U.S. Army Corps of Engineers, Huntington District
Water Management Section
Water Quality Team

Annual Water Quality Report

2021

Table of Contents

List of Tables

List of Figures

Executive Summary

U.S. Army Corps of Engineers policy necessitates the development and implementation of a holistic watershed monitoring plan designed to protect resources and execute an environmentally sound water quality management strategy for each project. The Water Quality Team, a component of the Water Resources Engineering Section, is organized to use a multidisciplinary approach to assess various environmental issues associated with operation of our projects. The Team's mission objectives include 1) Assessing compliance with applicable state and federal water quality regulations, 2) Supporting Water Control, Project Operations, and Waterways Section, 3) Monitoring and identifying current trends in water quality conditions, and 4) Evaluating the effectiveness of the Water Control Plan. Understanding the physical, chemical, and biological processes occurring in our waterways allows the Huntington District to efficiently operate projects for their authorized purposes while conserving the environmental value of the resources.

LRH Water Quality Team Activities in 2021:

1) In order to assess compliance with applicable state and federal regulations, the Water Quality Team completed intensive water quality surveys at six projects in the Twelve Pole and Muskingum River basins. Surveys were conducted six times each at Atwood, Beech Fork, Charles Mill, East Lynn, Leesville, North Branch of Kokosing, and Pleasant Hill lakes. Survey data were compared to fourteen water quality constituents that the Water Quality Team uses for long-term trend analysis and compliance determinations.
    a) All exceedances of state water quality criteria resulted from inputs by degraded inflow streams whose headwaters were not regulated by the USACE.
    b) Elevated pollutant levels will be reported to the appropriate regulatory agencies to facilitate potential mitigation efforts by the state.
2) Consistent with national trends, the Huntington District has observed increasing occurrences of harmful algal blooms (HABs) resulting in impacts to operations at flood control projects around the District. The Water Quality Team responded to HABs and coordinated with multiple local, state, and regional water quality agencies to determine potential impacts to project operations and public health. States currently take the leading role in HAB monitoring, sampling, and response while the District has adopted a supporting role. By 2018, all states within LRH had developed some kind of HAB monitoring and/or response plan. As states take the lead in HAB response they have requested that the Corps continue to monitor and report potential HABs. The Water Quality Team coordinated with Operations Division to host a HAB webinar to train flood control and navigation project staff on HAB identification, response, and reporting. The Team also attends yearly HAB Task Force Meetings with the states of West Virginia, Virginia, and Kentucky. Harmful algal blooms occurred at Dillon, John W. Flannagan, Paint Creek, Tappan, Pleasant Hill, Senecaville, and Burnsville Lake in 2021. There were no significant impacts or closures as a result of these HABs. Response efforts were handled primarily by the respective state agencies in accordance with established response plans and protocols. As part of the Water Quality Program mission, the Water Quality Team regularly provides support for other USACE offices and organizations.
3) The Water Quality Team maintains, calibrates, and distributes equipment necessary to collect lake profiles and river data for use in daily operations. Temperature and dissolved oxygen measurements are collected through the water column and at control points to determine optimal withdrawal depths to maximize the effectiveness of selective withdrawal capabilities. These efforts allow the Water Quality Team to direct operations required to reach water quality targets established in the Water Control Manuals to protect downstream aquatic ecosystems.
4) The Water Quality Team monitored maintenance dredging operations below R.C. Byrd Locks & Dam as required per 401 Water Quality Certification stipulations in 2021. The Team monitored sediment deposition and effectiveness of steering currents for compliance with the Clean Water Act, Endangered Species Act, and the Inland Testing Manual regarding in-water disposal of dredged material. Additionally, sediment was collected and analyzed from the Big Sandy River, the Kanawha River, and on the Ohio River as per the rotating monitoring schedule. Results were presented to state and federal regulating agencies at the annual partnering meeting and future goals and objectives were discussed. Without the established cooperative and defensible monitoring program the District could be required to utilize upland disposal at a cost increase of up to $1.2M annually due to endangered species at R.C. Byrd alone.

5) Consistent with our mission, in 2021 the Water Quality Team was called to respond to environmental issues and to provide guidance to other USACE offices and lake projects. More information can be found in the Situational/Reactionary Support section.

   a) At the request of LRD, the Team conducted an analysis of the influence of USACE lake discharges on the overall flows and water quality on the Ohio River mainstem with a focus on nutrient loading. It was determined that while approximately 60% of the Ohio River's flow originates from USACE lakes, only some lakes are sources of nutrients that would affect water quality.

   b) The Team partners annually with the US Fish and Wildlife Service, the WV Division of Natural Resources, and Operations staff to deploy native mussel propagation systems in Burnsville and Sutton Lakes. Thus far propagation efforts have been successful.

   c) Two members of the Water Quality Team are involved in a national PDT to develop a USACE-wide water quality database. The database is still being developed but has basic functionality, and is estimated to be completed in FY2023.

   d) The Team was involved in three Sustainable Rivers Project studies at Beach City Lake, London Locks and Dam, and on the Ohio River mainstem. The goals of these studies were to determine if minor operational changes could bring any ecological benefits to the surrounding watersheds.

   e) During deep drawdowns for maintenance activities at Summersville and R.D. Bailey Lakes, the Water Quality Team was tasked by the Planning Branch to survey exposed lake shoreline to assess any negative impacts to native mussels. At both lakes it was determined that additional drawdown likely would not have any impact on mussel inhabitants due to the lack of suitable habitat.

   f) At the request of the Bluestone Phase 5 Dam Safety PDT, the Team collected bathymetry measurements at Bluestone Lake to determine a suitable area of the lake for implementing fish habitat. The Water Quality Team's analysis revealed that the area of interest was suitable for mitigating fisheries impacts caused by the dam safety project.

   g) The Team collected sediment depth measurements at two unused sewage lagoons in Milton WV as part of the Lower Mud Flood Damage Reduction project. Measurements indicated that sludge from only one pond would need to be removed before the ponds are emptied and backfilled.

   h) The Team coordinated with the Virginia Department of Health to address an untreated sewage leak into the Pound River near the Village of Pound. After collecting samples it was determined that the sewage releases were being significantly diluted prior to reaching J.W. Flannagan Lake and thus did not pose a risk to recreation.

6) The team assisted with the scoping of impact evaluations needed to mitigate for proposed surface mining at RD Bailey Lake. Impacts to water quality could negatively affect authorized project purposes of Water Quality, Recreation, Fish and Wildlife Conservation, and Flood Control.

7) The Team maintains regular partnerships with multiple outside organizations and State agencies including the Muskingum Watershed Conservancy District, Ohio Environmental Protection Agency, Kentucky Division of Water, and West Virginia Department of Environmental Protection. These partnerships reduce redundancy of work and facilitate monitoring and improvement efforts within watersheds across the District.

8) Reviewed non-federal hydropower projects and operations for Corps policy, NEPA, Clean Water Act, and Endangered Species Act compliance. This is an ongoing effort to ensure federal compliance and to protect authorized project purposes and federal interests.

Water Quality Program Overview

Water Quality – *The physical, chemical, biological, and radiological characteristics of surface and ground water affecting abiotic and biotic conditions and interrelationships.*

Figure 1. The USACE definition of water quality per ER 1110-2-8154 (2018).

Consistent with ER 1110-2-8154 (2018) the LRH Water Quality Program "provides one of the greatest opportunities for the USACE to demonstrate its commitment to environmental leadership, conservation, restoration, and stewardship."

Water quality is an authorized purpose at many LRH lakes, however, even if not an authorized project purpose, water quality is an integral consideration during all phases of a project's life. This commitment is supported by several authorities, regulations, and acts, all requiring compliance with applicable water quality and environmental standards set forth by federal, state, and interstate agencies (Figure 2). The guiding policies necessitate the development and implementation of a holistic watershed monitoring plan needed to protect resources and execute an environmentally sound water quality management strategy for each project. Establishing and maintaining a strong viable water quality program will ensure achievement of the water control plan objectives for congressionally authorized water resource projects and aid in evaluating project performance.

- Public Law 92-500 of the Federal Water Pollution Control Act; 18 October 1972
- Section 313 of the Clean Water Act (CWA) of 1979
- Executive Order 12088; 13 October 1978
- USACE ER 1110-2-8154; Water Quality and Environmental Management for Corps Civil Works Projects; 31 May 1995
- USACE EM 1110-2-3600; Management of Water Control Systems; 30 November 1987
- USACE ER 1110-2-8156; Preparation of Water Control Manuals; 31 Aug 95
- Endangered Species Act of 1973
- Water Quality Program Management Plan
- Federal Facilities Act of 1990
- LRH Water Management Program Plan
- USACE ER 1110-2-8154; Water Quality and Environmental Management for Corps Civil Works Projects; 2018

Figure 2. Policies and authorities that guide water quality operations.

Understanding the physical, chemical, and biological processes occurring in our waterways allows the Corps the opportunity to efficiently operate projects in ways that provide for sustainable human uses while conserving the environmental value of the resource. The ultimate responsibility to control water quantity and quality at all Corps projects rests with the Corps.

Furthermore, a full commitment to environmental stewardship requires a comprehensive understanding of the interactions between the uses and users of the watershed and the impact of USACE activities on the aquatic and upland environment. Water quality data collection at inflow, lake, discharge, and tailwater stations is essential for

1) Developing an understanding of cause-and-effect relationships that create unique water chemistry and sediment conditions at each project

2) Providing needed information for integrating environmental consideration into water management decisions

3) Supporting management of multiple competing project purposes and providing support for evaluating effects of the water control plan

Water quality data collection activities will be carried out to support **one or more** of the following objectives **as appropriate** for a given project or system of projects:
(1) Assess compliance with applicable Federal, State, and local water quality standards.
(2) Provide an adequate database for monitoring project conditions and facilitating coordination with Federal, State, and local agencies.
(3) Investigate special problems and design/implement modifications to improve water management procedures.
(4) Provide data to support reservoir regulation/management and address environmental problems.
(5) Provide water quality data required for real-time project regulation.
(6) Evaluate sediment and water quality interactions and their effects overall.
(7) Understand, protect, and restore, aquatic and riparian environments and ecosystems.
(8) Develop and maintain the awareness essential for sound stewardship of water resources .
(9) Monitor recreational areas and water supplies to ensure public safety and resource integrity.
(10) Ensure stormwater, erosion, and sediment control practices meet requirements.
(11) Collect water quality data to support studies, evaluations, and resource modeling.
(12) Consider spatial watershed relationships through seasonal or annual trends in water quality.
(13) Modify data collection requirements to meet evolving management requirements and regulations.
(14) Develop a sufficient data base to document external impacts or harm to water resource projects.
(15) Provide timely response to incidents that could impact project operations or resources.

Figure 3. Objectives that drive water quality data collection programs per ER 1110-2-8154 (2018).

Organization of the LRH Water Quality Team

The Water Quality Program is organized to use a multidisciplinary approach for addressing various environmental issues associated with operational goals and project purposes. Physics, chemistry, and biology are used for evaluating emerging concerns that may impede operation efficiency. It is important to understand the unique interactive effects among surface water, groundwater, terrestrial, and atmospheric systems at each project. Partnerships with State, Federal, and regional agencies, non-governmental organizations, and educational institutions are necessary to effectively understand environmental concerns (see Coordination with Other Agencies).

The Water Quality Team is part of the Water Management Section of the Geotechnical and Water Resources Engineering Branch. There were six personnel working on the Water Quality Team in 2021: Josh Daugherty (Aquatic Biologist), Nathan Fleshman (Student), Andrew Johnson (Wildlife Biologist), Luke Sadecky (Aquatic Biologist), Kamryn Tufts (Aquatic Biologist), and Thad Tuggle (Fisheries Biologist).

The Water Quality Operations Center is located at the R.C. Byrd Locks and Dam in Apple Grove, West Virginia and is comprised of the following components: biological laboratory for analyses of macroinvertebrates, fish, and algae identification/enumeration; administrative area for offices; staging area for equipment calibration and repair; staging area for sample processing/storage; and a garage and carport for storage of boats, sampling equipment, and electronics. This facility serves as the staging area for all field work. Water Quality staff maintain work space at the Huntington District Office and often telework in response to the ongoing COVID-19 pandemic.

Survey Implementation Strategy

A fixed-site sampling program has been implemented to monitor long-term water quality at each flood control project. These sites are visited on a predetermined schedule and extend throughout the calendar year to establish any temporal trends. Sites are carefully chosen to be the most representative of a lake's watershed and to provide the best overall assessment for that project. Extra sites and increased sampling effort may be necessary depending on environmental conditions and budgetary constraints. A more detailed sampling strategy is outlined in the *Water Quality Program Management Plan*. Current and future survey schedules are outlined in the most current *Water Quality Annual Operating Plan* (Appendix B).

Types of Surveys Implemented by the Water Quality Team

- Intensive surveys are designed to fully assess water quality parameters within a watershed. Such surveys are conducted on a five-year rotation at each lake/watershed and involve collecting water chemistry six or more times at each station as budget permits.
- Biological surveys such as fish community surveys and benthic macroinvertebrate surveys are typically performed in coincidence with intensive surveys. These are designed to support any observed physical or chemical water quality trends and are used to assess impacts of water quality to the biota. Biological data can be scored using indices that allow sites to be compared for evaluation of the ecological health. Biological surveys are conducted where budget and staffing permit.
- Dredge surveys are designed to monitor sediment transport/quality, water quality, and potential impacts of dredge operations to federally listed mussels and surrounding habitat. These surveys are also completed for compliance with state 401 Water Quality Certifications.
- Project profiles are designed to monitor the progression of seasonal thermal and chemical stratification within lake projects. These types of surveys are conducted by project personnel and typically occur at projects with selective withdrawal capabilities. Data collected from this type of survey is used to manage the quality of dam releases.
- Acoustic Doppler surveys are completed at both Navigation and Flood Control projects. At Navigation projects, a Sontek M9 Acoustic Doppler is used to measure total river flow and to map the magnitude and direction of currents below the dam. At Flood Control projects, the team maps the bathymetry of the lakes to estimate sedimentation rates and changes to reservoir storage curves. The technology is also used to map stilling basins, verify stream gage flow measurements, and perform dam/levee safety inspections.

- Special surveys incorporate any surveys such as environmental flow (E-flow) surveys, bathymetric surveys, analyte-specific monitoring, and stream flow surveys that are not considered routine and are performed as needed in support of operations, emergency situations, needs of partner organizations, and other District programs.
- HAB (Harmful Algae Bloom) surveys are conducted in response to a visually observed algae bloom which could produce toxins that can be harmful to humans, wildlife, and pets/livestock. This survey type may include algae collection, toxin testing, water quality sampling, and visual inspections of the impacted areas. Coordination with state and federal agencies is crucial with HAB monitoring. Due to the Recreation mission at multipurpose projects, the District will assist the states with HAB responses where funding and scheduling allow.

Water Quality Mission Objectives

The Huntington District (LRH) covers approximately 45,000 square miles of drainage area that contain nine river basins flowing into a 311 mile stretch of the Ohio River. Water quality monitoring is implemented to fulfill four major objectives that drive the LRH water quality program: 1) assess compliance with state and federal water quality standards by monitoring current water quality conditions effected by a project's operation; 2) provide support to water control, project operations, and navigation for regulation and modifications; 3) monitor water quality conditions, establish baseline conditions, assess current water quality status, and identify any significant water quality trends; and 4) evaluate the effectiveness of the Water Control Plan.

1) Assess Compliance

Applicable state and federal compliance responsibilities are established by the following authorities:

> *"The Corps water quality management requirements derive from the Federal Water Pollution Control Act of 1948 and its amendments, including the Clean Water Act of 1977 and the Water Quality Act of 1987. The Clean Water Act of 1977 strongly affirms the Federal interest in water quality and recognizes, preserves, and protects the primary responsibility and rights of states 'to prevent, reduce, and eliminate pollution'. When permitted by Federal supremacy and when not specifically exempted by the President, Executive Order 12088 (Federal Compliance with Pollution Control Standards), 13 October 1978, provides that each Federal agency is responsible for compliance with applicable pollution control standards in the same manner as any non-Federal entity."* – **ER 1110-2-8154; Section 2-2. Authorities**

> *"The Corps commitment to environmental compliance and protection of estuaries, rivers, lakes, and other navigable waters arises from directives in many Federal statutes, Executive Orders, and the Corps environmental regulations. These regulations are designed to minimize pollution, maximize recreation, protect aesthetics, preserve natural resources, and promote the comprehensive planning and use of water bodies to enhance the public interest. Therefore, the Corps, in the design, construction, management, operation, and maintenance of its facilities, will exert leadership within existing authorities and appropriations in the nationwide effort to protect, enhance, and sustain the quality of the nation's water and land resources. Federal facilities must comply with all applicable Federal, state, and local requirements in the same manner and extent as other entities. The Corps water quality management responsibilities are responsive to the overall objectives established in the Clean Water Act (see Engineer Manual (EM) 1110-2-3600) to restore and maintain the chemical, physical, and biological integrity of the nation's waters and the laws, regulations, and Executive Orders…"* **– ER 1110-2-8154; Section 2-3. Policy**

Other compliance responsibilities are defined by, but not limited to:

- **Water Control Manuals**
- **PL 78-534 Flood Control Act of 1944 (recreation, surplus water)**
- **PL 85-624 Fish and Wildlife Coordination Act of 1958**
- **PL 85-500 Water Supply Act of 1958**
- **PL 91-190 National Environmental Policy Act of 1969**
- **PL 92-500 Federal Water Pollution Control Act of 1972**
- **PL 93-205 Endangered Species Act of 1973**
- **PL 95-217 Clean Water Act of 1977**
- **Executive Order 12088**
- **Executive Order 13148**

- **WV Title 47-2 Legislative Rules Requirements Governing Water Quality Standards**
- **KY 401 KAR 5:031 Surface Water Standards**
- **OH OAC Chapter 3745-1 Water Quality Standards**

Partnerships with state regulating agencies keep the Corps current with any criteria changes and newly listed 303d streams within the Huntington District jurisdiction that may affect data analysis and site monitoring.

