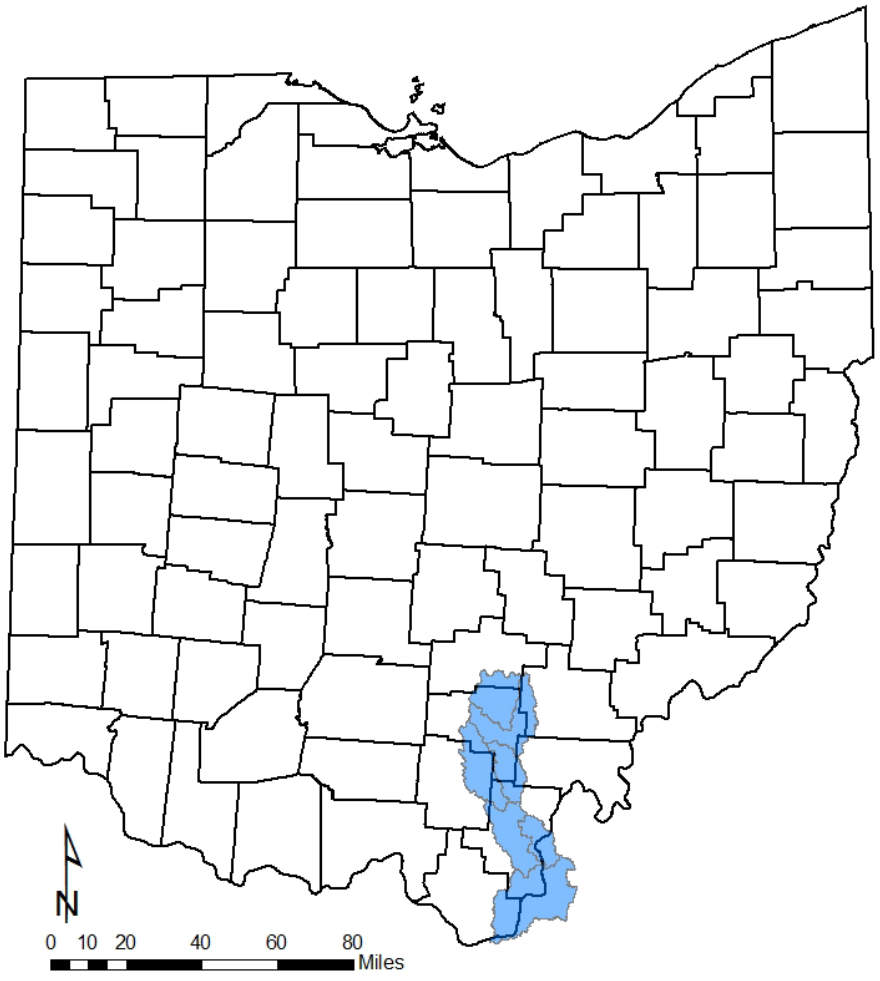
Study Plan for the 2016 Biological and Water Quality Survey of the Raccoon Creek Basin

Vinton, Jackson, Hocking, Athens, Gallia & Meigs Counties, Ohio



Division of Surface Water
June 30, 2016

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Vinton, Jackson, Hocking, Athens, Gallia & Meigs Counties, Ohio

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Introduction

Raccoon Creek watershed is located in southeastern Ohio in Vinton, Jackson, Athens, Hocking, Gallia, and Meigs counties and drains 683.5 square miles of the Western Allegheny Plateau (WAP) ecoregion. Raccoon Creek is formed at the junction of its east and west branches and flows into the Ohio River south of Gallipolis. Municipalities in the watershed include McArthur, Wellston, Rio Grande, and Gallipolis. Lake Hope, Tycoon Lake, Lake Rupert, and Lake Alma are located in the watershed. Coal mining was historically a major activity that has severely impacted the watershed. The last comprehensive survey of Raccoon Creek was conducted in 1995 and the leading cause of partial and non-attainment was acid mine drainage.

As part of the TMDL process and in support of the basin approach for NPDES permitting, an intensive ambient assessment will be conducted during the 2016 field sampling season within the Raccoon Creek Watershed. The study area is composed 24 HUC 12 watershed assessment units, including those for Chickamauga Creek (Table 1). Additionally, five tributaries that are designated State Resource Water (SRW) will be assessed in the watershed as part of a 106 USEPA-funded grant. A total of 91 sampling stations are allocated to this effort and will provide for the assessment of 50 streams (Table 2) (Figure 3). Ambient biology, macrohabitat quality, water column chemistry, and bacteriological data will be collected from most of these sites. Diel water quality (DO, pH, conductivity, and temperature), sediment chemistry (metals, organics, and particle size), nutrients, continuous temperature, and fish tissue will be evaluated at selected sampling locations.

Sampling Objectives

1) Systematically sample and assess the principal drainage network of the Raccoon Creek basin in support of both the TMDL process and NPDES permitting,

2) Gather ambient environmental information (biological, chemical, and physical) from undesignated water bodies, so as to recommend an appropriate suite of beneficial uses (e.g., aquatic life, recreational, water supply),

3) Verify the appropriateness of existing, unverified, beneficial use designations

4) Establish and evaluate baseline ambient biological conditions at selected reference stations to evaluate the effectiveness of past, on-going and future pollution abatement efforts,

5) Document any changes in the biological, chemical, and physical conditions of the study areas where historical information exists, thus expanding the Ohio EPA data base for statewide trends analysis (e.g., 305[b]),

6) Collect fish samples for the Ohio Sport Fish Consumption Advisory Program (used to assess chemical contaminant levels in fish) from eight locations on Raccoon Creek.

Issues

Total Maximum Daily Load (TMDL)
Information collected as part of this survey will support TMDL development for the study area. The objectives of the TMDL process are to estimate pollutant loads from the various sources within the basin, define or characterize allowable loads to support the various beneficial uses, and to allocate pollutant loads among different pollutant sources through appropriate controls (e.g., NPDES permitting, storm water management, 319 proposals, nonpoint source controls or other abatement strategies).

The components of the TMDL process supported by this survey are primarily the identification of impaired waters, verification (and redesignation if necessary) of beneficial use designations, gathering ambient information that will factor into wasteload allocations, and ascribing causes and sources of use impairment. These data are necessary precursors to the development of effective control or abatement strategies.

Aquatic Life Use Designations
Aquatic life use (ALU) designations have been verified or otherwise affirmed for 38 of the 50 named streams in this study area. The remaining 11 waterbodies are classified as either unverified (identified in the WQS, but have not been subjected to a use attainability analysis) or not listed (absent from the WQS). The Ohio EPA is obligated to review, evaluate, or recommend (where appropriate) beneficial uses prior to basing any permitting actions on existing, unverified designations, or wholly unclassified water bodies.

NPDES Permits
There are 37 individual NPDES permitted facilities within the Raccoon Creek watershed. Significant major and minor NPDES permitted facilities will be evaluated as part of this study. These include both publicly owned treatment works and private entities. A list of all permitted facilities along with discharge and monitoring locations are presented in Table 3.

Mining Impacts
Historic mining impacts are prevalent in the Raccoon Creek watershed. The entire lengths of Hewett Fork, East and West Branches of Raccoon Creek, Brush Run, Pierce Run, Strongs Run, Rockcamp, Indian camp, and Karr Run have been impacted by acid mine drainage (AMD). The Raccoon Creek mainstem from river miles (RMs) 102.9 to 111.9 and RM 92.52 to 102.9 has also been impacted from mining. Many other smaller streams in the watershed also suffer from AMD. A map of the mining in the upper and lower portions of the Raccoon Creek watershed is presented in Figure 1 and 2. Extensive monitoring and reclamation projects are being conducted in the Raccoon Creek basin by the Raccoon Creek Partnership. These efforts include capping gob piles with clay to prevent surface water from leaching through, slag leach beds to introduce alkalinity, limestone leach beds, and dosers to incrementally add alkaline material. The main goal of Raccoon Creek Partnership is to restore Raccoon Creek and Little Raccoon Creek.

Nutrients
In order to provide more objective and robust characterization of the sources and effects of nutrient loads in the Raccoon Creek basin, select stations will be sampled.

Lake Monitoring
Lake Rupert (impoundment of Little Raccoon Creek) and Lake Alma is scheduled for monitoring assessment in 2016. Southeast District Office (SEDO) DSW staff are responsible for the development of a work plan, associated data collection and related field work, and the final data analysis and assessment of Rupert and Alma lakes.

Public Water Supplies Sampling – Stream Intake
There are six PWS intakes within the Raccoon Creek study area that will be sampled in 2016. These include intakes on Little Raccoon Creek at RM 30.0 and 32.95, Johnson Run, Sugar Run, Tripp Run, and Sand Run. Lake Alma has had harmful algal blooms (HAB) detections in the past, but the Lake Alma intake has not been used for two years. No other HAB issues are known.

