4 and 19.5 that scored poorly in 2006. By 2014, half of the sites along the creek's 24 mile length were meeting the target MAIS score of '12'; in 2018 all of the sampled sites met or exceeded this target.

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	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2018	Linear trends	R square	P-value	No. of observations
LRC0080	24.4	8	10	11	11	9	9	13	11	11	12		11	12	**improved**	0.357396254	0.040067	12
LRC0071	22.3	8	10	10	9	10	10	10	10	13	11		15	13	**improved**	0.693137588	0.000777	12
LRC0055	19.5		7		9	11	12	13	10	11	14		12					
LRC0045	18.7	14	9	12	9	13	11	11	12	11	10		12	13	no change	0.014185906	0.712364	12
LRC0030	12.7	3	11	13	13	14	14	14	14	15	16		13	14	**improved**	0.353032719	0.041624	12
LRC0010	1.2	14	14	13	15	17	16	16	16	14	17		16	16	no change	0.307753957	0.061197	12

MONDAY CREEK WATERSHED REPORT

2017–2018 NPS Report - Monday Creek Watershed

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

Monday Creek Restoration Project

Reductions

Total acid load reduction 2017–2018= 4,006 lbs/day

Total metal load reduction 2017–2018= 393 lbs/day

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

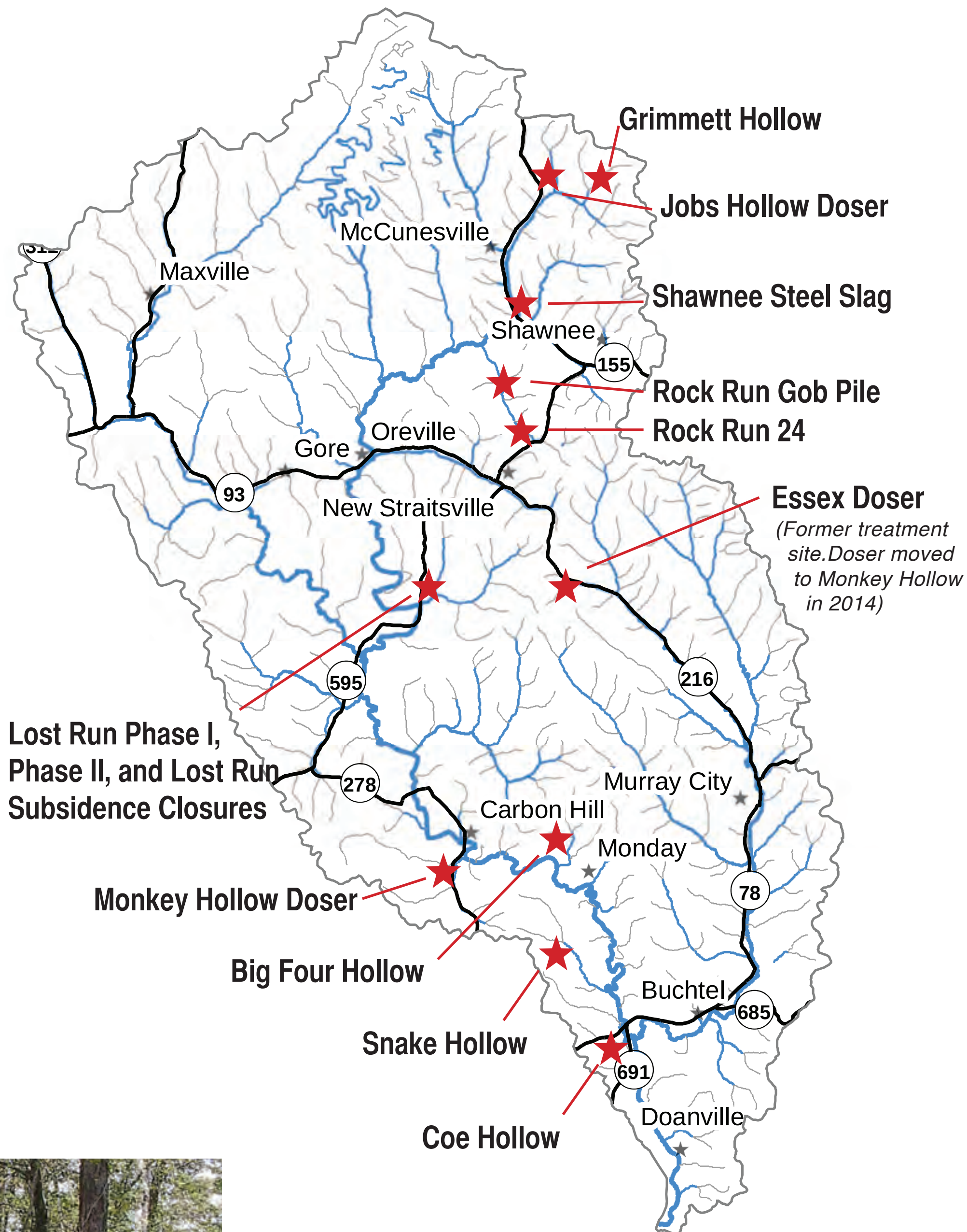
Acid and metal load reductions based on projects monitored during 2017/2018: Jobs Doser, Rock Run Gob Pile, Lost Run Phase I & II, Coe Hollow, Big Four, and Monkey Hollow Doser.

Cost

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

Construction $7,047,825

Total costs through 2018 = $7,496,369




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

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.
2017 2018	• New fish species, Stonecat Madtom, (Noturus Flavus) found in Monday Creek. • ODNR and OSM funded maintenance on existing projects.

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

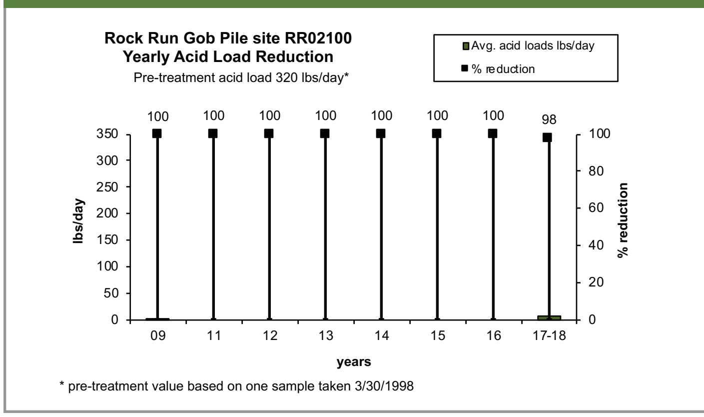
Big Four Wetland Enhancement (BF00100) - Three wetlands installed for metal retention

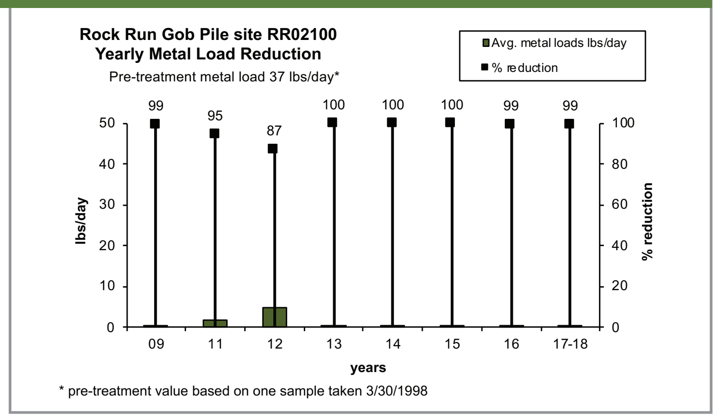
Italicized indicated projects are not actively monitored for acid mine drainage and metal load reduction purposes

Yearly acid and metal load reduction trends per project

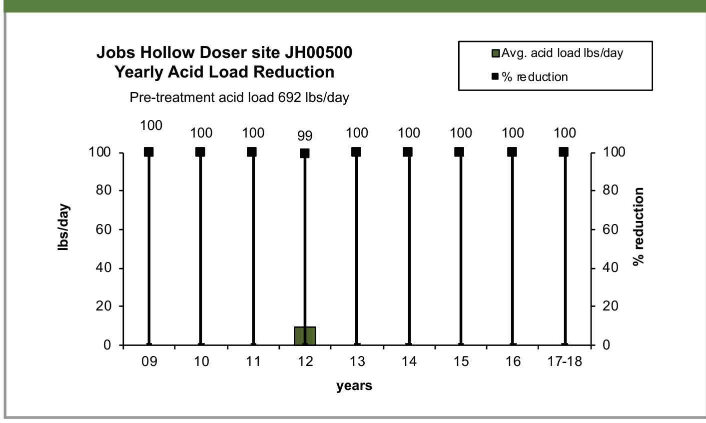
Similar to other environmental best management practices (BMPs), performance of passive acid mine drainage reclamation projects are also expected to decline with time. Active treatment systems are not expected to decline with time but sometimes need to be maintained to perform adequately. Currently, 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.

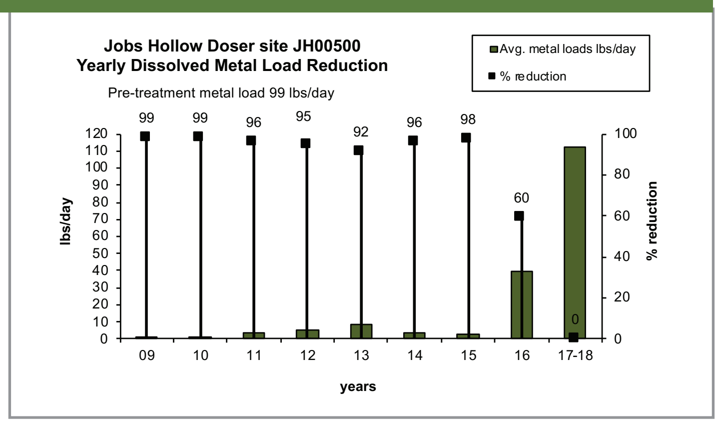
Rock Run Gob Pile site RR02100



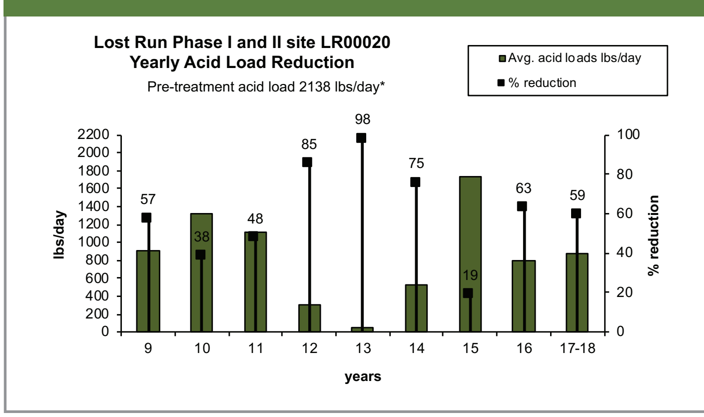


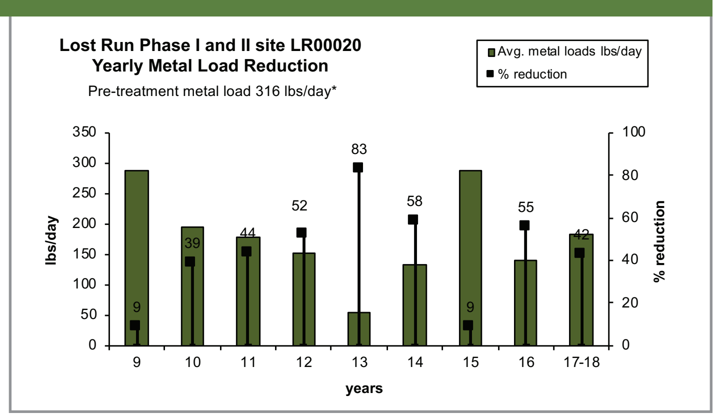
Jobs Hollow Doser site JH00500





Lost Run Phase I and II site LR00020





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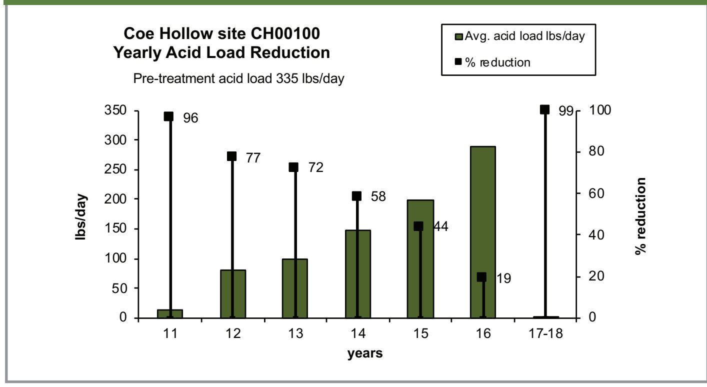
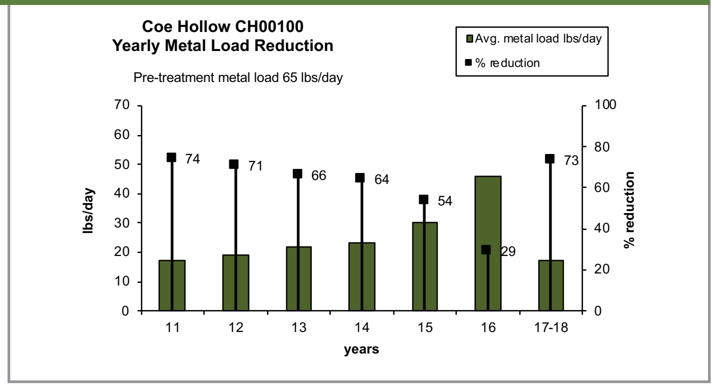
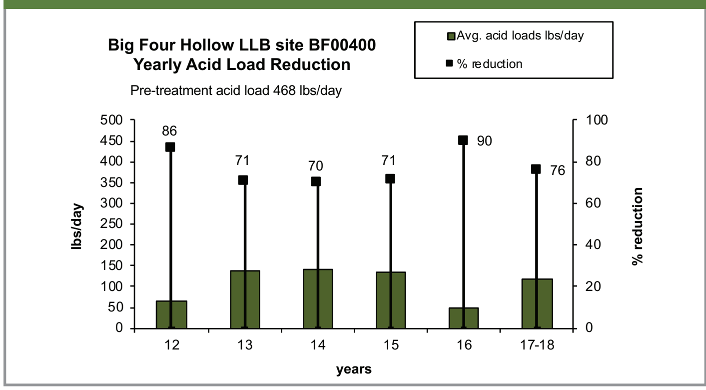
Yearly acid and metal load reduction trends per project

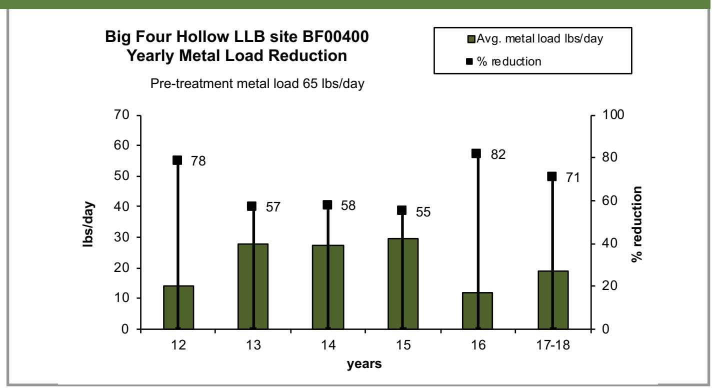
Coe Hollow site CH00100



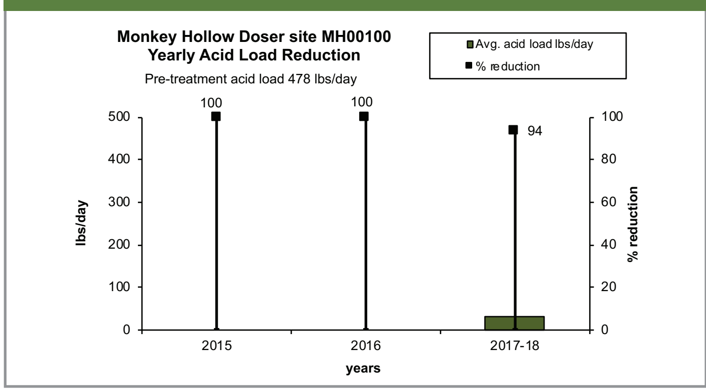


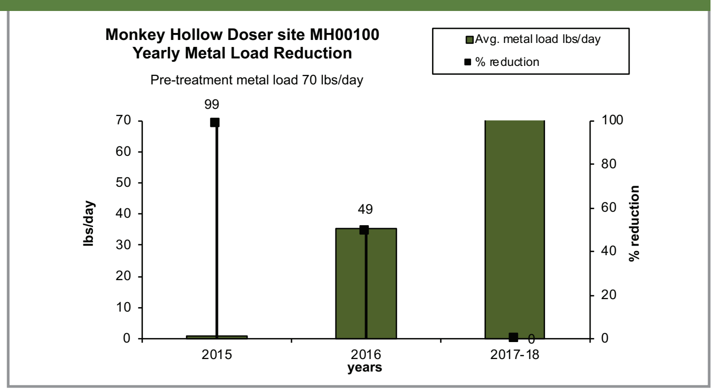
Big Four Hollow LLB site BF00400





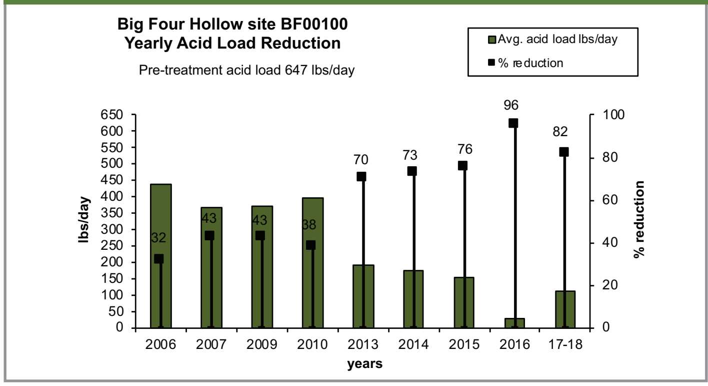
Monkey Hollow Doser site MH0010

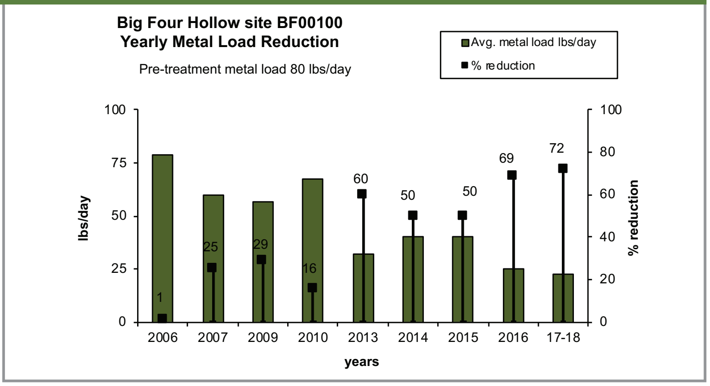




Yearly acid and metal load reduction trends per project

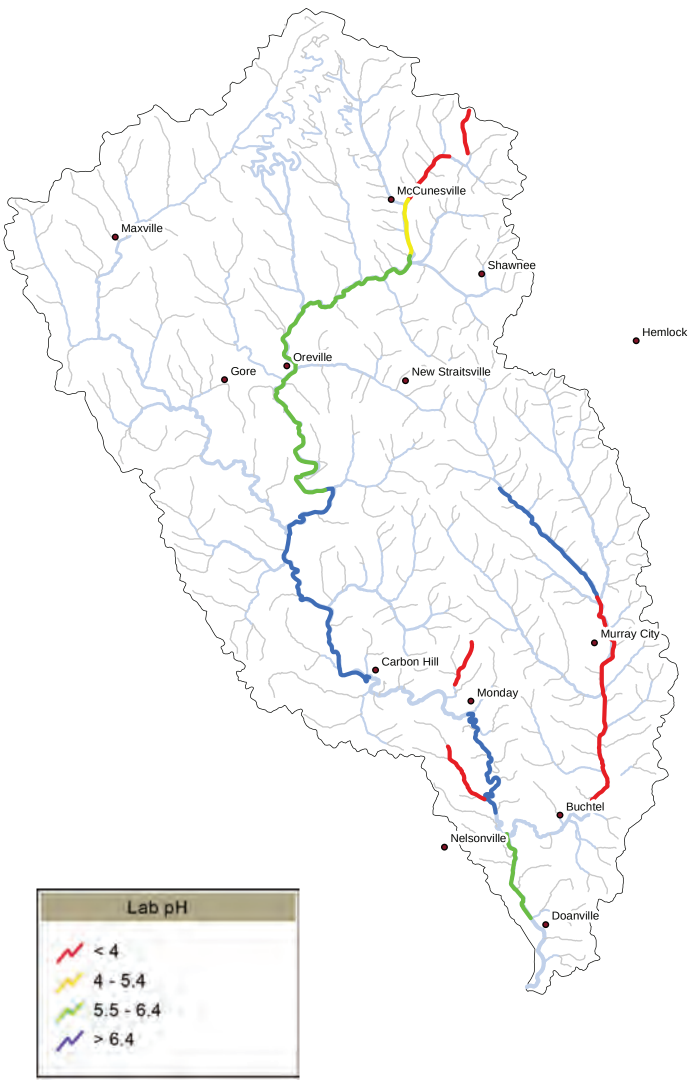
Big Four Hollow site BF00100



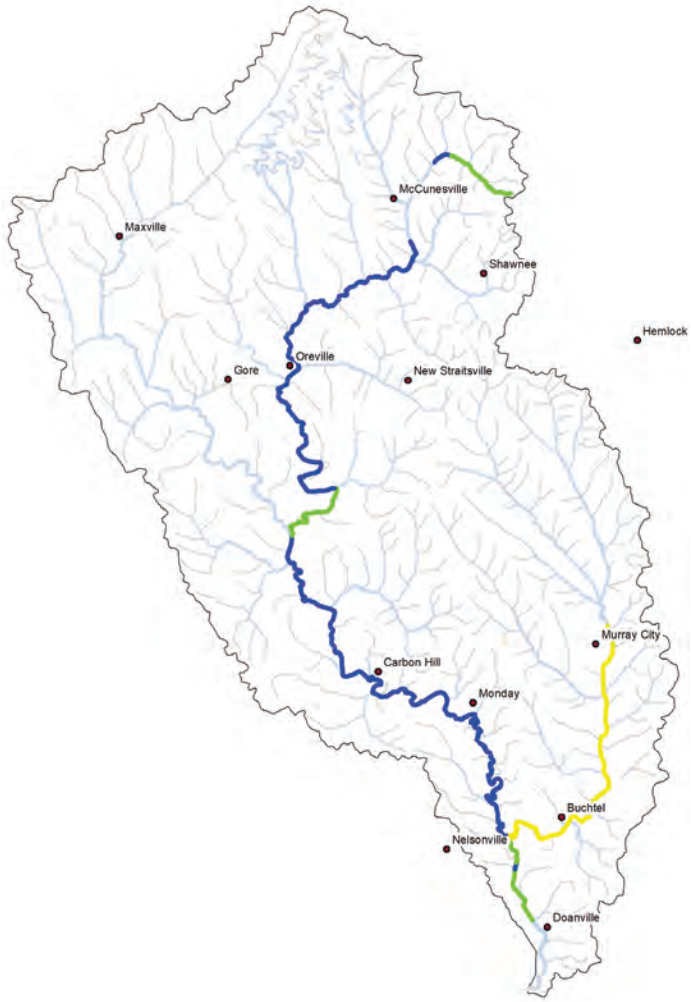


Chemical Water Quality

Monday Creek baseline pH



Monday Creek 2017–2018 pH

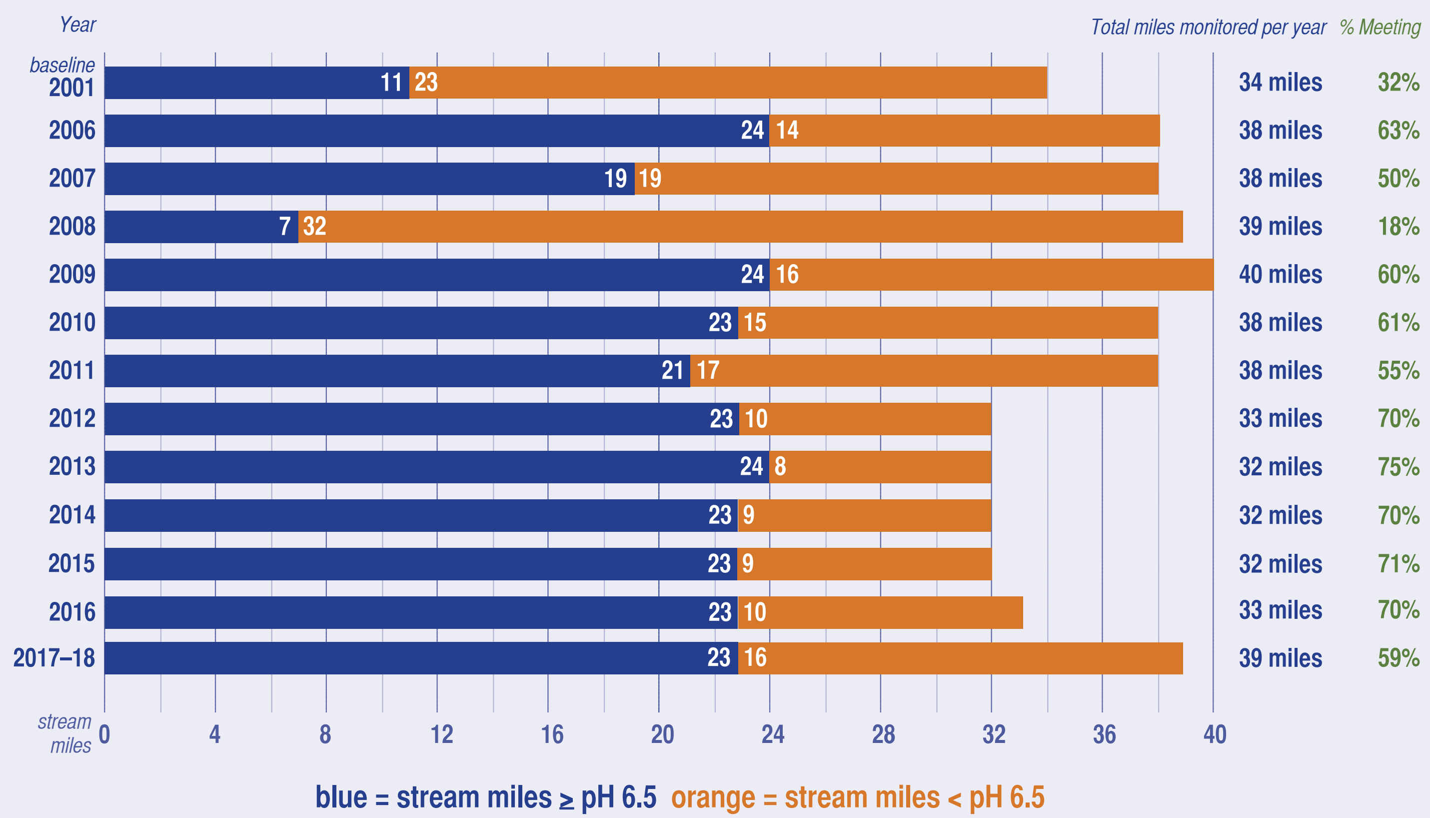


In Monday Creek pH values have improved throughout the watershed from baseline conditions (2001) to 2018. In 2017–2018, stream miles meeting pH target of 6.5 is approximately 27.5 miles of the 33 miles monitored (83%).