2) Provide Support to Water Control and Project Operations

The Huntington District manages thirty-five flood control lakes in nine major watersheds. While flood damage reduction is the primary purpose of the lakes, there are other allied purposes which define more than ninety percent of their operation. Water quality is the driving issue for most of those allied purposes. Water management decisions must include valid water quality and biological assessments as part of the daily decision process. These real-time actions are necessary to help meet project purposes such as flood damage reduction, recreation, water supply, low flow augmentation, whitewater release, and fish and wildlife conservation (Table 10). Specifics of the LRH water quality program can be found in the *Water Quality Program Management Plan* and the *Water Quality Annual Operating Plan*.

Seventeen LRH lakes have, at minimum, some selective withdrawal capability. In the summer stratification season, operators can mix poor quality water (cold, little to no dissolved oxygen, high dissolved metals, etc.) from lower depths with better quality water (warm, high dissolved oxygen, low dissolved metals, etc.) from higher depths to achieve a release that supports aquatic life below the dams. To determine the quality and quantity of releases, lake operators are required to collect lake profiles at routine intervals. The Water Quality Team provides support in this area by supplying and maintaining the equipment necessary to perform these duties, and by managing the data that is collected by project operators. Water Quality staff use this data to direct lake project operations to meet water quality targets.

3) Provide Support to Waterways Section

There are nine locks and dams on the Ohio and Kanawha rivers within the Huntington District. The USACE is mandated by Congress to maintain the navigation channel depth on these rivers. With the passage of the National Environmental Policy Act of 1970, the Corps started an environmental monitoring program to evaluate impacts associated with maintenance of the navigation channel. Sediment contaminants and plumes must be monitored prior to, during, and after dredging activities to protect any sensitive mussel species known to exist near dredging activities. Due to the abundance of riverine habitat immediately downstream of many locks and dams, high quality mussel beds tend to aggregate in these locations. Many of these beds are known to contain endangered species or provide the density and diversity of mussel beds known to support endangered mussels. State and Federally listed species of concern are regulated by the Endangered Species Act of 1973 and other local state authorities.

4) Monitor Current Water Quality Conditions and Identify Trends

A robust and defensible database is necessary to assess the constantly changing nature of our environment. While many watersheds are improving thanks to remediation efforts and more sustainable land management practices, many of the District's watersheds are continually in poor health, and some are even in decline. The Water Quality Team monitors the health of watersheds within LRH through the implementation of various water chemistry and biological surveys upstream, downstream, and within LRH lake projects. Routine surveys allow the Water Quality Team to establish baseline conditions, assess current water quality status, and identify any significant water quality trends within LRH watersheds.

Many authorized project purposes, including recreation and fish and wildlife conservation, rely on the District assessing water quality consistent with applicable state and federal standards. The District currently tracks fourteen water quality constituents for long-term trend analysis and compliance determinations. If a constituent exceeds the District threshold value, that data will be compared to historical data from the same site and within the watershed to determine if water quality has changed. If the District determines that the water quality of a site has been impacted, a plan will be developed to further analyze the new source of impairment. The District will determine if any project modifications could mitigate impairments to water quality. Additionally, the respective state will be notified of any exceedance of state water quality standards to address the source of impairment.

5) Evaluate the Effectiveness of the Water Control Plan

All Huntington District multi-purpose flood control projects are operated according to the guidelines set forth in their respective Water Control Manuals (WCMs). Water Control Plans are documents established within each project's WCM that detail a project's authorized purposes and requirements, how and when to operate said project to achieve its authorized purposes, and any constraints surrounding its operation. Routine monitoring conducted by the Water Quality Team per Mission Objective 4 (above) contributes to evaluating the effectiveness of a project's Water Control Plan, and monitoring results are included in WCM updates. Water Quality data are routinely utilized by the Water Management Team to adjust project operations to maintain the integrity of water resources surrounding Corps facilities.

Other sections of the WCMs contain information regarding land use and other watershed characteristics that are subject to temporal changes. Many water quality constituents are indicators of land use change and analyzing these data may reveal and support any updates necessary to the WCMs. The District will determine if any project modifications could mitigate impairments to water quality found via Mission Objective 4 (above). Any changes to the manuals will be completed following reporting of intensive survey data.

Water Quality Data Management

The Water Quality Team uses a software service, Aquarius Samples (AQS), to manage water quality data. AQS is a cloud-based data management service hosted by Aquatic Informatics, Inc. that provides access to chemical, physical, and biological data from any device with an internet connection. Utilizing the service thus far has been favorable and the future is promising due to constant updates and improvements by the developers. In addition, the USACE is currently developing an enterprise level database for storage, retrieval, and analysis of Corps water quality data.

Time series temperature and dissolved oxygen data are maintained in the Corps Water Management System (CWMS) database for use in daily operations. Lake profile data are currently managed in Excel spreadsheets and posted online for public availability. Time series lake buoy data has been collected and will be managed in the CWMS database.

The Water Resources Development Act (WRDA) of 2014 required that all USACE water quality data be made accessible to the public. Initial efforts to satisfy these requirements involved uploading water chemistry data to the USEPA STORET Water Quality Exchange (WQX) system. The District currently relies on the USACE's Access to Water public website (water.usace.army.mil) to maintain compliance.

Real-Time Data Collection

Real-time data are needed for many aspects of water control and quality assessment. Precipitation modeling, forecasting, water management/control, and water quality monitoring are the main uses of the real-time data. Most of the data are accessible online and are provided by a vast national network of gaging stations maintained cooperatively by USACE, U.S. Geological Survey (USGS), and the National Weather Service (NWS). Locations and associated data of active gaging stations can be found at http://waterdata.usgs.gov/nwis/rt.

Multiparameter sondes offer another source of real-time data and are used in applications where continuous measurement of multiple physical parameters is needed such as water temperature, dissolved oxygen, conductivity, turbidity, and pH. For instance, the Kanawha River has a sonde deployed during summer months to monitor temperature and dissolved oxygen levels in the Winfield pool to determine flow augmentation requirements (see Support for Other USACE Elements).

Water Quality Activities in 2021

Water Quality Compliance and Long-Term Trend Analyses

Many authorized project purposes, including recreation and fish and wildlife conservation, rely on the District assessing water quality consistent with applicable state and federal standards. The District currently tracks fifteen water quality constituents for long-term trend analysis and compliance determinations. These fifteen constituents make up a broad spectrum of water quality analytes that can be used by the District to describe impacts from poor land use practices, agriculture, silviculture, poor sewerage, resource extraction, etc. The District has developed threshold values for each constituent to serve as a screening for potential water quality problems in a watershed (Table 1). Oftentimes, these threshold values are based on the most stringent appropriate state and/or USEPA water quality standard. Where no criteria exist for a constituent, the District has developed threshold levels using historical data from all District projects as well as best professional judgment. If a constituent in a sample exceeds the threshold value, that data will be compared to historical data from the same site and within the watershed to determine if water quality has changed. If the District determines that the water quality of a site has been impacted, a plan will be developed to further analyze the new source of impairment. Additionally, the native state will be notified of any exceedance of state water quality standards to address the source of impairment. In this report the District will not be reporting exceedances below surface depths of lakes. The importance of each constituent is described below:

Aluminum – Geologically, aluminum occurs naturally and in great abundance. Elevated aluminum levels in water can indicate watershed impairments from poor land use practices, increased suspended sediments, and resource extraction. A District threshold value of 750 µg/l is consistent with the West Virginia water quality standard for total aluminum. Any results that did not exceed the minimum detection limit for aluminum were removed for trend and boxplot analysis. This is appropriate due to the consistent detection of aluminum and the rarity of samples that are below detection.

Ammonia – Ammonia is a nitrogen compound that is present in surface and ground waters from both natural and man-made sources. Naturally occurring sources of ammonia include waste products from wildlife, decomposition of animal and plant matter, and nitrogen fixation from certain species of bacteria. Man-made sources include point source discharges from wastewater treatment plants, discharges from the manufacture and application of fertilizers, runoff from livestock operations, and atmospheric deposition from burning fossil fuels (indirectly). Although ammonia typically will quickly oxidize into other usable compounds (nitrite, nitrate, etc), high concentrations of ammonia can be toxic to aquatic life and an indicator of improper waste discharge or a failing septic system. State criteria for ammonia vary between states, therefore the USACE will use the native state's method for determining exceedances.

Bromide – Historically, the District has seen bromide levels below detection limits at our sample sites. In response to increased horizontal fracturing for natural gas extraction adjacent to our flood control projects, the District is concerned about elevated bromide levels. Any detection of bromide at a site could indicate a new impairment in the watershed. Due to the overall lack of consistent bromide data, all data is being used for analysis including results that do not meet the minimum detection level.

Chloride – Increased chloride levels in water can be attributed to natural gas extraction, mineral extraction, and poor land use practices. The District has used a threshold value of 860 mg/l for chloride that is consistent with West Virginia, Virginia, and the USEPA. Any results that did not exceed the minimum detection limit for chloride were removed for trend and boxplot analysis. This is appropriate due to the consistent detection of chloride and the lack of samples that are below detection.

Dissolved Oxygen – Dissolved oxygen (DO) is affected by many factors including temperature, nutrient concentrations, and physical aeration. In order to support healthy aquatic life, adequate DO levels of 5 mg/l (warm water) and 6 mg/l (cold water) must be maintained. These District threshold values are consistent with Kentucky water quality standards.

Iron – Similar to aluminum, iron is abundant in the geology of the District. Elevated iron levels in water can indicate watershed impairments from poor land use practices, increased suspended sediments, and resource extraction. A District threshold value of 1,000 µg/l is consistent with the Kentucky standard for chronic iron exposure. Any results that did not exceed the minimum detection limit for iron were removed for trend and boxplot analysis. This is appropriate due to the consistent detection of iron and the rarity of samples that are below detection.

Kjeldahl Nitrogen – Total Kjeldahl nitrogen (TKN) is measured to determine impacts from wastewater treatment plants, sewage, agriculture, or animal feed lots. The District threshold value of 0.5 mg/l for TKN was determined using historical data from the District. Any results that did not exceed the minimum detection limit for TKN were removed for trend and boxplot analysis. This is appropriate due to the consistent detection of TKN and the rarity of samples that are below detection.

Manganese – Increased manganese levels are usually associated with mineral extraction. A District threshold value of 1,000 µg/l is based on historical data from within the District. Values exceeding this threshold would indicate a new impairment in the watershed. Any results that did not exceed the minimum detection limit for manganese were removed for trend and boxplot analysis. This is appropriate due to the consistent detection of manganese and the rarity of samples that are below detection.

Mercury – Atmospheric deposition of mercury is the largest contributor of this constituent to District waters. Coal fired power plants are a major source of the pollutant. The District threshold value of 1.4 µg/l is consistent with the standards developed for Kentucky and Virginia. It is difficult to measure trends with mercury data due to the abundance of samples that do not exceed the MDL. As a result, trend analysis for mercury uses all available results and expressions of an MDL.

pH – Normal pH values for healthy streams range between the District threshold values of 6.5 to 9.0. This threshold value is consistent with the water quality standard of Ohio.

Phosphorus – Elevated phosphorus levels are usually associated with agricultural land uses. Increased phosphorus levels have been linked to increased potential for harmful algal blooms. The District threshold values for warm lakes (0.04 mg/l) and cold lakes (0.03 mg/l) are consistent with the standards for West Virginia. A less stringent 0.05 mg/l is used for streams in the District. For data and trend analysis purposes all results below MDL will be set to zero.

Selenium – Elevated selenium levels are most often associated with mineral extraction in the District. The District threshold value of 5 µg/l is consistent with West Virginia and Virginia water quality standards. It is difficult to measure trends with selenium data due to the abundance of samples that do not exceed the MDL. As a result, trend analysis for selenium uses all available results and expressions of an MDL.

Strontium – Elevated strontium levels are often associated with horizontal fracturing for natural gas extraction. Elevated levels are also often seen in areas where agriculture is the primary land use. Strontium isotopes are known to be a tracer component in fertilizers. The District threshold value of 200 µg/l for strontium was developed using historical data from within the District's watersheds. Any results that did not exceed the minimum detection limit for strontium were removed for trend and boxplot analysis. This is appropriate due to the consistent detection of strontium and the lack of samples that are below detection.

Sulfate – Elevated sulfate levels are most often associated with mineral extraction. The District threshold value of 200 mg/l for sulfate was developed using historical data from within the District's watersheds. Any results that did not exceed the minimum detection limit for sulfate were removed for trend and boxplot analysis. This is appropriate due to the consistent detection of sulfate and the lack of samples that are below detection.

Specific Conductance – In general, elevated conductivity is associated with human activity. Any land change or instability can result in increased conductance in the watershed. The District threshold of 500 µS/cm is a rule of thumb value that is often associated with some form of biological impairment.

Trophic State Index (TSI) – North American Lake Management Society defines trophic state as the total weight of living biological material or average productivity in a lake at a specific location and time. The Huntington District estimates the trophic states using the values for chlorophyll-a, total phosphorus, and secchi depth.

Table 1. Water quality constituents/analytes observed for long-term trend analysis of state criteria and/or District levels of concern.

Analyte	USACE Threshold	West Virginia	Kentucky	Ohio	Virginia
Aluminum	750 ug/l	750 ug/l	None	None	None
Ammonia	0.5 mg/L	Temp/pH dependent	0.05 mg/L (unionized)	Temp/pH dependent	Temp/pH dependent
Bromide	any detection	None	None	None	None
Chloride	860 mg/l	860 mg/l	1,200 mg/l	None	860 mg/l
Dissolved Oxygen	5.0 mg/l warm 6.0 mg/l cold	5 mg/l	5.0 mg/l warm 6.0 mg/l cold	None	4.0 mg/l
Iron	1,000 ug/l	1,500 ug/l	4,000 ug/l	None	None
Kjeldahl Nitrogen	0.50 mg/l	None	None	None	None
Manganese	1,000 ug/l	None	None	None	None
Mercury	1.4 ug/l	2.4 ug/l	1.4 ug/l	1.7 ug/l	1.4 ug/l
pH	<6.0 or >9.0	<6.0 or >9.0	<6.0 or >9.0	<6.5 or >9.0	<6.0 or >9.0
Phosphorus	0.04 mg/l warm lake 0.03 mg/l cold lake 0.05 mg/l stream	0.04 mg/l warm lake 0.03 mg/l cold lake	None	None	0.02 mg/l JWF 0.04 mg/l NFP
Selenium	5 ug/l	5 ug/l	None	None	20 ug/l
Specific Conductance	500 uS/cm	None	None	None	None
Strontium	200 ug/l	None	None	None	None
Sulfate	200 mg/l	None	None	None	None

Intensive Surveys

Water Chemistry Surveys

Intensive surveys were completed at six projects in 2021 per the five-year rotating sampling schedule. Intensive survey data were used to report analyte concentrations of concern, compliance monitoring, suggestions for operational changes impacting water quality, and to assess fulfillment of authorized project purposes. Sampling locations were chosen based on historical site data, 303d listings of impaired waters, known or potential land disturbances, proximity to the lake, and spatial distribution within the watershed. Station information and 303d listings are available in Appendix A. Each location was sampled for a predetermined water quality suite consisting of physical parameters, solids, nutrients, major ions, metals, acidity, and hardness (Table 2). These constituents are commonly used to gauge ecosystem health and their thresholds (Table 1) are considered supportive of aquatic life use criteria proposed by state and federal regulatory agencies. Inflow and outflow sites were sampled during four seasonal flow periods: winter intermediate, spring high, summer intermediate, and summer low flow. Lake stations were sampled four times at multiple depths during summer stratification. Benthic macroinvertebrate and fish community data were collected where budget, staffing, and site conditions allowed.