Sampling Effort

Geo-Referenced Site Labels
The sites listed in the study plan table are coded with EA3 Station IDs that link data across several tables. They must be included on all field, lab and sample sheets and reported with all data results. If for some reason a location other than the one listed in the study plan is sampled, and that location is a trivial distance away from the one listed in the table and is fully representative of the EA3 Station, use the river mile listed in the study plan, and simply record the location information separately. An exact river mile can be assigned later to an Absolute Location Point (ALP) if warranted. If the location is not representative of the site listed on the study plan due to distance or a confounding factor, it should probably not be sampled, but if it is, it should be separated as a new station. It is also imperative that, if a new station is sampled, the study plan coordinator be notified so that this information can be distributed to all of the study team.

Field and Laboratory Load
Summarized field and laboratory load (stations, number of samples, and parameters for analysis, etc.) can be found in Tables 4 and 5. All scheduled locations and necessary stipulations are provided in Table 4.

Water Quality
Water column chemistry samples will be collected from 84 ambient stations within the study area. Water column grab samples and standard field parameters will be collected/measured at least five times from all locations. The collection of water samples for bacteriological analysis is schedules for 29 stations at least five times during the recreational season (Table 4).

Datasonde® deployment is requested for 30 locations. The deployment of continuous monitors should coincide with typical low summer/fall flows (i.e., approaching $Q_{7,10}$). The Modeling section will be responsible for deployment of the Datasondes®.

Sediment Sampling
Eight sets of sediment samples will be collected at sites indicated in the table of sampling locations (Table 2) using procedures outlined in the *Ohio EPA Sediment Sampling Guide and Methodologies*, 3rd edition (Ohio EPA, 2012b). Fine grained multi-incremental sediment samples will be collected in the upper four inches of bottom material using either clean stainless steel scoops or dredges. Samples will be homogenized and split into 500 ml amber glass jars with Teflon lined lids for organic compound testing and 250 ml HPDE containers for metals testing. They will then be secured inside coolers with wet ice and

delivered to the Ohio EPA Division of Environmental Services for analysis. Pollutants to be tested and their analytical methods are listed in the table of chemical/physical parameters (Table 5).

Data will primarily be used as a resource to help determine causes and sources of aquatic life impairment. More detailed follow up studies may be recommended in some instances. To determine the potential for sediment contaminants to exert adverse effects the data will first be compared to Ohio sediment reference values and consensus based sediment quality guidelines. This constitutes a Tier I assessment as described in *Guidance on Evaluating Sediment Contaminant Results* (Ohio EPA, 2010). No further assessment is needed if the sediment passes the screening. If not, it is considered above levels of concern and further evaluation is needed using the Tier II process. This process estimates bioavailability using total organic carbon to normalize pollutant concentrations.

Benthic Macroinvertebrate Assessment

The condition of the macrobenthos will be evaluated at 83 locations. Artificial substrate samples (quantitative) will be collected at 32 stations within the study area. Qualitative benthic macroinvertebrate samples (natural substrates) will be collected at 51 locations. Locations of benthic macroinvertebrate sampling stations are listed in Table 2.

Fish Community Assessment

The condition of the fish assemblages within the study area will be evaluated at 83 locations. Multiple pass fish community samples will be collected at 36 sites. Single pass fish community samples will be collected at 47 stations. Single pass evaluations are limited to headwaters, with the exception of reference sites or significant permit issues. The locations of all fish sampling stations are listed in Table 2.

Sentinel Sites

To aid in the development of a TMDL models(s), sentinel sites have been established at nine designated locations. At each sentinel site, samples are collected monthly beginning prior to the routine field season that typically begins on June 15th to test for routine water chemistry parameters, pesticides (methods 525.2, 531.1, and 547) and stream stage is measured to the nearest 100th of a foot, as the water line against a designated bridge piling or abutment. Sampling events at sentinel sites should cover the range of stream flow from the 10th to 90th percentiles. If conditions warrant, bacteriological sampling at all sentinel sites may be expanded beyond five runs. The locations of sentinel sites are indicated in Table 2.

Public Water Supplies Sampling – Stream Intake

Methodologies in support of the assessments of the PWS use designation were adopted in 2006. The 2008 reporting cycle marked the first formal PWS use evaluations and subsequent 305[b] and 303[d] listings. In addition to pesticides and nitrate indicators, methodologies have been revised for 2014 to include algae derived impairments, employing cyanotoxin indicators. Field sampling efforts in the Raccoon Creek study area supporting PWS evaluation will be divided between 2016 and 2017 for drinking water reservoirs. The stream (intake) spring/summer sampling (2016) will include five runs, ideally collected during periods of high or otherwise elevated flows. All of the 2016 intake sampling regime will include critical periods for each parameter/indicator of concern, as provided below.

- Atrazine

  Five sample minimum during critical period (April through June). If possible, sample during spring as part of sentinel site runs, coincidental to periods of high flow. ELISA analysis method is approved for year 1 samples.
- Nitrate

  Five sample minimum, during critical period (December through June). If possible, sample during winter/spring as part of sentinel site runs, coincidental to periods of high flow.

QUALITY ASSURANCE

Ohio EPA Manuals

All biological, chemical, data processing, and data analysis methods and procedures adhere to those specified in the Surface Water Field Sampling Manual for water column chemistry, bacteria and flows (Ohio EPA 2013), Biological Criteria for the Protection of Aquatic Life, Volumes II - III (Ohio EPA 1987, 1989a, 2015b), 2015 Updates to the Biological Criteria for the Protection of Aquatic Life, Volume II (Ohio EPA 2015a), and The Qualitative Habitat Evaluation Index (QHEI); Rationale, Methods, and Application (Ohio EPA 1989b, 2006) for habitat assessment, Ohio EPA Sediment Sampling Guide and Methodologies (Ohio EPA 2012a), and Ohio EPA Fish Tissue Collection Guidance Manual (Ohio EPA 2012b).

Use Attainment

Attainment/non-attainment of aquatic life uses will be determined by using biological criteria codified in Ohio Administrative Code (OAC) 3745-1-07, Table 7-17. Numerical biological criteria are based on multimetric biological indices including the Index of Biotic Integrity (IBI) and modified Index of Well-Being (MIwb), indices measuring the response of the fish community, and the Invertebrate Community Index (ICI), which indicates the response of the macroinvertebrate community.

Performance expectations for the basic aquatic life uses (Warmwater Habitat [WWH], Exceptional Warmwater Habitat [EWH], and Modified Warmwater Habitat [MWH] were developed using the regional reference site approach (Hughes et al. 1986; Omernik 1987). This fits the practical definition of biological integrity as the biological performance of the natural habitats within a region (Karr and Dudley 1981). Attainment of an aquatic life use is FULL if all three indices (or those available) meet the applicable criteria, PARTIAL if at least one of the indices did not attain and performance did not fall below the fair category, and NON if all indices either fail to attain or any index indicates poor or very poor performance.

Recreational use attainment will be determined using *E. coli* bacteria. *E. coli* is now the primary indicator organism for the potential presence of pathogens in surface water resulting from the presence of untreated human or animal wastes, and is the basis for recreational use water quality criteria in Rule 3745-1-07 of the Ohio Administrative Code (OAC).

Stream Habitat Evaluation

Physical habitat is evaluated using the Qualitative Habitat Evaluation Index (QHEI) developed by the Ohio EPA for streams and rivers in Ohio (Ohio EPA 1989b). Various attributes of the available habitat are scored based on their overall importance to the establishment of viable, diverse aquatic faunas. Evaluations of type and quality of substrate, amount of in-stream cover, channel morphology, extent of riparian canopy, pool and riffle development and quality, and stream gradient are among the metrics used to evaluate the characteristics of a stream segment, not just the characteristics of a single sampling site. As such, individual sites may have much poorer physical habitat due to a localized disturbance yet still support aquatic communities closely resembling those sampled at adjacent sites with better habitat, provided water quality conditions are similar. QHEI scores from hundreds of segments around the state have indicated that values higher than 60 were generally conducive to the establishment of warmwater faunas while those which scored in excess of 75-80 often typify habitat conditions which have the ability to support exceptional faunas.

Biological Community Assessment

Macroinvertebrates will be collected from artificial substrates and from the natural habitats. Quantitative sampling will be conducted at reference sites and at sites with drainage areas in excess of 20 mi^2.

Qualitative sampling will be conducted in headwater sites with drainages smaller than 20 mi². The artificial substrate collection provides quantitative data and consists of a composite sample of five modified Hester-Dendy (HD) multiple-plate samplers colonized for six weeks. At the time of the artificial substrate collection, a qualitative multihabitat composite sample is also collected. This sampling effort consists of an inventory of all observed macroinvertebrate taxa from the natural habitats at each site with no attempt to quantify populations other than notations on the predominance of specific taxa or taxa groups within major macrohabitat types (e.g., riffle, run, pool, and margin). Fish will be sampled at each sampling location with pulsed DC current. Two passes will be conducted at sites larger than 20 mi² and at reference sites. Detailed biological sampling protocols are documented in the Ohio EPA manual Biological Criteria for the Protection of Aquatic Life, Volume III (Ohio EPA 2015b).

Sediment

Fine grained multi-incremental sediment samples will be collected in the upper 4 inches of bottom material using either decontaminated stainless steel scoops or Ekman dredges. Collected sediment will be placed into appropriate containers, placed on ice (to maintain 4°C) and shipped to the Ohio EPA lab. Sampling and decontamination protocols will follow those listed in Ohio EPA (2015a Appendix III).