Chemical Water Quality

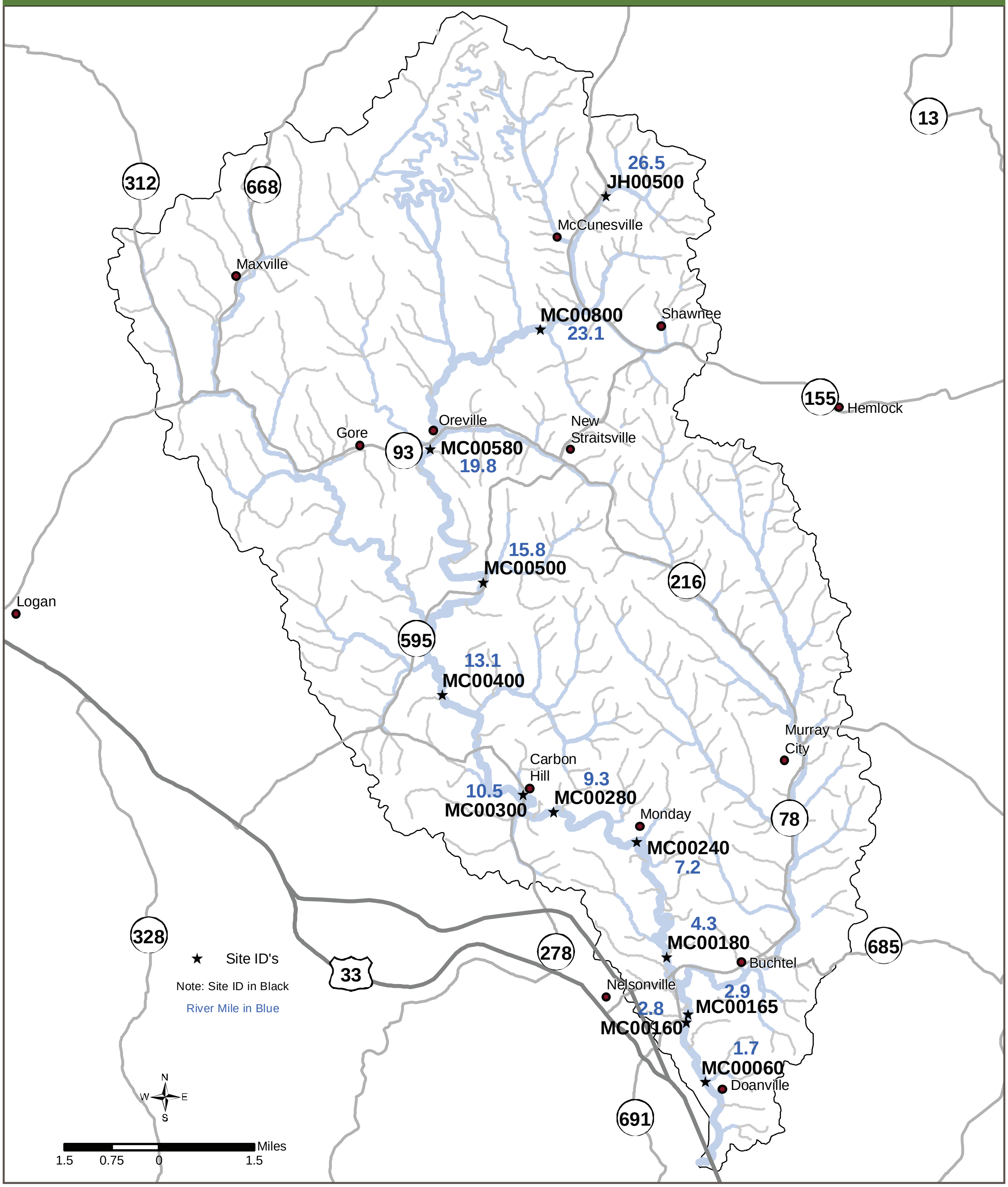
There are approximately 33 stream miles monitored each year along the mainstem of Monday Creek, 38 miles when major tributary Snow Fork is included. The restoration target for pH is 6.5. In 2007, 19 stream miles of the 38 monitored met the pH target of 6.5. However in 2008 only 7 miles of the 39 miles 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, and this site has continued to fluctuate across the pH target, averaging 6.3 for 2017-2018. From 2012 -2018, the rest of the stream miles meeting the pH target have remained relatively constant. The mainstem of Snow Fork, downstream of Essex Doser has been discontinued for monitoring, as treatment in this basin is unlikely. Snow Fork was sampled in the 2017-2018 period, however, and is therefore shown with its average below the target pH.

Figure 1. Monday Creek pH



Chemical Water Quality

Monday Creek

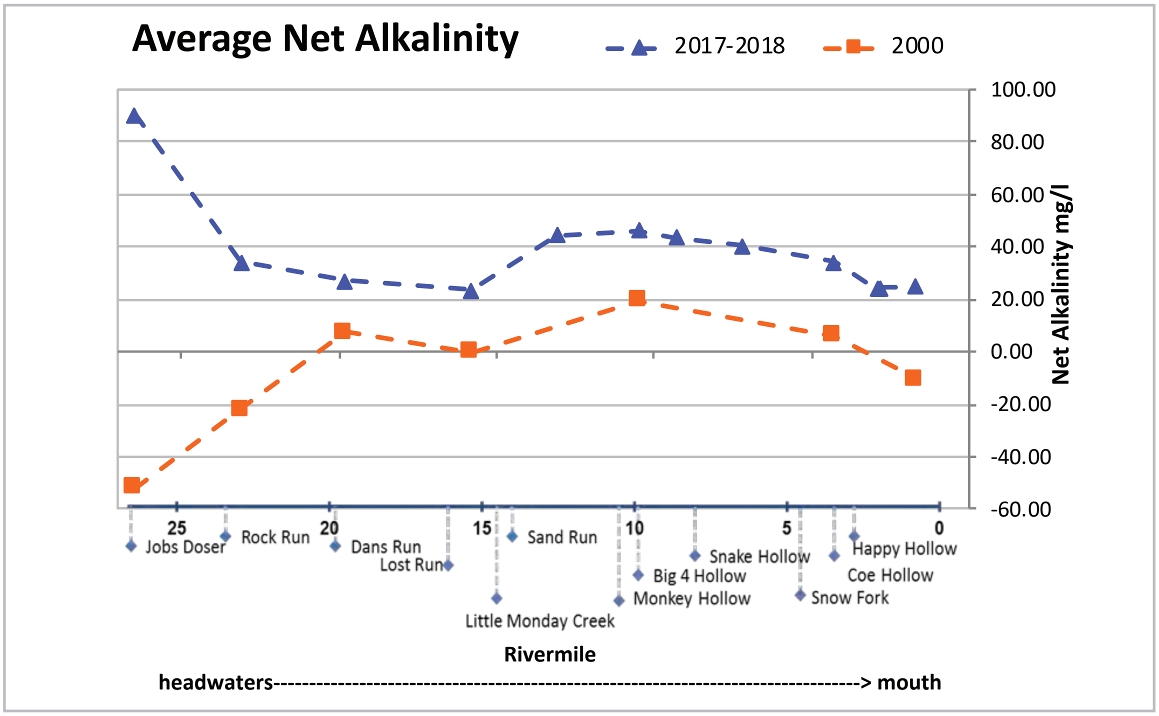


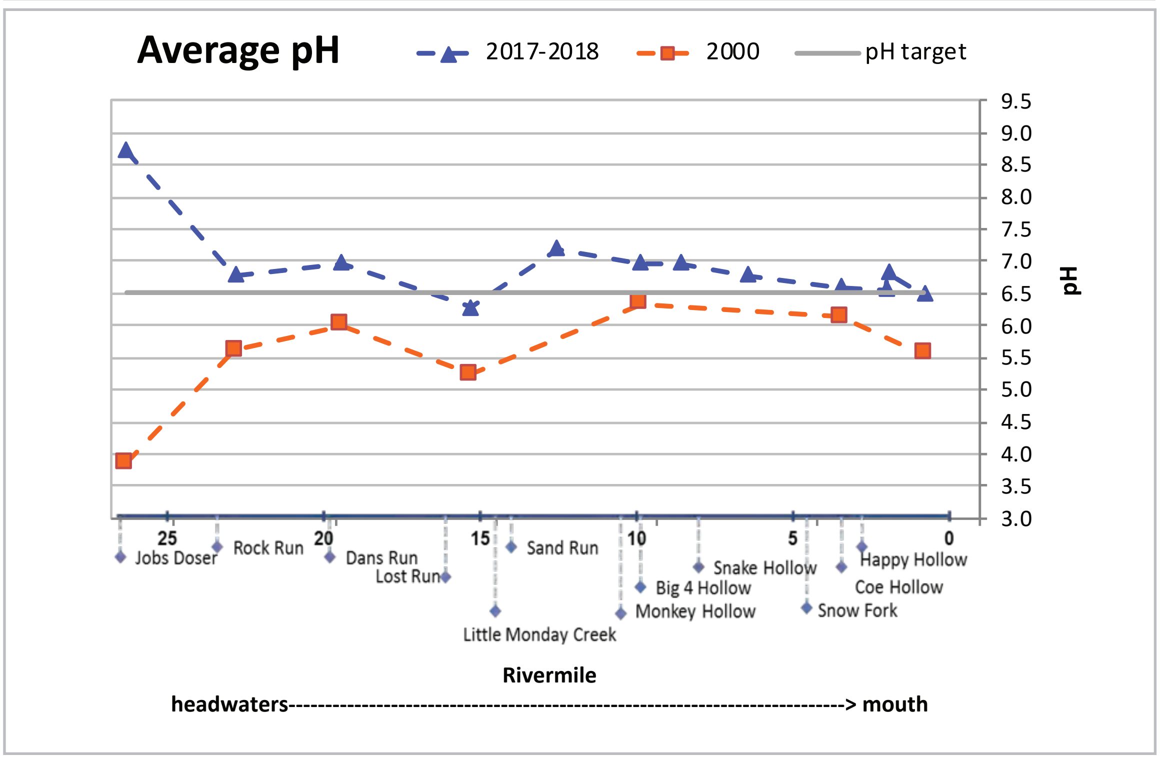
Chemical water quality analysis per stream reach

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

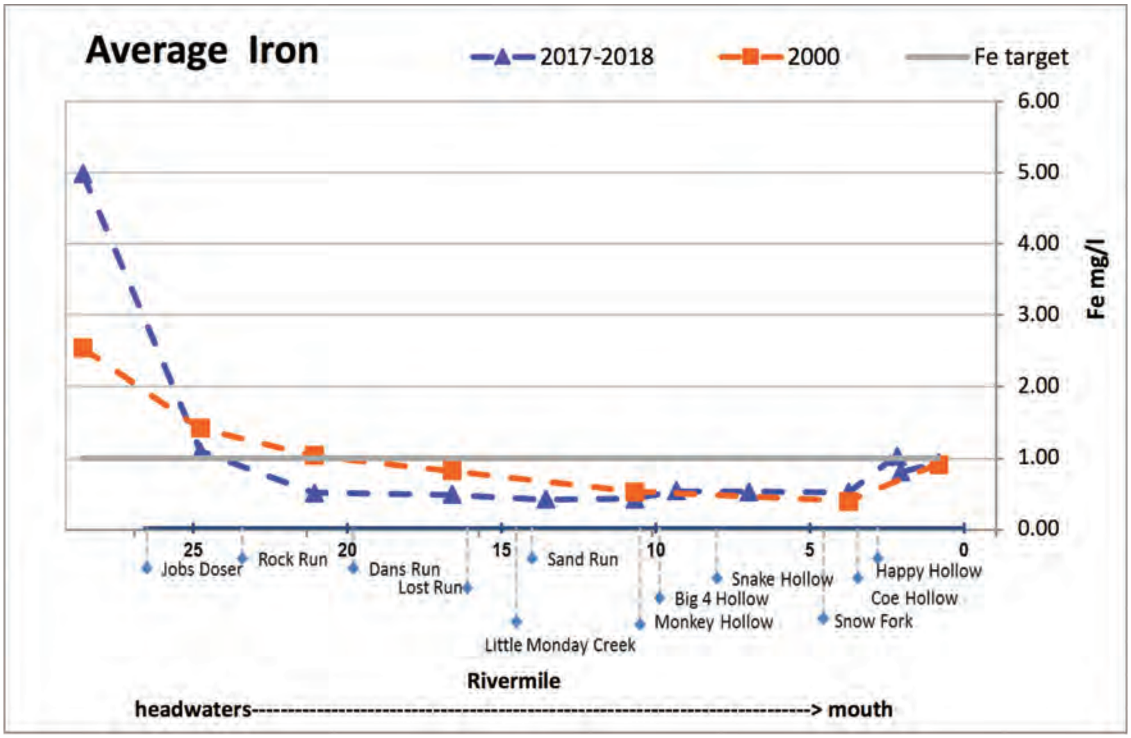


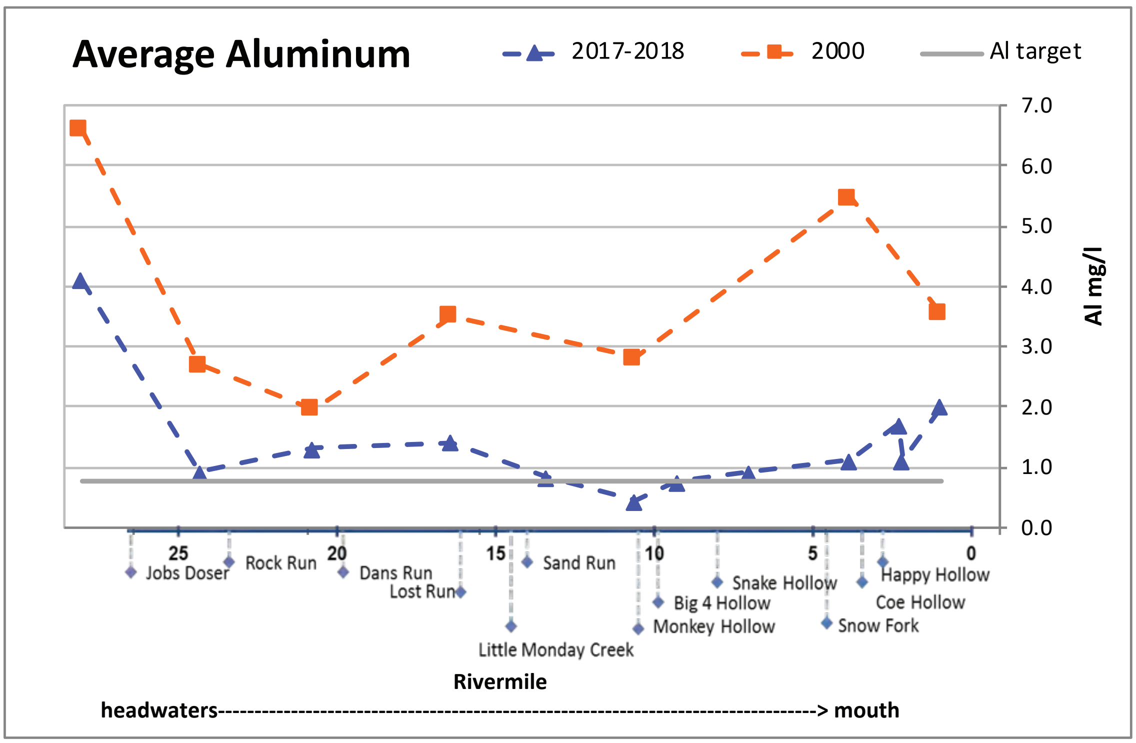


Chemical water quality analysis per stream reach

Monday Creek Mainstem

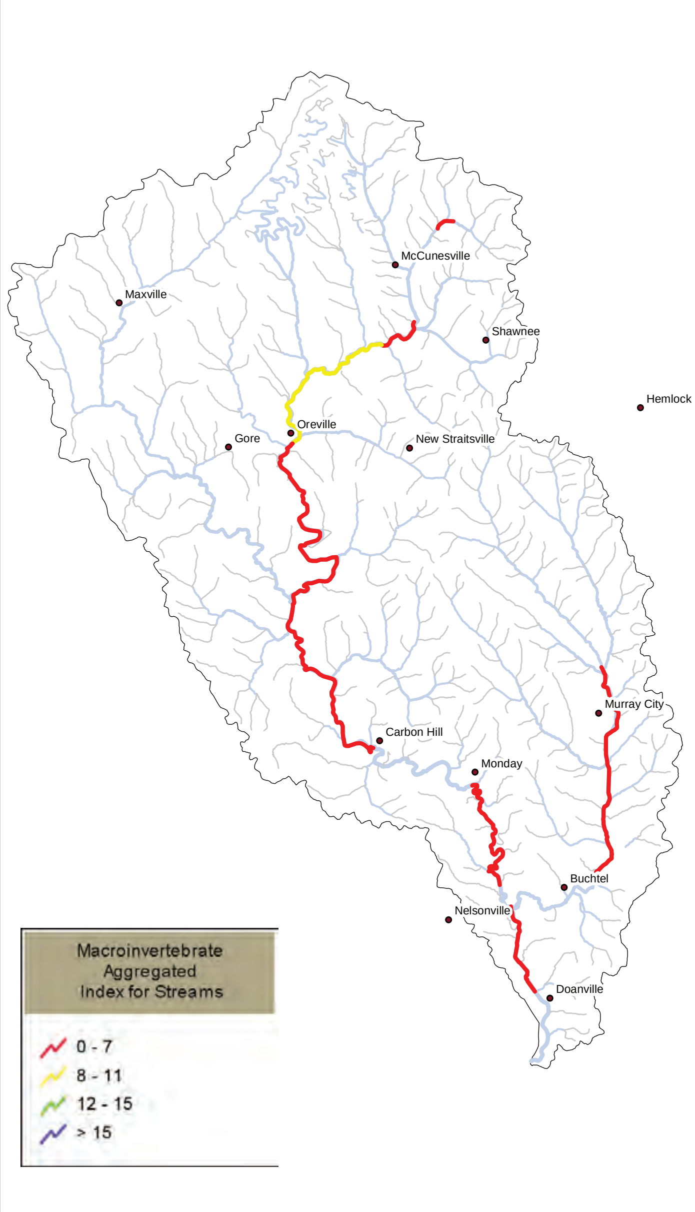
Site ID	JH00500	MC00800	MC00580	MC00500	MC00400	MC00300	MC00280	MC00240	MC00180	MC00165	MC00160	MC00060
Rivermile	26.5	23.1	19.8	15.8	13.1	10.5	9.3	7.2	4.3	2.9	2.8	1.7



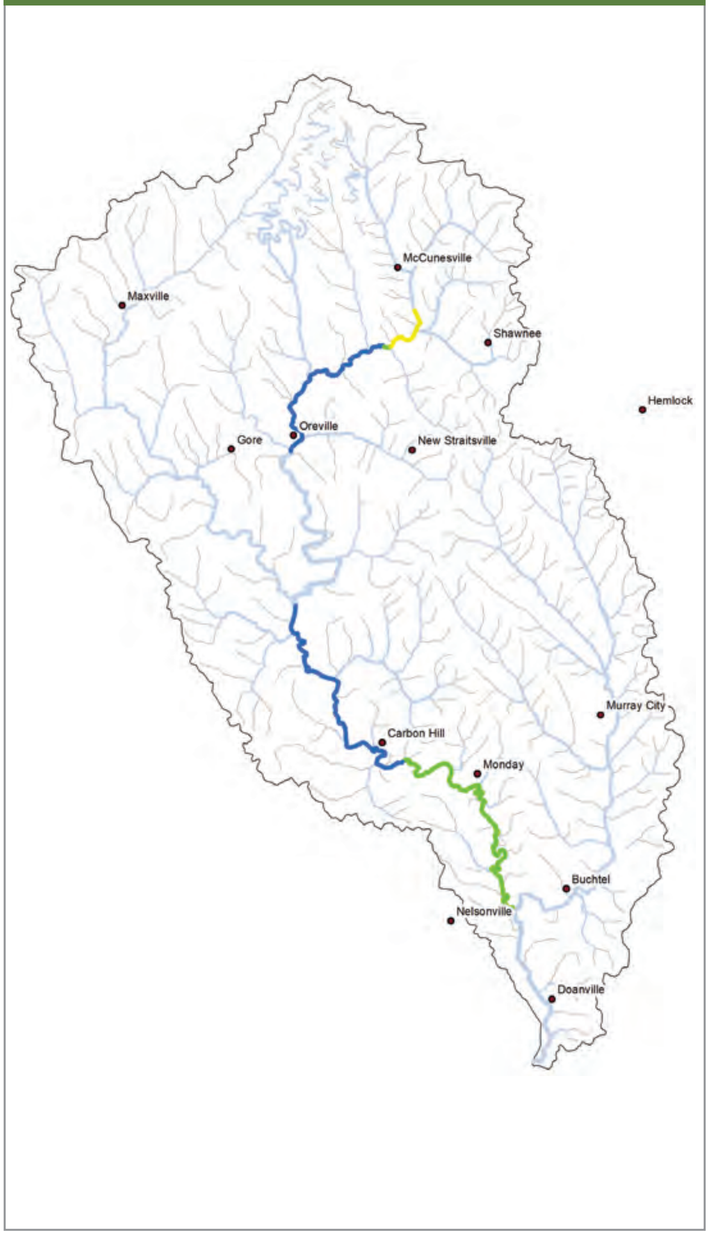


Biological Water Quality

Monday Creek baseline MAIS



Monday Creek 2017–2018 MAIS

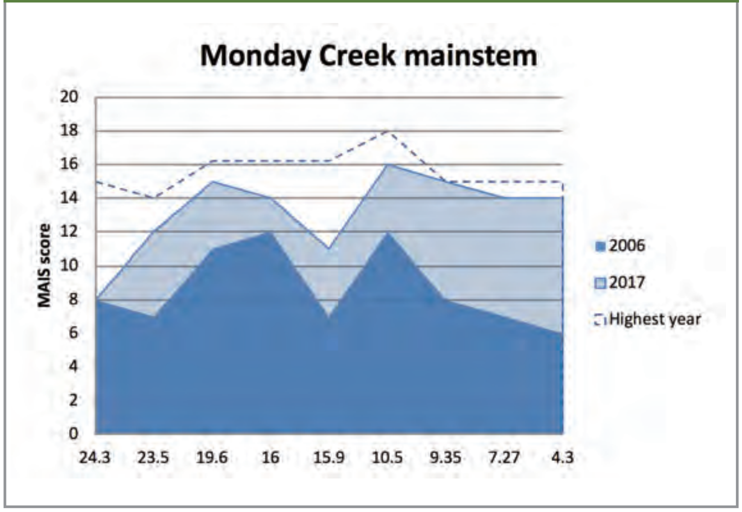


MAIS samples were collected throughout Monday Creek at established annual monitoring stations from 2001 through 2017-2018.

Biological Water Quality

The Monday Creek mainstem continued to maintain the improvements in biological quality observed over the last ten years. One exception was an unusually low score at RM 24.3 (MC00900), downstream of the Shawnee wastewater treatment plant, which received an '8' in 2017 when it normally scores above '12'. A second site with a persistently low biological score (RM 15.9, MC00500) has room for improvement. In 2012 and 2013 this section of stream earned high scores of '15' and '16', respectively, suggesting that it has restoration potential. A closer examination of specific causes of impairment at this site may help with future improvements.

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

MONDAY	RM	'01	'02	'03	'05	'06	'07	'08	'09	'10	'11	'12	'13	'14	'15	'16	'17	Linear trends	R square	P-value	No. of observations
JH 0902					8	6	6	4	4	4	4										
MC 148		4	6	4	7	6	5	4	7	8	9	11	10	13	8	5					
MC 0095	25.3				7	8	7	4	9	6	10	10	10	12	13	11					
MC 0090	24.3				6	8	12	12	11	11	12	12	14	12	15	12	8	no change	0.193930	0.132059	13
MC 0083	23.5	5	3	1	11	7	9	12	7	13	11	13	12	14	14	13	12	improved	0.675235	9.44249	17
MC 103	19.6	8	9	10	13	11	12	12	13	16	14	16	15	14	16	15	15	improved	0.778725	6.06063	17
MC 0051	16	2	6	6		12	11	10	10	10		14	14	14	14	14					
MC00500	15.9					7	8		5			15	16	9	13	11					
MC 153	10.5	5	10	13	13	12	14		12	16	16	15	16	16	18	16	16	improved	0.698982	5.46974	17
MC 154-B	9.4					8	9	10	9	14	12	10	15	11	14	12	15	improved	0.534246	0.00692	12
MC 152	7.3				8	7	7	8	10	14	10	8	11	13	11	12	14	improved	0.557603	0.00336	13
MC 151	4.3	2	6	2	8	6	9	7	4	13	9	9	15	11	13	12	14	improved	0.696600	5.78834	17

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.