A seasonal approach has been implemented for intensive surveys to capture the natural variance in constituent levels that occurs during different flow periods (Figure 4). In regards to natural variance, the "Summer Low Flow" season (Jul-Oct) is the most stable flow period for both water volume and water quality. Consistent monthly sampling during this period allows the team to detect true water quality changes in the lake and watershed because the water chemistry is subject to fewer natural fluctuations. During other seasons, flows and water chemistry can be extremely variable, making it more difficult to determine true water quality trends or identify watershed disturbances. As a result, water chemistry sampling is less likely to detect smaller changes to a watershed, but we can bracket the range of “normal” conditions for those water bodies.

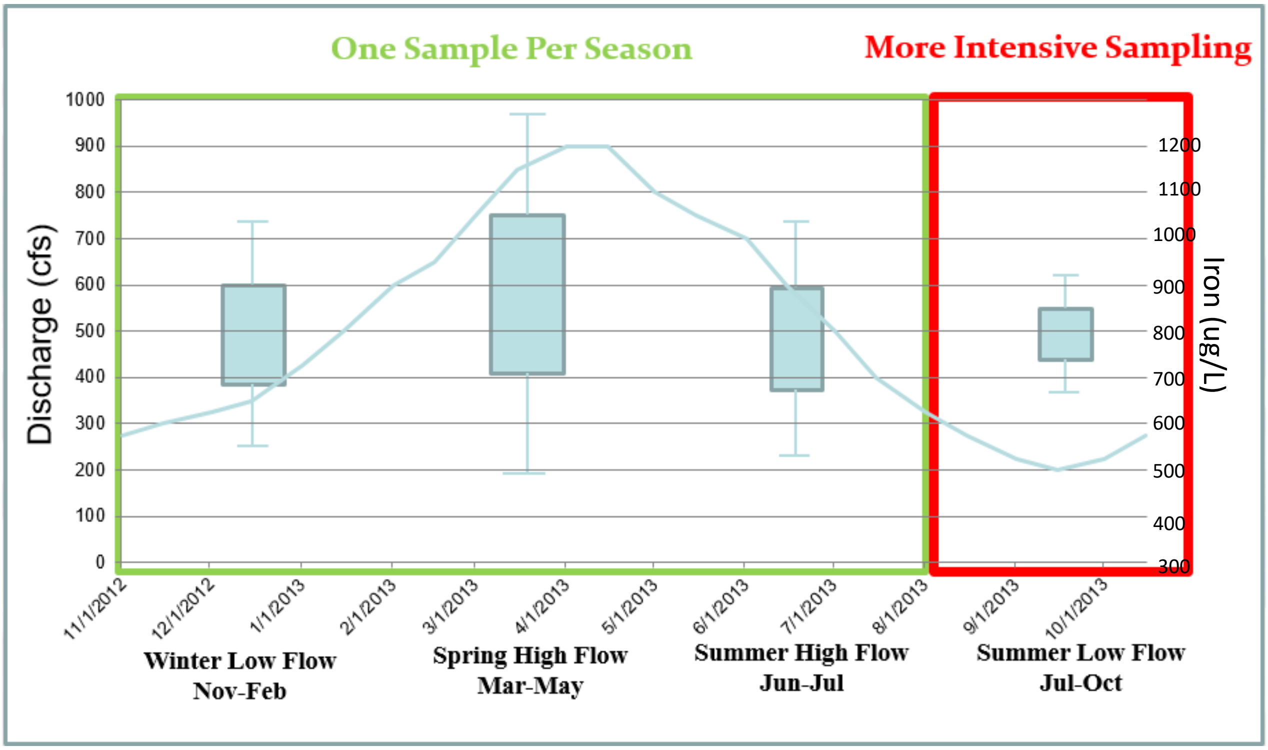


Figure 4. Demonstrates the flow and water quality variability that accompany different seasons of the year.

The Water Quality Team completed intensive water quality surveys at seven projects in the Twelvepole Creek and Muskingum River basins. Surveys were conducted six times each at Beech Fork, East Lynn, Atwood, Charles Mill, Leesville, North Branch Kokosing, and Pleasant Hill Lakes. The sections below summarize the most recent information that was collected in 2021. More detailed information for these and other projects can be found in Appendix C. Additional information will be added as the projects are sampled and the information becomes available.

Typical suite of analytes used in intensive monitoring program:

Hot Peroxide Acidity, Total Alkalinity, Aluminum, Ammonia as N, Antimony, Arsenic, Barium, Beryllium, Bicarbonate, Boron, Bromide, Cadmium, Calcium, Chloride, Chlorophyll, Chromium, Cobalt, Copper, Iron, Total Hardness, Total Kjeldahl Nitrogen, Lead, Magnesium, Manganese, Mercury, Nickel, Nitrite + Nitrate as N, Oxygen Saturation, Oxygen Concentration, Total Phosphorus, pH, Potassium, Total Dissolved Solids, Total Suspended Solids, Total Solids, Secchi depth, Selenium, Silver, Sodium, Specific Conductance, Strontium, Sulfate, Temperature, Thallium, Tin, Titanium, Turbidity, Vanadium, Zinc

Table 2. Water quality analytes tested for in 2021.

Project	Analytes
Beech Fork	Typical suite
East Lynn	Typical suite
Atwood	Typical suite, acidity, bromide

Project	Analytes
Leesville	Typical suite, acidity, bromide
Charles Mill	Typical suite
North Branch Kokosing	Typical suite
Pleasant Hill	Typical suite

Fish Surveys

Electrofishing surveys were conducted at 18 sites in 2021 as part of the intensive sampling schedule. Survey methods included backpack electrofishing and tote barge electrofishing. Upon completion of surveys, fish that could be positively identified in the field were then counted and batch weighed and released back to the stream. Fish that were small and/or difficult to identify were fixed in formalin and taken to the Water Quality Operations Center and subsequently transferred into ethanol and later identified.

The metrics used in the Kentucky and Ohio Index of Biotic Integrity (IBI) are Number of Native Species, Darter Species, Sunfish Species, Sucker Species, Intolerant Species, Percent Tolerant, Percent Omnivores, Percent Insectivores, Percent Top Carnivores, Percent Simple Lithophils, Percent DELT Anomalies, and Number of Fish.

During 2021 electrofishing surveys, 8518 individuals were identified and data were input into IBI calculators for Kentucky and Ohio. The Kentucky IBI was used for sites in West Virginia as it is the most compatible IBI currently available. The Ohio IBI was used for sites located in Ohio. NBN0004 and NBN0005 received the best IBI scores in Ohio scoring 46 in the good category while ATI0021 scored 33 which places it in the fair category and the worst of sites sampled in Ohio in 2021. The best site in West Virginia was ELT0036 with a score of 86 (excellent) and the lowest was 1ELT0032 scoring 39 (poor).

For 2021 sites where historic IBI data was available, scores are displayed in Figure 5. All sites have IBI scores that have consistently improved since first sampled in 2002, with the exception of Kiah Creek and Lick Creek. It is important to note that Kiah Creek has historically been a source of pollutants to the lake. It was also subject to two scour events in March and August prior to being surveyed which may have impacted biological scores. The IBI metrics largely driving the decline in the Kiah Creek score are native species richness, intolerant species, percent insectivores, water column species, simple lithophilic spawners, and darter/madtom/sculpin richness.

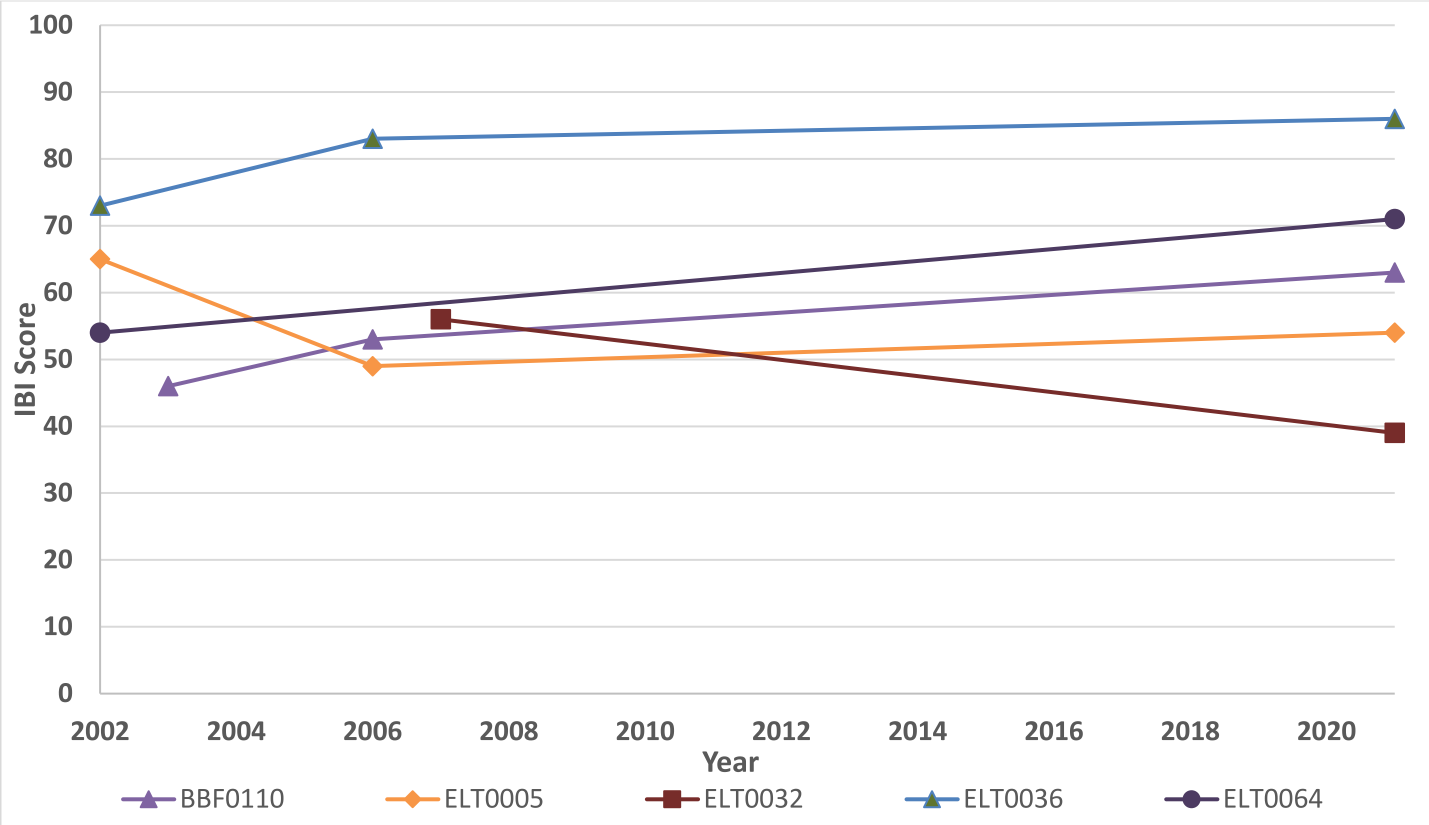


Figure 5. IBI Trends for 2021 sites where historic data is available.

Table 3. IBI classifications.

Rating	OH Score	KY Score
Excellent	> 50	> 70
Good	37-50	63-69
Fair	29-36	41-62
Poor	19-28	20-40
Very Poor	< 18	< 20

Table 4. Summary of electrofishing results in 2021.

Site	Stream	Number of Individuals	Species Richness	Dominant Species	IBI Score	IBI Rating	Method	Drainage Area mi^2
1ATI0021	Unnamed trib to Atwood Lake	793	13	bluntnose minnow	33	Fair	Backpack	3.43
1BBF0101	Beech Fork of Twelvepole Creek	754	27	bluegill	47	Fair	Backpack	80.0
1BBF0107	Beech Fork of Twelvepole Creek	565	20	bluntnose minnow	47	Fair	Backpack	38.9
1BBF0108	Long Branch of Beech Fork	496	16	creek chub	61	Fair/Good	Backpack	4.6
1BBF0110	Millers Fork of Beech Fork	412	22	bluntnose minnow	63	Good	Backpack	9.7
1CMB0011	Seymor Run of Black Fork	801	9	mottled sculpin	34	Fair	Backpack	6.5
1ELT0001	East Fork of Twelvepole Creek	605	30	bluegill	64	Good	Barge	138.0
1ELT0005	Lick Creek of East Fork Twelvepole Creek	371	14	bluntnose minnow	54	Fair	Backpack	8.5
1ELT0031	East Fork of Twelvepole Creek	423	30	bluegill	73	Excellent	Backpack	53.0
1ELT0032	Kiah Creek of East Fork Twelvepole Creek	252	12	creek chub	39	Poor	Backpack	27.8
1ELT0036	Big Laurel Creek of Kiah Creek	209	17	rainbow darter	86	Excellent	Backpack	3.6
1ELT0064	Troughs Fork of Kiah Creek	174	16	bluntnose minnow	71	Excellent	Backpack	4.6
1LEM0003	North Fork of McGuire Creek	133	14	bluegill	34	Fair	Backpack	12.8
1LEM0012	McGuire Creek of Conotton Creek	115	13	bluegill	34	Fair	Backpack	12.6
1NBN0001	North Branch of Kokosing River	676	24	yellow bullhead	34	Fair	Backpack	45.6
1NBN0004	North Branch of Kokosing River	745	26	bluntnose minnow	46	Good	Backpack	27.7
1NBN0005	Unnamed trib to N Br Kokosing Lake	633	28	creek chub	46	Good	Backpack	13.1
1PHC0006	Switzer Creek of Clear Fork	361	16	Mottled Sclupin	42	Good	Backpack	11.6
	Total	8518	59					

A total of 59 different species were collected at the sites sampled in 2021. Bluntnose minnows (Pimephales promelas) and bluegill (Lepomis macrochirus) were found at 17 out of 18 sites sampled. Conversely, there were 16 species found at only one site. Table 5 lists the species found as well as how many sites where they were present.

Table 5. Fish species collected and occurrence across all sites.

Species	Number of sites where present
bluegill	17
bluntnose minnow	17
central stoneroller	16
green sunfish	16
johnny darter	15
logperch	14
northern hogsucker	14
rainbow darter	14
white sucker	14
yellow bullhead	13
creek chub	12
largemouth bass	10
striped shiner	10
fantail darter	9
golden redhorse	9
silverjaw minnow	9
spotted bass	9
brook silverside	7
greenside darter	7
least brook lamprey	7
longear sunfish	7
sand shiner	7
banded darter	6
brindled madtom	6
rock bass	6
gizzard shad	5
rosyside dace	5
spotfin shiner	5
white crappie	5
blacknose dace	4
mottled sculpin	4
pumpkinseed sunfish	4
hybrid sunfish	3
orangespotted sunfish	3
redside dace	3
river chub	3
smallmouth bass	3
western blacknose dace	3
black crappie	2
black redhorse	2
common shiner	2
silver redhorse	2
spotted sucker	2
American brook lamprey	1
brown trout	1
channel catfish	1
common carp	1
dusky darter	1
eastern sand darter	1
emerald shiner	1
freshwater drum	1
golden shiner	1
mimic shiner	1
redear sunfish	1
river shiner	1
saugeye	1
southern redbelly dace	1
trout perch	1
yellow perch	1

Benthic Macroinvertebrate Surveys

Macroinvertebrate surveys were conducted at 2021 intensive sites and data from the 2020 sampling season were provided after finalizing the 2020 Annual Water Quality Report. Both sets of data are displayed below. Sampling and scoring followed the protocol for the state in which samples were taken. For Kentucky, the Macroinvertebrate Bioassessment Index (MBI) sets forth sampling protocols and 7 metrics for calculating scores. Each metric can receive a score 0-100 percent based on the statewide reference dataset and the MBI is calculated as the average of all equally weighted metric scores. Each site can therefore range between 0 and 100. For Ohio, the Invertebrate Community Index

(ICI) is used for scoring sites. The ICI uses 10 variables and each variable can receive a score of 6, 4, 2, or 0 depending on the undisturbed site comparison. Each site can therefore range between 0 and 60. For Virginia, the Virginia Stream Condition Index (VSCI) is used for scoring. The VSCI uses a 100 point scale based on 8 metrics. While there isn't an official established narrative rating based on the scores, the VSCI protocol indicates that a score below 60 is considered impaired, 60-80 is considered similar to reference, and a score of approximately 81 or higher is considered exceptional. West Virginia uses the West Virginia Stream Condition Index (WVSCI) which consists of 6 metrics and a 100 point scoring scale.

Table 6. Summary of benthic macroinvertebrate results in 2021.