Surface Water

Surface water grab samples will be collected from the upper 12 inches of river water into appropriate containers. Collected water will be preserved using appropriate methods, as outlined in Ohio EPA (2015a) and shipped via courier to the Ohio EPA lab for analysis. Field measurements of dissolved oxygen, pH, temperature, and conductivity will be made using YSI 556MPS meters along with all grab samples for surface water chemistry. Datasonde© continuous recorders will be placed at select locations to evaluate diurnal measurements of dissolved oxygen, pH, temperature, and conductivity.

Bacteria

Water samples will be collected into appropriate containers, cooled to 4°C, and transported to and submitted to the lab for analysis within six hours of collection. All samples will be analyzed for *E. coli* bacteria using U.S.EPA approved methods (STORET Parameter Code 31648).

Field Quality Control Samples

Five percent of the water samples will be submitted to the lab as field duplicates. One Datasonde® recorder site will have two instruments placed in the river as field duplicates. Field blanks will occur at a minimum of 5 percent of the water samples. Field instruments will be calibrated daily, using manufacturer guidelines and requirements noted in Ohio EPA (2015a). Matrix spike duplicates will be collected for organic water samples at a minimum of 5 percent.

Chlorophyll-*a*

Benthic chlorophyll-*a* samples will be collected and preserved using appropriate methods, as outlined in Ohio EPA (2015a Volume II) and delivered to the Ohio EPA Division of Environmental Services lab for analyses. Alkalinity must be requested as a routine water quality parameter at all study sites along with the routine field parameters, especially temperature and pH.

Field Staff and Other Contacts

OEPA Staff
Ohio EPA (Central Office) Laura Hughes (614) 836-8783 - Macroinvertebrates Jordan Jenkins (614) 836-8786 - Fish Sarah Becker : (614) 728-2385 - Modeling Keith Orr: (614) 644-2885 -Modeling supervisor Jeff DeShon: (614) 836-8780 – EAS manager Gregg Sablak (614) 644-4132 - TMDL Chris Skalski: (614) 644-2144 - Standards **Ohio EPA-SEDO (Logan)** Randy Spencer: (740) 380-5240 – Water quality Carol Siegley: (740) 380-5225 – Water quality Rachel Taulbee: (740) 380-5433 – Water quality supervisor Jennifer Witte: (740) 380-5206 – NPDES supervisor
Other Contacts
Ohio DNR-MRM (Athens) Jeff Calhoun: (740) 592-3748 Ben McCament: (740) 592-3748 **Ohio University – Voinovich School of Leadership and Public Affairs (Athens)** Jen Bowman: (740) 597-3101 **Raccoon Creek Watershed Contacts** Amy Mackey: (740)-597-1473 Sarah Landers- sdlanders@gmail.com

Safety:	
ODNR Wildlife Officers:	**County Sheriff Offices:**
Athens County – Allen Patton (740) 589-9980 Gallia County – Roy Rucker (740) 589-9983 Hocking County – Chris Dodge (740) 589-9985 Jackson County - Ted Witham (740) 589-9986 Vinton County – Jared Abele (740) 589-9997	Athens – (740) 592-3264 Gallia-- (740) 446-1221 Hocking – (740) 385-2131 Jackson – (740) 286-6464 Vinton – (740) 596-5242
Hospitals:	
Athens County:	**Jackson County:**
O'Bleness Hospital 55 Hospital Drive Athens, OH 45701 (740) 593-5551	Holzer Medical Center-Jackson 500 Burlington Rd, Jackson, OH 45640 (740) 288-4625
Gallia County:	**Hocking County:**
Holzer Medical Center- Gallipolis 90 Jackson Pike Gallopolis, OH 45631 (740) 446-5002	Doctors Hospital – Nelsonville 1950 Mt St. Marys Dr. Nelsonville, OH 45764 740-753-3345

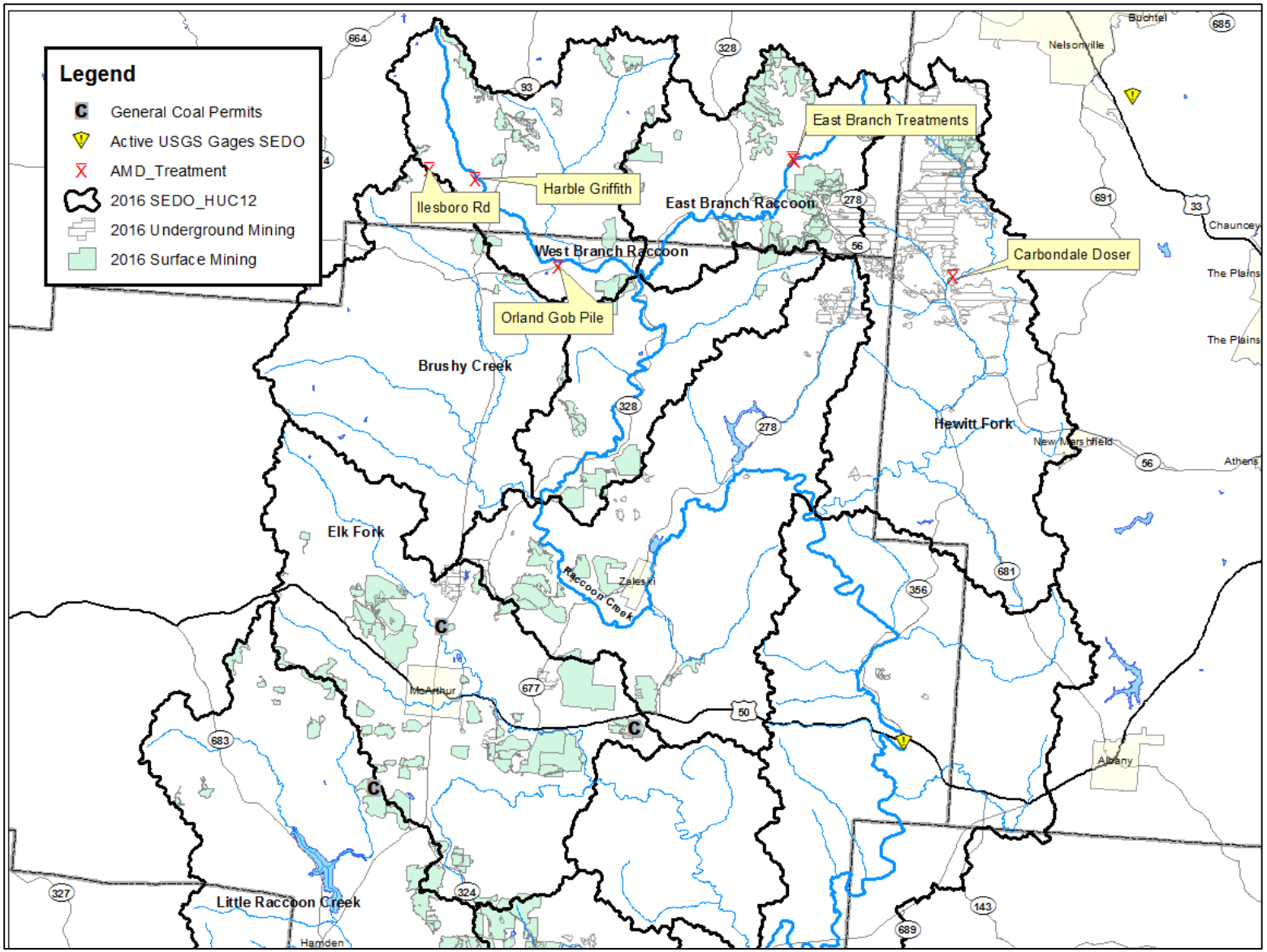
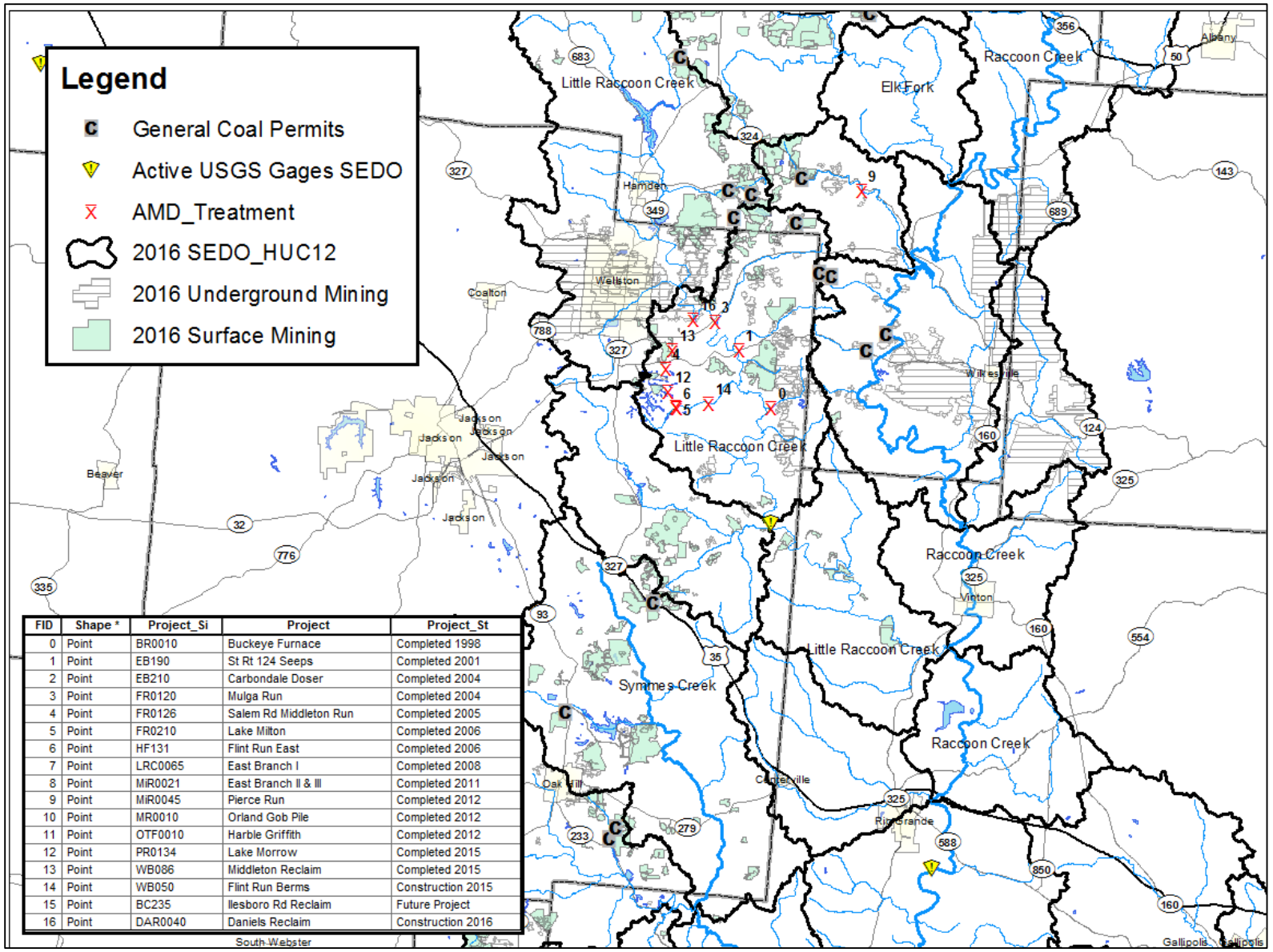