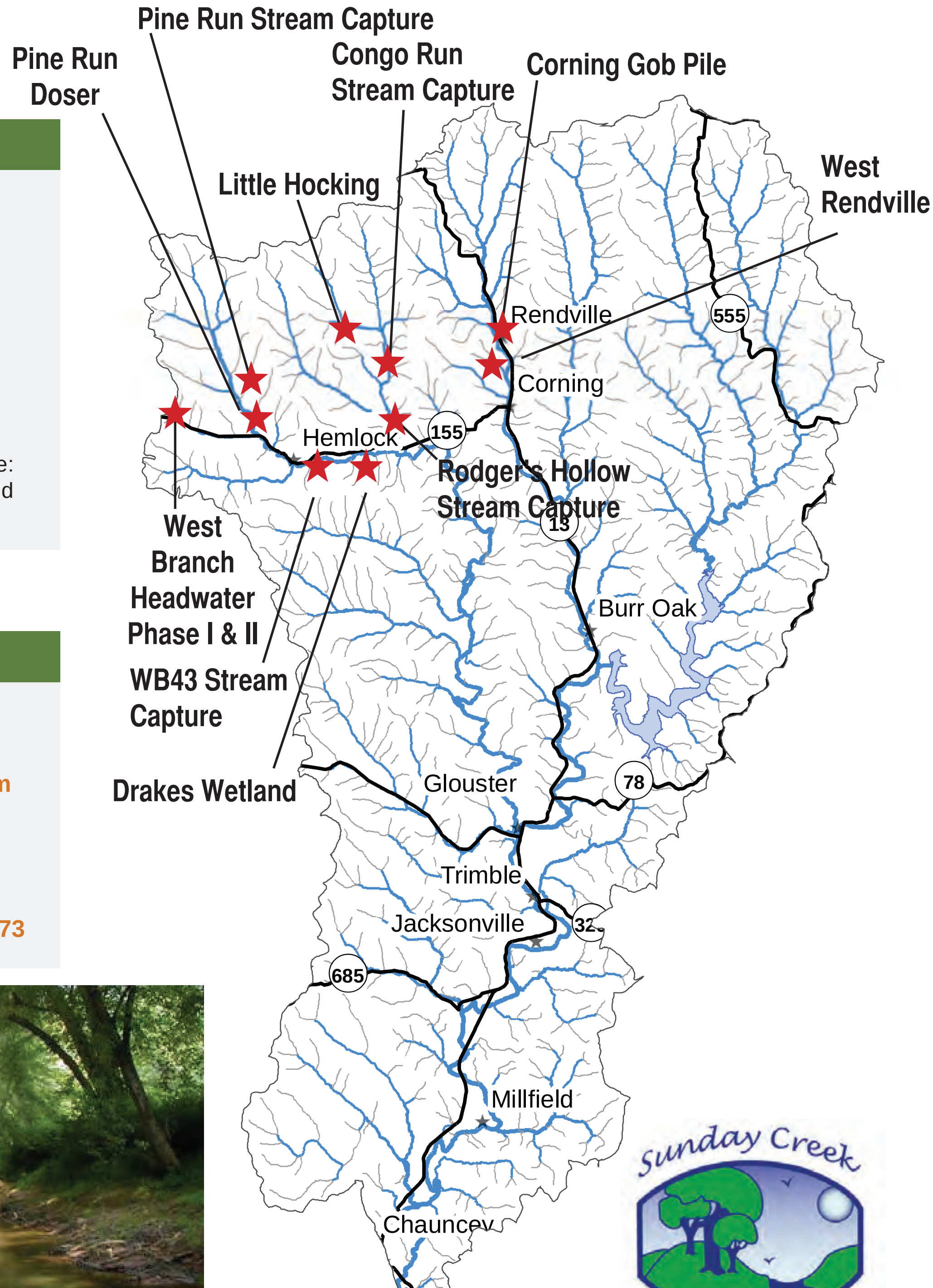
** Insufficient data to calculate acid and metal loads for 2017-2018 reporting period.*

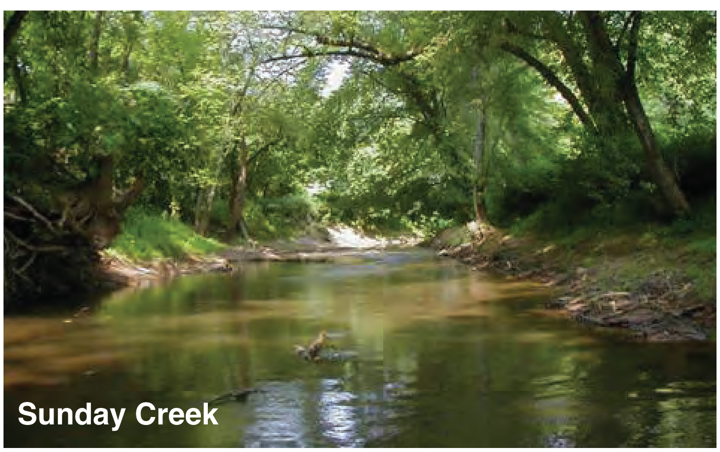
Costs

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

Construction = $2,191,186

Total costs through 2018 = $2,718,273





Sunday Creek

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

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 (PR 001) – 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

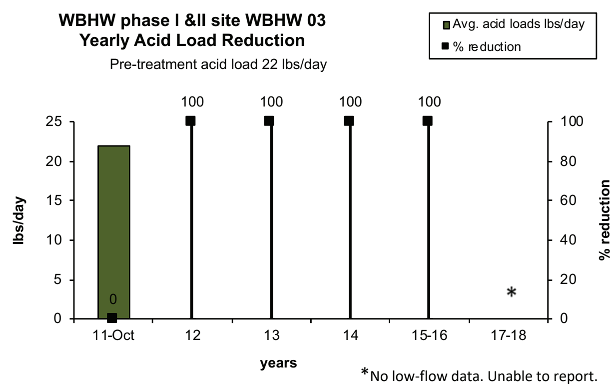
Most of the remediation in Sunday Creek consists of source control (i.e. stream capture, gob pile capping, etc….) and aren't actively monitored for acid and metal load reductions. Therefore target restoration sites along West Branch of Sunday Creek mainstem have been selected to analyze the acid and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

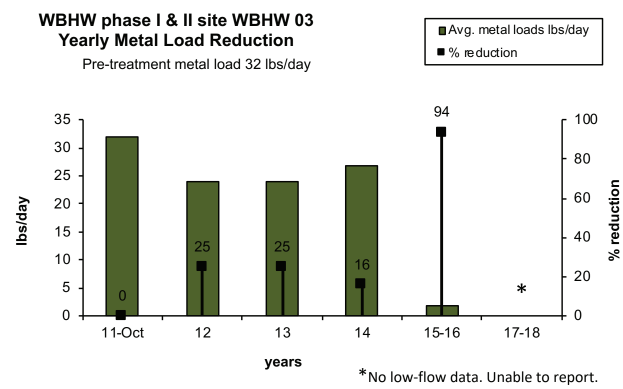
WBHW 03, WB 51, and WB 002. Yearly loads and load reductions for these mainstem sites are shown on the next few pages.

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.

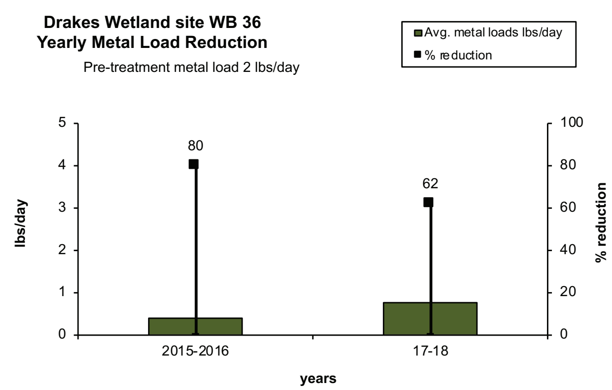
WBHW phase I & II site WBHW 03





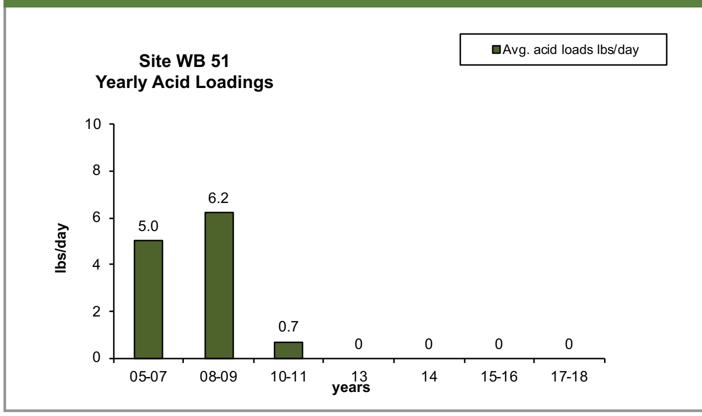
Drakes site WB 36

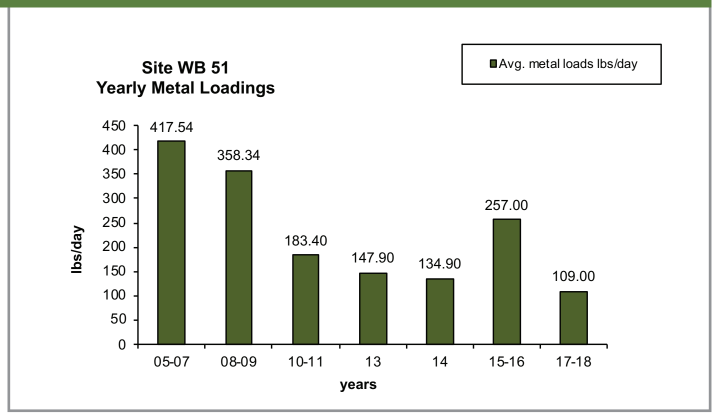
Drakes Wetland site WB 36 is net alkaline pre-treatment, Wetland was enhanced to maintain the longevity of the wetland.



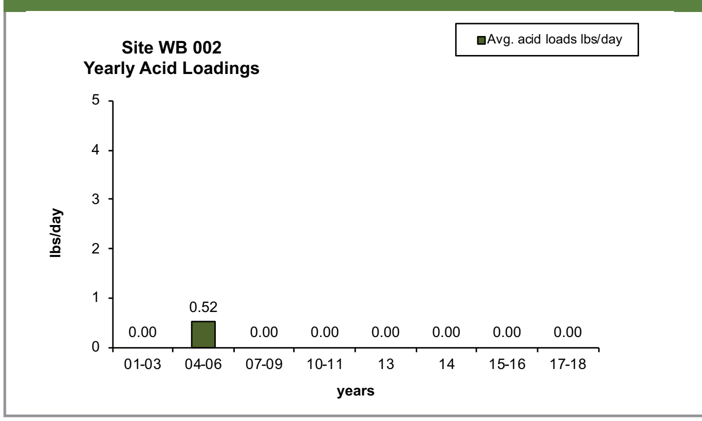
Yearly acid and metal load reduction trends per project

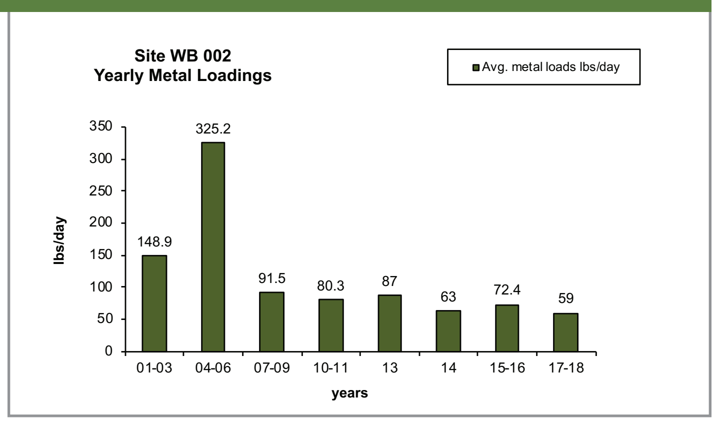
Site WB 51





Site WB 002

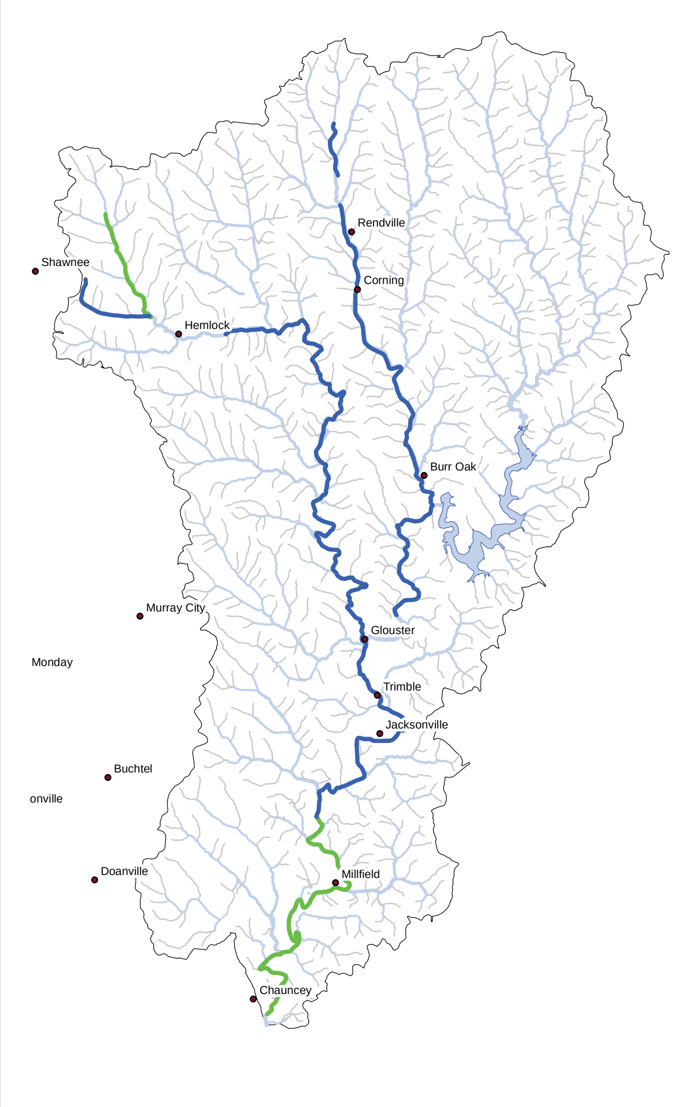




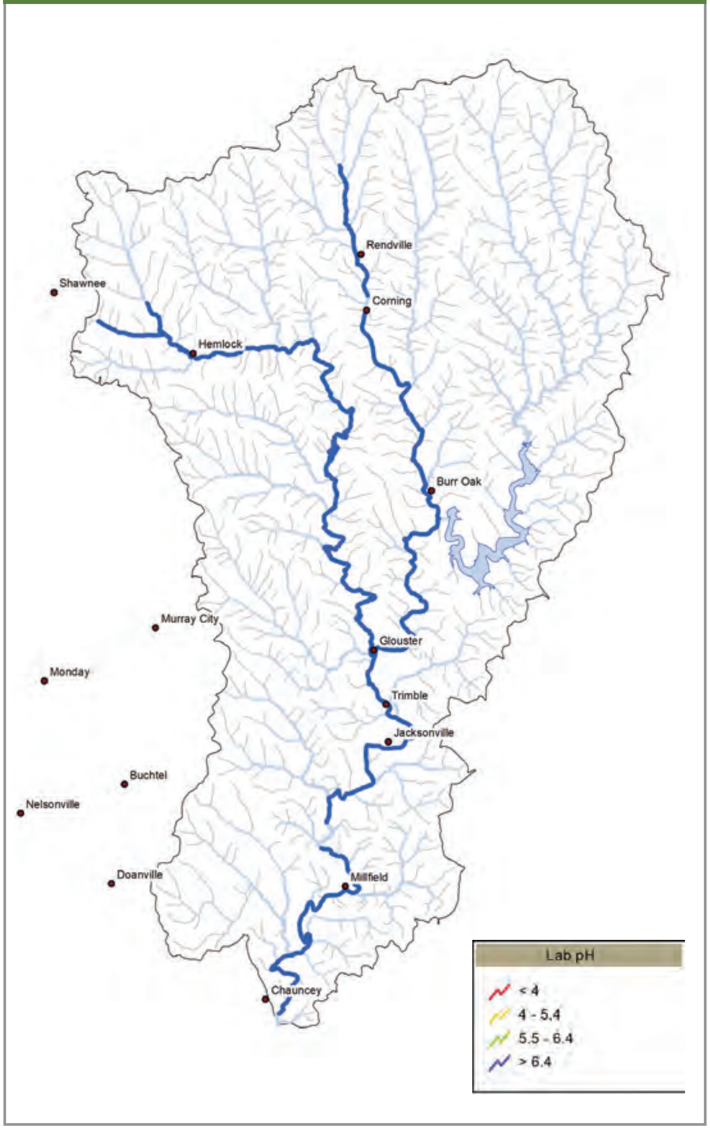
Sites WB 51 and WB 002 are reported in loads only because pre-construction loadings are not available for reduction calculation.

Chemical Water Quality

Sunday Creek baseline pH



Sunday Creek 2017-2018 pH

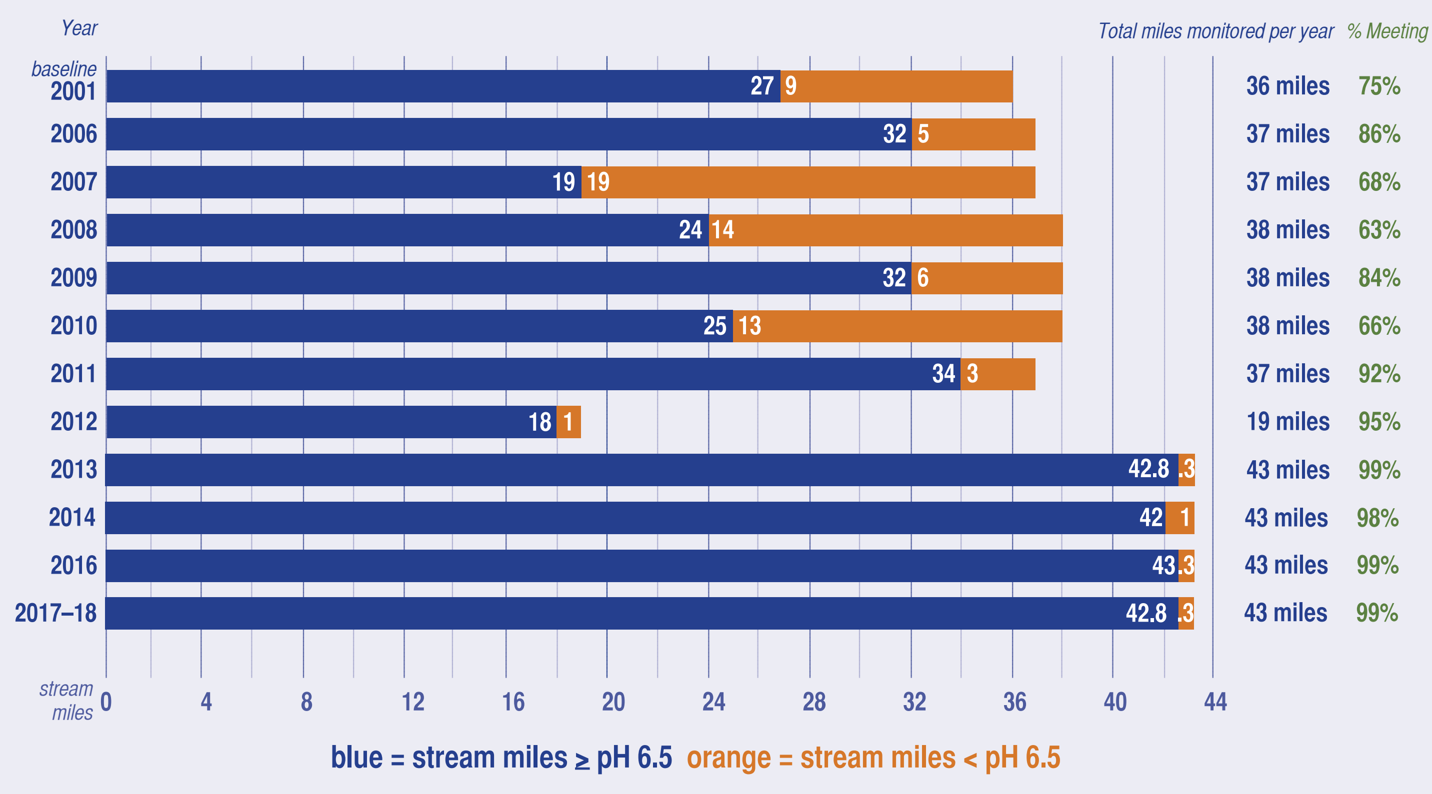


Water quality along the West Branch of Sunday Creek was degraded from baseline conditions in 2001 to 2007. Values of average pH dropped from >6.4 to 4.0-5.4 range in 2005 to 2006 and remained constant in 2007. When the subsidence features increased in Rodger's Hollow, funneling more water into the mine 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 2018 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.

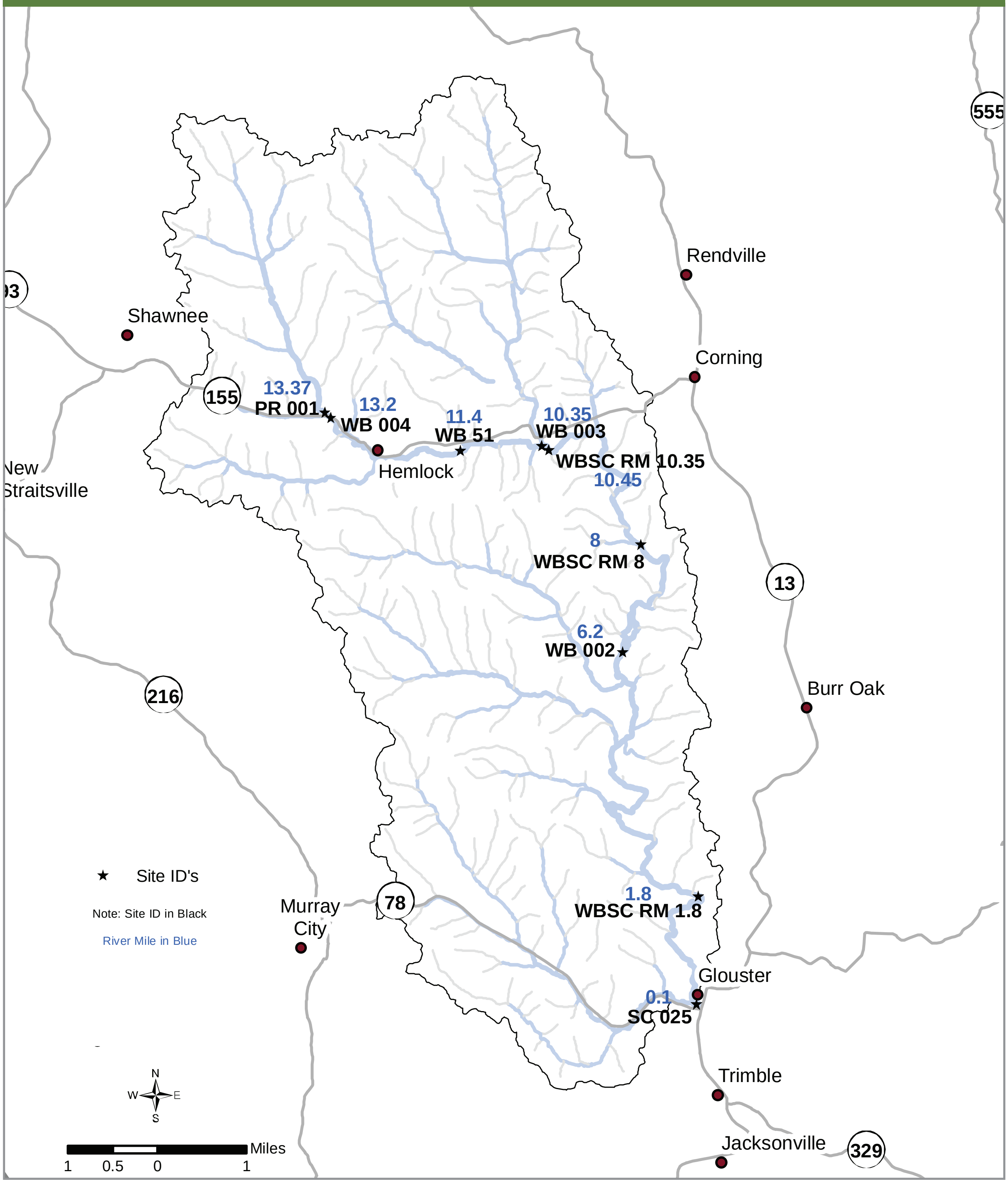
Chemical Water Quality

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. In 2017-2018, all stream miles monitored met the target pH, except for .3 miles directly downstream of the Corning discharge, which was not sampled during the report period.

Sunday Creek pH



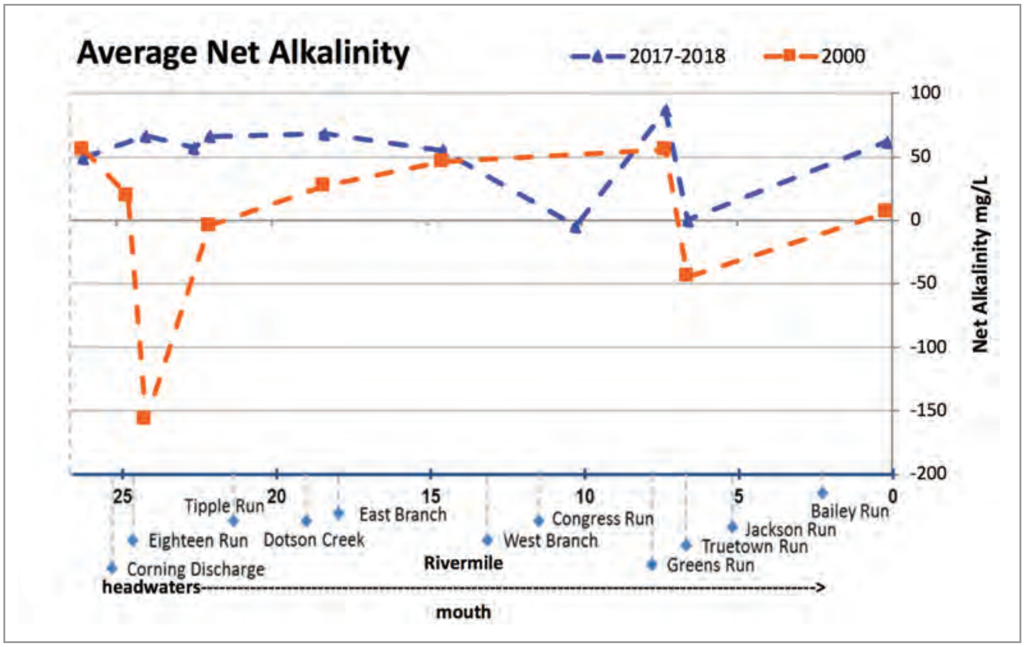
Sunday Creek

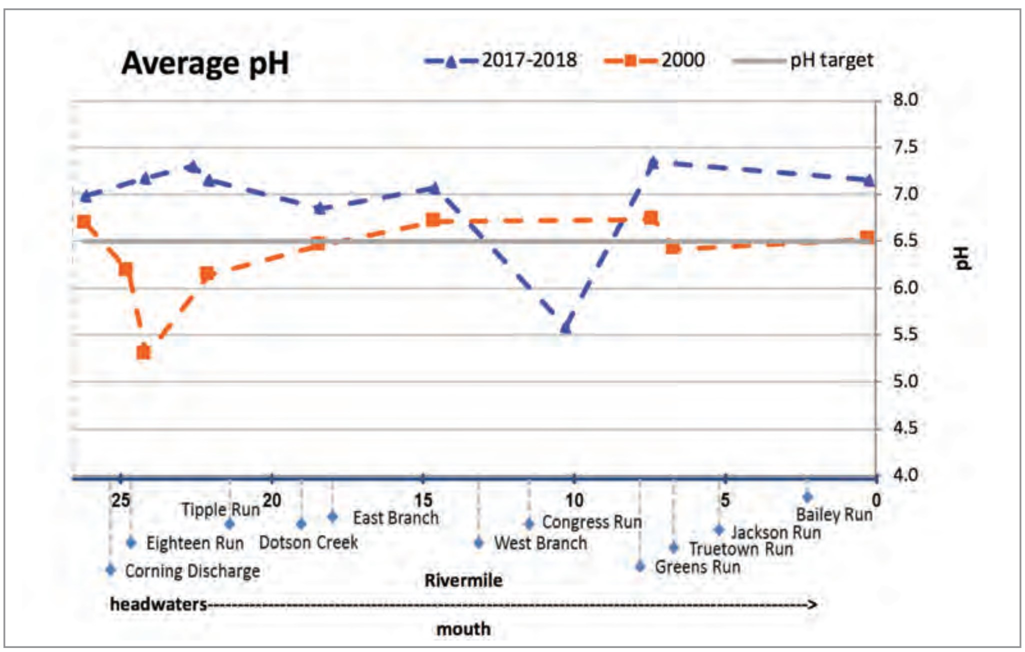


For purposes of analyzing chemical water quality changes along the mainstem of receiving stream where AMD reclamation projects have been completed, Sunday Creek has been divided into the following stream segments: Sunday Creek Mainstem and West Branch of Sunday Creek. Within these stream reaches, chemical 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.