Site	Stream	Score	Rating	State
DEW0001	Johns Creek	52.7	Fair	KY
DEW0005	Brushy Fork	46.8	Poor	KY
DEW0024	Stratton Branch	52.0	Fair	KY
DEW0050	Buffalo Creek	47.7	Poor	KY
FRL0001	Levisa Fork	39.2	Poor	KY
FRL0021	Lick Creek	52.8	Fair	KY
FRL0025	Grapevine Creek	70.3	Fair	KY
JWF0001	Pound River	50.0	Impaired	VA
JWF0025	Cranes Nest River	64.8	Similar to reference	VA
JWF0026	Pound River	68.2	Similar to reference	VA
NFP0001	North Fork Pound River	65.1	Similar to reference	VA
NFP0008	Bad Creek	63.4	Similar to reference	VA
NFP0009	North Fork Pound River	75.9	Similar to reference	VA
WEW0003	Wills Creek	12	Poor	OH

Table 7. Summary of benthic macroinvertebrate results in 2021.

Site	Stream	Score	Rating	State
ATI0014	Unnamed trib of Indian Fork	18	Low Fair	OH
ATI0021	Unnamed trib to Atwood Lake	18	Low Fair	OH
CMB0009	Black Fork of Mohican River	16	Low Fair	OH
LEM0001	McGuire Creek of Conotton Creek	12	Low Fair	OH
LEM0003	North Fork of McGuire Creek	24	Fair	OH
LEM0012	McGuire Creek of Conotton Creek	18	Low Fair	OH
NBN0001	North Branch of Kokosing River	20	Low Fair	OH
NBN0004	North Branch of Kokosing River	42	Very Good	OH
NBN0005	Unnamed trib to N Br Kokosing Lake	30	Marginally Good	OH

PHC0001	Clear Fork of Mohican River	42	Very Good	OH
PHC0005	Clear Fork of Mohican River	42	Very Good	OH
PHC0006	Switzer Creek of Clear Fork	42	Very Good	OH
BBF0101	Beech Fork of Twelvepole Creek	59.4	Slightly Impaired	WV
BBF0107	Beech Fork of Twelvepole Creek	69.4	Unimpaired-Good	WV
BBF0108	Long Branch of Beech Fork	63.0	Impaired-Gray Zone	WV
BBF0110	Millers Fork of Beech Fork	69.6	Unimpaired-Good	WV
ELT0001	East Fork of Twelvepole Creek	32.1	Moderately Impaired	WV
ELT0031	East Fork of Twelvepole Creek	80.5	Unimpaired-Very Good	WV
ELT0032	Kiah Creek of East Fork Twelvepole Creek	75.2	Unimpaired-Good	WV
ELT0064	Troughs Fork of Kiah Creek	75.6	Unimpaired-Good	WV

The EPA Rapid Bioassessment Protocol (RBP) visual-based habitat assessment was used in conjunction with and macroinvertebrate surveys. Scores listed are out of a possible 200. The qualitative scores for each of the IBIs are shown in table 8 below.

Table 8. Comparison of fish, macroinvertebrate, and habitat scores.

Site	Stream	IBI Score	IBI Category	Macroinvertebrate Score	Macroinvertebrate Category	RBP Score (out of 200)	RBP Categories Scoring Marginal or Worse
1ATI0021	Unnamed trib to Atwood Lake	33	Fair	18	Low-fair	88	available cover, embeddedness, velocity/depth regime, sediment deposition, riffle frequency, bank stability, vegetative protection
1BBF0101	Beech Fork	47	Fair	59.4	Slightly impaired	125	channel flow status, vegetative protection, riparian width
1BBF0107	Beech Fork	47	Fair	69.4	Unimpaired-good	103	available cover, embeddedness, sediment deposition, riffle frequency, channel flow status, bank stability, vegetative protection
1BBF0108	Long Branch	61	Fair/Good	63	Impaired-Gray zone	113	channel flow status, bank stability, vegetative protection, riparian width
1BBF0110	Millers Fork	63	Good	69.6	Unimpaired Good	149	None
1CMB0011	Seymor Run	34	Fair			156	vegetative protection
1ELT0001	East Fork	64	Good	32.1	Moderately Impaired	162	None
1ELT0005	Lick Creek	54	Fair			not scored	not scored
1ELT0031	East Fork	73	Excellent	80.5	Unimpaired-Very Good	152	riffle frequency
1ELT0032	Kiah Creek	39	Poor	75.2	Unimpaired-Good	159	riparian width
1ELT0036	Big Laurel Creek	86	Excellent			not scored	not scored
1ELT0064	Troughs Fork	71	Excellent	75.6	Unimpaired-Good	152	channel alteration, riparian width

Site	Stream	IBI Score	IBI Category	Macroinv-ertebrate Score	Macroinv-ertebrate Category	RBP Score (out of 200)	RBP Categories Scoring Marginal or Worse
1LEM0003	North Fork of McGuire Creek	34	Fair	24	Fair	97	available cover, embeddedness, velocity/depth regime, sediment deposition, riffle frequency, bank stability,
1LEM0012	McGuire Creek	34	Fair	18	Low-Fair	85	embeddedness, velocity/depth regime, sediment deposition, riffle frequency, bank stability, vegetative protection, riparian width
1NBN0001	N Br of Kokosing River	34	Fair	20	Low-Fair	61	riparian vegetative zone
1NBN0004	N Br of Kokosing River	46	Good	42	Very Good	156	riparian vegetative zone
1NBN0005	Unnamed trib to N Br Kokosing Lake	46	Good	30	Marginally Good	103	available cover, velocity/depth regime, riffle frequency, bank stability
PHC0006	Switzer Creek	42	Good	42	Very Good		

Muskingum Area Structural Modification Impact Study

Five lakes within the Muskingum River Watershed, Tappan, Atwood, Piedmont, Leesville, and Clendening have had historic hydrogen sulfide, temperature, and low oxygen issues in the tailwaters during summer stratification. This hydrogen sulfide results in degradation to the concrete structures on the dam, creates a dead zone for aquatic life downstream, degrades air quality, becomes a public safety issue, and decreases downstream recreation. In response to this major issue, in the spring of 2015, a structural modification was completed to the outlet structure at Tappan Lake (Figure 6). The purpose of this structure was to minimize the release of hydrogen sulfide gas that is produced from outflow water originating in the hypolimnion. This low cost, effective structural modification is a solution to a historical problem in the Muskingum River basin and has proven to have many benefits.

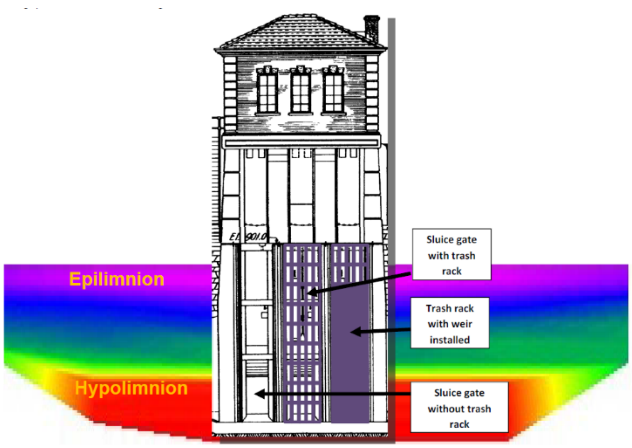


Figure 6. A structural drawing depicting the modifications made to Tappan Dam in 2015.

To examine the effects of the structural modification on the lakes, buoys with sondes were deployed near the intake tower at each lake, collecting time series profile data for dissolved oxygen levels, temperature, pH, and specific conductivity. Additional sensors were deployed by Operations staff to measure hydrogen sulfide emissions. This data was used to compare emissions between lakes and the pre and post modification conditions at each lake.

Structural modifications are tentatively planned at Atwood and Leesville lakes, but these projects require additional considerations due to design differences of their intake structures. Operations Division has initiated a study at Leesville Lake to determine if a trash rack weir can be deployed within the structural constraints at the lake. The Water Quality Team continued to collect buoy data at these lakes to provide baseline data for future structural modifications planned for those projects. The Water Quality Team also advised the project delivery team regarding all water quality concerns.

Harmful Algae Bloom (HAB) Response

Consistent with national trends, the Huntington District has observed increasing occurrences of HABs resulting in impacts to operations at our flood control projects. Toxins that are known to cause human and animal health problems can be released from the blooms, often leading to closures of public areas at Corps projects. HABs occur under many different environmental conditions and are nearly impossible to predict. The prevalence of HABs at both our projects and other water bodies has required our state partners to establish response strategies to protect the water users.

All states within LRH have developed HAB monitoring and/or response plans. Currently, states are taking the leading role in HAB monitoring, sampling, and response while LRH has adopted a supporting role. The LRH Water Quality Team has made itself available as necessary for any sampling, sign-posting, or monitoring efforts that cannot be accomplished by state or local authorities in the event of a HAB on a USACE lake. The Water Quality Team also attends yearly HAB Task Force Meetings with the States of West Virginia, Virginia, and Kentucky.

As states take the lead in HAB response they have requested that the Corps continue to monitor and report potential HABs. The Water Quality Team coordinated with Operations Division to host a HAB webinar to train flood control project staff and navigation project staff on HAB identification, response, and reporting. Project managers were advised to report any out of the ordinary water conditions to the Water Quality Team so that it can be evaluated and directed to the appropriate agency.

Harmful algal blooms occurred at Dillon, John W. Flannagan, Paint Creek, Tappan, Pleasant Hill, Senecaville, and Burnsville Lake in 2021. There were no significant impacts or closures as a result of these HABs. Response efforts were handled primarily by the respective state agencies in accordance with established response plans and protocols.

Support for Other USACE Elements

Dredge Mission at R.C. Byrd Locks and Dam in 2021

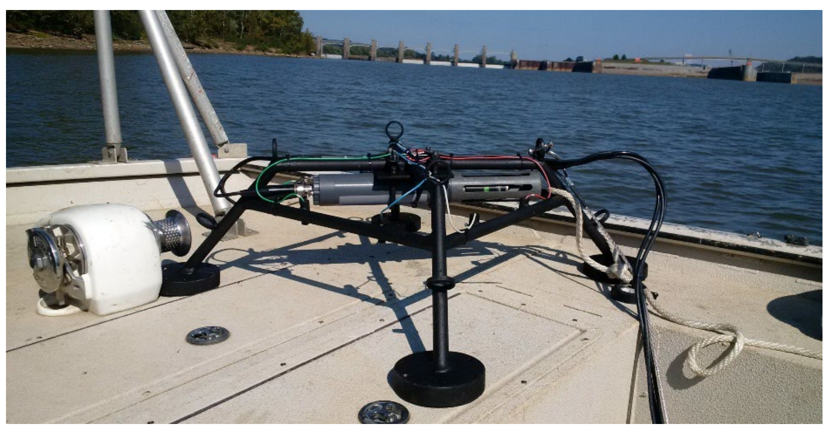


Figure 7. The WIZARD measures conditions in the actual substrate and the water column.

Due to significant sedimentation below the R.C. Byrd Lock and Dam (RCB), presence of endangered mussels, and the importance of the RCB navigation mission, dredging at RCB requires continued scrutiny to best meet objectives. The District has continually shown an ability to avoid and/or minimize impacts to these mussel beds during dredging operations through an evolution of monitoring capabilities. Additionally, the District has employed the use of steering currents (Figure 8) from the RCB dam to direct dredge disposal plumes away from endangered mussels. Dam operators create steering currents by opening and closing a combination of gates to control the direction and magnitude of flow through the dam. Turbidity, sedimentation, and dissolved oxygen levels are intensely monitored downstream of the dredge disposal area and adjacent to valuable mussel beds. The team uses a monitoring platform that provides real-time data transmissions to the District with the most current environmental conditions surrounding the mussel beds. No other USACE District has deployed such an innovative and advanced monitoring platform or operated for steering currents during dredging operations. These innovations have garnered praise from our partners in the state and federal resource agencies.

Figure 8. Velocity vectors demonstrating the effectiveness of steering currents employed below R.C. Byrd Dam.

Significantly less maintenance dredging occurred at R.C. Byrd in 2021. A total of 4 days of dredging were completed with 3 days in June and 1 day in November. During the June operations, flows were high (>90kcfs) and the tailwater stage rose from 12' to 22'. On the day dredge activities were completed in November, flows were normal and averaged greater than 25kcfs. The Waterways Section contracted a mechanical dredge for work in 2021. This type of dredge operation is great for minimizing impacts associated with dredge material disposal. The combination of mechanical dredge and steering current flows (Figure 8) allowed the dredging operations to continue without impact to the mussel beds. Figure 10 shows the flow, stages and dates of R.C. Byrd dredging.

Figure 7 shows the WIZARD monitoring platform that monitors our mussel beds for impacts from dredge disposal. The WIZARD is a real-time platform measuring sedimentation, dissolved oxygen, and turbidity. The WIZARD was deployed in June prior to dredge operations and remained in the water for further analysis. Data showed that there was likely no accumulation of sediments over the mussel beds as a result of dredge operations. However, the data was corrupted by temperature interference from the electrical components of the WIZARD (Figure 9). This produced false diurnal swings in the data. Due to the normally higher flows and the short duration of the dredging activity, no WIZARDs were deployed during the November operations. As a result of this monitoring, good flow and stage levels, and steering currents, no changes were required during dredging operations at R.C. Byrd in 2021.

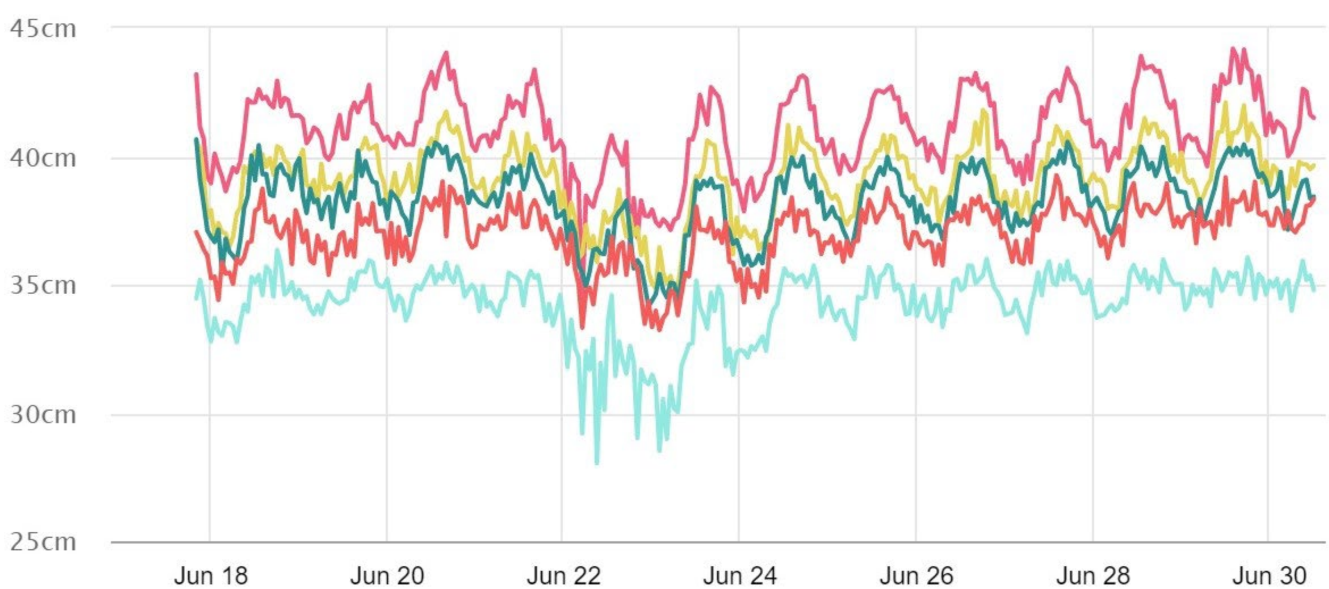


Figure 9. WIZARD transducer results for June deployment showing daily temperature interference.

Figure 10. Flows, stages and dredge dates (yellow boxes) for R.C. Byrd dredging in 2021.

Dredge Mission Sediment Analysis

To maintain proper 401 Water Quality certification, the Huntington District is required to sample sediment and raw water from dredging and receiving locations at least once every three years. The LRH Water Quality Team conducts these sampling efforts on behalf of the Waterways Section on a three-year rotating schedule. Locations comprised of more than 20% silt and clay require in-depth elutriate analyses, whereas locations comprised of less than 20% fine sediment require only particle size analyses to confirm less than 20% fines. Elutriate analyses include metals, nutrients, solids, pesticides, polychlorinated biphenyls (PCBs), chlorinated herbicides, semi-volatile organic compounds, volatile organic compounds, oil & grease, sieve analysis, and some individual specific analytes. Additional elutriate sampling will be performed when locations historically less than 20% fine sediment suddenly yield results greater than 20% fine sediment. Table 8 provides a summary of the locations where sampling was conducted in 2021 and lists any constituents that exceeded state criteria or an EPA recommendation. For more detailed information, see the Maintenance Dredging Program Mitigation Reports for 2021 (Appendix B).