Figure 1. Upper Raccoon Creek mining



FID	Shape *	Project_Si	Project	Project_St
0	Point	BR0010	Buckeye Furnace	Completed 1998
1	Point	EB190	St Rt 124 Seeps	Completed 2001
2	Point	EB210	Carbondale Doser	Completed 2004
3	Point	FR0120	Mulga Run	Completed 2004
4	Point	FR0126	Salem Rd Middleton Run	Completed 2005
5	Point	FR0210	Lake Milton	Completed 2006
6	Point	HF131	Flint Run East	Completed 2006
7	Point	LRC0065	East Branch I	Completed 2008
8	Point	MiR0021	East Branch II & III	Completed 2011
9	Point	MiR0045	Pierce Run	Completed 2012
10	Point	MR0010	Orland Gob Pile	Completed 2012
11	Point	OTF0010	Harble Griffith	Completed 2012
12	Point	PR0134	Lake Morrow	Completed 2015
13	Point	WB086	Middleton Reclaim	Completed 2015
14	Point	WB050	Flint Run Berms	Construction 2015
15	Point	BC235	Ilesboro Rd Reclaim	Future Project
16	Point	DAR0040	Daniels Reclaim	Construction 2016

Figure 2. Lower Raccoon Creek mining

Table 1. Waterbodies and allocated biological sampling effort for each assessment unit (HUC 12).

HUC 12	Sites	Waterbodies
050901010101	2	Chickamauga Creek, Little Chickamauga Creek
050901010103	0	[1]
050901010201	2	East Branch Raccoon Creek
050901010202	3	West Branch Raccoon Creek, Honey Fork
050901010203	3	Brushy Creek, Silvery Creek
050901010204	3	Raccoon Creek, Twomile Run
050901010205	5	Raccoon Creek, Trib. to Raccoon Creek (98.96)
050901010301	7	Hewett Fork, Rockcamp Creek, Coal Run Pine Run, Grass Run
050901010302	5	Elk Fork, Wolf Run, Puncheon Fork
050901010303	2	Elk Fork
050901010304	8	Raccoon Creek, Long Run, Flat Run, Onion Creek, Laurel Run
050901010401	5	Little Raccoon Creek, Meadow Run
050901010402	2	Dickason Run
050901010403	3	Little Raccoon Creek
050901010404	2	Little Raccoon Creek
050901010501	2	Pierce Run
050901010502	2	Strongs Run
050901010503	6	Raccoon Creek, Flatlick Run, Indiancamp Run, Rockcamp Run
050901010504	2	Raccoon Creek, Robinson Run
050901010601	2	Raccoon Creek, Indian Creek, Little Indian Creek
050901010602	2	Raccoon Creek, Barren Creek
050901010603	2	Raccoon Creek, Big Beaver Creek
050901010604	2	Bullskin Creek, Little Bullskin Creek,
050901010605	3	Raccoon Creek, Clear Fork, Claylick Run

[1] No streams of significant size to warrant sampling in this HUC 12

Table 2. Raccoon Creek Basin sampling stations, 2016.

Station	River Code	RM	Stream Name	Location	Sample Type[1]	Drainage Area	Latitude	Longitude	County
300742	09-037-000	6.36	Chickamauga Creek	Off Buck Ridge Road	F, Mq, C, B	6.46	38.861364	-82.251770	Gallia
W03S19	09-039-000	0.6	Little Chickamauga Creek	Bittersweet Drive	F, Mq, C	5.74	38.841236	-82.213247	Gallia
301747	09-500-000	109.5	Raccoon Creek	Twomile Rd, upstream Twomile Run	F2, MQ, C, B, Sn, D, N, Sed	43.6	39.358009	-82.384856	Vinton
301746	09-500-000	104.6	Raccoon Creek	Downstream Mitchell Hollow, at St Rt 328	F2, MQ, C, FT, D, N	56.4	39.320336	-82.417968	Vinton
W03W32	09-500-000	102.1	Raccoon Creek	Creek Road (TR18)	F2, MQ, C, B	95.8	39.297040	-82.431750	Vinton
W03W44	09-500-000	98.34	Raccoon Creek	Township Hwy F3, at ford	F2, MQ, C	100	39.267093	-82.402485	Vinton
W03W33	09-500-000	92.3	Raccoon Creek	Downstream Sandy Run, Wheelabout Road (CR 3)	F2, MQ, C	134	39.317053	-82.351401	Vinton
302520	09-500-000	89.9	Raccoon Creek	Hope-Moonville Road, upstream Hewett Fork	F2, MQ, C, FT	136	39.309809	-82.324696	Vinton
302519	09-500-000	89.36	Raccoon Creek	Buck Lane (CR 18B), downstream Hewett Fork	F2, MQ, C, B, Sn, D, N, Sed	176	39.302798	-82.325804	Vinton
W03W34	09-500-000	83.0	Raccoon Creek	St Rt 356, near Bunker Hill Rd	F2, MQ, C	194	39.254812	-82.302918	Vinton
W03G50	09-500-000	80.62	Raccoon Creek	St Rt 50, at Bolins Mills, USGS gage	F2, MQ, C, B, Sn, D, N, Sed	200	39.230878	-82.286063	Vinton
W03P07	09-500-000	71.2	Raccoon Creek	US 32 W	F2, MQ, C, FT	223	39.167614	-82.313661	Vinton
W03W35	09-500-000	66.1	Raccoon Creek	US 32 W	F2, MQ, C, FT, D, N	296	39.157520	-82.345777	Vinton
W03P18	09-500-000	58.2	Raccoon Creek	Clarion Road canoe access	F2, MQ, C, B, Sn, D, N, Sed	318	39.106311	-82.384314	Vinton
W03S34	09-500-000	50.1	Raccoon Creek	Covered Bridge Road (CR 4)	F2, MQ, C, FT, D, N	336	39.047935	-82.376422	Vinton
W03P05	09-500-000	40.2	Raccoon Creek	Vinton Park, downstream dam, St Rt 325	F2, MQ, C, B, Sn, D, N, Sed	381	38.978100	-82.338680	Gallia
W03S44	09-500-000	35.3	Raccoon Creek	Glassburn Road, just off of Woodsmill Road	F2, MQ, C, B, FT	543	38.934861	-82.334528	Gallia
601400	09-500-000	29.3	Raccoon Creek	Bob Evans Camp, OH 558	F2, MQ, C, B, Sn, D, N, Sed	586	38.873600	-82.356100	Gallia
303503	09-500-000	22.1	Raccoon Creek	MacIntyre Park, Dan Jones Rd	F2, MQ, C, B, FT	615	38.803802	-82.370776	Gallia
W03S24	09-500-000	8.9	Raccoon Creek	Ingalls Road, see coordinates	F2, MQ, C, B, FT	657	38.771360	-82.268190	Gallia
W03P16	09-500-000	5.36	Raccoon Creek	St. Rt. 218	B	661	38.736700	-82.245300	
203928	09-500-011	0.1	Trib to Raccoon Creek (98.96)	lane off Powder Plant Road	F, Mq, C, D, N	1.9	39.269274	-82.409886	Vinton
303508	09-500-012	0.9	Big Beaver Creek	Guthrie Road, off Cora Mill Road	F, Mq, C, B	7.3	38.841294	-82.380145	Gallia
W03K21	09-502-000	1.13	Bullskin Creek	Williams Hollow Road	F, Mq, C, B, D, N	13.2	38.725654	-82.251873	Gallia
W03K22	09-503-000	2.4	Little Bullskin Creek	Little Bullskin Road	F, Mq, C	1.15	38.708777	-82.298550	Gallia
W03K23	09-506-000	0.1	Clear Fork	Ingalls Road	F, Mq, C	7.7	38.781479	-82.273940	Gallia
203929	09-507-000	0.4	Claylick Run	Lincoln Pike	F, Mq, C, B	7.7	38.758631	-82.304760	Gallia
W03S09	09-510-000	36.67	Little Raccoon Creek	Wolf Hill Road (CR 25)	F, Mq, C	12.1	39.208088	-82.541721	Vinton