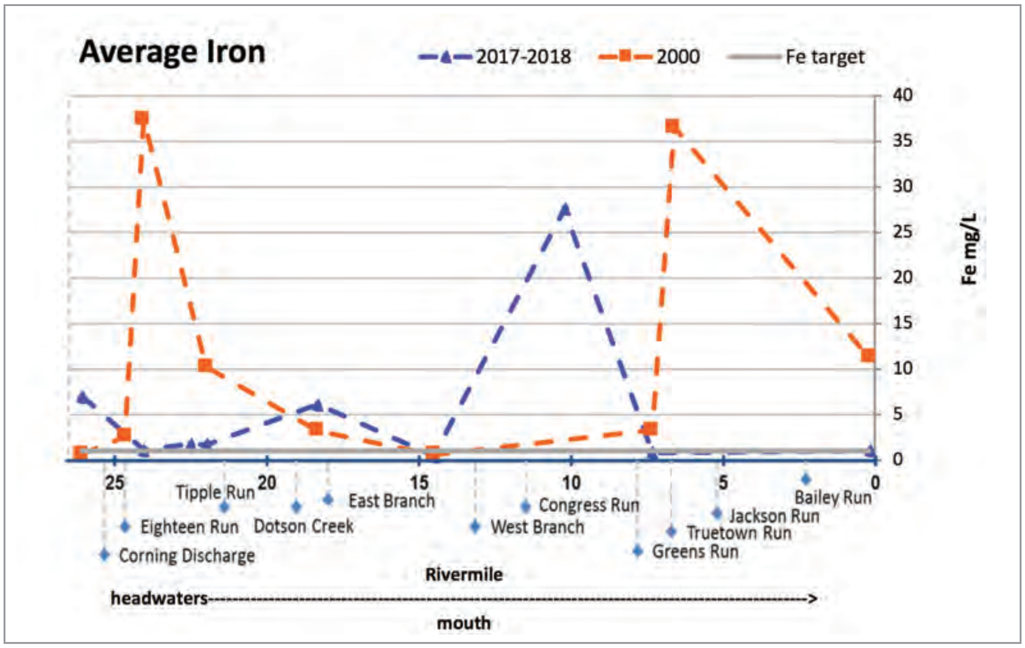
Sunday Creek Mainstem

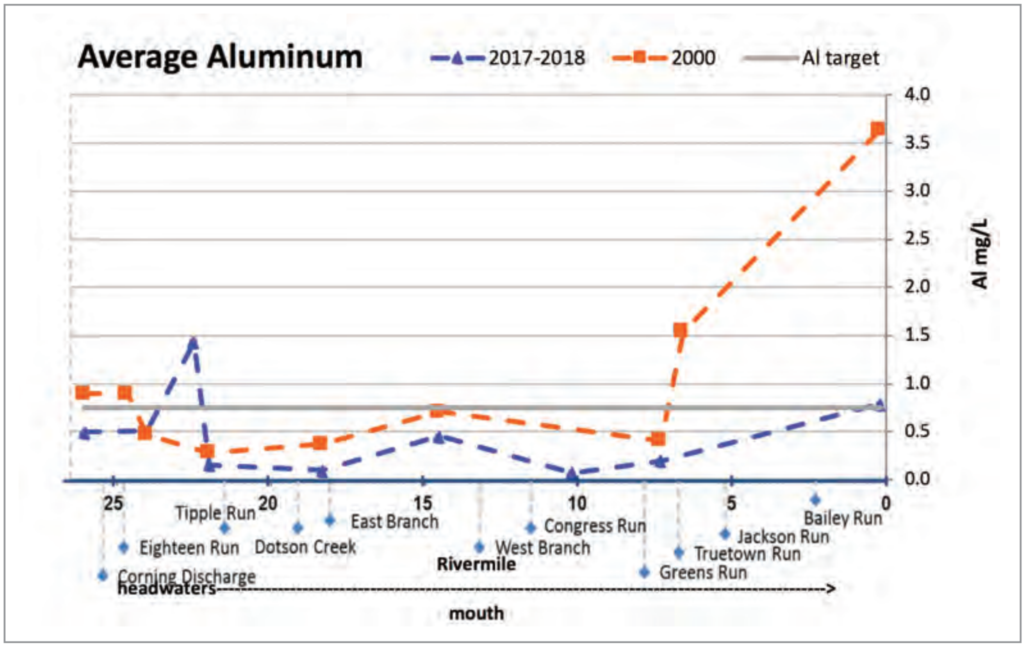
Site ID	SC 077	SC 079	SC 078	SC 080	SC 076	SC 075	SC 074	SCRM 10.2	SC 073	SC 072	SC 071
Rivermile	26.05	23.87	23.65	23.5	22.04	18.3	14.5	10.2	7.3	6.6	0.2



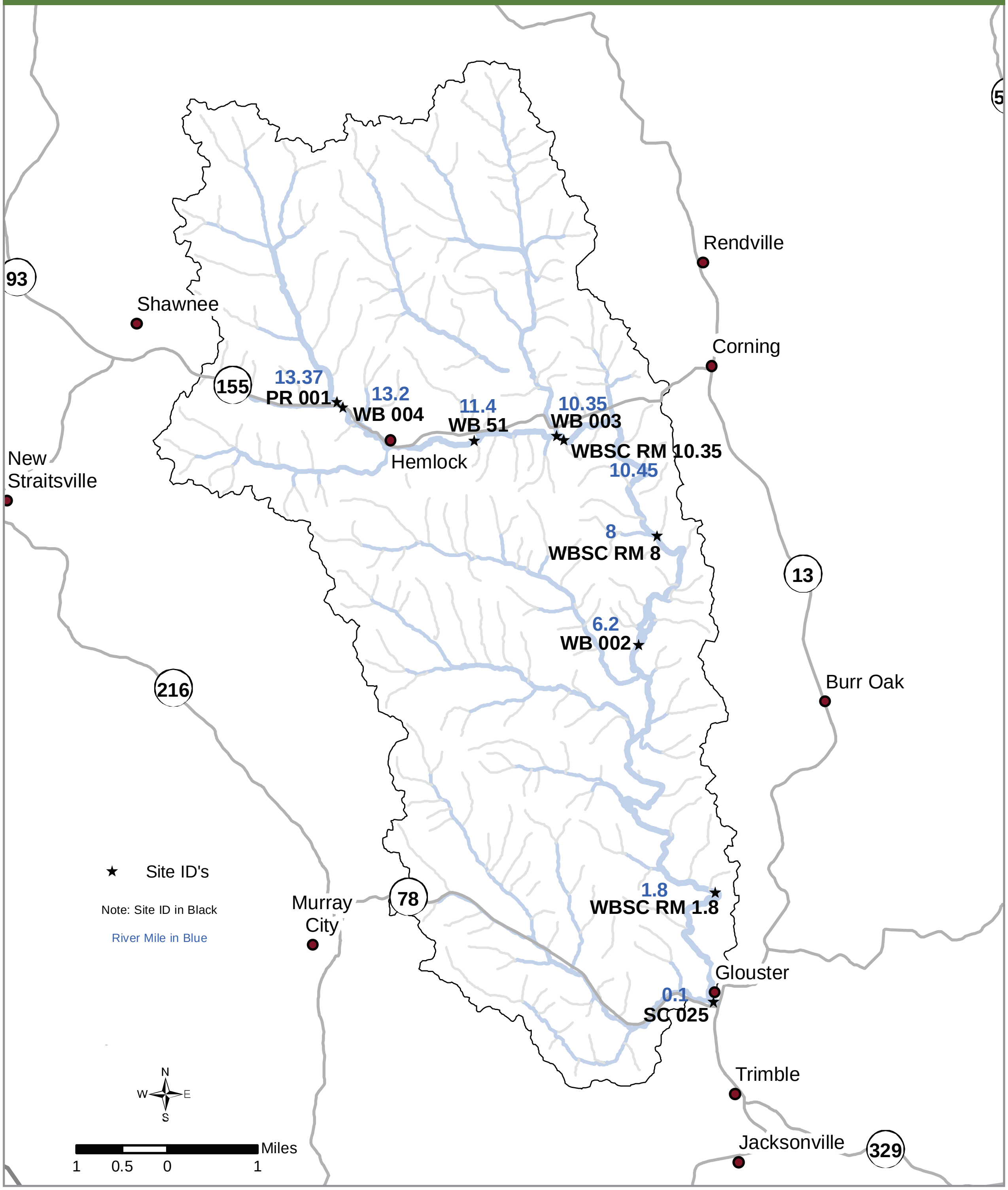


Sunday Creek Mainstem											
Site ID	SC 077	SC 079	SC 078	SC 080	SC 076	SC 075	SC 074	SCRM 10.2	SC 073	SC 072	SC 071
Rivermile	26.05	23.87	23.65	23.5	22.04	18.3	14.5	10.2	7.3	6.6	0.2



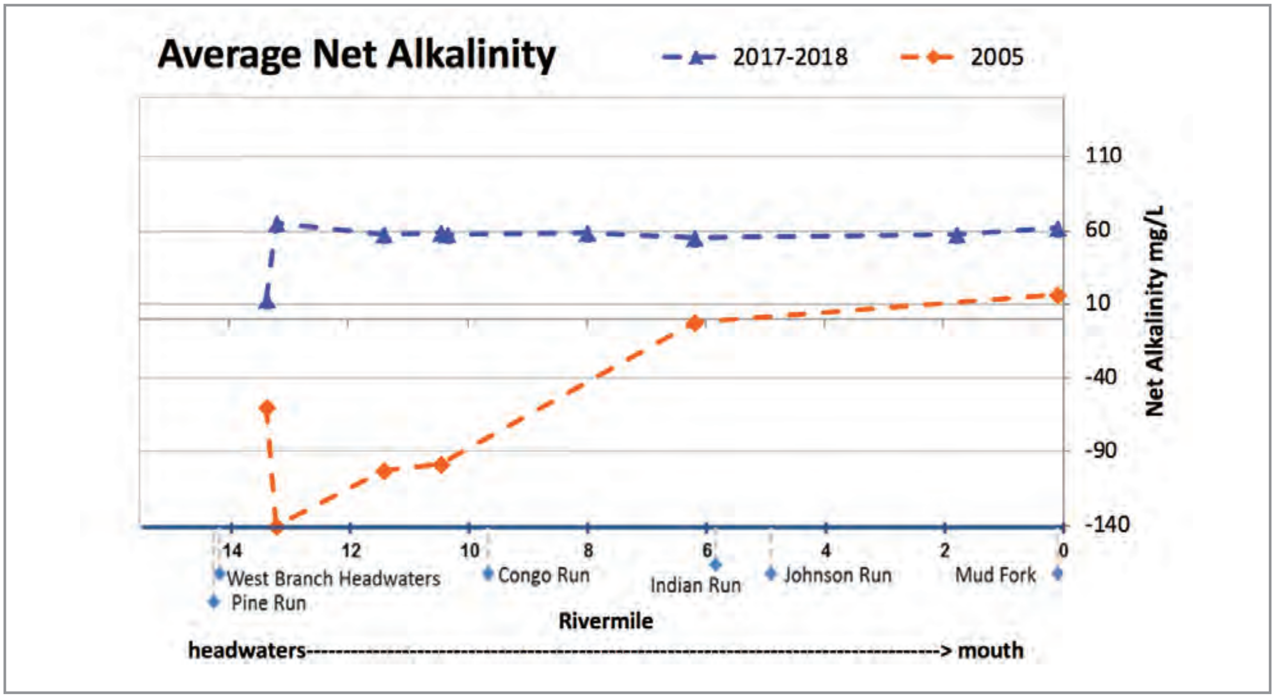


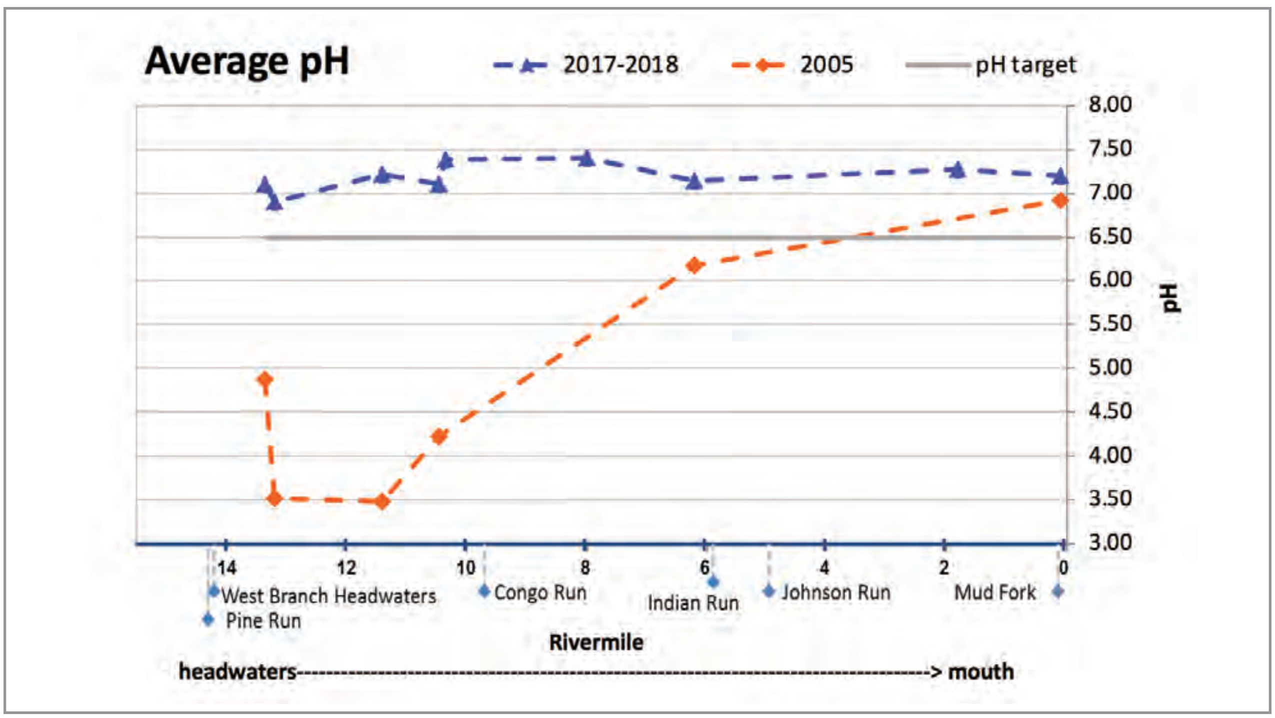
West Branch of Sunday Creek



Chemical water quality analysis per stream reach

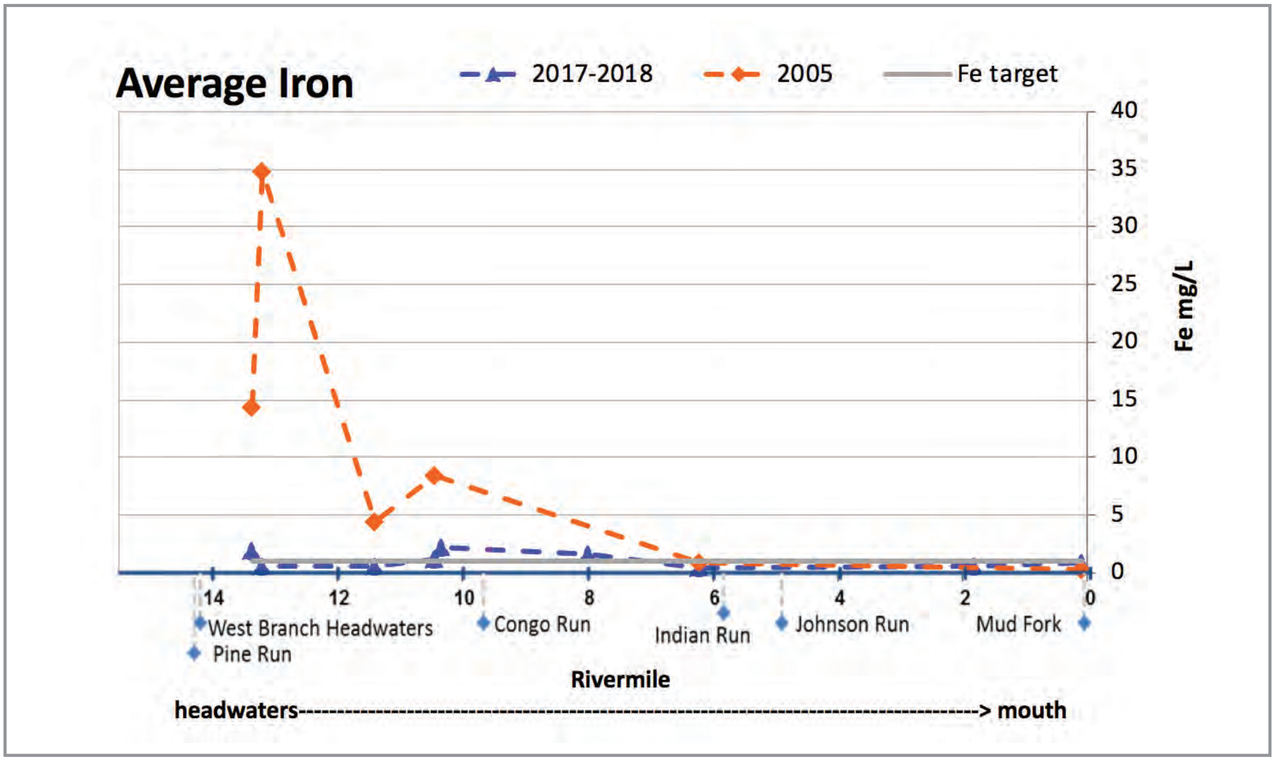
West Branch of Sunday Creek									
Site ID	PR 001	WB 004	WB 51	WB 003	WBSC RM 10.35	WBSC RM 8	WB 002	WBSC RM 1.8	SC 025
Rivermile	13.37	13.2	11.4	10.45	10.35	8	6.2	1.8	0.1

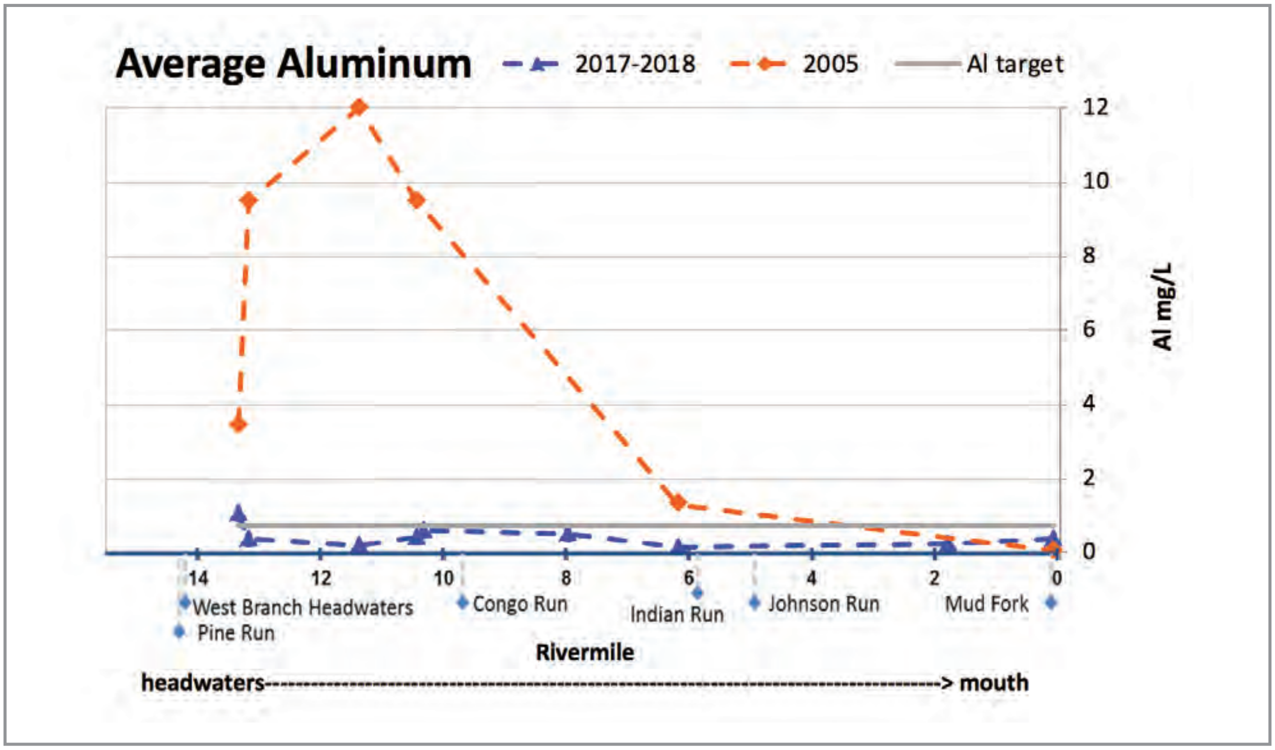




Chemical water quality analysis per stream reach

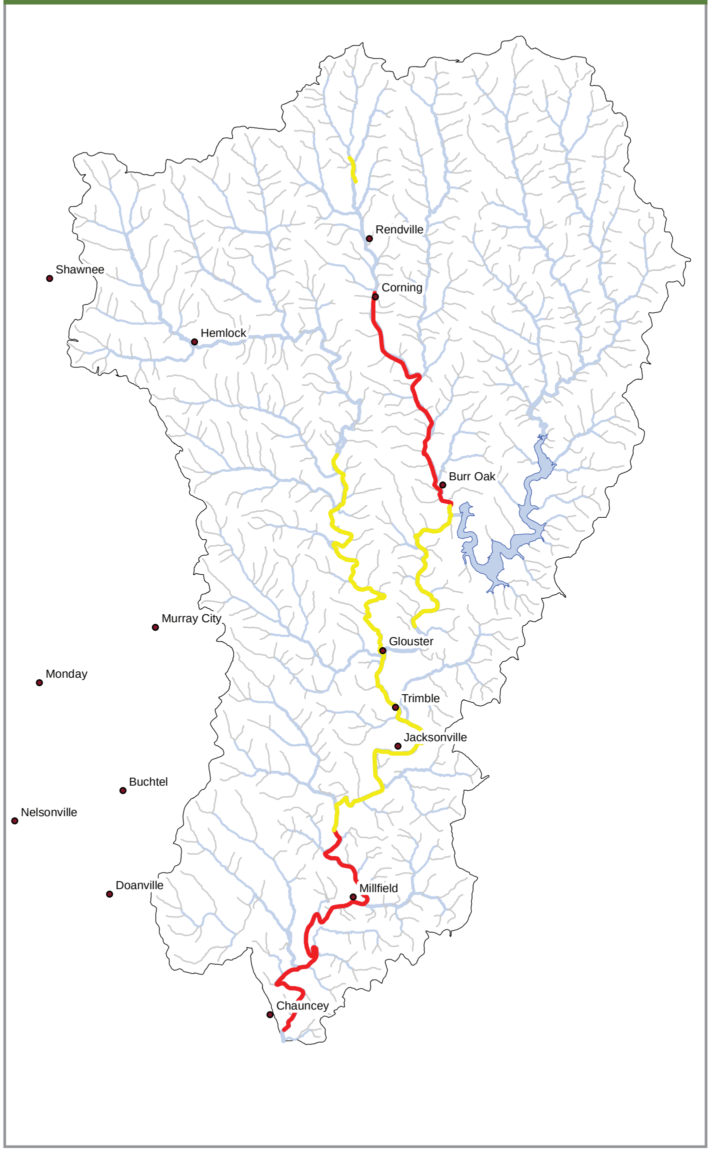
West Branch of Sunday Creek									
Site ID	PR 001	WB 004	WB 51	WB 003	WBSC RM 10.35	WBSC RM 8	WB 002	WBSC RM 1.8	SC 025
Rivermile	13.37	13.2	11.4	10.45	10.35	8	6.2	1.8	0.1



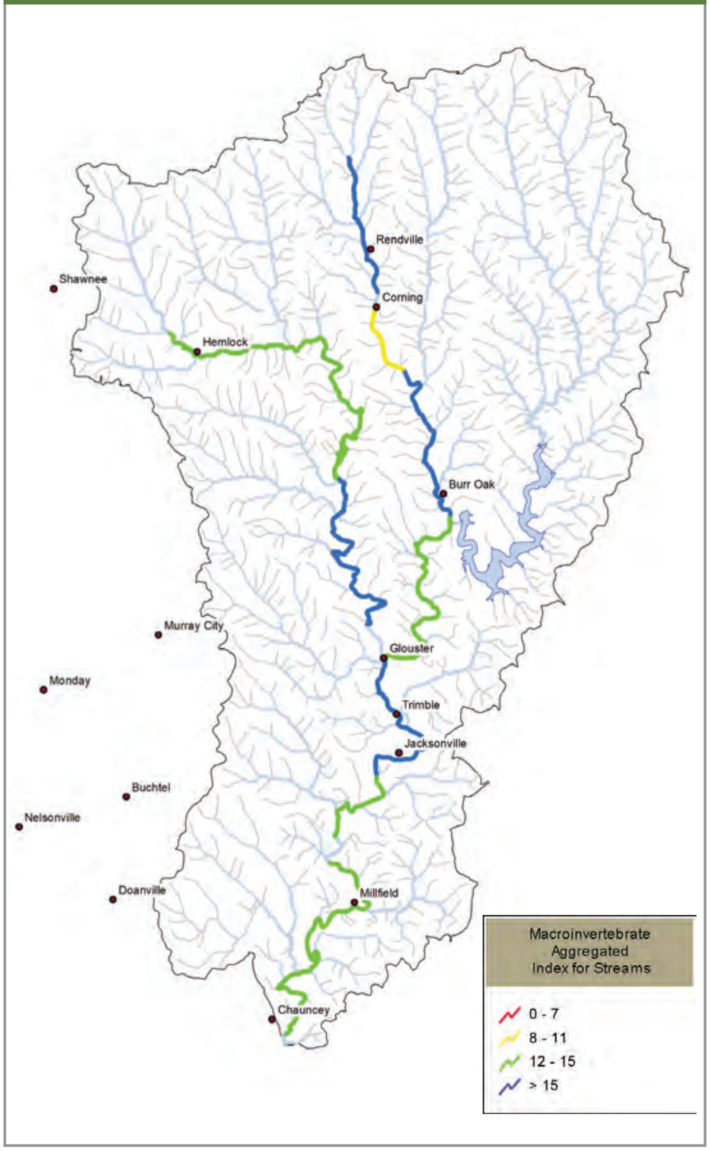


Biological Water Quality

Sunday Creek baseline MAIS



Sunday Creek 2017–2018 MAIS



MAIS samples were collected throughout Sunday Creek at established annual monitoring stations from 2001 through 2018.