Bed material at the dredging and disposal locations below Winfield Locks on the Kanawha River is historically less than 20% fine sediment. In the 2021 sampling event, however, particle size analyses yielded results that were greater than 20% fine sediment. Per the stipulations of the 401 certification, elutriate analyses will be scheduled for FY2022. This has occurred over multiple years, therefore the option to add Winfield Lower Approach to the elutriate schedule is being discussed. Sufficient bed material could not be collected from the disposal site below London Locks and the dredge site at Hurricane Creek Bar. There were no particle size analyses done for these sites in 2021.

Some analysis results from elutriate samples below R.C. Byrd Locks were inconclusive. The samples analyzed using EPA method 200.7 were much lower than would be expected given historical data. The reason is unknown, but likely that the wrong specimen was tested or samples were mixed up in the field. Field measurements and lab results were congruent with historical data, therefore it is assumed that conditions at the dredging location have changed little. The R.C. Byrd locations will need to be re-sampled in 2022 to be compliant with 401 certifications.

Willow Island, Racine, and RC Byrd Lower Approaches were sampled for elutriate analyses in 2021, as well as the Shawnee Public Access ramp near Portsmouth OH. Racine Lower Approach had one detection for chloroform, while all other organics analyses at each project were below reporting limits.

Table 9. Summary of locations sampled for the Maintenance Dredging Program in 2021 and constituents that exceeded state criteria or EPA recommendation.

River	Dredge Location	Analysis Type	Constituents that Exceeded One or More State Criteria or EPA Recommendations
Ohio	Racine Locks Lower Approach	Elutriate	aluminum, chromium, copper, iron, manganese
Ohio	R.C. Byrd Locks Lower Approach	Elutriate	n/a
Ohio	Shawnee Public Access Ramp	Elutriate	aluminum, chromium, iron, manganese
Ohio	Willow Island Locks Lower Approach	Elutriate	aluminum, arsenic, chromium, copper, iron, manganese
Kanawha	Hurricane Creek Bar	Particle size only	n/a
Kanawha	London Locks Lower Approach	Particle size only	n/a
Kanawha	Marmet Locks Lower Approach	Particle size only	n/a
Kanawha	Winfield Locks Lower Approach	Particle size only	n/a

Mussel Surveys for Navigation Channel Maintenance Program

To maintain compliance with the Endangered Species Act, the Water Quality Team develops and reviews mussel surveys for USACE dredging projects. These surveys are conducted on a five-year rotation at most projects and include semi-quantitative sampling. Additional quantitative surveys are conducted at R.C. Byrd every five years and as needed at C.A. Meldahl.

Mussel surveys were developed for the Navigation Channel Maintenance Program to assist in the minimization and avoidance of impacts to mussel resources adjacent to dredging operations. In 2021, quantitative and semi-quantitative survey plans and cost estimates were developed for mussel beds downstream of RC Byrd and Greenup Locks and Dam, respectively. These surveys were developed for comparison of previous quantitative and semi-quantitative surveys and to aid the District in the avoidance and minimization of impacts to mussel resources during maintenance dredging activities at these locations. Task orders were awarded to Lewis Environmental Consulting on the regional IDIQ contract. The results of the of the survey below RC Byrd show that there has been a statistically significant increase in the numbers of mussels collected since previous surveys in 2011 and 2016. In addition, species richness was higher in 2021 than in the previous two surveys. The survey at Greenup was postponed for one year due to unacceptable river conditions during the scheduled survey effort.

Basin Level Nutrient Assessment for LRD

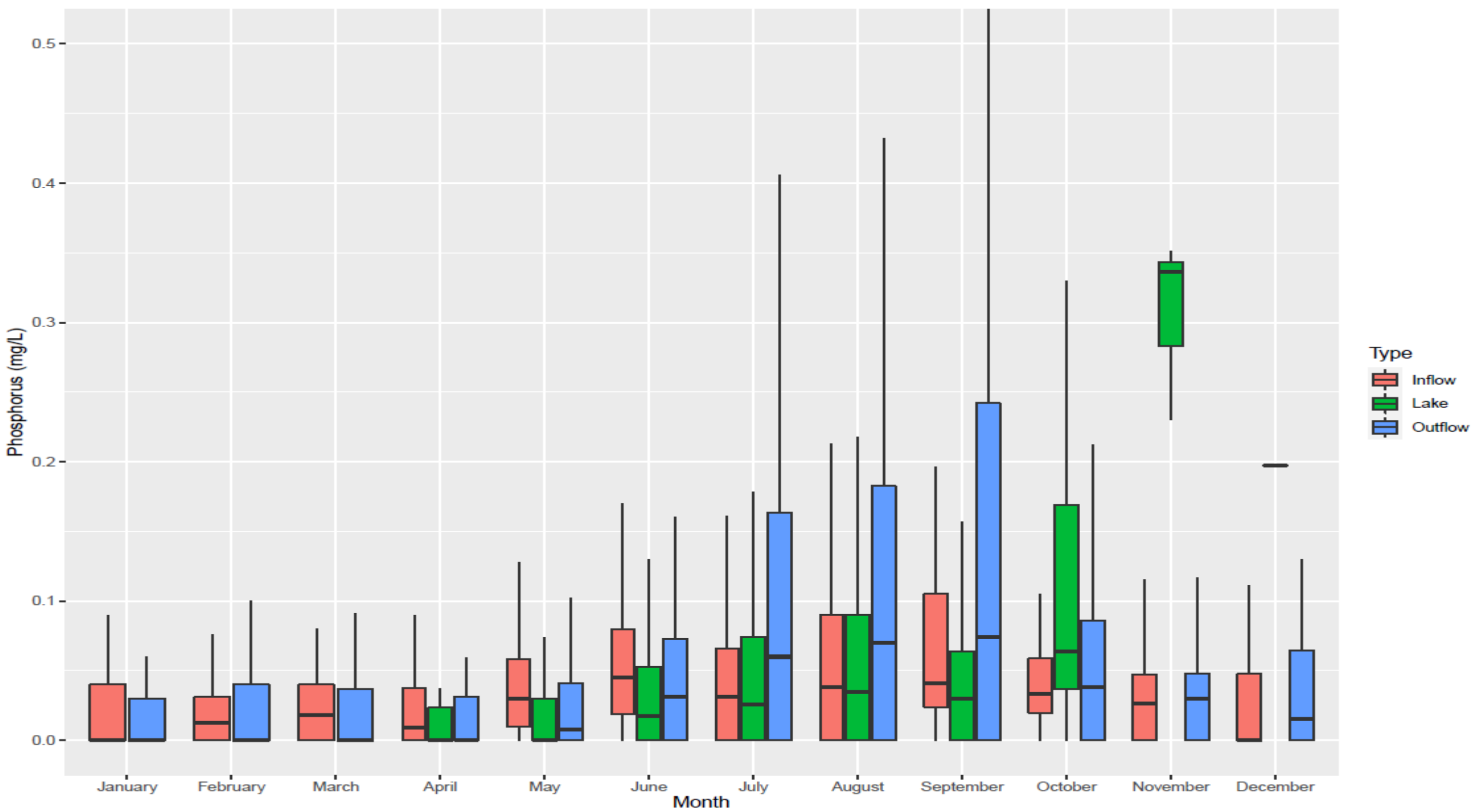
Approximately 60% of basal flow on the Ohio River during summer low flow periods is contributed by discharges from USACE Lake projects. Subsequently, USACE lakes may also be significant drivers of the water quality of the Ohio River and its tributaries during these low flow periods. Due to the rise in awareness of HABs and the implication of nutrients being the driving factors in HAB production, there has been increased focus on USACE lakes potentially contributing to

HABs on the Ohio River. LRD requested the LRH Water Quality Team to assess whether LRH lakes act as nutrient sinks or nutrient sources during the summer low flow months. This assessment focused on TKN, Nitrate + Nitrite, and Total Phosphorus as these are commonly understood and measured parameters in nutrient monitoring programs.

The data for this study was compiled from the 31 multipurpose reservoirs found within the District from samples collected between 1990 and the present. This data, approximately 35k results, represents major inflows, lake outflows, and in-lake samples taken during this 30-year period. Around half (~14K) of these results were "non-detects", meaning the samples had an analyte concentration below the limits of the laboratory analysis method and could not be definitively measured. For this assessment, all results that were "non-detects" were changed to zero to allow for statistical analyses. For visualization and comparison, the data was aggregated and analyzed by major watershed.

The results of this assessment suggest that LRH lakes act as sources of nutrients to downstream waterbodies during summer months in most basins with few exceptions. Nutrient concentrations in lake inflow streams were frequently lower than nutrient concentrations in the lake outflows during the summer months. This suggests that the lakes discharge higher concentrations of nutrients than would be the case were the lakes not present. Total Kjeldahl nitrogen accounted for most of the increased nitrogen output from the lakes. The natural breakdown of organic material in lakes is the largest contributor to total Kjeldahl nitrogen. Inadequate amounts of data were available for the Hocking River and Little Sandy River basins to allow for adequate graphical representation of the assessed parameters.

One interesting result came from comparing phosphorus concentrations from the Muskingum River and Scioto River basins (Figure 11), both of which are located in Central Ohio in heavy agricultural areas. The phosphorus data for the Muskingum River basin shows that the 13 lakes in that basin act as sources, as is consistent with most of the District. However, the four lakes found in the Scioto River basin act as sinks for phosphorus during the summer despite receiving higher inputs of phosphorus throughout the year. The operation of selective withdrawal systems at 3 of the 4 Scioto lakes (Alum Creek, Deer Creek, Paint Creek) allows for retention of poorer quality water typically found at lower depths and release of better quality water from higher elevations. Conversely, the lakes in the Muskingum River basin are much older and do not have selective withdrawal capabilities, resulting solely in sluice discharges. During summertime lake stratification, water at lower depths tends to harbor higher concentrations of nutrients, which are then passed downstream through the sluice gates. We believe the presence or absence of selective withdrawal systems may be contributing to the lakes acting as nutrient sinks versus sources.



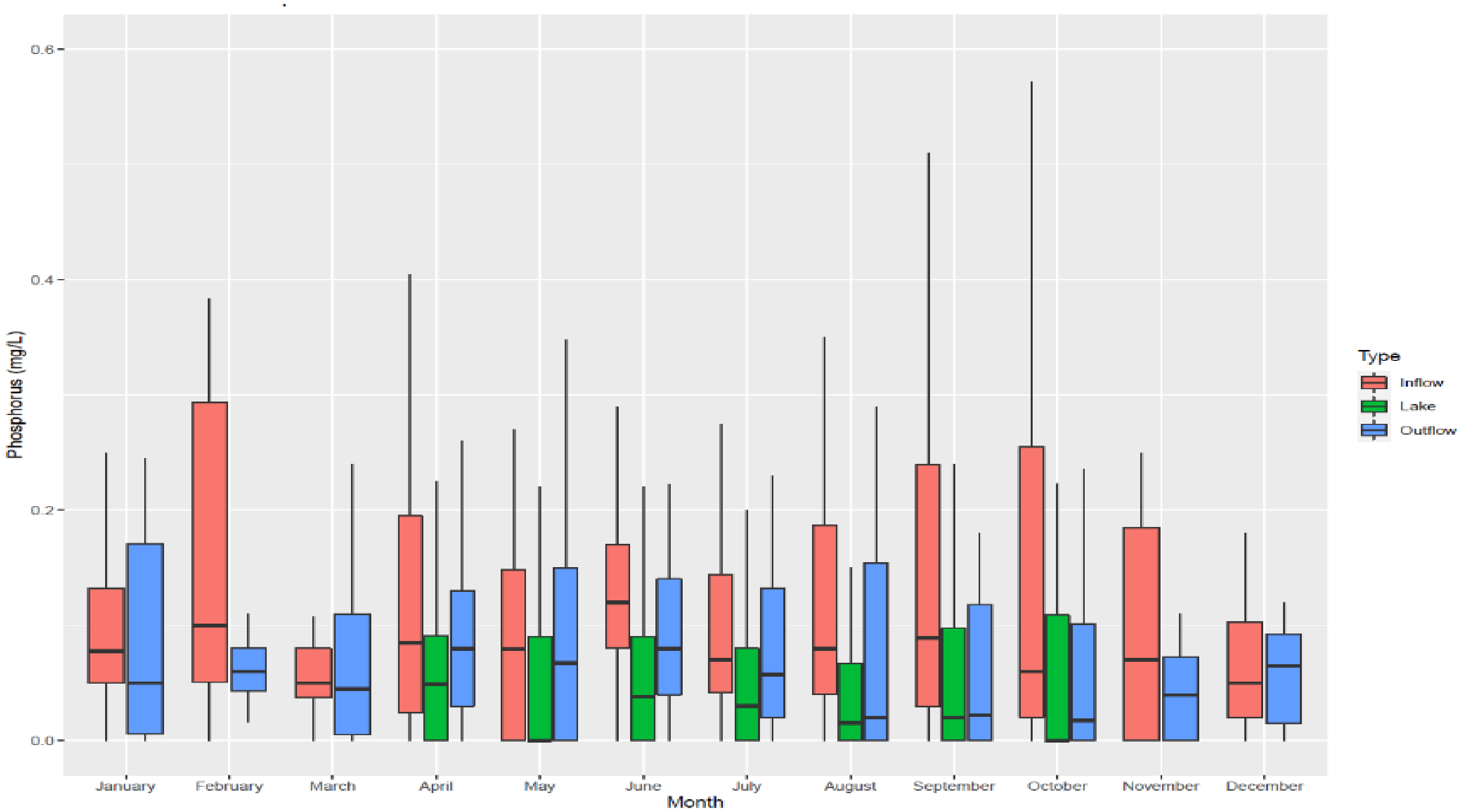


Figure 11. Phosphorus concentrations in Muskingum River Basin lakes (top) and Scioto River Basin lakes (bottom) from 1990 to present. Muskingum lakes act as "sources" for phosphorus during the summer months, while Scioto lakes act as "sinks".

Annual Dredge Partnering Meeting

Due to staffing changes within Operations Division, the Water Quality Team led the Annual Partnering Meeting for the District's Dredging mission. The 2021 meeting was held in virtually. This meeting provides the District the opportunity to discuss the previous year's dredging, the proposed dredging, the results of any mussel surveys, the 401 Water Quality Certifications, and the mussel concerns surrounding our dredge and disposal areas. Representatives from the WV DNR, US FWS, WV DEP, OH EPA, OH DNR, KY FWR, KY DOW, and other USACE Districts are invited to participate. Due to our environmental compliance work for the Waterways Section, the Water Quality Team was able to fill the role of District experts for the LRH dredging program.

Water Control Operations

At projects with multi-level intake structures, gates within the structures are opened or closed to satisfy a downstream water quality target (e.g. temperature and/or dissolved oxygen concentration). The degree of success is dependent upon the design of these selective withdrawal structures and the quality of data used to determine water temperatures within lake strata.

To manage dam releases, water quality lake profile data are needed. These data are collected by lake project personnel according to schedules developed by Water Quality staff. Prior to "profiling season" all equipment used to collect water quality lake profile data is quality checked, maintained, and calibrated to ISO 9001:2008 standards by the Water Quality Team. After each lake profile was completed, the data were transmitted to the District, reviewed, and posted for use in daily operations. Calibrated profiling equipment is distributed to selective withdrawal projects.

The Huntington District lake operation strategy is as follows:

> *1) Store as much cold water in the lakes as possible.*
>
> *2) Regulate downstream temperatures based on trends of current conditions in conjunction with guide curves to better match current weather patterns.*
>
> *3) Incorporate ecological sustainability into the overall strategy when possible.*
>
> 4) *Use deep intakes to make releases after lakes have mixed in the fall and until they re-stratify the following spring.*
>
> *5) Evaluate e-flow releases as a way to improve downstream habitat.*

The Water Quality team supported these goals by providing accurate water quality profiles of the lakes as well as supportive data from the outflow and the projects' significant inflows.

In addition, the Water Management Section is continuing to merge the concept of sustainable water resource management into its operation of flood control projects as it aligns with the USACE's Environmental Operating Principles. Based on these principles, the section continues its efforts to measure effects of its projects on the environment and to explore alternate ways of managing releases in order to improve environmental conditions and achieve project purposes. With more multi-level intake structures than any other USACE District, Huntington has a leading role in achieving sustainable solutions when operating flood control projects.

As stated above, project staff collect lake profile data. The data are used by the Water Quality Team and Water Management Section to make daily operations determining the quality of the release water. The data are also posted to the District Water Management website (www.lrh-wc.usace.army.mil/wm/) in summary plots (Figure 12). The most current temperature and dissolved oxygen profiles along with pool information, water condition, gate operation, and historical average conditions are displayed on the website plots.