Station	River Code	RM	Stream Name	Location	Sample Type[1]	Drainage Area	Latitude	Longitude	County
W03W38	09-510-000	32.95	Little Raccoon Creek	Lake Rupert discharge (St Rt 93)	DW	25.0	39.172200	-82.520300	Vinton
303474	09-510-000	30.0	Little Raccoon Creek	Wellston Intake	DW	36.1	39.138611	-82.516870	Vinton
W03S07	09-510-000	27.9	Little Raccoon Creek	Mulga Road (CR 39), upstream Meadow Run	F2, MQ, C, B, D, N	48	39.122143	-82.499049	Jackson
W03W25	09-510-000	24.6	Little Raccoon Creek	St Rt 32, upstream Mulga Run	F2, MQ, C, FT, D, N	62.5	39.100216	-82.484707	Jackson
W03K10	09-510-000	18.45	Little Raccoon Creek	Buckeye Furnace Rd, at State Memorial	F2, MQ, C	87	39.054375	-82.459734	Jackson
W03S06	09-510-000	12.71	Little Raccoon Creek	Keystone Rd, ust Dickason Run	F2, MQ, C, Sn, B, D, N, Sed	99	39.010420	-82.452333	Jackson
W03K09	09-510-000	11	Little Raccoon Creek	Keystone Furnace Road, Downstream Dickason Run	F2, MQ, C, FT	129	39.009439	-82.445003	Jackson
W03P04	09-510-000	1.2	Little Raccoon Creek	St Rt 325, or Woods Mill Rd	F2, MQ, C, B, FT, D, N	154	38.953265	-82.365672	Gallia
W03S11	09-510-002	0.17	Sugar Run	Carr Ridge Run	DW	5.0	39.156400	-82.508900	Vinton
W03P15	09-511-000	0.2	Deer Creek	Adj., St Rt 325, near mouth	F, Mq, C	5.9	38.952969	-82.366863	Vinton
W03S48	09-514-000	2.4	Dickason Run	Keysone Furnace Road, or Ridgeland Road	F, Mq, C	17.7	39.016822	-82.503649	Jackson
W03P43	09-514-000	0.1	Dickason Run	Orpheus-Keystone Road	F2, MQ, C, B, D, N	26.9	39.008732	-82.455195	Jackson
W03P22	09-520-000	0.01	Flint Run	Southeast of Middleton, at mouth	C	4.0	39.071400	-82.471700	Jackson
W03S10	09-524-000	3.1	Meadow Run	Upstream General Mills, on property	F2, Mq, C	5.1	39.095926	-82.546886	Jackson
W03W27	09-524-000	2.1	Meadow Run	St Rt 327 (Pennyslvania Road)	F2, Mq, C	8.7	39.104613	-82.537206	Jackson
W03W18	09-524-000	0.7	Meadow Run	Cheatwood Road	F, Mq, C, D, N	9.9	39.115586	-82.515599	Jackson
W03P10	09-525-000	0.33	Sand Run	St Rt 349	DW	9.2	39.135600	-82.521100	Jackson
W03P45	09-526-000	0.33	Tripp Run	St Rt 349	DW	0.9	39.156700	-82.512200	Vinton
W03P53	09-527-000	0.93	Johnson Run	Norhtwest of Hamden, at Tripp Road	DW	2.1	39.173200	-82.533800	Vinton
303688	09-528-000	1.98	McConnels Run	Lake Road (TR15)	F, Mq, C	0.8	39.221381	-82.516539	Vinton
W03W06	09-530-000	13.9	Elk Fork	Morgan Road (CR 11), upstream Puncheon Fork	F, Mq, C	14.4	39.246783	-82.460101	Vinton
W03P30	09-530-000	13.26	Elk Fork	St Rt 50, 1 Mi. E McArthur	F2, MQ, C, B, D, N	24.5	39.241393	-82.453426	Vinton
W03W14	09-530-000	8.55	Elk Fork	downstream Wolf Run, Adj Stone Quarry Road (CR 8)	F2, MQ, C	44.4	39.216210	-82.404442	Vinton
W03P31	09-530-000	0.01	Elk Fork	CR 43B, Northeast of Radcliff	F2, MQ, C, B, Sn, D, N, Sed	60	39.161494	-82.352306	Vinton
W03W09	09-530-004	0.43	Trib to Elk Fork (Austin Powder trib.)	East of McArthur, at CR 7	F, Mq, C, D, N	2.4	39.238001	-82.431976	Vinton
203947	09-533-000	3.8	Wolf Run	Vinton Station Road (CR 24)	F, Mq, C	4.7	39.215793	-82.461270	Vinton
W03K30	09-534-000	4.0	Puncheon Fork	Bolar Road (TR 19)	F, Mq, C	2.0	39.261548	-82.520410	Vinton
W03W07	09-534-000	0.5	Puncheon Fork	St Rt 50	F, Mq, C	9.51	39.244646	-82.468306	Vinton
W03P36	09-539-000	1.6	Indian Creek	upstream Rio Grande WWTP, St Rt 325	F2, Mq, C, B, D, N	10.4	38.889141	-82.382508	Gallia

Station	River Code	RM	Stream Name	Location	Sample Type[1]	Drainage Area	Latitude	Longitude	County
W03W55	09-539-000	1.45	Indian Creek	Downstream Rio Grande WWTP, St Rt 325, upstream Little Indian Run	F2, Mq, C	10.4	38.890946	-82.380480	Gallia
W03P14	09-540-000	0.2	Little Indian Creek	Buckeye Hills Road	F, Mq, C	10.2	38.893440	-82.383662	Gallia
203953	09-542-000	0.3	Barren Creek	OH 554, powerline easement, or upstream at bridge	F, Mq, C, B, D, N	9.1	38.904697	-82.337075	Gallia
W03S40	09-544-000	0.5	Robinson Run	St Rt 325	F, Mq, C	9.19	38.995930	-82.329830	Gallia
W03S36	09-546-000	5.2	Strongs Run	Tower Road (TR 24)	F, Mq, C	5.6	39.070300	-82.302800	Meigs
W03S47	09-546-000	0.6	Strongs Run	Adney Road	F, Mq, C, B, D, N	16.4	39.014799	-82.336005	Gallia
203956	09-547-000	0.2	Williams Run	Williams Run Road	F, Mq, C	3.23	39.055535	-82.300527	Meigs
W03S39	09-549-000	0.6	Flatlick Run	Newsome Road (CR 8)	F, Mq, C	7.2	39.046791	-82.345344	Vinton
W03W56	09-551-000	0.3	Indiancamp Run	Adj. Minerton Road (CR 26)	F, Mq, C	2.1	39.084186	-82.397226	Vinton
W03W52	09-552-000	0.11	Rockcamp Run	Hawk Station Road	F, Mq, C	2.8	39.109506	-82.388633	Vinton
W03L08	09-553-000	5.5	Pierce Run	St Rt 160, near Hamden	F, Mq, C, D, N	3.4	39.165411	-82.421694	Vinton
W03W47	09-553-000	1.7	Pierce Run	Township Hwy 2A	F, Mq, C, B, D, N	9.5	39.141186	-82.380155	Vinton
203960	09-556-000	1.4	Long Run	Adj Long Run Road (CR 11)	F, Mq, C	2.2	39.205907	-82.309860	Vinton
W03W51	09-557-000	1.6	Flat Run	Brooks Road, near US 50	F, Mq, C	4.8	39.220137	-82.270840	Vinton
W03W45	09-561-000	1.4	Onion Creek	CR 4 (Worley West Road)	F, Mq, C	8.3	39.261058	-82.268151	Vinton
W03W59	09-562-000	0.16	Laurel Run	near Knox, at TR 18 (Mulby Road)	F, Mq, C	2.6	39.267880	-82.290024	Vinton
W03K37	09-563-000	13.1	Hewett Fork	adj. Cabondale Road	F, Mq, C	8.3	39.391869	-82.249360	Athens
W03P08	09-563-000	4.31	Hewett Fork	ust Rockcamp Creek, Rockcamp Road (TR 20)	F2, MQ, C, B	28.1	39.317587	-82.278266	Athens
W03P32	09-563-000	0.01	Hewett Fork	at mouth	F2, MQ, C, D, N	40.5	39.304409	-82.322622	Vinton
W03P33	09-564-000	0.3	Rockcamp Creek	Rockcamp Road,	F, Mq, C	7.69	39.316202	-82.280805	Athens
W03W50	09-565-000	0.1	Coal Run	St Rt 681	F, Mq, C	0.8	39.297016	-82.249481	Athens
301579	09-566-000	0.1	Pine Run	at mouth, 750 ft W OH 356	F, Mq, C	2.0	39.336382	-82.273492	Athens
W03P41	09-567-000	0.1	Grass Run	St Rt 356	F, Mq, C, D, N	2.7	39.346021	-82.254750	Athens
203966	09-568-000	2.7	Sandy Run	King Hollow Road	F, Mq, C	5.0	39.333708	-82.331951	Vinton
303689	09-569-000	0.4	Little Sandy Run	St Rt 278	F, Mq, C	1.5	39.312796	-82.360733	Vinton
W03K40	09-571-000	6.87	Brushy Creek	At gravel lane, off St Rt 93	F, Mq, C	8.4	39.354422	-82.455758	Vinton
W03K39	09-571-000	0.36	Brushy Creek	OH 328, near mouth	F2, MQ, C, B, Sn, D, N	33.4	39.308551	-82.440039	Vinton
W03K42	09-571-002	0.3	Siverly Creek	adj. Siverly Creek Road	F, Mq, C	10.1	39.329457	-82.465648	Vinton
W03W58	09-573-000	0.16	Twomile Run	near mouth, Long Ridge Road	F, Mq, C	4.9	39.357268	-82.382520	Vinton
W03W37	09-574-000	6.64	E. Br. Raccoon Creek	CR 26 (Laurel Run Rd)	F, Mq, C	3.2	39.415631	-82.330991	Hocking
W03K17	09-574-000	2.1	E. Br. Raccoon Creek	Adj. St Rt 56, Wayne National Forest land	F, Mq, C, B, D, N	15.3	39.392050	-82.381312	Hocking
W03W36	09-575-000	5.68	W. Br. Raccoon Creek	Ilesboro-Cedar Falls Road	F, Mq, C	3.8	39.419700	-82.469187	Hocking
W03W43	09-575-000	0.15	W. Branch Raccoon Creek	St Rt 328, near mouth	F2, MQ, C, B, D, N	22.7	39.380293	-82.397800	Vinton