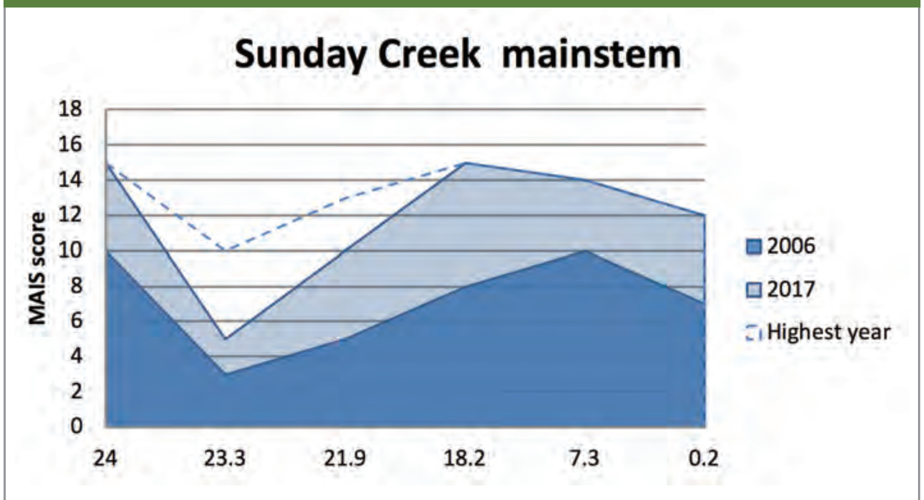
Sunday Creek

The mainstem sites of Sunday Creek have improved since 2006, although the five mile section from RM 23.3 downstream of the Corning discharge (across from the entrance to Tom Jenkins Dam) continues to be poor quality. Although some sites in this section occasionally support high MAIS scores, in most years the section is not reaching its full recovery potential. RM 23.3 in particular has large amounts of metal precipitates which sometimes are observed at RM 21.9. This section of stream has not shown sustained improvement since 2006.

Quality in the mainstem improves further downstream, and in 2017 RM 18.1 (across the entrance to Tom Jenkins Dam) exceeded the macroinvertebrate recovery target for the first time with a MAIS score of ‘15’. This new high score confirms that the physical habitat at the site is capable of supporting high quality biota and that this year the water chemistry may have improved. Notable improvement in the macroinvertebrate score was also observed in 2017 at the furthest downstream monitoring site, RM 0.1. This site at the dog shelter has improved significantly since 2006, but until this year had never actually reached the target score of ‘12’.

It is unclear whether these improvements are due to changes in minewater discharges from Corning and Truetown, increased flow of clean water inputs, or remediation efforts in the West Branch. Improvements in the West Branch observed in 2016 (all but the most upstream site, WBHW003, scored above ‘12’) remained in place in 2017.

Area of Degradation 2006-2018

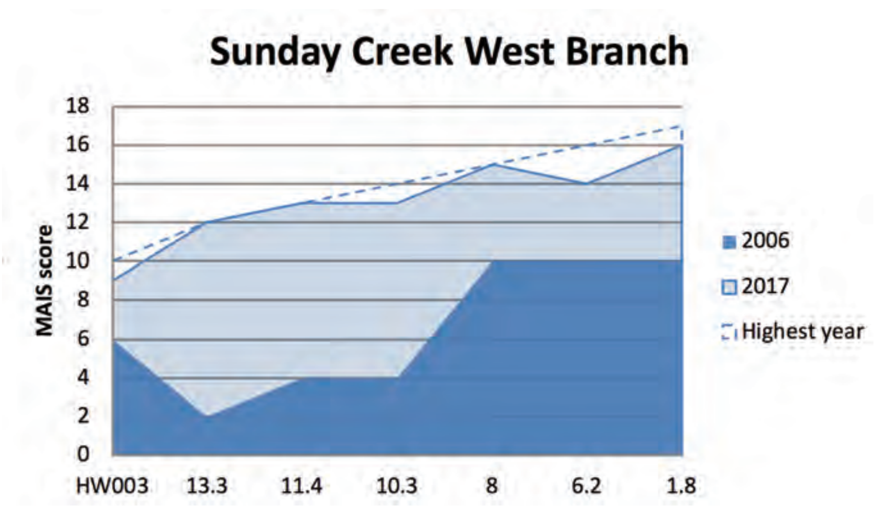


The blue dashed line identifies the highest MAIS score ever achieved at that site throughout the monitoring time period.

Sunday Creek MAIS Regressions

Mainstem	RM	‘01	‘02	‘03	‘05	‘06	‘07	‘08	‘09	‘10	‘11	‘12	‘13	‘14	‘15	‘16	‘17	Linear trends	R square	P-value	No. of observations
SC RM	26.6									14	14	13	16	15	13	dry	16	no change	0.169298	0.359080	7
SC 079	24				12	10	10	14	12	13	12	11	15	14		13	15	**improved**	0.413344	0.024130	12
SC 080	23.3				5	3	2	7	12	5	10	4	9	4	9	5		no change			12
SC 076	21.9	2	1	2	11	5	5	9	2	3	7	5	8	8	10	6	10	**improved**	0.338528	0.018060	16
SC 075	18.2	5	9	8	10	8	10	5	7	8	11	10	9	9	10	11	15	**improved**	0.382931	0.010597	16
SC RM 10.2	10.2										17	13	15	16	14	14	16	no change	0.011904	0.815871	7
SC 073	7.3	10	11	11	11	10	10	10	12	11	14	9	11	13	13	11	14	**improved**	0.267747	0.040093	16
SC 071	0.2	4	2	3	8	7	3	6	11	8	10	7	9	7		8	12	**improved**	0.523015	0.002312	16

Area of Degradation 2006-2018



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

Sunday Creek MAIS Regressions

Westbranch	RM	'01	'02	'03	'05	'06	'07	'08	'09	'10	'11	'12	'13	'14	'15	'16	'17	Linear trends	R square	P-value	No. of observations
WBHW 50	14.7					11	10	11	8	12	13	11	11	11							
WBHW 003	13.4				5	6	4	8	6	8	10	8	10	8		9					
WB 004	13.3				1	2	2	5	5	7	7	5	11	8	7	12					
WB 051	11.4				8	4	2	7	9	5	12	10	7	9		12	13	**improved**	0.499495	0.010174	13
WB 003	10.3				8	4	3	4	8	4	7	7	7	11	6	14	13	**improved**	0.492198	0.007528	13
WB RM8	8									14	13	15	14	15		13					
WB 002	6.2				7	10	8	10	10	13	13	15	16	15	12	15	14	**improved**	0.677760	0.000544	13
WB RM1.8	1.8									12	17	15	16	16	13	16	16	no change	0.082406	0.490591	8
SC025										15	16	17	17	15	15	15					

HUFF RUN
WATERSHED REPORT

2017–2018 NPS Report - Huff Run Watershed

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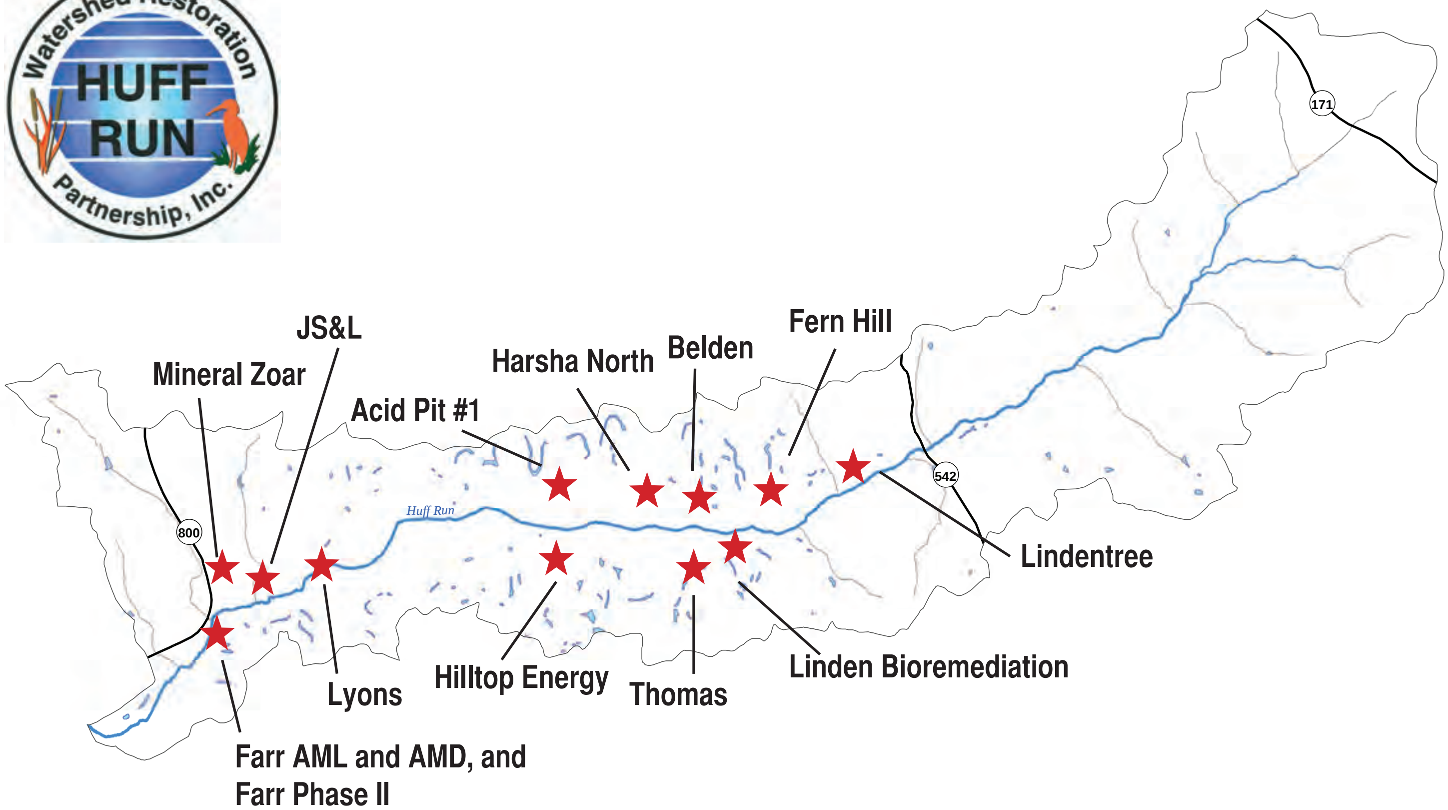


Reductions

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 2017–2018 = $5,644,950

**Insufficient data to calculate acid and metal loads for 2017-2018 reporting period.*

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.

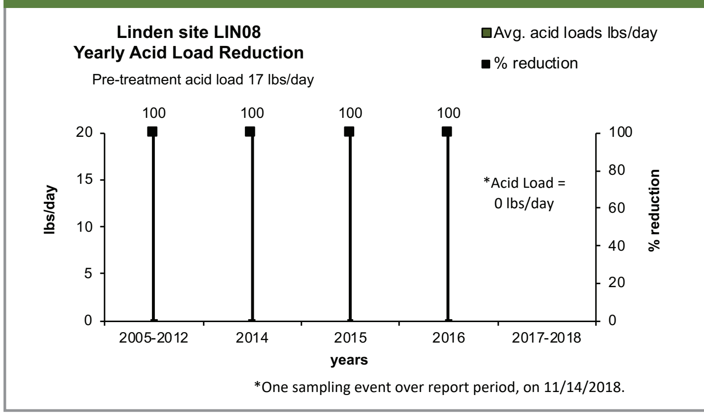
Italicized indicates projects are not actively monitored for acid and metal load reduction purposes

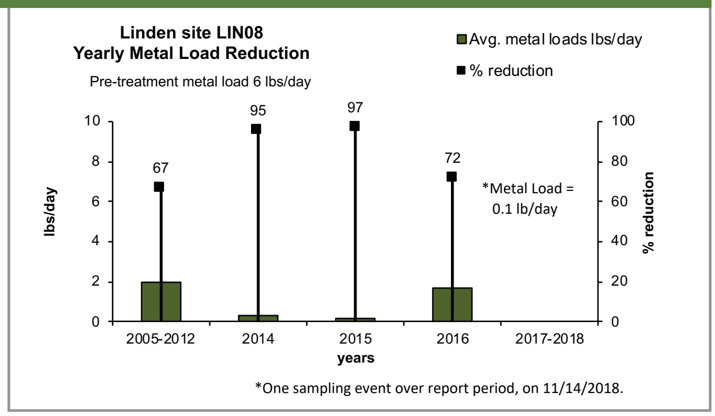
**Indicates no yearly trend graphs due to lack of pre or post data*

Yearly acid and metal load reduction trends per project

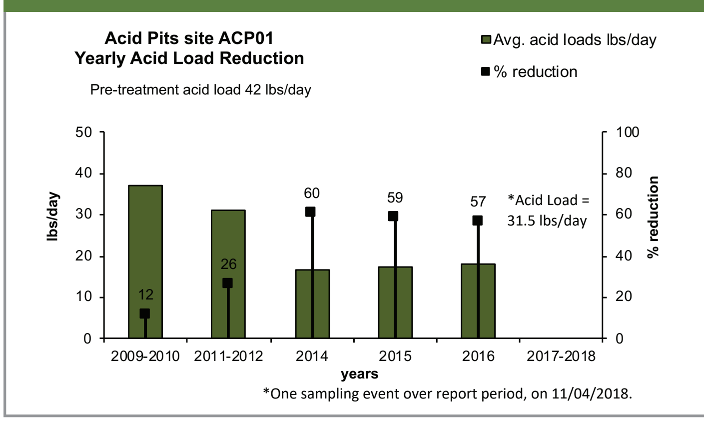
Similar to other environmental best management practices (BMPs), performance of passive acid mine drainage reclamation projects are also expected to decline with time. Active treatment systems are not expected to decline with time but sometimes need to be maintained to perform adequately. Currently, 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.

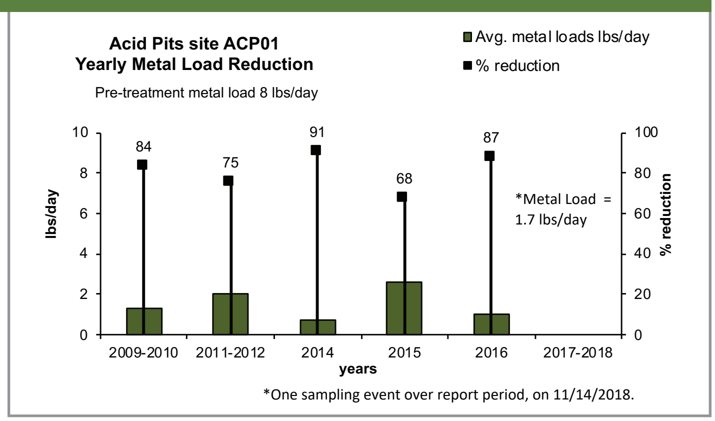
Linden site LIN08



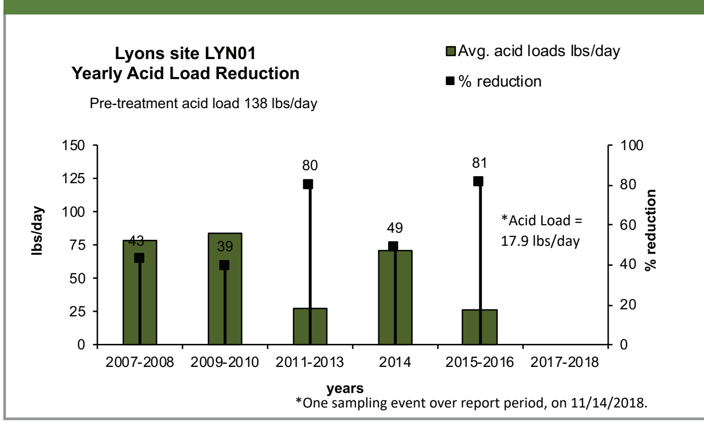


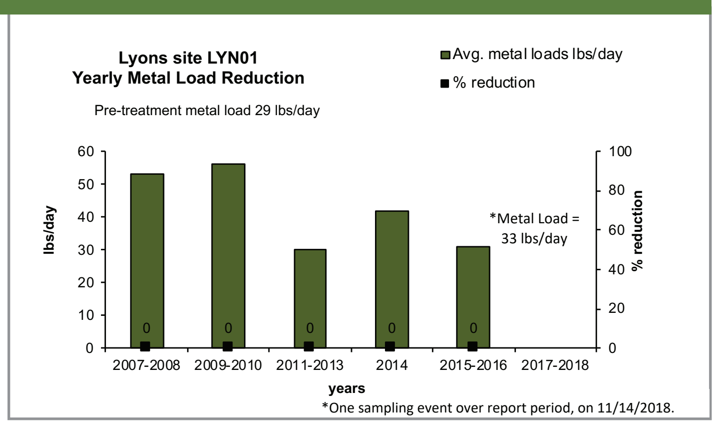
Acid Pits site ACP01





Lyons site LYN01





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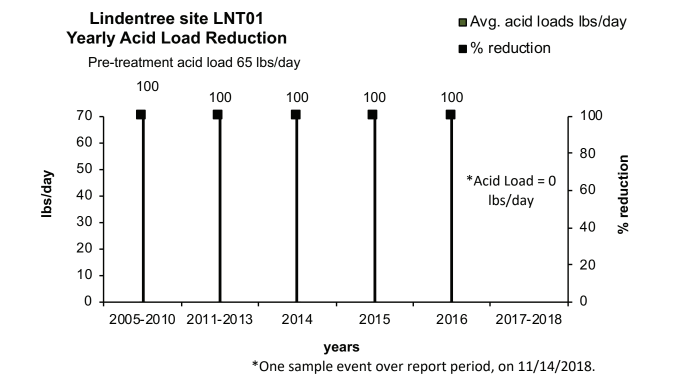
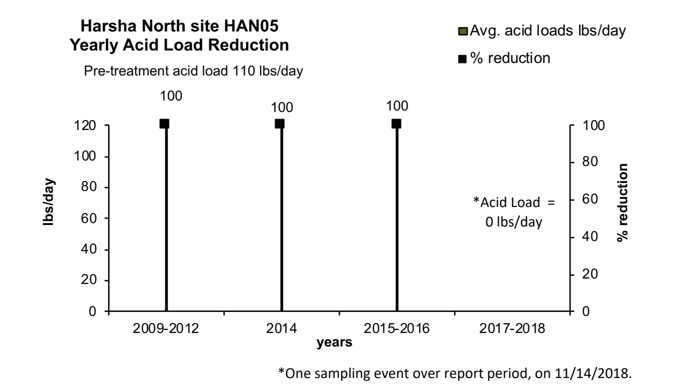
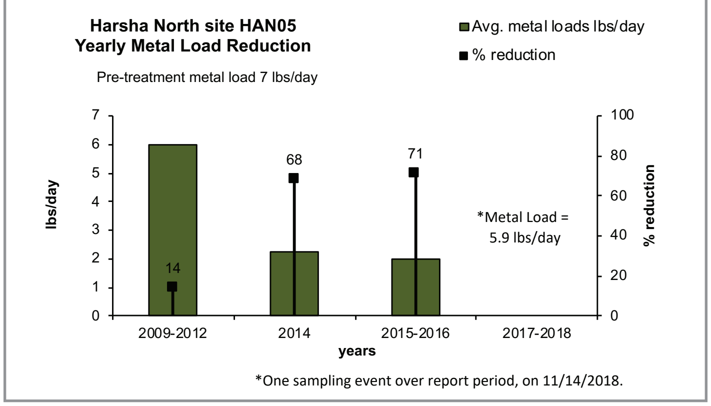
Yearly acid and metal load reduction trends per project