Beginning in early September, the Water Resources Engineering Section evaluates hydro-meteorological conditions, water quality conditions, and recreational factors to determine when winter drawdown should start. The winter drawdown schedule takes not only water quality into consideration, but also other competing projects purposes such as white water, recreation, and fish and wildlife conservation.

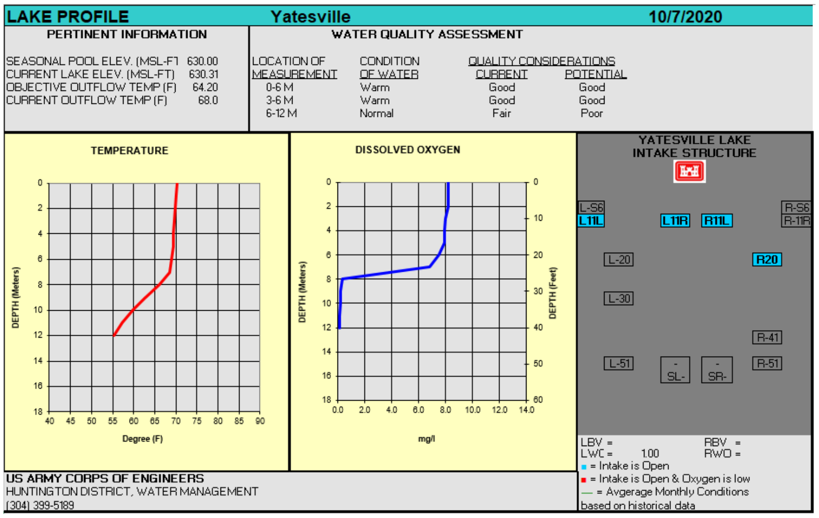


Figure 12. An example of the informational plots featured on the District Water Management public website. The plots are an output of the LRH lake profiling program.

In coordination with the lake profiles, real-time flow measurements below a project are also sometimes necessary to "calibrate" gate settings to meet low flow guidelines established by the Water Control Manual. The Water Quality Team is often employed for this task, using either an Acoustic Doppler Current Profiler (ADCP) or a traditional hand-held flow meter.

Kanawha River Augmentation

A YSI multiparameter sonde is deployed annually upstream of the Winfield Locks and Dam for the determination of augmentation needs on the Kanawha River. This probe is maintained throughout the critical summer water quality period. Depending on temperature and dissolved oxygen levels at Winfield, additional flows can be released from Sutton and Summersville lakes to meet water quality targets developed in coordination with the West Virginia Department of Environmental Protection. Weather and flow conditions during 2021 resulted in conditions that required augmentation to maintain adequate oxygen levels and temperatures. As a result, both Sutton and Summersville Lakes increased flows from 2 August through 11 August in order to meet downstream flow and water quality targets.

ISO Certification

Water Quality staff continue to meet ISO Certification procedures. The ISO process covers documentation and calibration procedures for maintenance of multiparameter data sondes. Being ISO certified improves accuracy and ensures quality of data collected by the Water Quality Team. In 2021, the Water Quality calibration and Program Management Plan processes were internally audited within Engineering & Construction in preparation for a Division-wide audit. The results from the audit yielded some areas for Water Quality to improve upon, these areas were updated and filed in Qualtrax.

National Committee on Water Quality

Andrew Johnson is a member of the USACE National Committee on Water Quality which is comprised of representatives from many districts and results in technical support related to water quality operations throughout the Corps.

Situational/Reactionary Support

The list below describes instances where the Water Quality Team provided situational/reactionary support or guidance to other organizations in 2021.

Bluestone Habitat Mapping

In July 2021, the Water Quality Team used an rQPOD outfitted with a Sontek M9 Acoustic Doppler to collect bathymetry measurements at Bluestone Lake. This data was requested by the Bluestone Phase 5 Dam Safety PDT to determine a suitable area of the lake for implementing fish habitat. The bathymetry measurements were used to create a TIN model in HYPACK and develop a bathymetric mesh of the survey area (Figure 13). The Water Quality Team's analysis revealed that the area of interest was a suitable depth for adding large boulder habitat that could provide mitigation for fisheries impacts caused by the dam safety project.

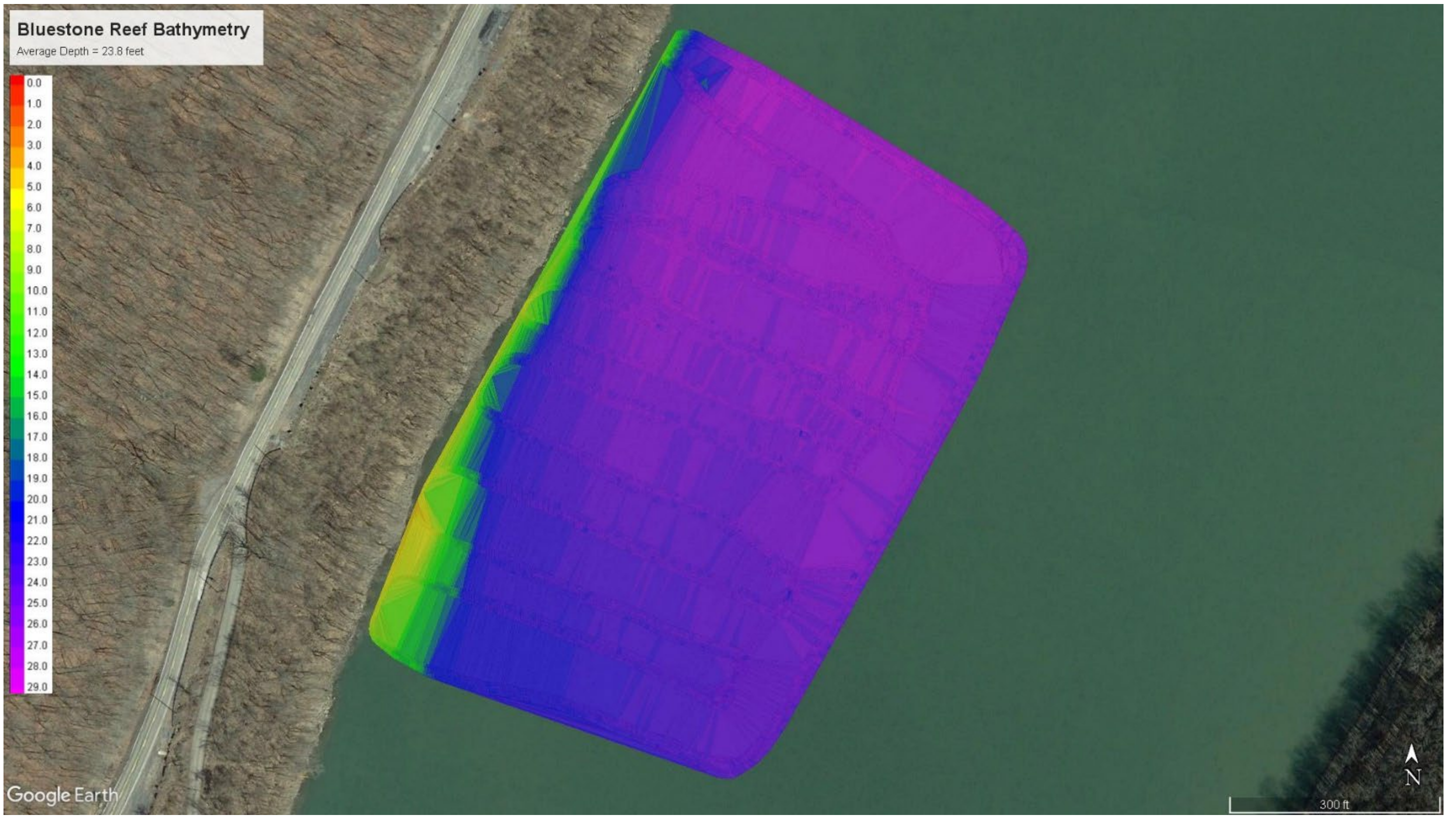


Figure 13. Bathymetry survey results for the Phase 5 Safety Mitigation Project at Bluestone Lake. Depths are in feet.

Clendening Double Turnover

Figure 14. White precipitate during a second turnover event at Clendening Lake in 2021.

Water Management was notified of a potential HAB event at Clendening Lake on 15 November 2021. The water near the dam suddenly took on a cloudy green appearance which can be an indicator of a HAB. As seen in the photo (Figure 14), the Water Quality Team had a buoy transmitting lake conditions during the time of this event. After assessing the buoy data, the Water Quality Team determined that this change in surface water condition was the result of a second turnover event occurring late in the season. Initially, the lake had a turnover event on 15 October. After a period of warm, sunny and calm weather in November, the lake restratified. On the days preceding this second turnover event, the area was dominated by cold (10-15˚F) and windy (20mph) weather which resulted in a quick remixing of the lake. This sudden remixing event caused an emergence of white precipitates (likely sulfur) on the surface of the lake creating the cloudy green appearance. During this time, dissolved oxygen at the surface went from 11mg/L to 2mg/L (Figure 15). Overall, impacts were likely minimal to the lake and aquatic habitats.

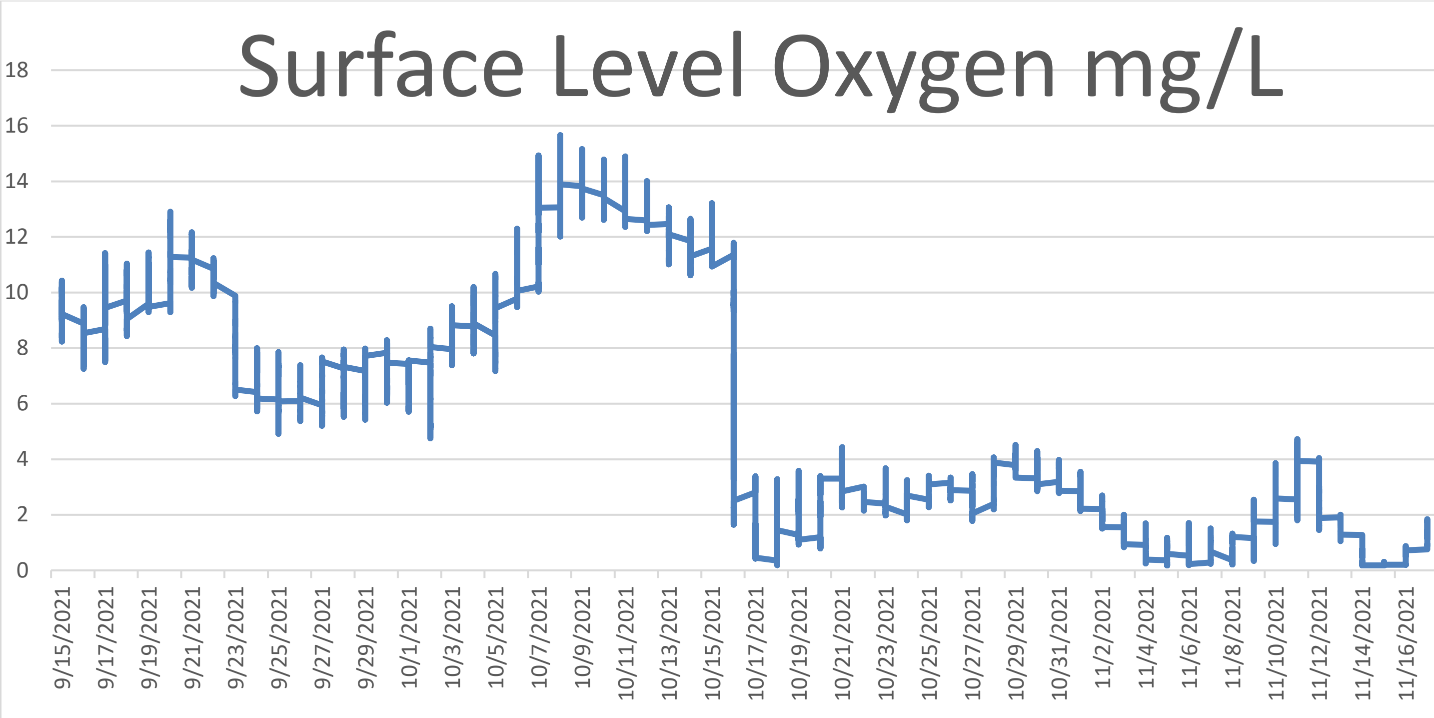


Figure 15. Surface level dissolved oxygen (mg/L) at Clendening Lake during a second turnover in 2021.

No fish kills were reported during this time. Ohio DNR was also conducting a fisheries assessment on the lake at this time and they did not report any concerns. Water Management advised that no changes to operations or the drawdown schedule were required as a result of this event. This information was coordinated with our partners at MWCD.

London Pool SRP

The Sustainable Rivers Program (SRP) funded a study within the London Pool of the Kanawha River to determine if there are opportunities to provide ecological uplift. Specifically, the Huntington District (LRH) team investigated the potential for ecological uplift upstream of London Locks and Dam on Kanawha River by reducing the elevation of this navigation pool by up to 2 feet during the normal growing season. This seasonal reduction in pool could expose mudflats and shallow bank habitat allowing the growth of beneficial, emergent aquatic vegetation. Due to the local topography, the London Pool provided only one sizeable area with the potential for significant ecological uplift. The area assessed is in the Upper Approach of the London Locks & Dam and currently contains small pockets of emergent vegetation which would imply there is currently a seed bank present within the area (Figure 16).

The LRH Water Quality Team conducted bathymetry surveys of this site to determine exactly how much area would be exposed if the navigation pool was reduced. A SonTek M9 Acoustic Doppler Current Profiler (ADCP) unit attached to the hull of the boat was used to survey the area. These soundings were analyzed within Hypack software and a TIN model was generated (Figure 17). This model developed total area (in acres) for each level the pool would be dropped. The analysis revealed that approximately 8 acres of river bottom would be exposed if the pool was dropped 2’ and only 3 acres would be exposed if the pool was dropped only 1’ (Table 10).

Figure 16. Small areas of emergent vegetation can be seen within in the Upper Approach of the London Locks & Dam. These pockets of vegetation suggest that a seed bed is established within the area that would be exposed if the navigation pool were dropped 2’.

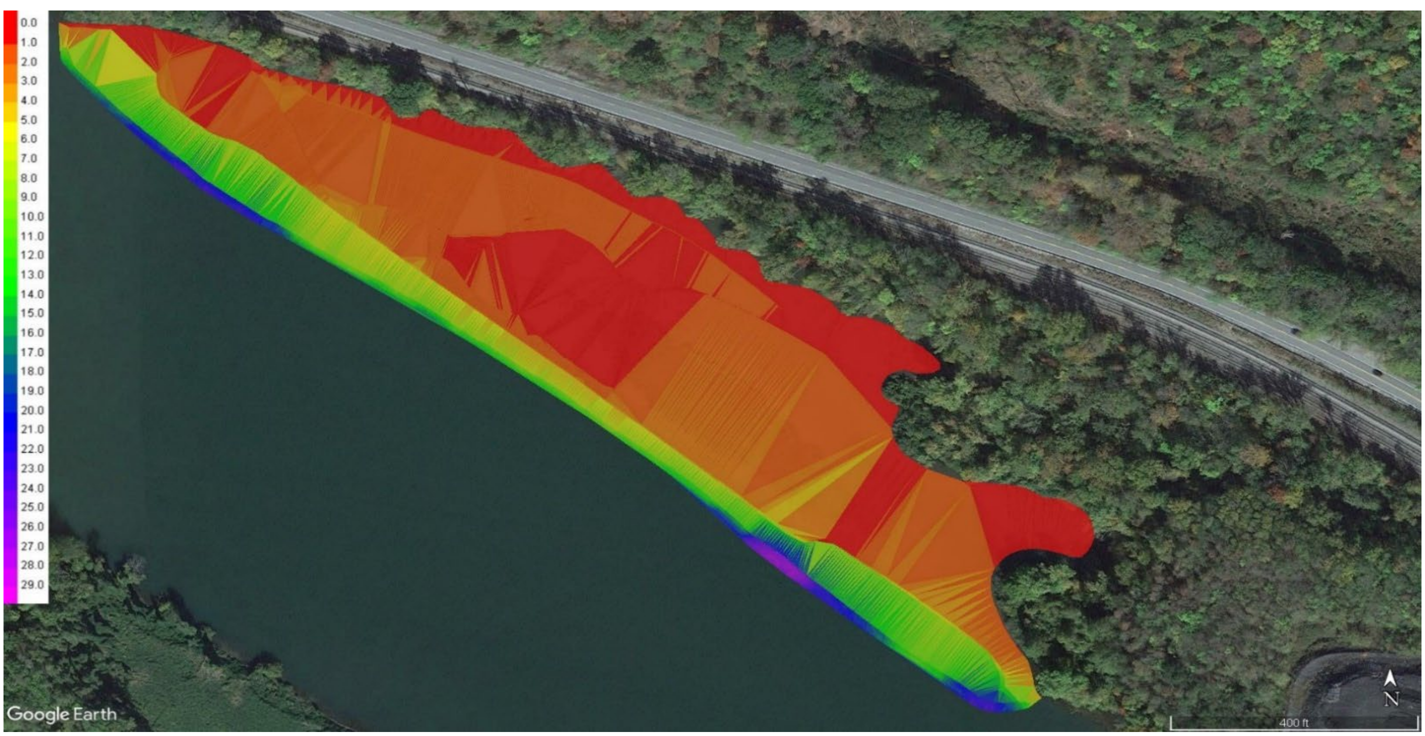


Figure 17. TIN model generated for the area of study in the London Pool. Depths are in feet.