Station	River Code	RM	Stream Name	Location	Sample Type[1]	Drainage Area	Latitude	Longitude	County
W03P35	09-576-000	0.01	Honey Fork	Orlando Flat Road	F, Mq, C	10.5	39.382894	-82.418719	Vinton

1: Sample types

B- bacteria sampling
D- DataSonde® continuous monitors
F2- two pass fish sampling
N- nutrient sampling
C- water chemistry sampling
FT- fish tissue sampling
Mq- macroinvertebrate qualitative sampling
DW- drinking water
Sed- sediment sampleF- single pass fish samplingMQ- macroinvertebrate quantitative samplingSn- sentinel site

*Supplemental 106 grant sites are in orange

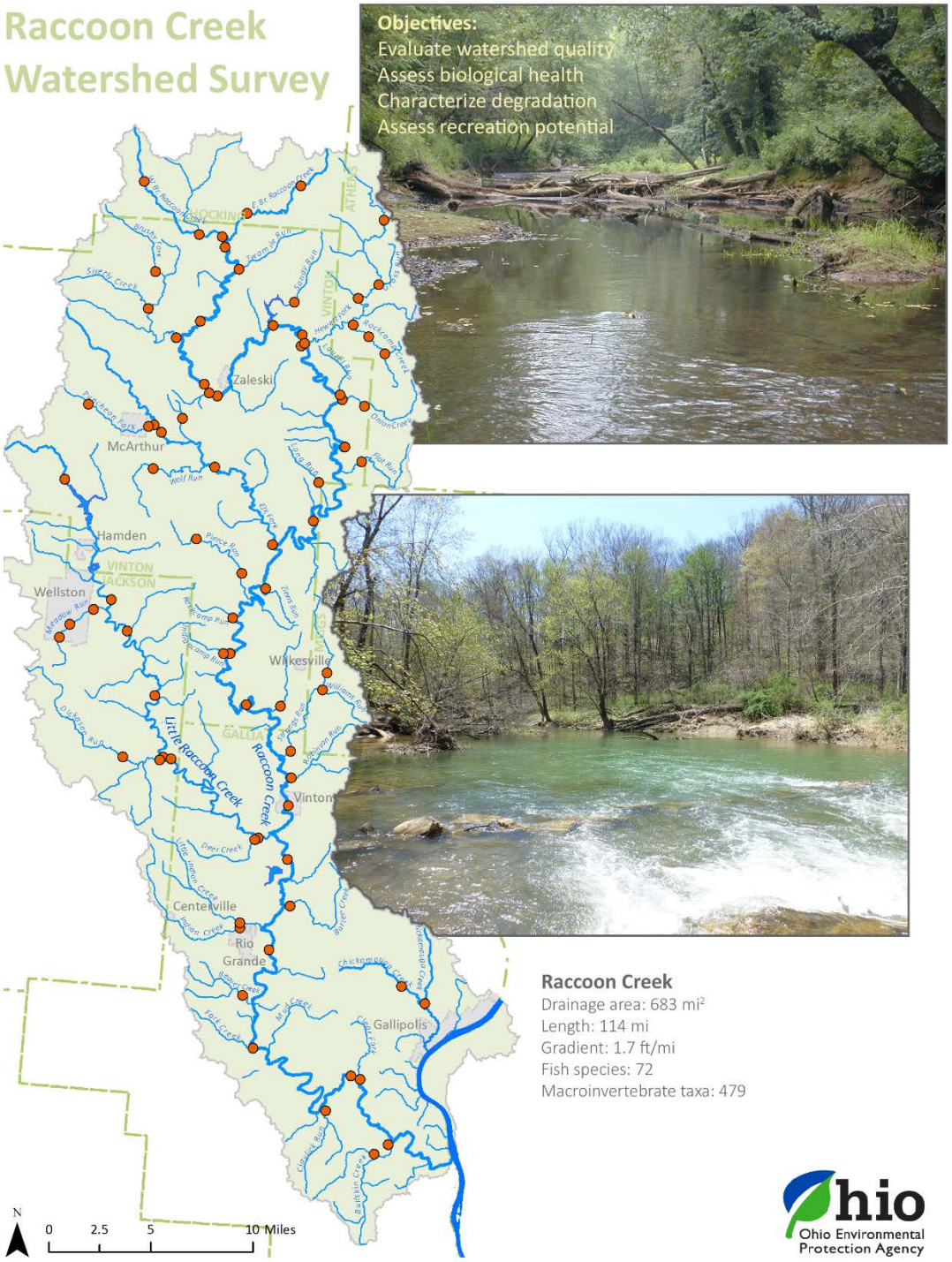


Figure 3. Sampling locations for the 2016 Raccoon Creek watershed survey.

Table 3. NPDES facilities in the Raccoon Creek Basin study area.

Facility Name	Ohio EPA Permit No.	USEPA Permit No.	Receiving Water	RM	Latitude	Longitude
Austin Powder Company	0IF00003	OH0006173	UNT Raccoon Cr (98.96)	1.0	39.2606	-82.41881
Austin Powder Company	0IF00003	OH0006173	Austin Powder Trib	1.6	39.25207	-82.43059
Austin Powder Company	0IF00003	OH0006173	Austin Powder Trib	1.8	39.25648	-82.42754
Austin Powder Company	0IF00003	OH0006173	UNT Raccoon Cr (98.96)	1.0	39.26182	-82.42378
Austin Powder Company	0IF00003	OH0006173	Austin Powder Trib	1.11	39.24704	-82.43461
Austin Powder Company	0IF00003	OH0006173	Austin Powder Trib	1.7	39.25529	-82.43072
Austin Powder Company	0IF00003	OH0006173	UNT Raccoon Cr (98.96)	0.9	39.262344	-82.419947
Austin Powder Company	0IF00003	OH0006173	Austin Powder Trib	1.5	39.2525	-82.435
Bidwell Porter WWTP	0PG00068	OH0124664	UNT Barren Run (1.4)	0.32	38.90749	-82.31673
General Mills Wellston Site	0IH00046	OH0094951	Meadow Run	1.19	39.11236	-82.5247
General Mills Wellston Site	0IH00046	OH0094951	Meadow Run	3.18	39.09586	-82.54676
Hamden WWTP	0PB00089	OH0134945	Sand Run	1.71	39.14861	-82.53806
M & S Mfg Buckeye Automatic Div	0IS00020	OH0094919	UNT Puncheon Fork (1.11)	0.44	39.234397	-82.479451
McArthur WWTP	0PB00080	OH0048241	Puncheon Fork	0.88	39.2431	-82.47465
ODNR Lake Hope State Park	0PP00067	OH0090981	Little Sandy Run	1.49	39.325471	-82.366439
ODNR Lake Hope State Park Beach	0PP00073	OH0091367	Sandy Run	0.25	39.319227	-82.356059
ODNR Lake Hope State Park Lodge	0PP00066	OH0090972	UNT Sandy Run (0.6)	0.5	39.330374	-82.349322
Pine Meadow	0PV00033	OH0139831	UNT Grass Run (0.59)	0.3	39.343039	-82.242405
Quail Creek MHP	0PV00002	OH0041289	UNT Mud Cr (RM3.58)	1.35	38.84504	-82.3072
Rio Grande WWTP	0PB00035	OH0027278	Indian Creek	1.4	38.88973	-82.38136
Rodney Village No 2 WWTP	0PG00054	OH0048526	Rayan Run	2.7	38.85308	-82.31083
Rolling Hills Generating Plant	0IB00036	OH0134821	UNT Flatlick Run (2.11)	1.3	39.08072	-82.3303
Rumpke Waste Beech Hollow Landfill	0IN00169	OH0108171	UNT Mulga Run (2.1)	0.32	39.129913	-82.463671
Rumpke Waste Beech Hollow Landfill	0IN00169	OH0108171	UNT L Rac Cr. (28.74)	0.55	39.12617	-82.47934
Rumpke Waste Beech Hollow Landfill	0IN00169	OH0108171	UNT L Rac Cr. (28.74)	1.25	39.1339	-82.48102
Sands Hill Mining LLC - Sands Hill	0IL00074	OH0076431	Unt Sugar Run (1.64)	0.18	39.16019	-82.47617