Lindentree site LNT01

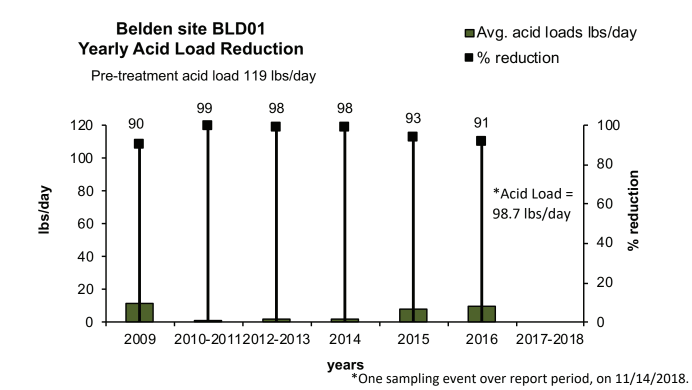


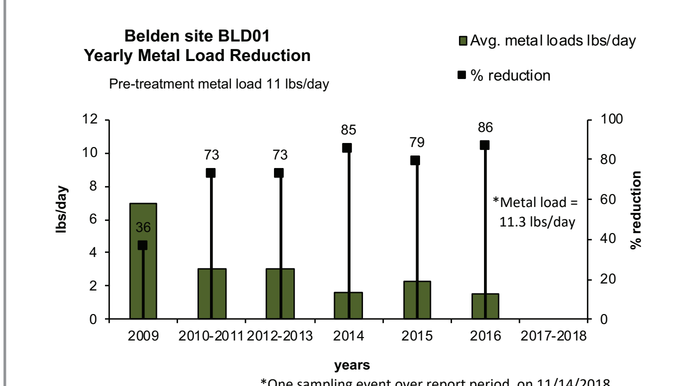
Harsha North site HAN05





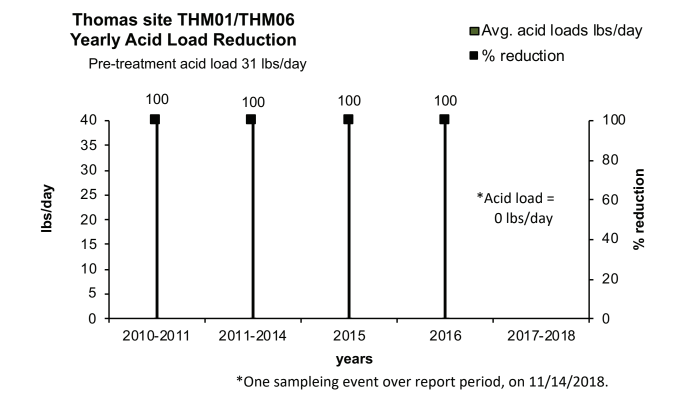
Belden site BLD01

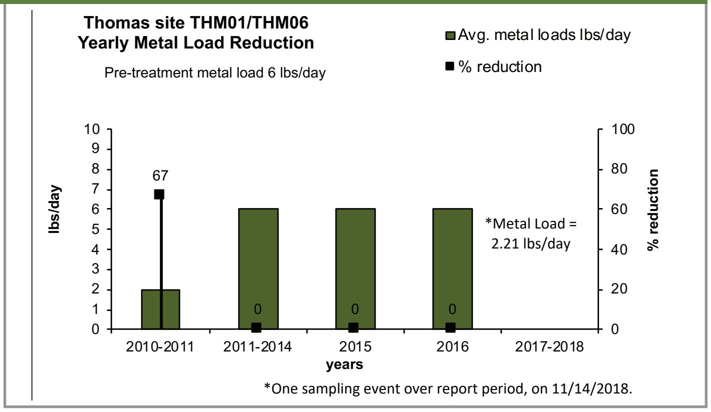




Yearly acid and metal load reduction trends per project

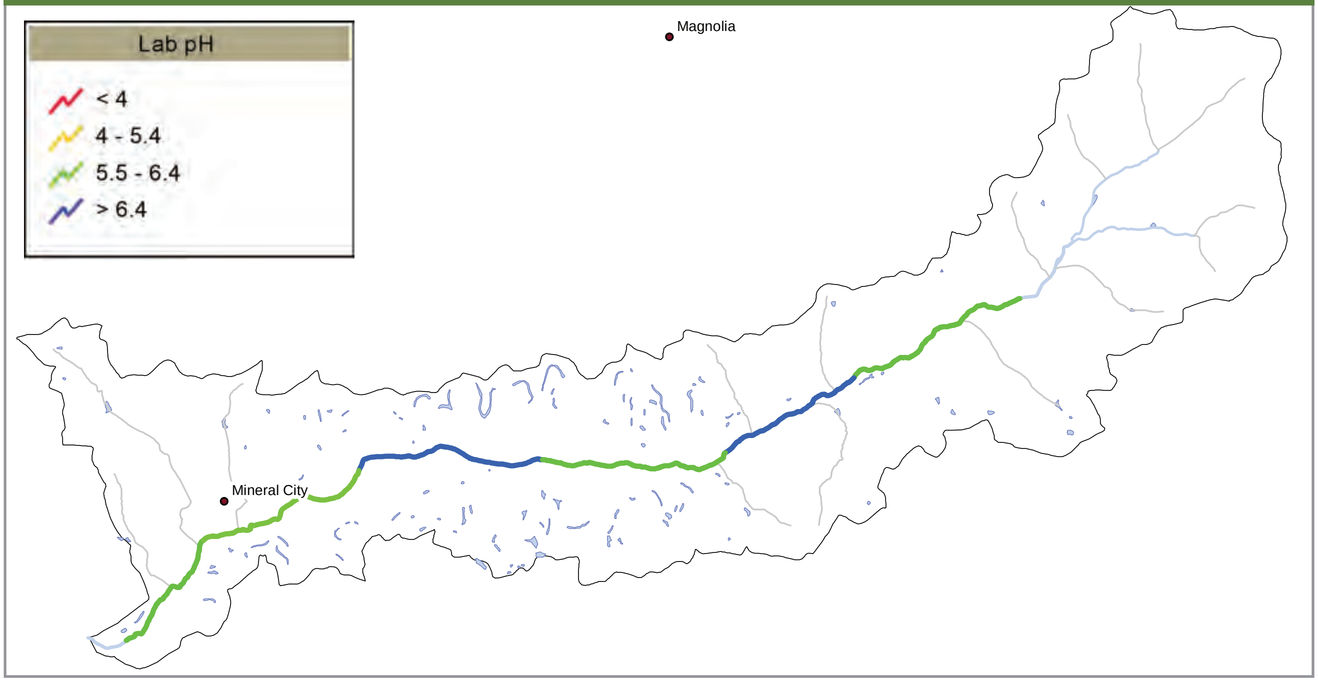
Thomas site THM01/THM06



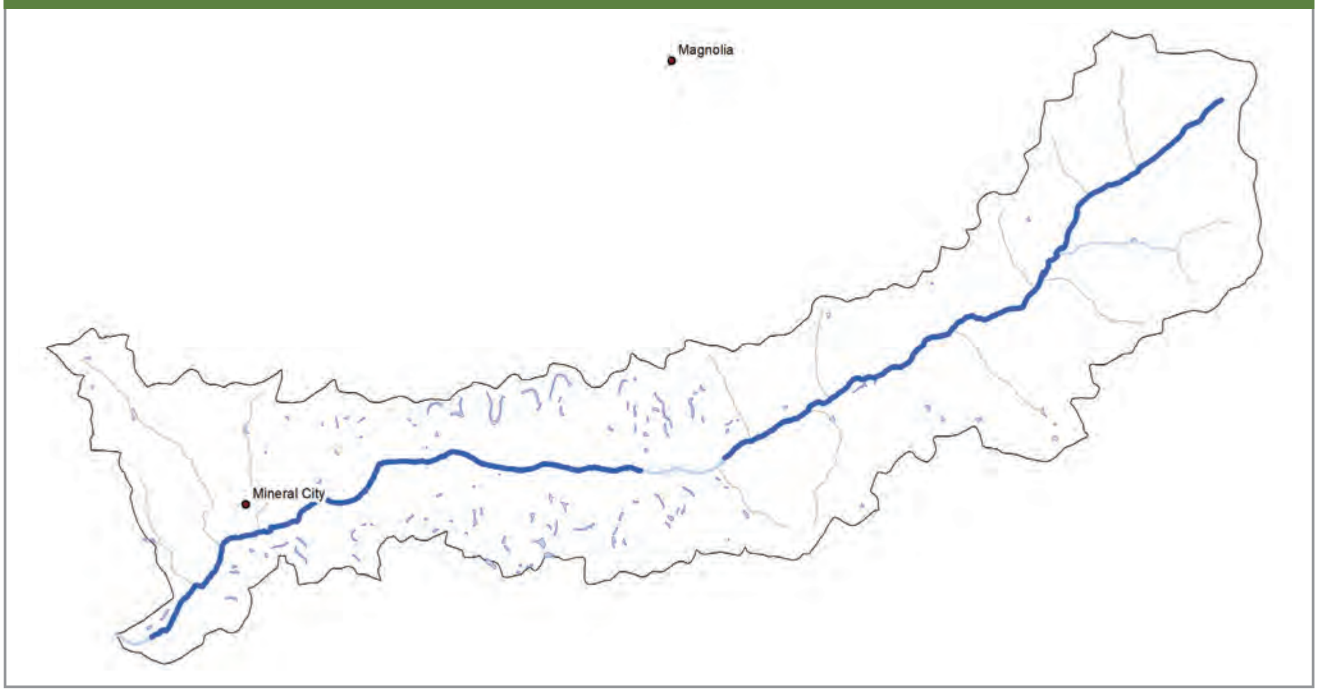


Chemical Water Quality

Huff Run baseline pH



Huff Run 2017–2018 pH

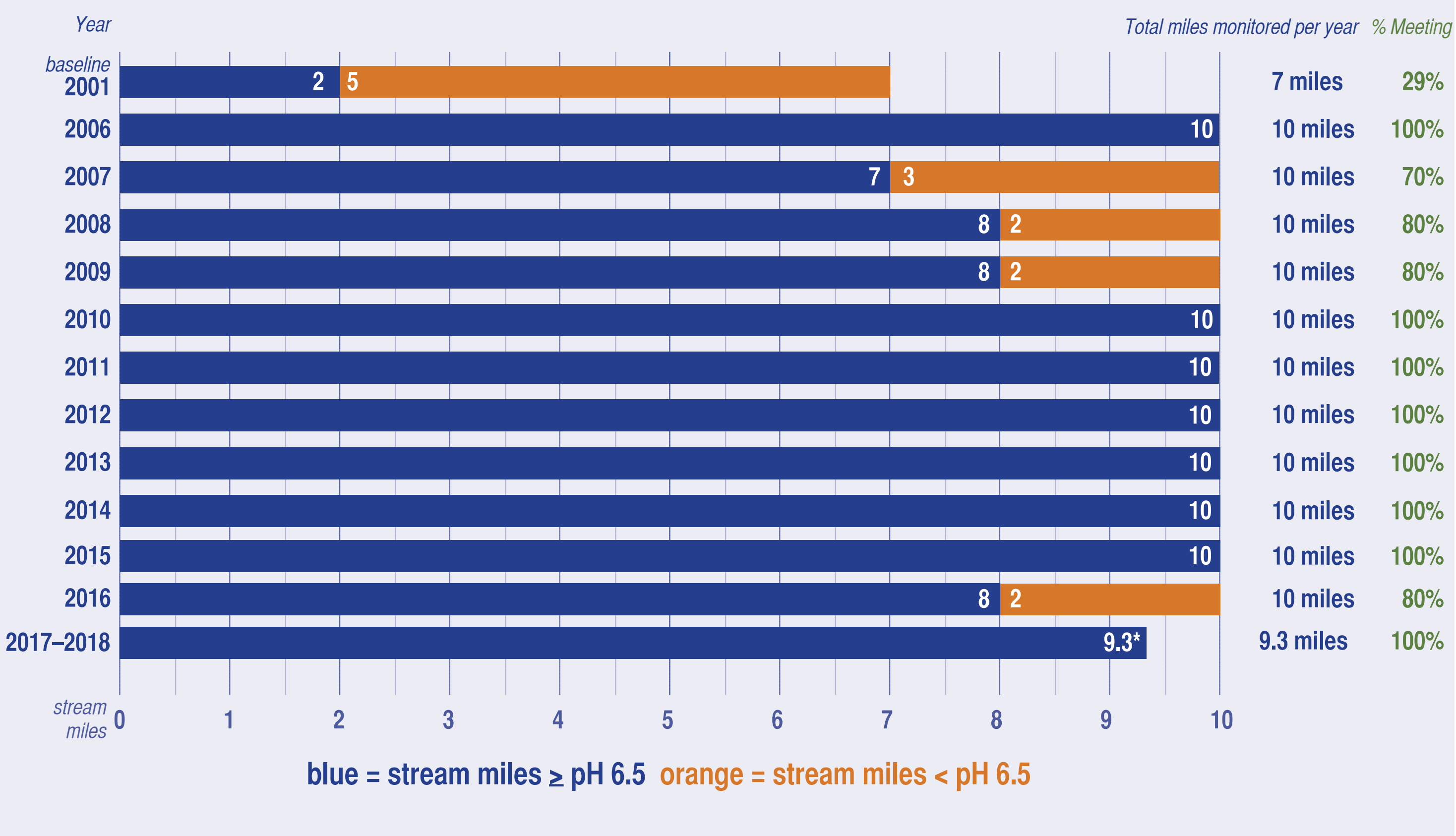


Huff Run pH values have improved from baseline conditions (1985-1998) to 2016. All of the 10 miles monitored in Huff Run in the 2017-2018 reporting period met the minimum pH target of 6.5.

Chemical Water Quality

The mainstem of Huff Run is approximately 10 miles in length. In 2009, 8 miles met the pH target of 6.5, while the two downstream reaches (HRR08 and HRR07) fell slightly below the target with an average of 6.4. From 2010 to 2015, all t=10 miles met the target. 2106 was similar to the 2008- 2009 stream conditions, where the mouth of Huff Run fell just below meeting the pH ttarget, leaving approximately 8 miles meeting and 2 miles slightly less than 6.5. In the 2017-2018 reporting period, Huff Run once again met the pH targets at all sites monitored, however, site HRR04, a 0.7 mile segment, was not monitored so is not included in total miles.

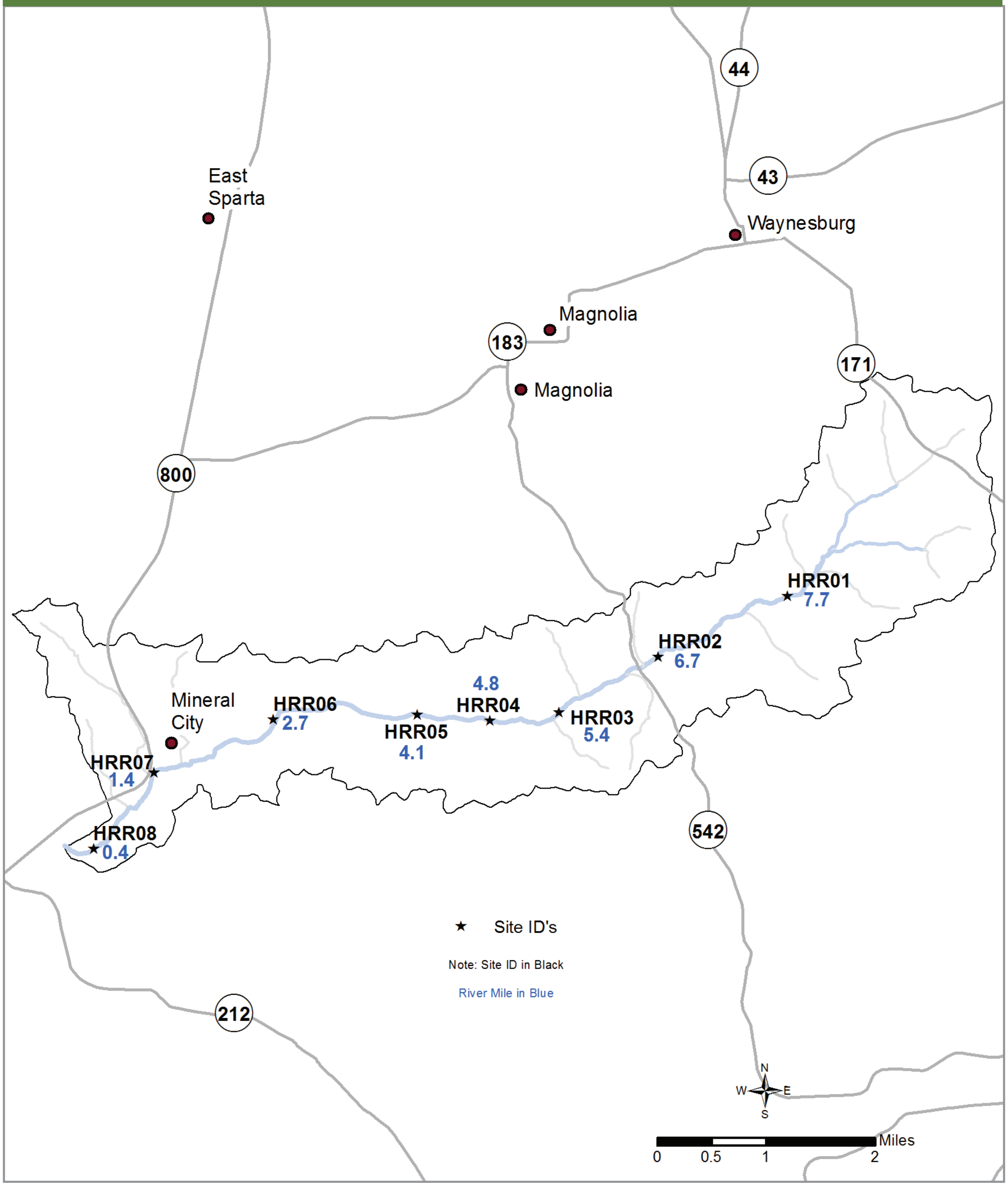
Huff Run pH



**Site HRR004 (0.7 mile reach) not monitored during this sample period.*

Chemical water quality analysis per stream reach

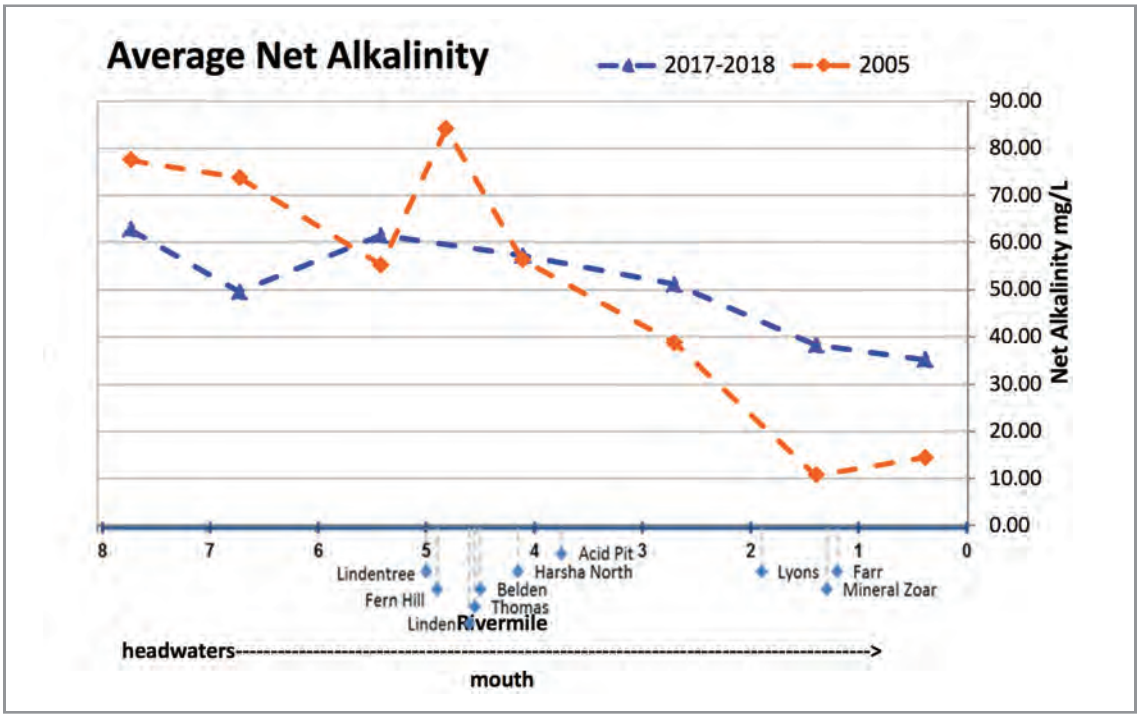
Huff Run

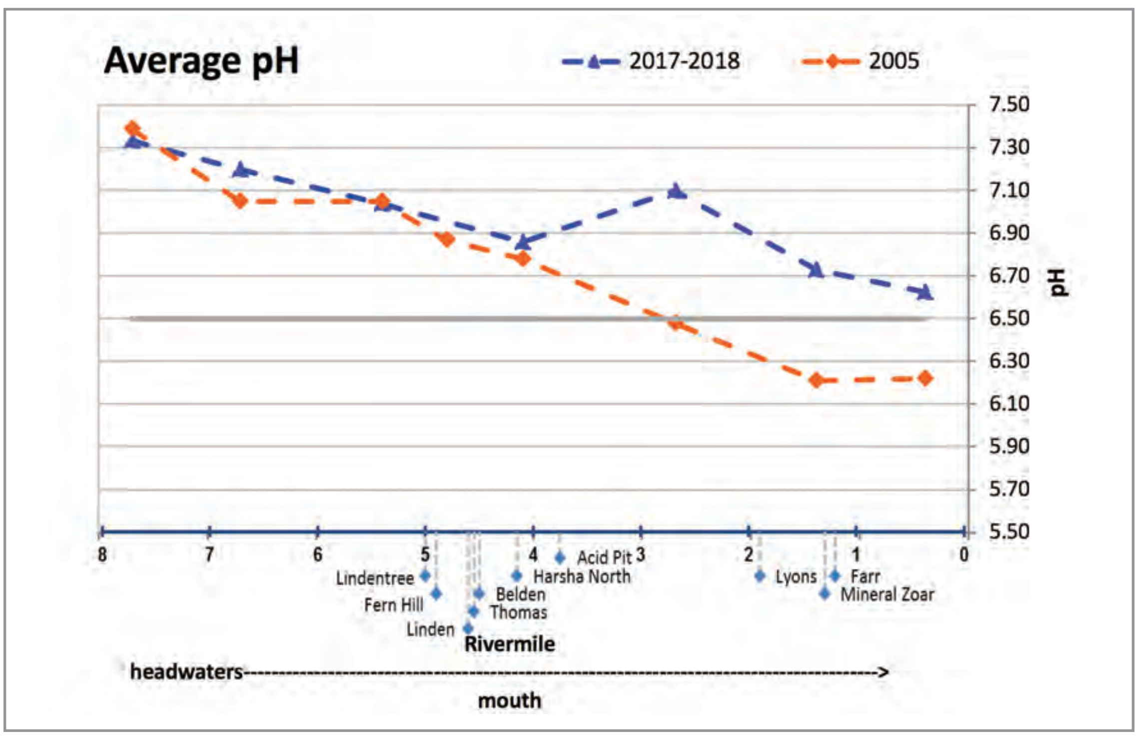


Chemical water quality analysis per stream reach

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.

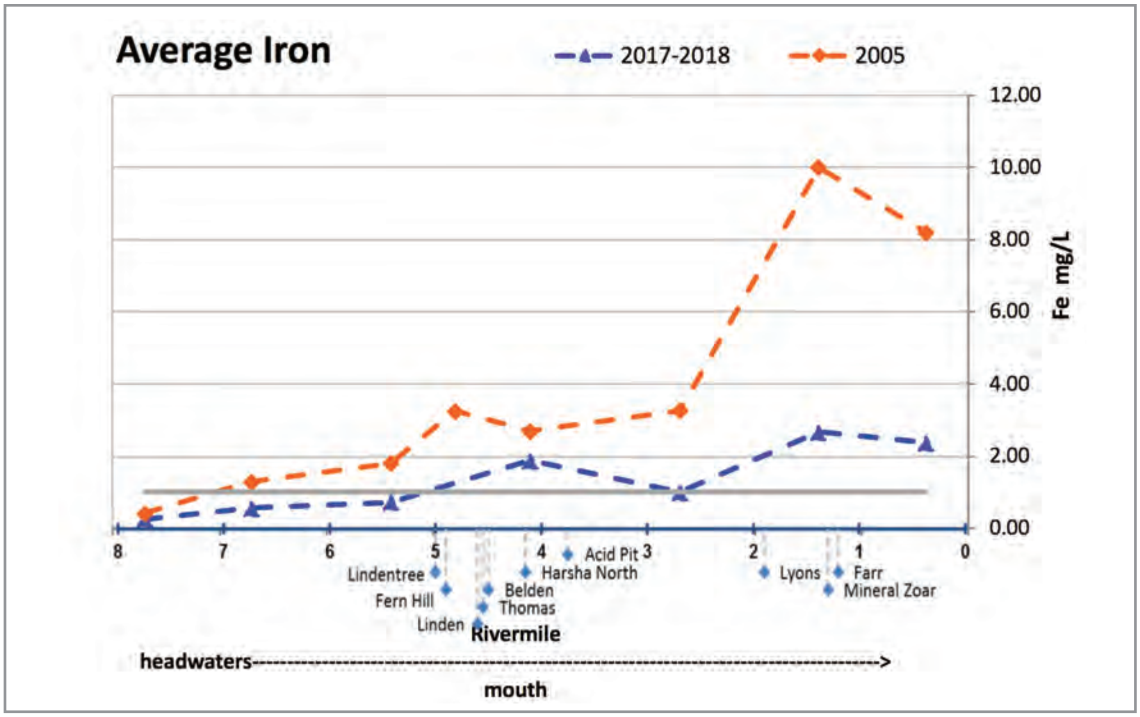
Huff Run								
Site ID	HRR01	HRR02	HRR03	HRR04	HRR05	HRR06	HRR07	HRR08
Rivermile	7.7	6.7	5.4	4.8	4.1	2.7	1.4	0.4

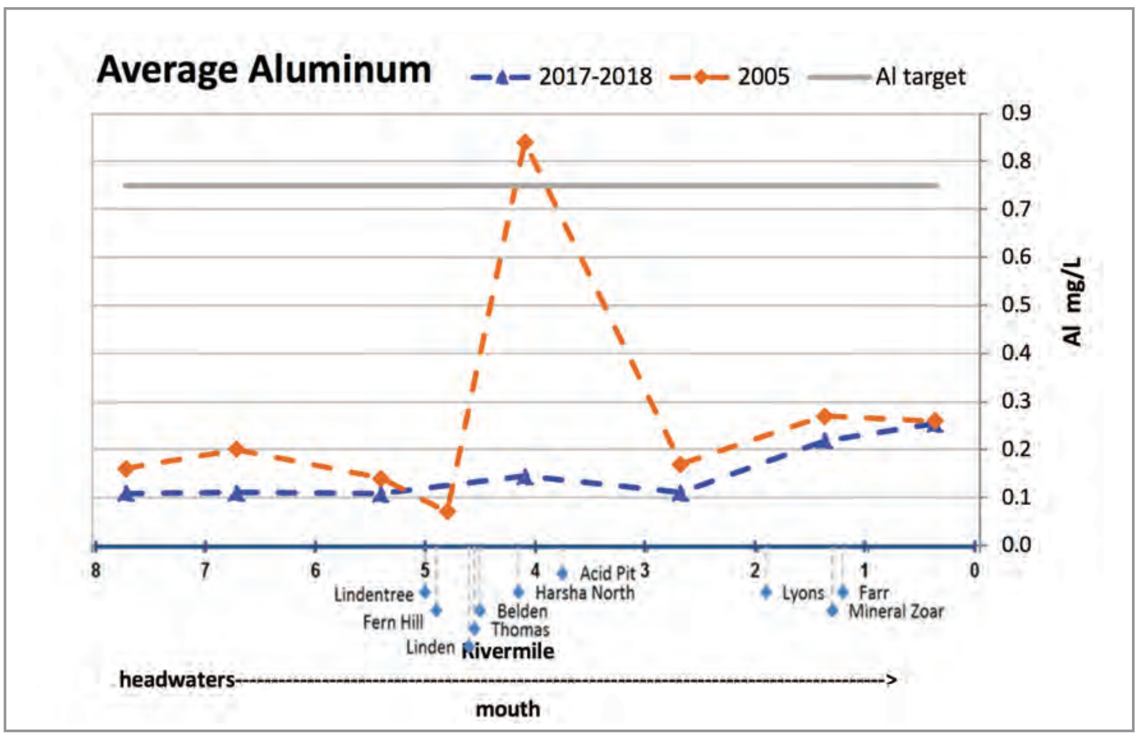




Chemical water quality analysis per stream reach

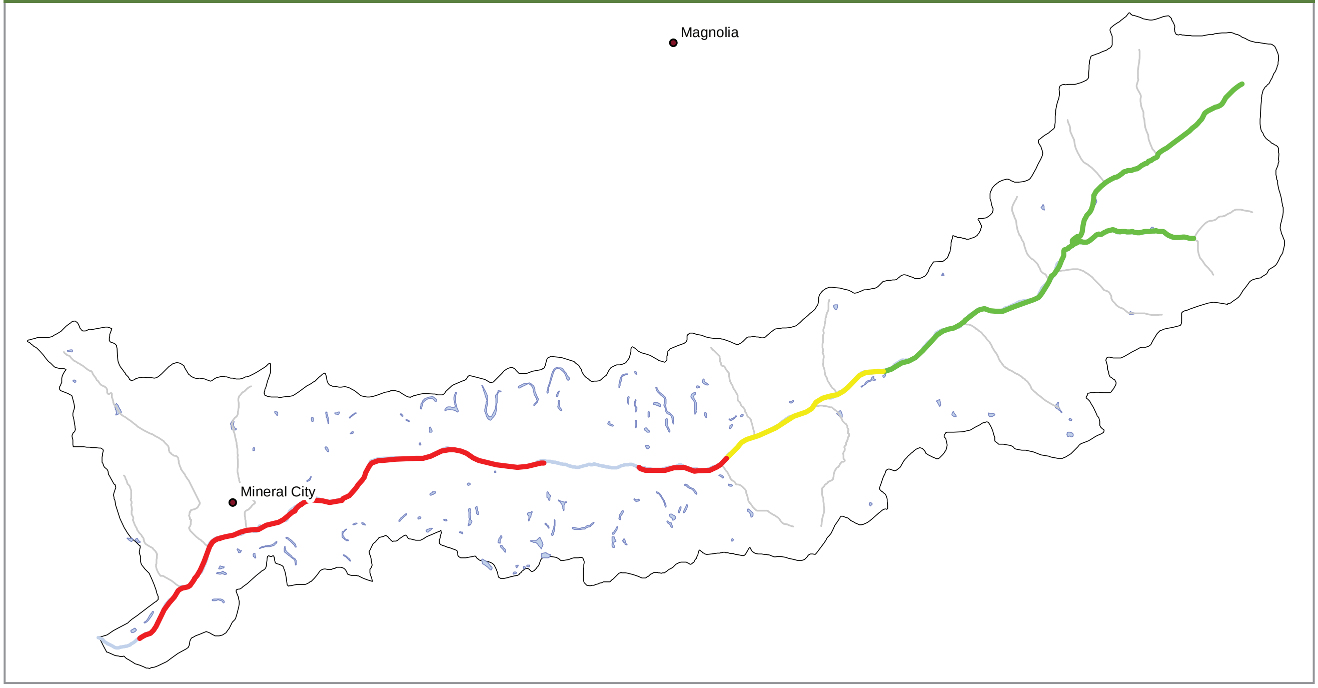
Huff Run								
Site ID	HRR01	HRR02	HRR03	HRR04	HRR05	HRR06	HRR07	HRR08
Rivermile	7.7	6.7	5.4	4.8	4.1	2.7	1.4	0.4



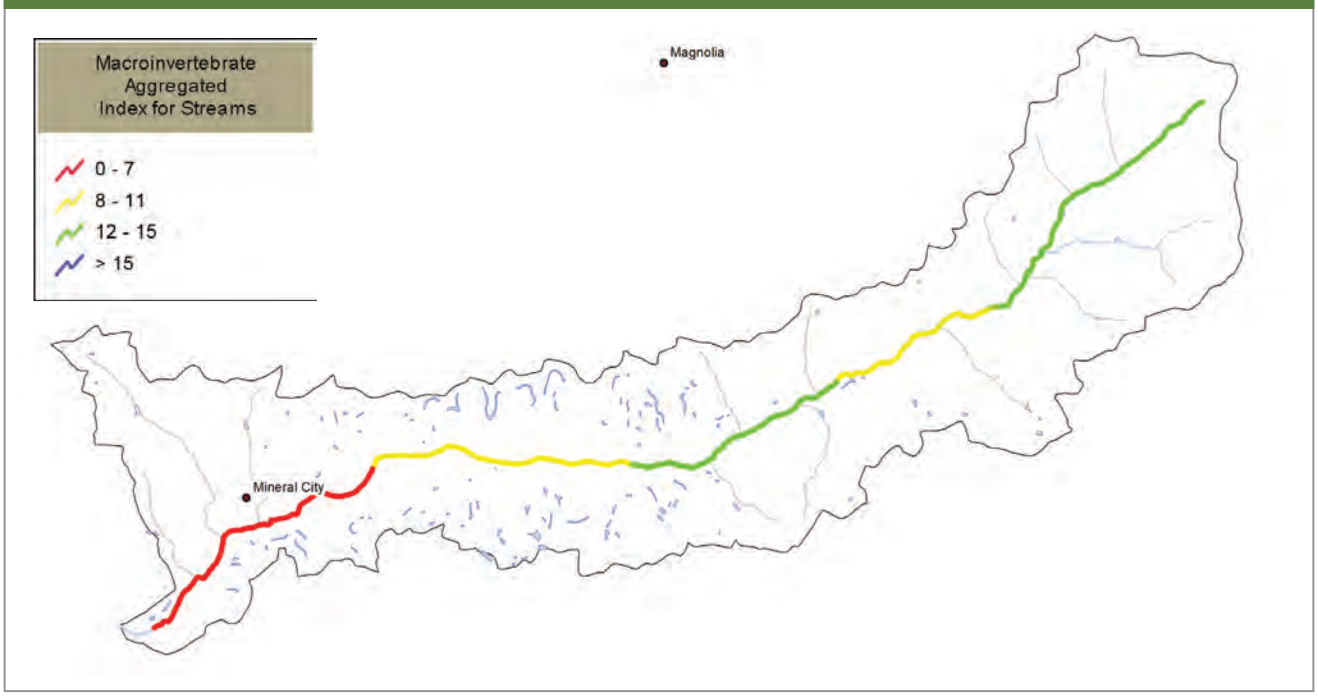


Biological Water Quality

Huff Run baseline MAIS



Huff Run 2017–2018 MAIS

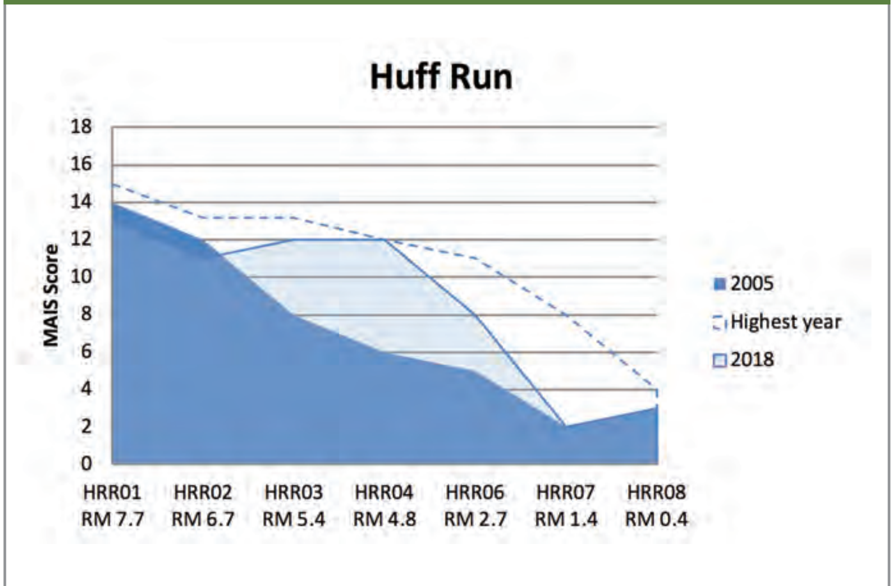


Biological quality in Huff Run decreases from headwaters to the mouth.