Table 10. The TIN model generated total amount of area exposed as the Navigation Pool is dropped in elevation. A 2' drop in elevation would result in roughly 8 acres of exposed mudflats in the Upper Approach of the London Locks & Dam.

Elevation	Area exposed (Acres)
Normal Navigation Pool (614’)	0
1' below Pool (613’)	2.93
2' below Pool (612’)	7.85

The LRH team concentrated the assessment on this location just above London Locks and Dam because it provided the largest contiguous area that could benefit from a lowering of the navigation pool. In addition, it is likely that all fringe habitat along the banks of the river and the islands within the pool would see some change from this operation. However, the LRH team did not attempt to quantify this additional exposure of bank and fringe habitat within the pool because of the significant data collection that such an analysis would require.

Milton Sewage Lagoons

The Water Quality Team took sludge depth measurements and water quality samples from two historic sewage treatment ponds in Milton, WV on 10 March 2021. These ponds are scheduled to be drained and backfilled as part of the Lower Mud Flood Damage Reduction Project. According to West Virginia Department of Environmental Protection procedures, the quantity of sludge must be determined prior to the draining and filling of these ponds. Ponds with greater than 6 inches of sludge must have a plan to remove the sludge prior to the pond being backfilled.

A “sludge judge” was used to measure sludge depth at 14 predetermined sites for each pond. The sludge judge was deployed via canoe. Consistent with the data collected in 2003, sludge depth was greater in Lagoon #1 than Lagoon #2 (see below).

Sludge depth in Lagoon #1 was consistently deeper than 6 inches and averaged 15.7 inches for the entire pond (Figure 18). The sludge in pond #1 consisted of deep, fine sediments with organic material dispersed throughout. The smell and color (black) of the sticky sludge was consistent with the anaerobic sediments that would be expected at the bottom of a pond.

The sludge depth in Lagoon #2 never exceeded 6 inches of depth and averaged 3.1 inches for the entire pond. The team encountered the hard bottom of Lagoon #2 at many sampling sites.

Andrew Johnson spoke with Robert Gates of the WV DEP regarding the results and sludge disposal procedures. Robert confirmed that a plan will need to be developed and approved for disposal of the sludge from Lagoon #1.

Figure 18. Lagoon #1 is on the left with an average sludge depth of 15.7 inches. Lagoon #2 is on the right with an average sludge depth of 3.1 inches.

The following results show the pertinent water chemistry and bacteria levels of the lagoons.

<u>**Water Chemistry Results**</u>

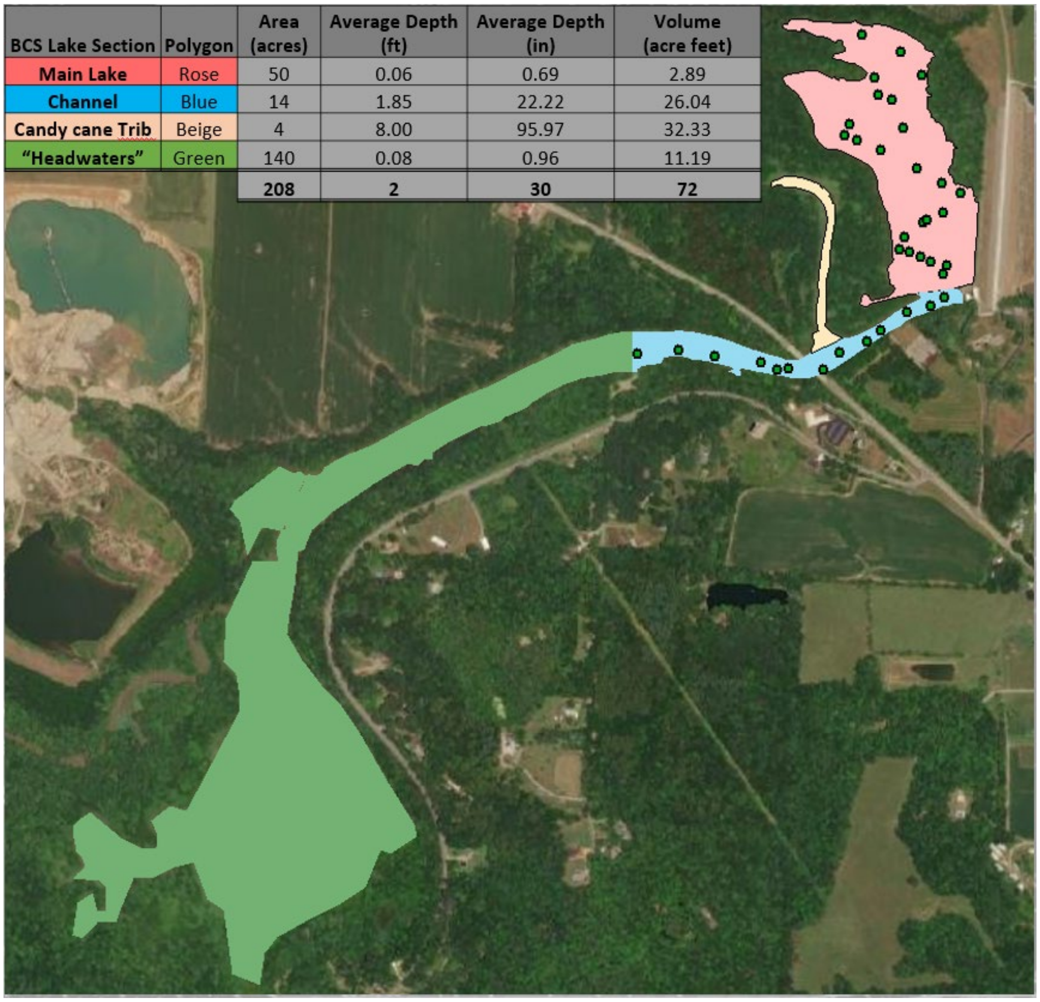
Lagoon #1:
Fecal: no detection
TSS: 22.8 mg/l
BOD: no detection
Ammonia: 0.14 mg/l

Lagoon #2:
Fecal: 3 colonies/100ml
TSS: 12.8 mg/l
BOD: 4.2 mg/l
Ammonia: 0.29 mg/l

Beach City SRP

The Sustainable Rivers Program (SRP) funded a study for the Huntington District to assess whether changes to operations at Beach City Dam could provide potential ecological uplift to areas upstream. Beach City Lake is located in northeastern Ohio and is a relatively small and shallow flood control lake. Due to the land use and land cover in the area, sedimentation has reduced the depth of the lake and in turn has limited the types of open water recreation available at this lake. However, this reduction in Conservation Pool has not reduced the flood storage capacity of the lake. Beach City also has a history of producing potentially Harmful Algal Blooms (HABs) which can be attributed to the shallow nature of the main part of the lake.

The LRH Water Quality Team completed bathymetric surveys of the lake to assist in calculating the current storage volumes. The Water Quality Team attempted to use a shallow-draft Jon boat with a SonTek M9 Acoustic Doppler Current Profiler (ADCP) unit attached to the hull of the boat; however, the lake has sedimented in so much that a boat could not be launched. As a result, a remote-controlled vessel called an rQPOD was used in conjunction with the ADCP to sample the deeper parts of the lake. Because most of the lake was too shallow, sampling consisted of kayaking into an area and taking depths manually with a measuring rod. These values from the ADCP and manual readings were all inputted into Hypack software for analysis and the results revealed that the lake has an average depth of 30 inches and 72 acre-feet of storage (Figure 19).



BCS Lake Section	Polygon	Area (acres)	Average Depth (ft)	Average Depth (in)	Volume (acre feet)
Main Lake	Rose	50	0.06	0.69	2.89
Channel	Blue	14	1.85	22.22	26.04
Candy cane Trib	Beige	4	8.00	95.97	32.33
"Headwaters"	Green	140	0.08	0.96	11.19
		208	**2**	**30**	**72**

Figure 19. Bathymetry measurements taken at Beach City Lake in the summer of 2021 show that the lake has an average depth of 30 inches and 72 acre-feet of storage. The "Main Lake" section of the lake has an average depth of 0.7 inches.

Paint Creek Loss of Selective Withdrawal

It was determined early in the spring of 2021 that the selective withdrawal system of Paint Creek Lake was inoperable. This required the dam to operate the outflow using only the sluices located at the bottom of the lake until the system was fixed. Water at this sluice elevation is normally characterized as cool and anoxic during the summer stratification season. Discharge of this lower elevation water would result in a loss of the colder water in the lake which acts as a protection against more harmful biological processes that can occur when lakes warm up too much. As a result, the District was concerned that this change to operations could result in significant impacts to the lake water quality and the fishery above and below the dam. After consulting with the Water Quality Team, the District coordinated these concerns with ODNR immediately.

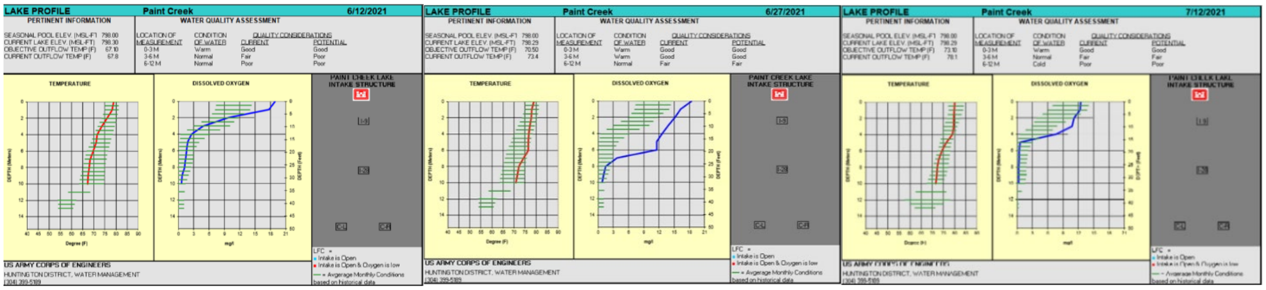


Figure 20. Paint Creek Lake selective withdrawal loss impacts to temperature and dissolved oxygen.

The Water Quality Team worked with Planning, Operations, ODNR, and other Water Management staff to monitor, coordinate, and mitigate the impacts of this action. The Water Quality Team sent weekly updates on the status of the lake's stratification and water quality. The team also discussed the potential impacts to the lake if the project maintenance did not occur on schedule. For this reason, the team was critical in the keeping the maintenance action on schedule.

The loss of selective withdrawal resulted in the flushing of cold water from the lake. This increased the overall temperature of the lake, reduced oxygen levels, created cold water discharges in the early summer, created warm discharges throughout the rest of the summer, and decreased overall water quality downstream. However, the lake's temperature and dissolved oxygen remained within reasonable values. The Water Quality Team's efforts helped to minimize impacts to the lake, the tailwater, and the fishery.

RD Bailey Deep Drawdown

Water Quality Staff completed a shoreline mussel assessment near the approximate winter pool elevation of 1012' at RD Bailey Lake on 01 November 2021. This assessment was requested by Planning in order to determine the potential impacts to mussel resources during a deep drawdown of the lake to elevation 995'. The concern is that healthy mussel beds were exposed to air during a deep drawdown. This additional drawdown was needed in order to complete maintenance on the outlet structure.

At winter pool, RD Bailey Lake shorelines are made up of rocky cliff walls, steep sandy beaches, and large exposed mud flats. The large mud flats begin at Big Cub Creek and extend to the headwaters of the lake. These extensive areas are inundated with organic, sticky mud that is not suitable mussel habitat. The lake downstream of Big Cub Creek is dominated by rocky cliffs. These cliffs extend from normal summer pool elevation to below winter pool. The only suitable mussel habitat exists as steep, sandy shores. Some of these sandy shores extended into mudflats close to the elevation of winter pool. Other sandy areas extended below the winter pool elevation of 1012'.

A similar survey event took place during a deep drawdown in 2018. At that time, staff assessed four areas of shoreline on RD Bailey Lake between the dam and Big Cub Creek (Figure 21). A total of 6.5 man hours was spent searching the banks for mussels and shell material. Staff assessed elevations between summer pool and winter pool, but additional effort was concentrated along the areas adjacent to the winter pool elevation. The only native mussel species that was encountered was *Utterbackia imbecillis* (paper pondshell). No *Utterbackia* were found near water's edge. All fresh dead mussels had perished as a direct result of the drawdown from summer to winter pool. Many weathered shells of *Corbicula* were also found along the banks.

During this recent assessment (approximately 4 man hours), Water Quality staff searched more of the headwaters of the lake because the main lake lacked any significant mussel resources in 2018. This survey took place while the lake was at elevation 995' (Figure 22) near the Day Use Area boat ramp. These areas were nearly devoid of sandy and rocky areas because of the inundation of silts and mud. We also assessed a smaller area near the Winter Boat Launch where sands and gravels were more common, but the banks were very steep. As in 2018, no significant mussel resources were located. Less than 20 individuals (fresh dead) were found consisting of two species of native mussels, *Utterbackia imbecillis* and *Leptodea fragilis*. One weathered dead *Potamilus alatus* was also found. Also consistent with 2018, the fresh dead were in areas that were exposed during the normal winter drawdown from elevation 1035' to 1012'. Most specimen looked to be young-of-year individuals.

It is unlikely that significant mussel resources exist below winter pool elevation due to: (a) the low densities of mussels found on sand and gravel habitat between winter and summer pools, (b) the lack of suitable habitat along the shores of the lake at winter pool, and (c) the lack of mussel material found directly adjacent to the winter pool. It is unlikely that this deep drawdown will have any significant impact to native mussels in RD Bailey Lake.

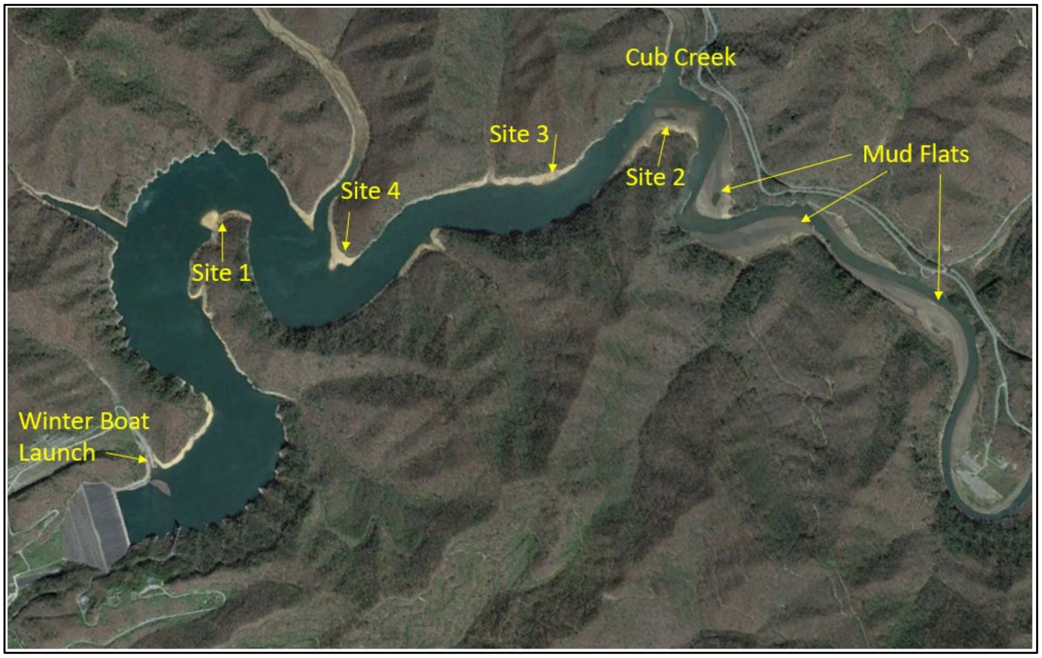


Figure 21. Mussel survey areas during a deep drawdown operation in 2018.

Figure 22. Mussel survey areas (highlighted in red) during a deep drawdown operation in 2021.

In addition, water quality staff completed an assessment of potential *Cambarus veteranus* habitat at R.D. Bailey Lake. The purpose of this visit was to characterize the quality of *C. veteranus* habitat within the normally impounded sections of the lake and to compare those areas with the free-flowing sections of the Guyandotte River upstream of the lake.