Facility Name	Ohio EPA Permit No.	USEPA Permit No.	Receiving Water	RM	Latitude	Longitude
Sands Hill Mining LLC - Sands Hill	0IL00074	OH0076431	Sugar Run	1.83	39.1583	-82.47531
Sands Hill Mining LLC - Sands Hill	0IL00074	OH0076431	UNT Sugar Run (1.31)	0.52	39.14904	-82.48019
Southern Ohio Coal Co General Office Building	0IM00003	OH0041564	Brush Fork	2.52	39.143651	-82.293018
Southern Ohio Coal Co Salem Portal	0IM00031	OH0135062	Williams Run	0.35	39.054169	-82.302472
Vinton Co Dry Kiln Inc	0IN00114	OH0090875	UNT McConnel Run (1.22)	1.0	39.19996	-82.48789
Vinton WWTP	0PA00019	OH0128007	Raccoon Creek	39.82	38.97333	-82.34056
Wellston PWS North Plant	0IV00120	OH0031780	L Raccoon Creek	29.9	39.13767	-82.51686
Wellston PWS South Plant	0IY00081	OH0128210	UNT Meadow Run (2.1)	0.47	39.09772	-82.53846
Wellston WWTP North (MAJOR PERMIT)	0PC00013	OH0023507	Meadow Run	1.17	39.11294	-82.52412
West Virginia Resources Inc - Dundas Prep Plant	0IL00075	OH0076465	UNT Pierce Run (6.44)	1.11	39.16507	-82.44873
Village of Zaleski WWTP	0PA00112	OH0144681	UNT Raccoon Cr (97.06)	0.6	39.283	-82.399

Table 4. Ohio EPA laboratory and field sampling load for the 2016 Raccoon Creek Basin survey. Total number of water column analytes does not include field parameters.

Sample Type	No. of Lab Parameters	No. Sites	Passes	Total Samples/Parameters
Conventional Water Quality (total)	31	84	3-5	420/13020
Pathogen (*E. coli)*	–	29	5	145
Datasonde®	–	30	1	30
Sediment	–	8	1	-/-
Sediment Inorganics*	Full Scan	8	1	8/-
Sediment Organics**	Full Scan	8	1	8/-
Sediment Particle Size	-	8	1	8/-
Sentinel Sites	37	9	5	45/1665
PWS (Atrazine, Nitrates, Nutrients)	-	1	5	
PWS (Nitrate and Nutrients)	-	5	5	
Fish Tissue		11		
Metals, including Hg	(FT Suite)	11	1	-/-
PCPs, pesticides, % lipids	–	11	1	-/-
Fish Stations (total)	–	83	1-2	-
2x	–	36	2	-
1x	–	47	1	-
Macrobenthos (total)	–	83	–	–
Quantitative (Hester Dendy)	–	32	–	–
Qualitative (Natural Substrates)	–	51	–	–

1- BNA Method 625, Wastewater Analysis
2- Pesticide Method 608, Wastewater Analysis and Atrazine ELISA Method
3- PCBs Method 608, Wastewater Analysis
A - Glyphosate Method 547, Drinking Water Analysis
*Particle Size, % Solids, TOC, Ammonia, Total P, ICP3, ICPMS2
**BNA 8270. Pesticides 8081, PCBs 8082 – SW846 Analysis

Table 5. List of chemical/physical water quality parameters to be analyzed/ measured in surface water, sediment, Lake and fish tissue from the Raccoon Creek study area, 2016. Water samples will be collected from streams 5 times (organics once), sediment once, and fish tissue once. Bacteria samples will be collected 5 times during the recreational use period.

Parameters	Test Method	Water (RL)	Sediment (RL)	Lake	Fish Tissue
Acidity	SM 2310B	X (5 mg/l)			
Alkalinity	USEPA 310.1	X (5 mg/l)		X	
Carbonaceous BOD, 20-day	OEPA 310.2	X (3 mg/l)			
Turbidity	OEPA 180.1			X	
Solids, Dissolved (TDS)	SM 2540C	X (10 mg/l)		X	
Solids, Suspended (TSS)	SM 2540D	X (5 mg/l)		X	
Solids, Volatile Suspended	SM 2540 D/E			X	
Organic Carbon	SM 5310 B			X	
Carbonate/Bicarbonate	SM 2320 B			X	
Ammonia-N	USEPA 350.1	X (0.05 mg/l)		X	
Total Kjeldahl Nitrogen (TKN)	USEPA 351.2	X (0.2 mg/l)		X	
Nitrate-Nitrite	USEPA 350.1	X (0.5 mg/l)		X	
Nitrite	USEPA 353.2	X (0.02 mg/l)		X	
Chloride	USEPA 325.1	X (5 mg/l)		X	
Chemical Oxygen Demand (COD)	USEPA 410.4	X (20 mg/l)			
Sulfate	USEPA 375.2	X (10 mg/l)		X	
Total Phosphorus	USEPA 365.4	X (0.01 mg/l)	X (50 mg/kg)	X	
Orthophosphate (as P)	USEPA 365.1	X (0.01 mg/)		X	
ICP 1 (Al,Ba,Ca,Fe, Mg, Mn, Na, K, Sr, Zn, Hardness)	USEPA 200.7	X		X	
ICP 3 (Al,Ba,Ca,Fe,Mg,Mn,Na,K,S,Zn)	USEPA 200.7		X		
ICPMS 1 (As,Cd,Cr,Cu, Ni,Pb,Se)	USEPA 200.8	X		X	
ICPMS 5 (As,Be,Cd,Co,Cr,Cu,Ni,Pb,Se)	USEPA 6020A		X		
BNA Organics (SVOCs)	USEPA 625	X	X (USEPA 8270)		
Herbicides (including Atrazine)	USEPA 525.2	X		X	
Microcystins	OEPA 701.0			X	
pH	Field Meter	X		X	
Conductivity	Field Meter	X		X	
Dissolved Oxygen (mg/l and % saturation)	Field Meter	X		X	
Temperature	Field Meter	X		X	
E.coli	USEPA 1603	X		X	
Chlorophyll a	USEPA 445.0	X		X	
Percent Solids	SM 2540G		X		
Total organic carbon	OEPA 335.2		X (0.1%)		
Cadmium, Copper, Lead, Nickel, Silver, Zinc	USEPA 200.8/ USEPA 200.7		X		
ICPMS 6 (As,Cd,Pb,Se)	USEPA 200.8/ SM3113B				X
Mercury	USEPA 245.1		X (USEPA 7471A)		X
PCBs	OEPA 590.1				X
Pesticides	OEPA 590.1				X
Percent Lipids	OEPA 581.5				X