Biological Water Quality

Biological recovery of the macroinvertebrate community in Huff run since 2005 has been relatively slow but steady in the upstream portions of the watershed. The uppermost two sites have not changed much, with the most upstream site at RM 7.7 already meeting the MAIS target and the site immediately downstream (RM 6.7) almost meeting it. 2014 was the first year that other sites (RM 5.4) showed sustained and statistically significant improvement in MAIS scores. Three upstream sites (RM 7.7, 4.8 and 2.7) achieved their highest scores that year. In 2015, RM 5.4 met the biological restoration target of a MAIS score >12. Between 2016 and 2018, all four of the upstream monitoring sites (RM 7.7, 6.7, 5.4 and 4.8) had met the restoration target of an MAIS score > 12 at least once. The biology at RM 2.7 has improved significantly since 2012 but has not met the restoration target of 12 yet. The two downstream sites (RM 1.4 and 0.4) show no improvement in MAIS scores.

Area of Degradation 2005-2018



Huff Run MAIS Regressions

	'05	'06	'07	'08	'09	'10	'11	'12	'13	'14	'15	'16	'18	Linear trends	R square	P-value	No. of observations
HRR01 RM 7.7	14	11	12	12	13	9	13	6	10	15	9	12	13	no change	0.00946	0.751908	13
HRR02 RM 6.7	12	8	8	8	9	11	11	11	10	9	7	13	11	no change	0.05783	0.428672	13
HRR03 RM 5.4	8	6	7	6	8	9	7	9		11	13	13	12	**improved**	0.76331	0.000204	13
HRR04 RM 4.8	6	7	9	8	9	9	6	7		11	9	8	12	**improved**	0.36064	0.038940	13
HRR06 RM 2.7	5	4	5	3	4	5	3	4		7	11	10	8	**improved**	0.52724	0.007496	13
HRR07 RM 1.4	2	3	3	2	8	2	2	3		7	2	4	2	no change	0.00450	0.835864	13
HRR08 RM 0.4	3	0	4	3	4	3	3	3	3	4	4	2	3	no change	0.04433	0.489862	13

LEADING CREEK
WATERSHED REPORT

2017–2018 NPS Report - Leading Creek Watershed

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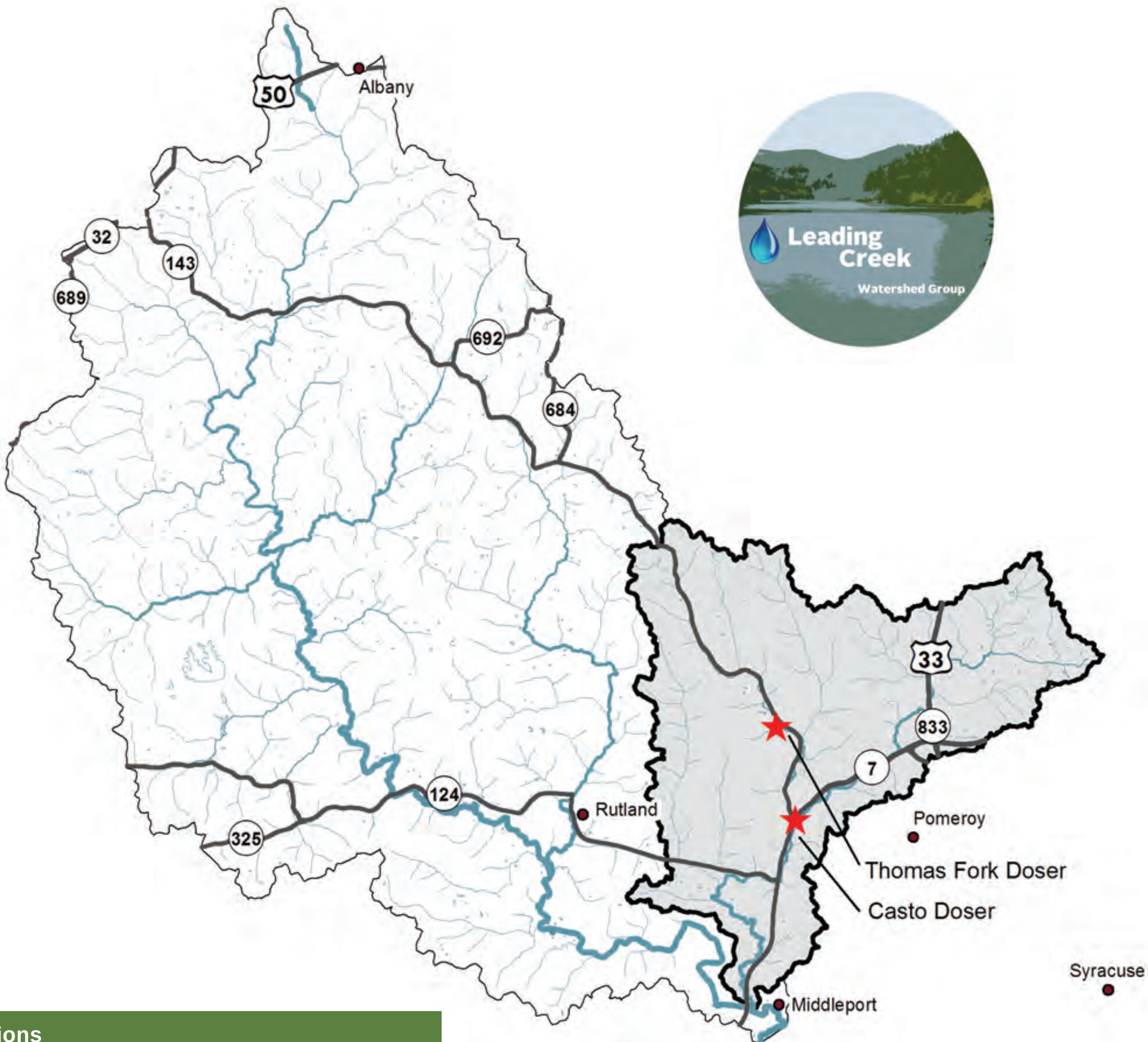


Reductions

Total acid load reduction = 663 lbs/day

Total metal load reduction = 234 lbs/day

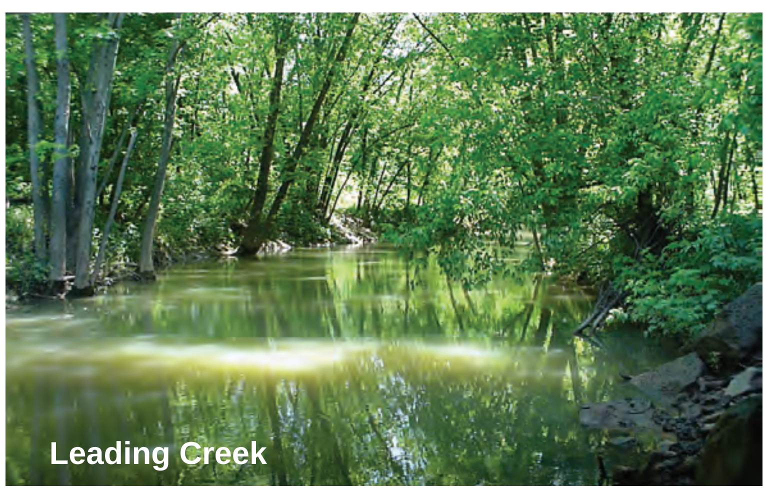
Acid and metal load reductions based on projects monitored during 2017-2018 listed here: Thomas Fork Doser, and Casto Doser.

Costs

Design $36,132

Construction $692,349

Total Costs through 2018 = $728,481



Timeline of the Leading Creek Watershed Project Milestones & AMD Projects

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:

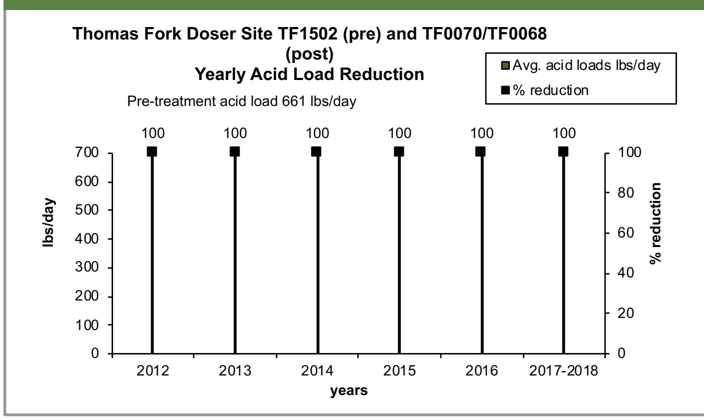
2012 Thomas Fork Doser (TF1502 pre/ TF0070 and TF0068 post) – Active calcium oxide doser

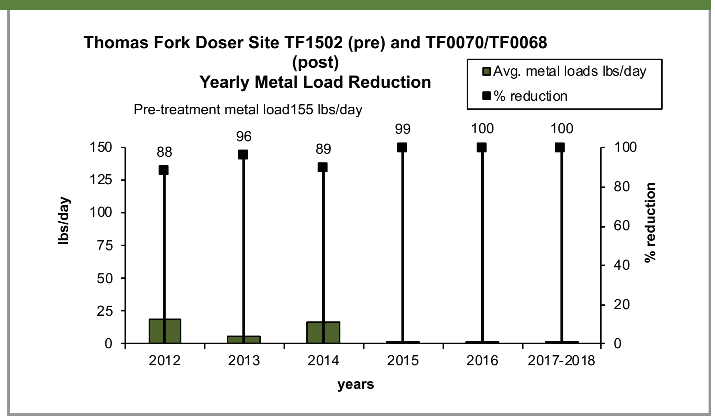
2015 Casto Doser (TF0030) – Super fine lime dust (CaCO3)

Yearly acid and metal load reduction trends per project

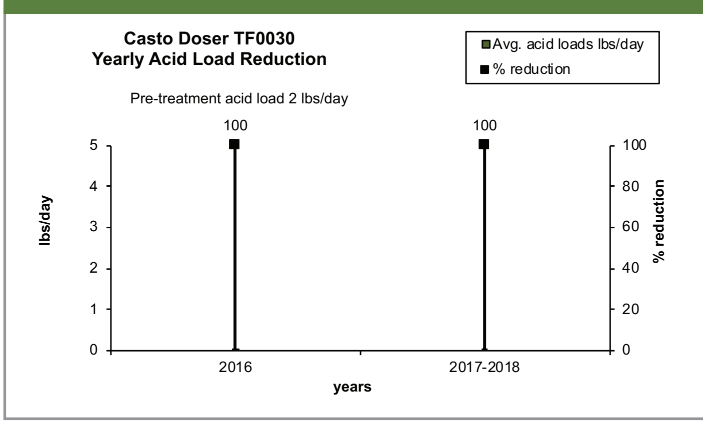
Similar to other environmental best management practices (BMPs), performance of passive acid mine drainage reclamation projects are also expected to decline with time. Active treatment systems are not expected to decline with time but sometimes need to be maintained to perform adequately. Currently, 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.

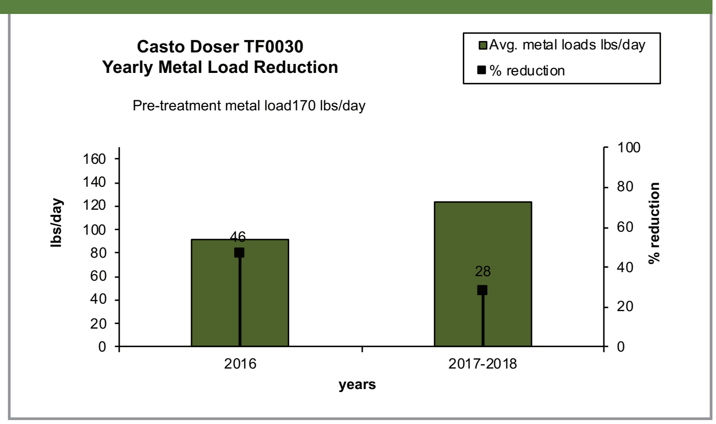
Thomas Fork Doser Site TF1502 and TF0070/TF0068





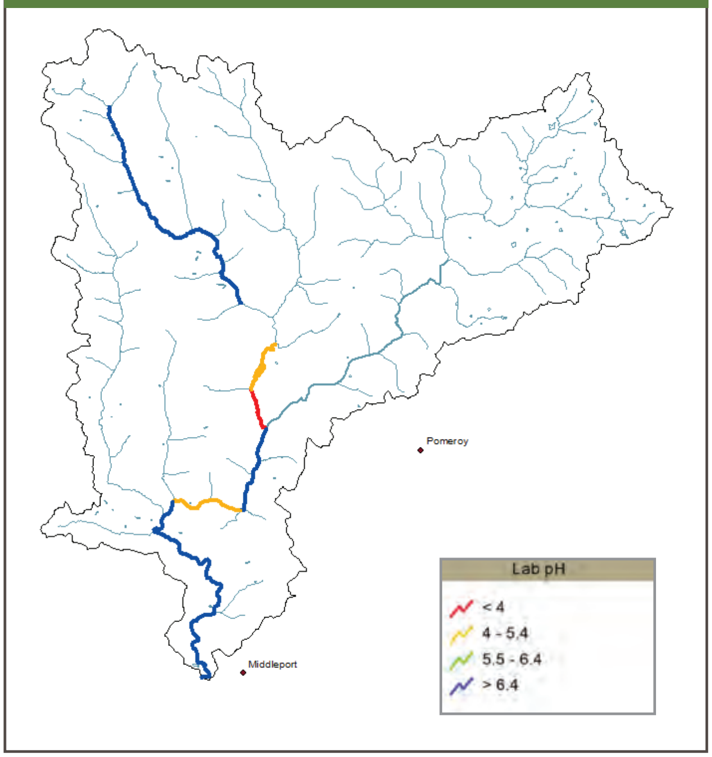
Casto Doser Site TF0030



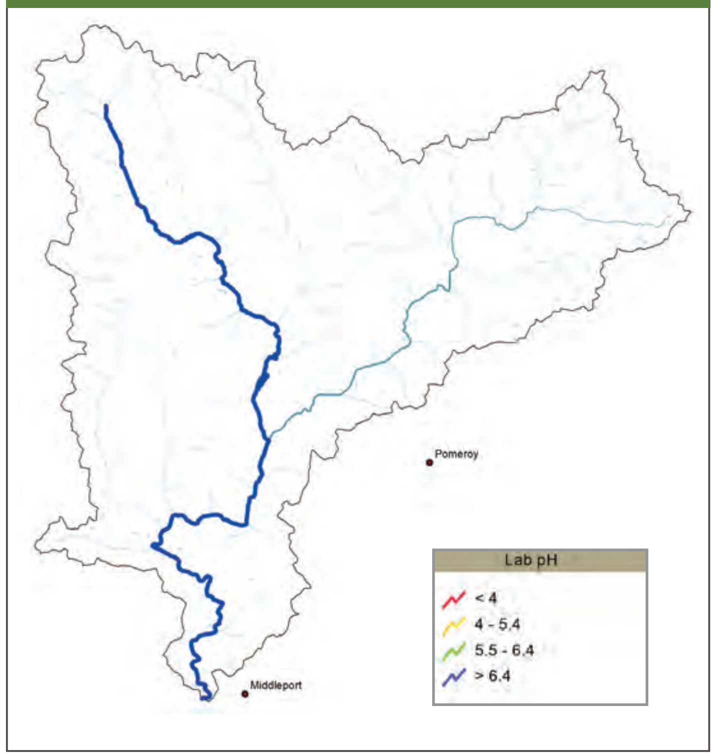


Chemical Water Quality

Thomas Fork baseline (2009) pH

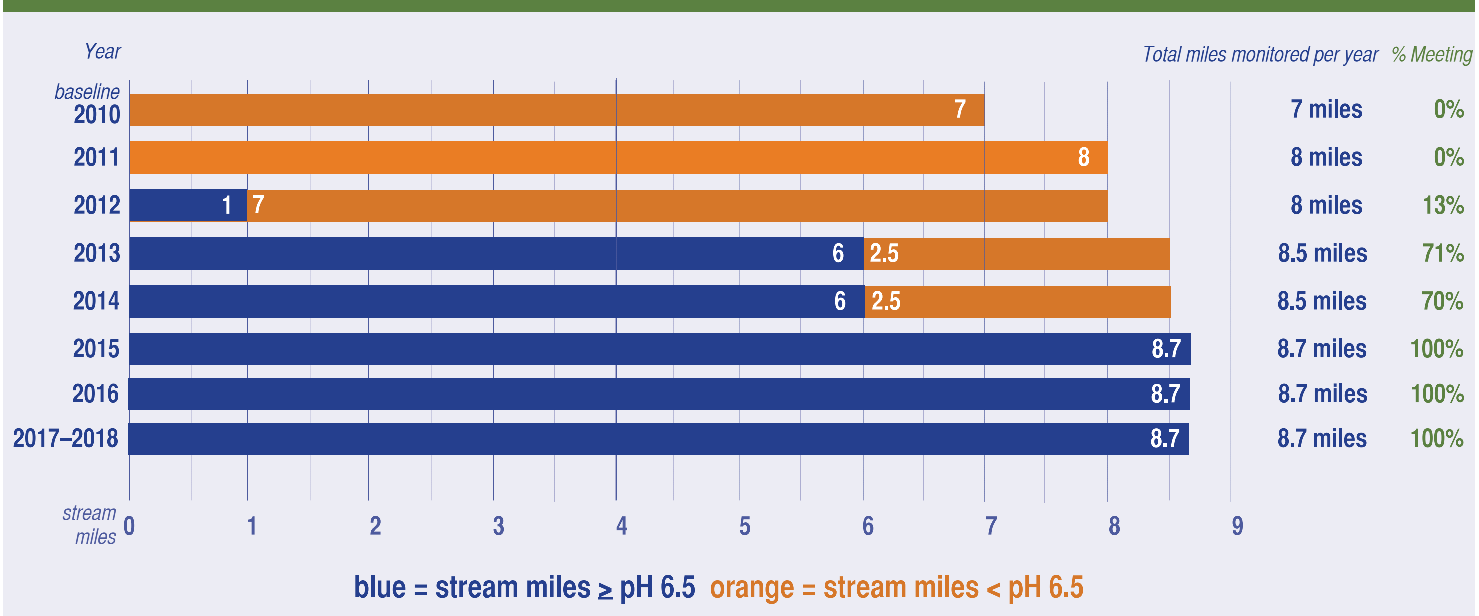


Thomas Fork 2017-2018 pH

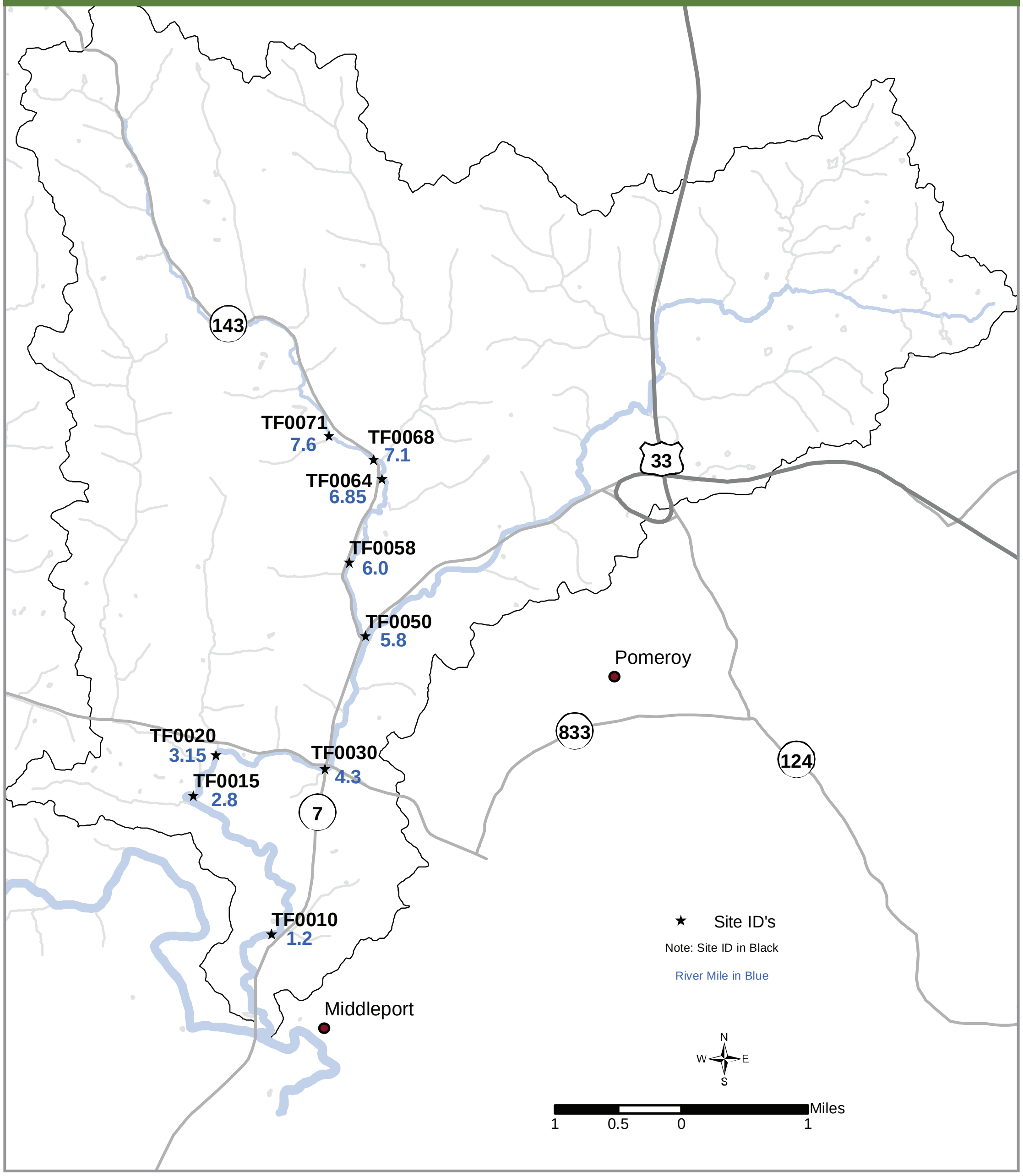


Thomas Fork in 2018, show 8.7 stream miles meeting the pH target of (6.5) of the 8.7 miles monitored (100%). The 2.5 miles of streams that didn't meet the pH target in 2014 are now meeting the pH target for the past three years.