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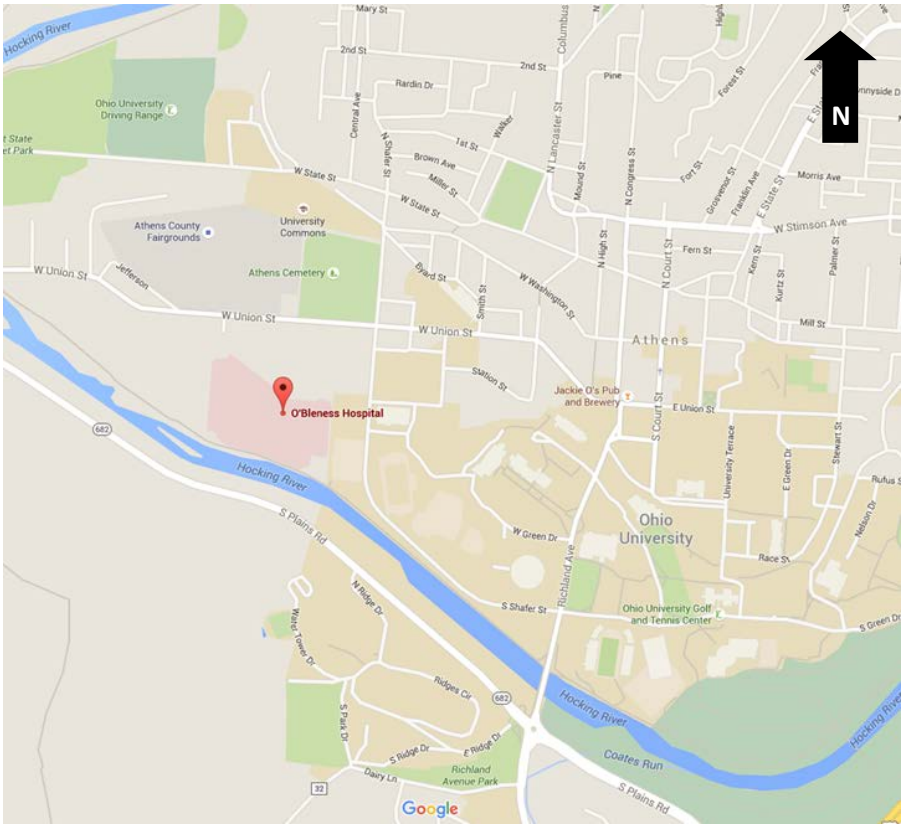

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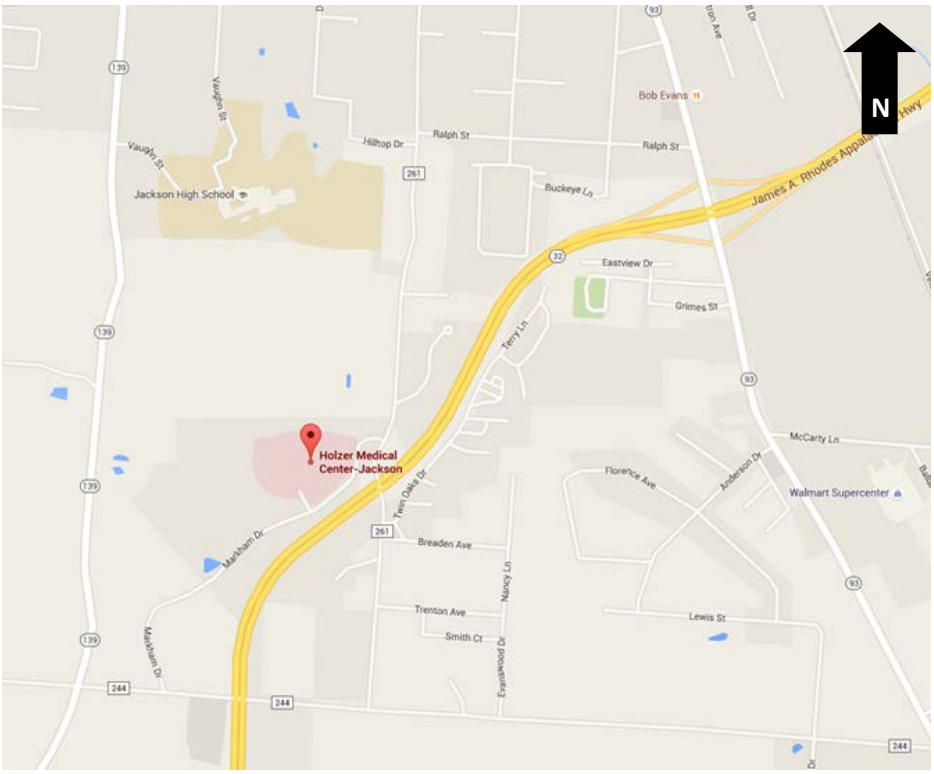

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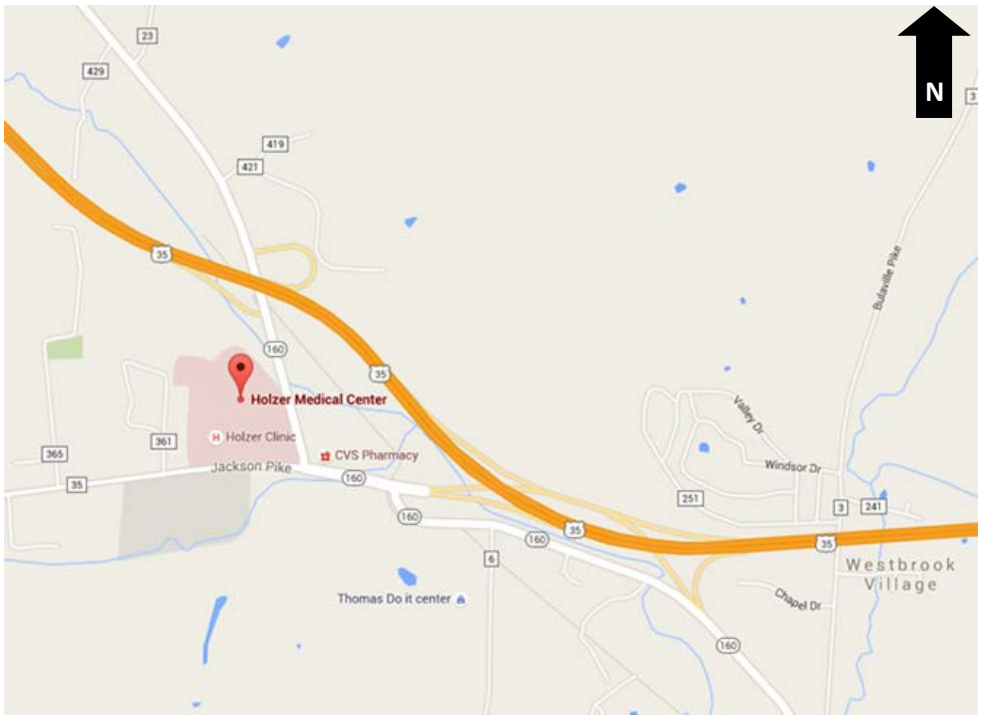

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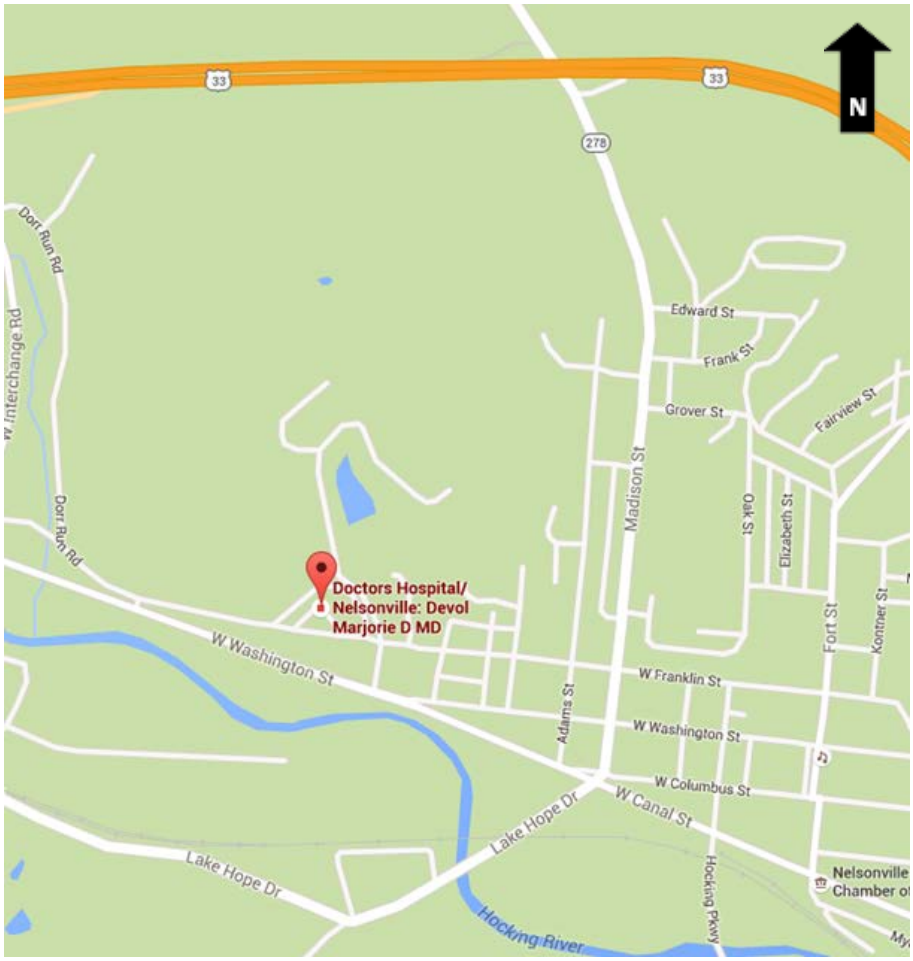

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