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



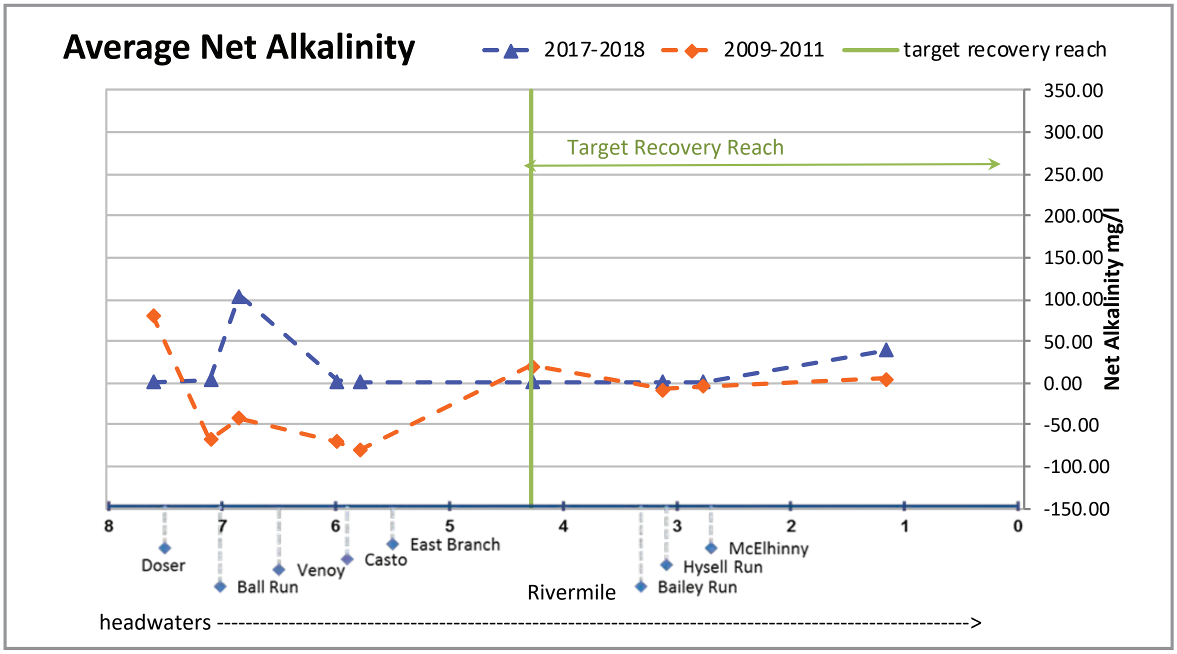
Thomas Fork

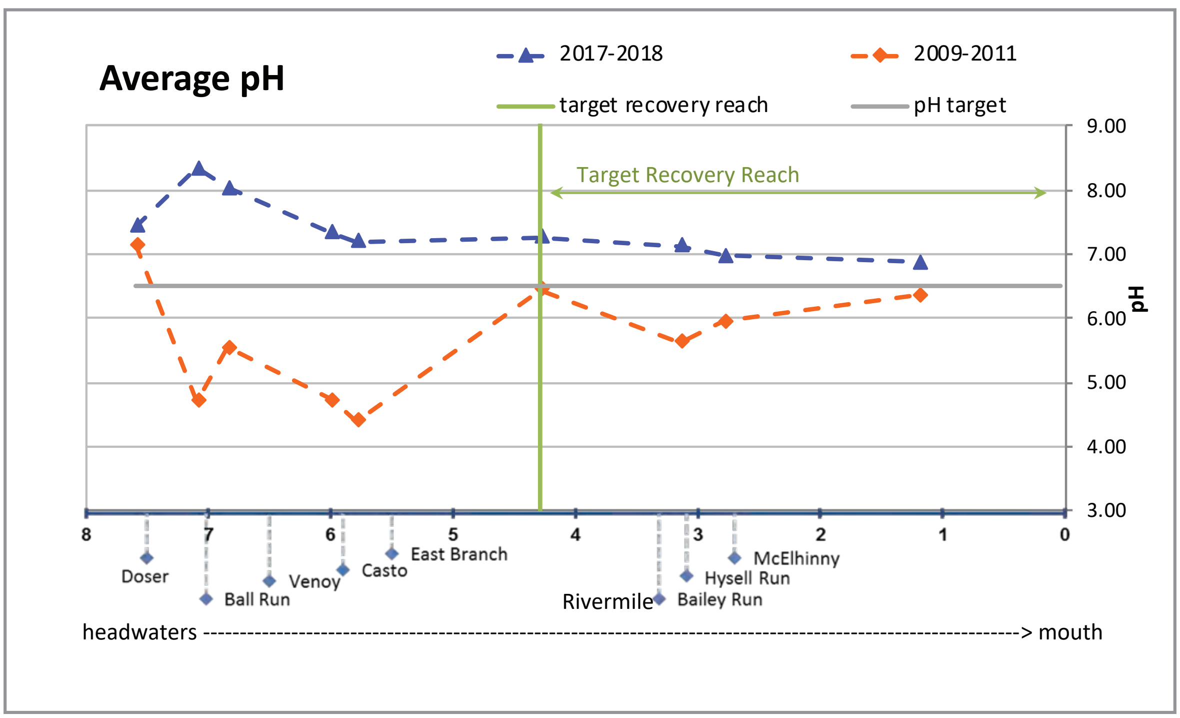


143
TF0071
7.6
TF0068
7.1
TF0064
6.85
TF0058
6.0
TF0050
5.8
33
Pomeroy
833
124
TF0020
3.15
TF0030
4.3
TF0015
2.8
7
TF0010
1.2
Middleport
Site ID's
Note: Site ID in Black
River Mile in Blue
N
W
E
S
Miles
1
0.5
0
1

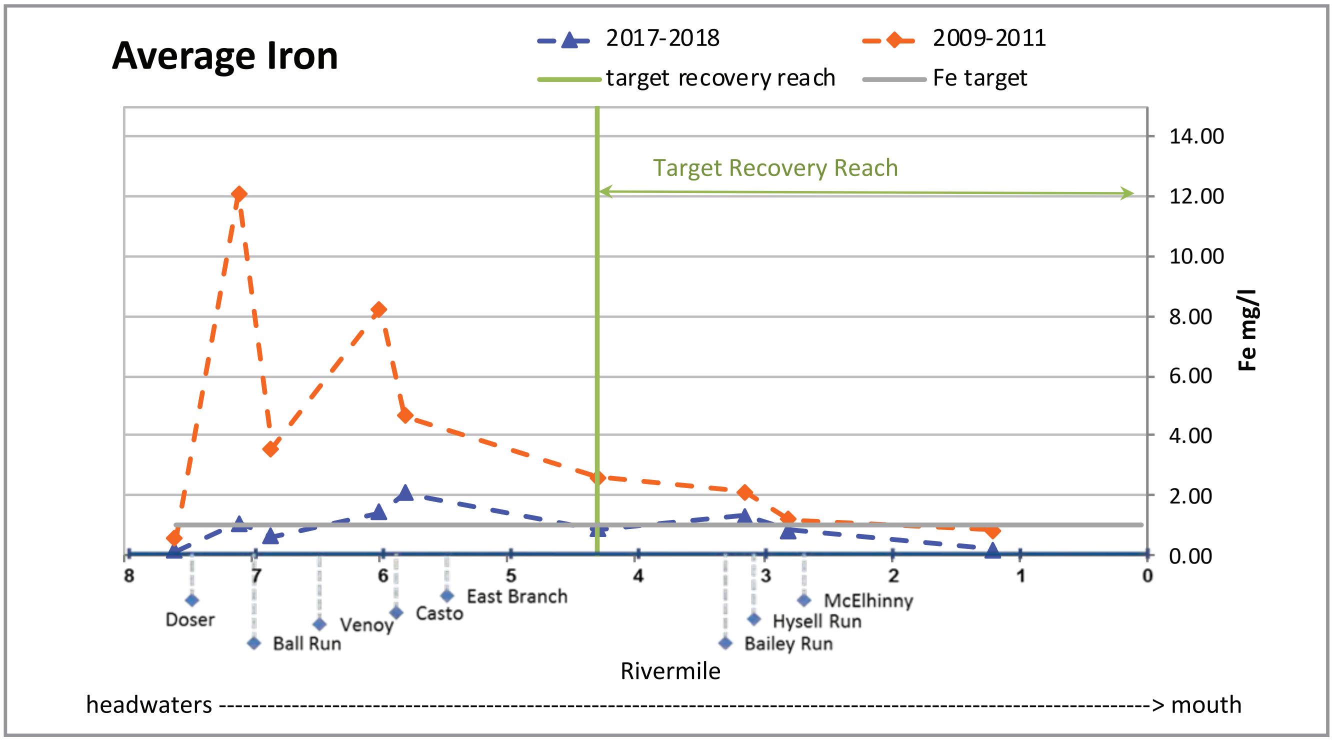
Chemical water quality changes along the mainstem of Thomas Fork are shown in the stream reach graphs below. Chemical long-term monitoring data is utilized to generate line graphs along the stream gradient from headwaters to the mouth. Along the x-axis named tributaries are shown to illustrate sources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

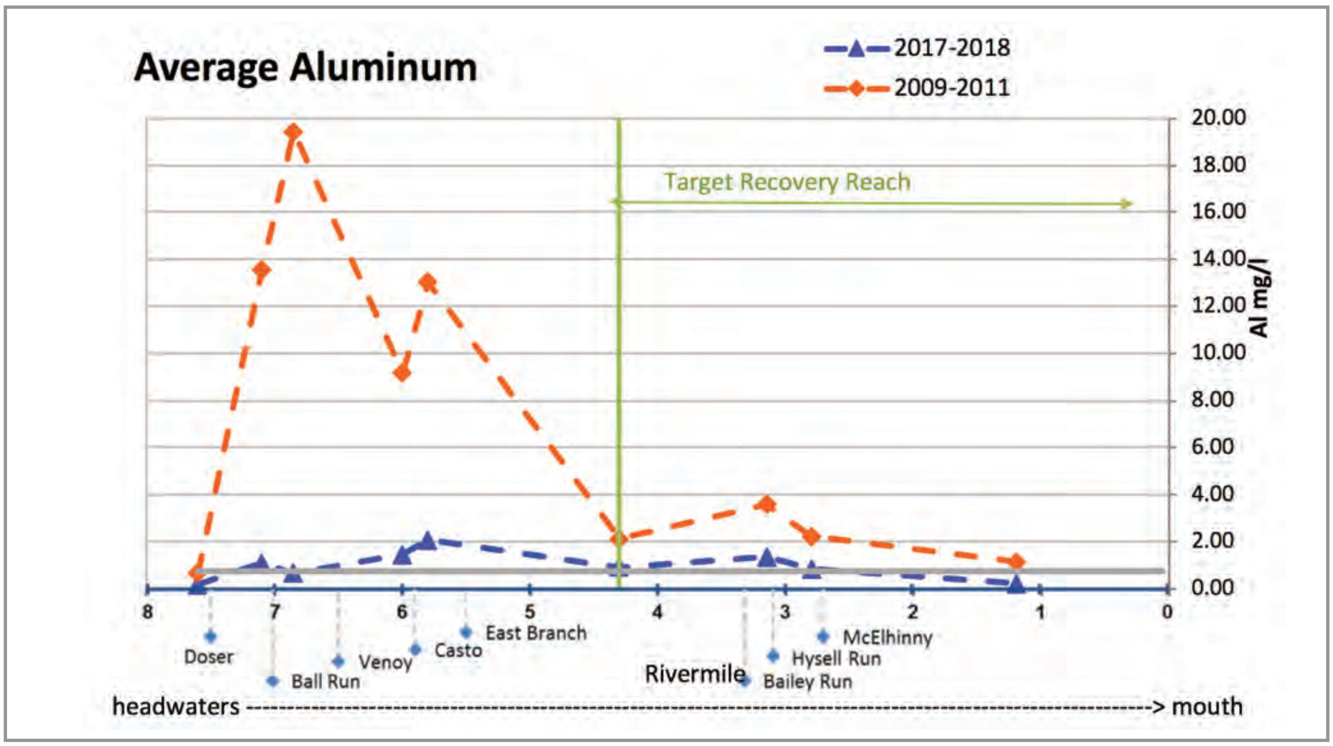
Leading Creek Watershed									
site ID	TF0071	TF0068	TF0064	TF0058	TF0050	TF0030	TF0020	TF0015	TF0010
Rivermile	7.6	7.1	6.85	6	5.8	4.3	3.15	2.8	1.2





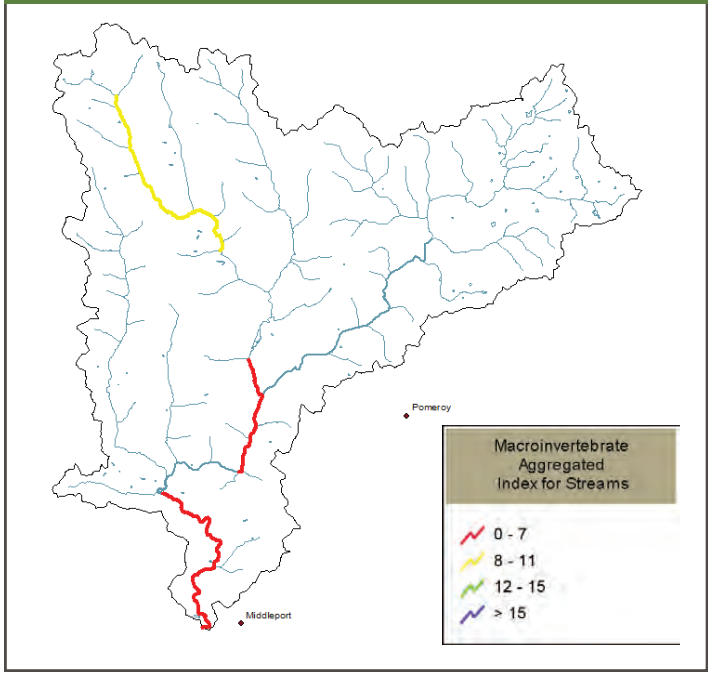
Leading Creek Watershed									
site ID	TF0071	TF0068	TF0064	TF0058	TF0050	TF0030	TF0020	TF0015	TF0010
Rivermile	7.6	7.1	6.85	6	5.8	4.3	3.15	2.8	1.2



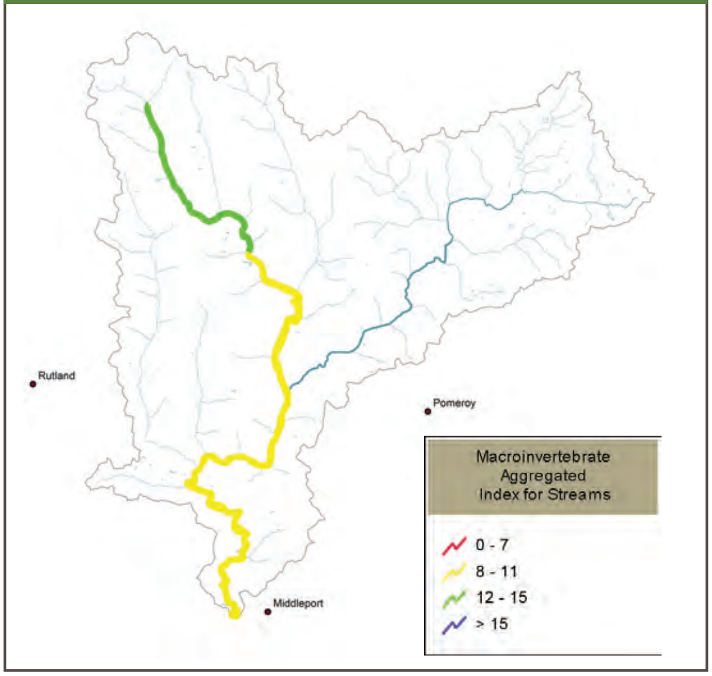


Biological Water Quality

Thomas Fork baseline MAIS



Thomas Fork 2017–2018 MAIS

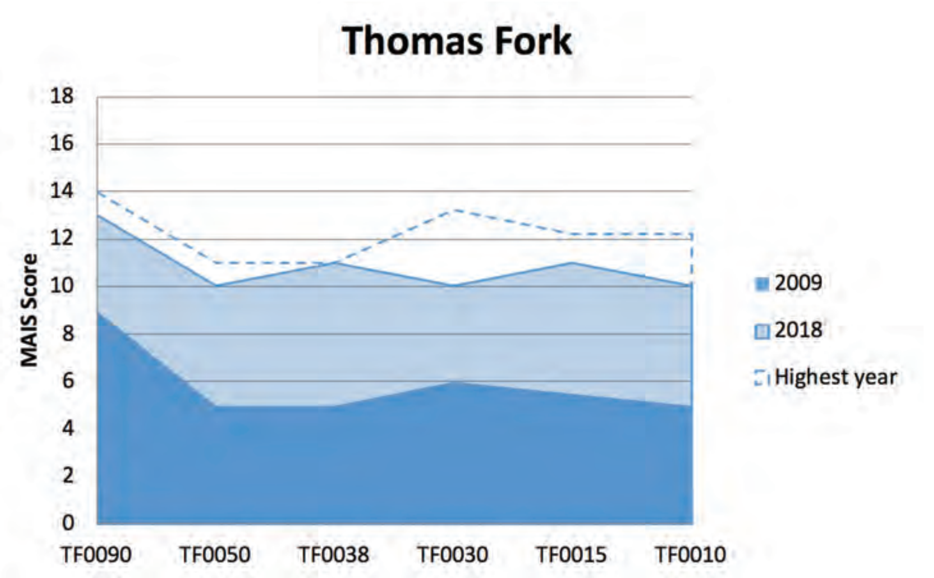


MAIS samples were collected along Thomas Fork a tributary to Leading Creek. These sites are along the mainstem at established long-term monitoring stations, collected from 2009 through 2018.

Thomas Fork

Prior to 2012, the aquatic biota in the lower reaches of Thomas Fork of Leading Creek were of very poor quality. In 2011 and 2012, MAIS scores ranged from 2 – 7 at all sites except the uppermost site at TF0090. By 2016, improvements in the macroinvertebrate community were evident. All three downstream sites met the biological target of a MAIS of '12' or higher and one (TF0015) met the statistical criteria for significant improvement. In 2018, although scores were slightly lower, a second site (TF0050) also met the statistical criteria for improvement since 2009.

Area of degradation 2009-2018



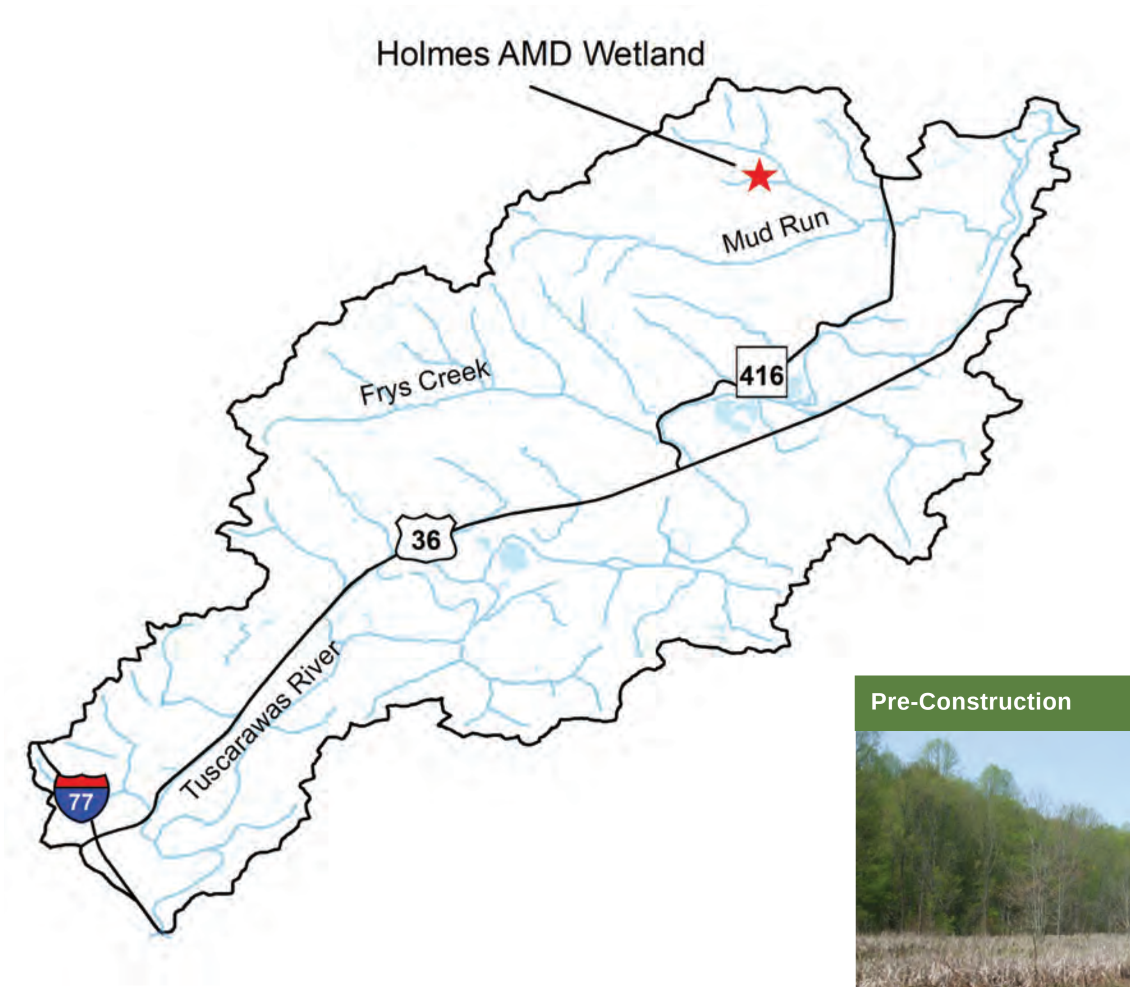
Thomas Fork MAIS Regressions

	2009	2010	2011	2012	2013	2014	2015	2016	2018	Linear trends	R square	P-value	No. of observation
TF0090	9	13	12	11	14	14	12	12	13	no change	0.208953	0.216067	9
TF0050	5	8	3	2	8	6	10	11	10	**improved**	0.44256	0.050531	9
TF0038	5	11	7	5	10	9	10	9	11	no change	0.304247	0.123668	9
TF0030	6	12	4	5	10	9	9	13	10	no change	0.225148	0.196853	9
TF0015		8	6	5	9	10	11	12	11	**improved**	0.623832	0.019704	8
TF0010	5	12	5	5	10	9	8	12	10	no change	0.218272	0.204802	9

OTHER PROJECTS

2017–2018 NPS Report - Mud Run Holmes Wetland

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



Pre-Construction

Acid and Metal Loads

Pre-treatment acid Load = 182 lbs/day
Post-treatment acid load = 98 lbs/day

Pre-treatment metal Load = 30 lbs/day
Post-treatment metal load = 13 lbs/day

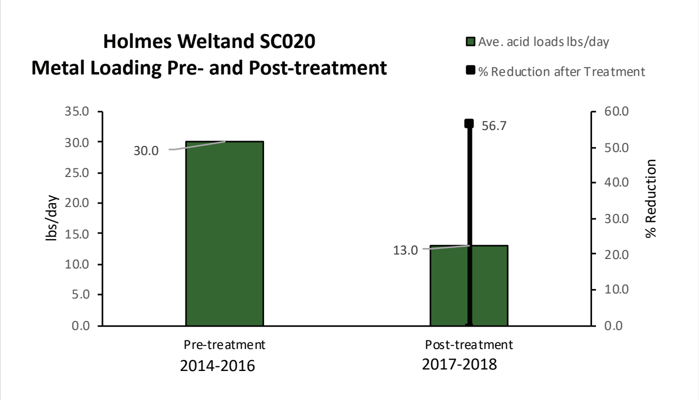
Post-Construction

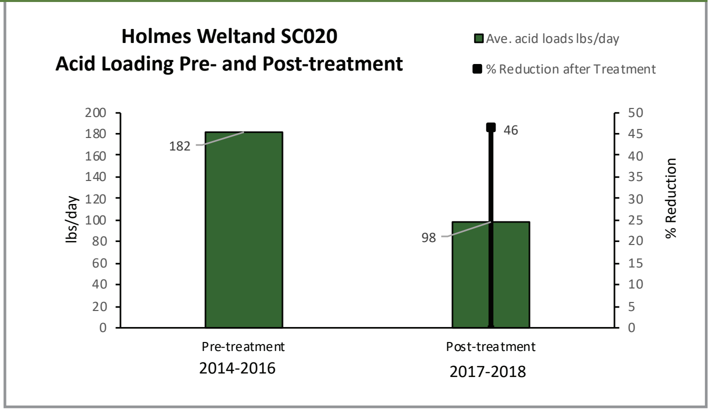
Costs

Total Costs of project = $284,763

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.

Holmes Wetland SC020





Holmes AMD Wetland site pre-construction contributes acidity and high amounts of iron from the abandoned coal mine site that drains to Mud Run, a tributary of the Tuscarawas River. The treatment strategy of the Holmes AMD Wetland Project, is to add alkalinity through a passive limestone leach bed. The goal of this project is to reduce iron levels in Silver Creek Tributary to Mud Run.

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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
	01/01/2017-12/31/2018	22	3	1
Percent of Samples		-	11%	3.6%

Percent Difference from Lab and Field

Leading Creek	% Difference pH	% Difference Conductivity
Range	0.14 -14.89	0.27 - 13.57
Median	1.82	1.55

Percent Difference of Duplicate Samples (2)

	% Difference pH	% Difference Conductivity	% Difference Iron	% Difference Aluminum	% Difference Acidity	% Difference Alkalinity
Range	0.01	0.01	0.15-0.91	0.04-1.02	0.09-0.11	0
Median	N/A	N/A	N/A	N/A	N/A	N/A

Appendix: Quality Assurance Quality Control (QAQC)

MONDAY CREEK

Monday Creek	Collection Period	Samples Collected	Duplicate Samples	Blanks
	2/14/2017 - 12/11/2018	335	17	6
Percent of Samples		-	5%	2%

Percent Difference from Lab and Field

	% Difference pH	% Difference Conductivity
Range	0.0-39.58	0.0-200
Median	3.36	0.9

Percent Difference of Duplicate Samples (16)

	% Difference pH	% Difference Conductivity	% Difference Iron	% Difference Aluminum	% Difference Acidity	% Difference Alkalinity
Range	0.00% - 4.77	0.00 - 1.09	0.00 - 25.86	0.00 - 30.20	0.00 - 52.87	0.00 - 17.62
Median	0.92	0.27	3.10	1.85	2.48	0.56

RACCOON CREEK

Raccoon Creek	Collection Period	Samples Collected	Duplicates	Blanks
	02/06/17-12/04/18	130	10	6
Percent of Samples			8%	5%

Percent Difference from Lab and Field

	% Difference pH	% Difference Conductivity
Range	0.28-29.5	0.06-36.7
Median	4.8	1.44

Percent Difference of Duplicate Samples (18)

	% Difference pH	% Difference Conductivity	% Difference Iron	% Difference Aluminum	% Difference Acidity	% Difference Alkalinity
Range	0.31-9.32	0.00-2.19	0.00-17.28	0.00-1.67	0.00-13.1	0.00-187.9
Median	0.67	0.20	0.57	0.81	8.7	0.57

HUFF RUN

Raccoon Creek	Collection Period	Samples Collected	Duplicates	Blanks
	1/26/2017-12/18/2018	105	9	6
Percent of Samples			8.5%	5.7%

Percent Difference from Lab and Field

	% Difference pH	% Difference Conductivity
Range	0.14 - 40.13	0.14 - 1.06
Median	5	0.78

Percent Difference of Duplicate Samples (18)

	% Difference pH	% Difference Conductivity	% Difference Iron	% Difference Aluminum	% Difference Acidity	% Difference Alkalinity
Range	0.14 - 1.06	0.00 - 1.61	0.00 - 3.98	0.84- 10.53	0.00 -21.73	0.19 - 2.26
Median	0.78	0.68	0.64	3.77	7.48	0.63

SUNDAY CREEK

Raccoon Creek	Collection Period	Samples Collected	Duplicates	Blanks
	3/28/2017-12/12/2018	35	3	0
Percent of Samples			8.5%	0

Percent Difference from Lab and Field

	% Difference pH	% Difference Conductivity
Range	0.36-21.93	0.09 - 42.72
Median	4.61	2.71

Percent Difference of Duplicate Samples (18)

	% Difference pH	% Difference Conductivity	% Difference Iron	% Difference Aluminum	% Difference Acidity	% Difference Alkalinity
Range	0.15-1.66	0.00-1.83	0.00 -4.65	0.00-6.62	4.67-35.94	0.25-1.49
Median	0.80	0.90	1.33	2.86	11.38	0.61