During this assessment, the lake elevation was at 995' which is 17 feet below the normal winter pool elevation of 1012'. Three distinct areas were assessed:

- Areas exposed that are normally impounded during winter pool,
- Areas that are impounded during summer pool, but are free-flowing during normal winter pool,
- Areas upstream of summer pool which are always free-flowing unless the project is impounding water for flood control operations.

Cambarus veteranus presence is closely associated with large streambed slab boulders with very little or no sediment deposition and embeddedness. Further, *C. veteranus* is most abundant in moderate to high velocity riffle habitat of high-quality streams (Loughman et. al., 2016). The closest known recorded specimen on the Guyandotte River was located near Pineville, WV which is approximately 25 river miles upstream of the lake (US Fish and Wildlife Service, personal communication).

We assessed a 0.6 mile reach of aquatic habitat from the R.D. Bailey Lake Day Use Area Boat Launch towards to dam. This area is inundated at the winter pool elevation of 1012' but was exposed during this scheduled deep drawdown. We estimate that approximately 1 mile of the lake habitat was affected during the deep drawdown by converting normally impounded waters to flowing waters. This section of lake is always impounded during normal operations and is likely inundated with fine materials. This area of the lake is shown as blue on the map (Figure 23). The substrate of this area is made up of transient sands and silts with large bank scars, point bars, and exposed mud flats (Figure 24). The bed material in this reach is consistently being eroded and moved downstream during normal winter pool and during the deeper drawdown. Based on the high levels of sedimentation and low velocities due to lake impoundment, this reach is not suitable for *C. veteranus* habitat.

The next upstream section of lake, shown as purple on the map (Figure 23), is free-flowing at the winter pool elevation of 1012' (Figure 25) but is completely impounded during the summer pool elevation of 1035'. This area was not impacted by the deep drawdown to elevation 995'. This reach encompasses 1.3 river miles from the R.D. Bailey Lake Boat Launch upstream to the terminus of summer pool, which is located near the unnamed boat launch at the end of the Guyandotte Campground road. We assessed roughly 0.6 miles of this reach from the R.D. Bailey Lake Boat Launch to just below the train trestle seen in (Figure 26). An additional 0.2 miles of this reach was assessed near the boat launch in the Guyandotte Campground. This reach is subjected to rapid, seasonal inundations of sediment and is covered by a minimum of 7 meters of water during summer pool. Although sections of this reach contain potential *C. veteranus* habitat, it is only available after scouring events during winter pool. Figure 26 further demonstrates the level of embeddedness of habitat within this reach between the winter pool elevation of 1012' and summer pool elevation of 1035'. Figure 27 shows potential *C. veteranus* habitat at the winter pool elevation of 1012', but demonstrates the level of sediment deposition during the normal summer pool elevation of 1035'. Seasonal operations of the lake result in habitat that is only temporarily available for *C. veteranus*. Based on warm-season embeddedness, lake inundation, and low velocities, this reach is not suitable to support *C. veteranus*.

Continuing upstream, the normally free-flowing section of the Guyandotte River was assessed. This area is shown as yellow on the map (Figure 23). Approximately 1 mile of this reach was assessed between the campground and the boat launch in the Guyandotte Campground. This area is not impounded during the normal summer pool elevation of 1035' but is subject to inundation during flood control operations. This area contained many, large slab-boulders oriented horizontally in fast moving riffles with little sediment deposition and embeddedness. Figure 28 shows this free-flowing section of the Guyandotte River which is above the normal summer pool elevation of 1035'. This reach does contain suitable habitat for *C. veteranus*, but is within the flood control pool and subject to frequent floodwater inundation.

For this assessment of *C. veteranus* habitat, approximately 2.4 miles of aquatic habitat were surveyed which included areas that are always impounded, areas that are impounded during both summer pool and flood control operations, and areas that are only impounded during flood control operations (Figure 29). The flood control lake has significant impacts to potential habitat within the summer and winter pool impoundment areas. These areas do not provide suitable habitat for *C. veteranus*. The areas upstream of the summer pool may provide habitat that is suitable to *C. veteranus* due to the presence of fast moving water and coarse, rocky habitat.

Figure 23. Map of R.D. Bailey Lake and the 3 different reaches assessed during the November 2021 scheduled deep drawdown. The blue area represents the extent of normal winter pool at elevation 1012'. The purple area represents the extent of summer pool at elevation 1035'. The yellow area represents the normally free-flowing sections of the Guyandotte River that is frequently subject to floodwater inundation during flood control operations. The downstream terminus of proposed Critical Habitat for C. veteranus is labeled with a yellow pin.

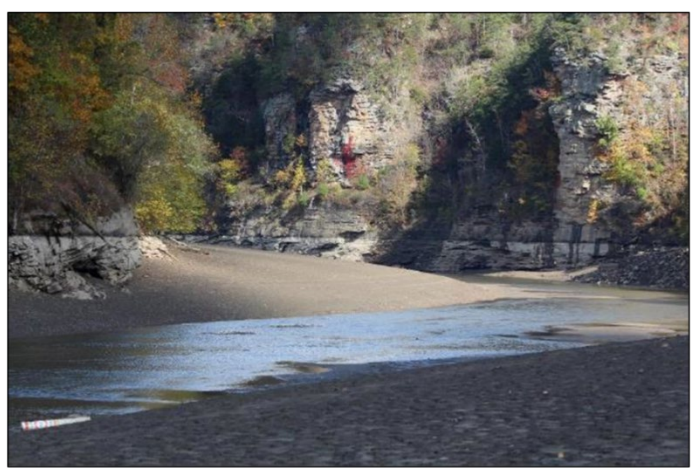


Figure 24. This is the section of the lake that is typically inundated during winter pool at 1012' but was exposed during the scheduled deep drawdown in November 2021 to 995'. This area is shown as blue on Figure 23.

Figure 25. This is the section of the lake between the R.D. Bailey Lake Boat Launch and the Co Hwy 9/1 bridge. This section is inundated at the summer pool elevation of 1035' but is free-flowing during winter pool. This area is shown as purple on Figure 23.

Figure 26. These photos show the lake area between the Route 9/1 Bridge and the railroad trestle. This section of the lake is shown as purple on Figure 23. These photos show the sedimentation of rocky habitat between normal winter pool elevation of 1012' and normal summer pool elevation of 1035'.

Figure 27. This photo shows the upper extent of normal summer pool near the unnamed boat launch at the end of Guyandotte Campground road. This area is likely subject to frequent deposition and scour cycles. This area is shown as purple in Figure 23.

Figure 28. Near the campground boat ramp is the free-flowing section of the Guyandotte River just upstream of the normal summer pool. This section is not impacted by summer pool but is subject to inundations from flood control operations. This area is shown as yellow in Figure 23.

Figure 29. Cambarus veteranus habitat assessment survey area 01 November 2021.

Summersville Deep Drawdown

Water Quality Staff completed a shoreline mussel assessment near the winter pool elevation of 1575' at Summersville Lake on 22 November 2021. Approximately six man-hours were spent surveying the shores for signs of native mussels. This assessment was requested by Planning to determine the potential impacts to mussel resources during a deep drawdown of the lake to elevation 1520'. The concern is that healthy mussel beds would be exposed to air during a deep drawdown. This additional drawdown was needed to complete maintenance on the lake's outlet structure.

Annually, Summersville Lake is drawn down from a summer pool elevation of 1652' to a winter pool elevation of 1575'. Additionally, the winter pool shorelines are made up of rocky cliff walls and steep sand/gravel beaches (Figures 30 & 31). This 77 foot drawdown along such steep banks makes it unlikely that any significant mussel resources would be at or below the normal winter pool elevation.

Four sites were assessed for mussel resources (Figure 32). Three of these sites were still impounded and in the area of the lake that would be impacted by the deep drawdown. Two of these impounded sites were within the main lake area while the third was located up a small tributary at the base of Salmon Run boat ramp. The fourth site was located just upstream of the winter pool limits on the mainstem of the Gauley River where the habitat was dominated by swift, riverine conditions. Approximately 2 miles of banks were assessed between the summer pool and winter pool elevations along the shoreline. Not a single native mussel shell was located in these areas. One fresh dead Asiatic clam was found along with one weathered shell.

Given that our team could not find any native mussels, shells, or fragments at these four sites within the 6 hours of searching, it is very unlikely that any significant mussel resources exist within Summersville Lake. The normal annual drawdown of 77' at the lake is likely prohibitive for any colonization of native mussels within the lake.

Figure 30. Steep banks are exposed during normal drawdowns at Summersville Lake.

Figure 31. Shoreline habitats are dominated by steep slopes with loose sand, gravels, and cobbles.

Figure 32. Summersville Lake mussel assessment areas are shown in yellow.

Village of Pound Sewage

In May 2021, the city of Pound, VA sewage treatment facility failed causing roughly 40k gallons of raw sewage being released into the Pound River. As a result of this failure, the Virginia Department of Health (VDH) released a recreational advisory for the headwaters of John W. Flannagan. The cause of the failure was due to several pipe fractures and failures leading to the treatment facility; these fractures allowed ground water inundation into the pipes, which in turn overwhelmed the facility resulting in the need for the facility to pass through the untreated wastewater. The LRH Water Quality team worked very closely with VDH to help take samples in various parts of the Pound River leading up to John W. Flannagan and the WQ Team coordinated with project staff to advise the public of the potential risks associated with water contact. It was quickly determined by the VDH that the sewage was being diluted before it reached John W. Flannagan and the CFU levels were well below State criteria for advisory posting; however, signage was placed for the duration of the summer of 2021 until the treatment facility was fixed in late summer.

Alum Creek Piezometer Sampling

In October 2021, the Water Quality Team sampled the groundwater in the piezometers at Alum Creek Lake. This was requested by Dam and Levee Safety to assess potential groundwater impacts to the steel cable anchors securing the dam. The groundwater was sampled from both piezometers using sterilized plastic tubes called bailers. The results from the groundwater analysis were delivered to Dam and Levee Safety to determine any potential safety concerns.

Greenup Restricted Zone

In November 2021, the Water Quality Team and Operations conducted a river velocity survey below Greenup Dam using a Sontek M9 Acoustic Doppler. This data was requested due to congressional inquiry and to determine if the current restricted zone was appropriate for safety concerns. Velocity vectors were generated for five transects within and outside of the restricted zone (Figure 33). In several areas the direction of the flow changes drastically creating eddies which could be hazardous to recreational boaters. This data was provided to the Ohio-Kanawha Locks Ranger to determine if the current restricted zone is appropriate to address boater safety concerns.

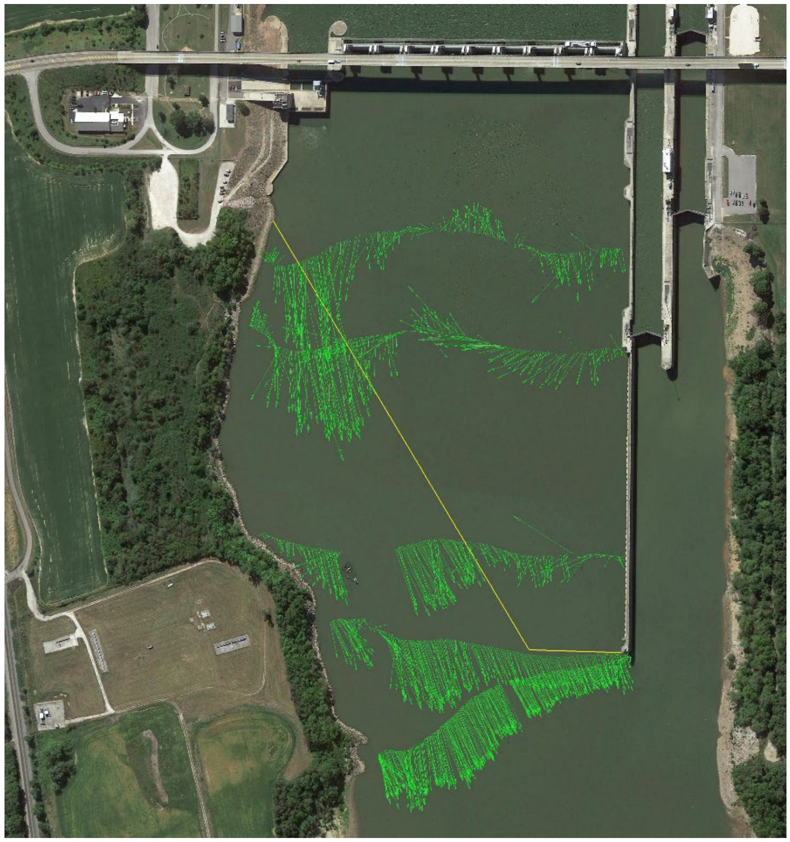


Figure 33. Results from the velocity vector survey below Greenup Dam. The yellow line delineates the restricted zone.

Ohio River SRP

A multi-District effort was funded by the Sustainable Rivers Program to assess potential operational changes at USACE flood control and navigation projects for ecological benefits on the Ohio River. Along with Planning, Operations, and Water Management, the Water Quality Team assisted in the development of operational strategies, impact and benefit forecasting, data analysis, and report writing. Most of this work was completed for the Environmental sub-team which reported to the larger project delivery team. The full report is scheduled to be completed in April 2022.

WV American Water Emergency Exercise

The Water Quality Team participated in the West Virginia America Water (WVAW) Source Water Protection Tabletop Exercise. The exercise was to test the preparedness of WVAW and how they respond to certain types of water emergencies. The focus of this tabletop exercise was their response to Harmful Algal Blooms. The District was able to participate to explain the role of USACE and to help WVAW have a better understanding of how the Water Quality Team responds to HABs within the Huntington District. As a result of this exercise, the American Water Enterprise Crisis Response Team reached out to the LRH Water Quality Team to help identify the other USACE Districts that are located within the 16 state footprint of WVAW.

Meldahl Hydropower Emergency Coordination and Plan Development

On 11 AUG 2021, the District received notification that the Ohio River, in the vicinity of the CA Meldahl Hydropower project, was in jeopardy of not meeting the dissolved oxygen standards set forth in the FERC License. This event required immediate coordination with the FERC Licensee (City of Hamilton, OH), KY DOW, ORSANCO, and KY DFW to determine if the continuation of power generation during this critical water quality period was allowable. The Water Quality Team coordinated with the LRH Hydropower PDT and the appropriate agencies to reach the determination that, if the dissolved oxygen fell below License standards, the navigation project would pass flows through the dam gates to provide additional aeration while the hydropower facility remained operational.

On 16 AUG 2021, the Water Quality Team worked with the City of Hamilton and PDT members to develop a plan for the operation of our navigation facility along with the hydropower project during critical water quality periods. This plan will allow the early operation of our navigation project gates during low dissolved oxygen periods to maximize water quality during power generation. It also provides for additional coordinated operations between the two sides (navigation and hydropower) of the facility during these times.

Trout Tailwaters at WV Lakes

The Water Quality Team coordinated with Planning on a request from WV DNR to evaluate outflow temperature data at West Virginia lakes to determine the feasibility of supporting a year-round trout fishery below one of these dams. In conversations with WV DNR, we agreed that most District lakes would not be good candidates due to lack of cool water storage, Federal Endangered Species Act protections, and inadequate water quality. However, RD Bailey Lake showed the most potential for achieving this management goal. The District Water Quality Team completed an analysis of the potential to operate RD Bailey Dam for a year-round trout fishery on the Guyandotte River. A ten year look at summertime outflows showed that RD Bailey Lake does not store enough water to provide the tailwater with a consistent source of cool, trout-friendly water.

An average volume of 81,267 acre feet of water is needed to operate RD Bailey Lake during the months of June through September, but RD Bailey Lake only stores 29,228 acre-feet at the summer pool elevation. This results in a short residence time within the lake and would prevent us from replenishing the needed cold water. We would also diminish our supply of cold water very quickly. As a result, any summertime operations to maximize trout conditions downstream could only occur temporarily and would be subject to consistent periods of warmwater discharges. These results were coordinated directly with WV DNR.

Master Plans

Operations funded Master Plan updates for JW Flannagan/North Fork of Pound, Dillon/Jenkins, Deer Creek/Paint Creek, Ohio River Locks, Paintsville, Beech Fork/East Lynn, Sutton/Burnsville, Bluestone, Muskingum/Kokosing, and Summersville Lakes. The Water Quality Team was represented on each Master Plan team and provided all water quality data and reporting for the District. In addition, the environmental and water quality portions of these documents were reviewed multiple times. These efforts will continue into 2022.

RD Bailey Mining

The Bureau of Land Management received a surface mining proposal for a significant portion of in-fee lands surrounding RD Bailey Lake. The proposed mine would be situated adjacent to Leatherwood Creek which discharges directly into the lake. The Water Quality Team has had representation at all District PDT meetings regarding the proposal. The team has assisted the District in the development of impact scoping and review of policy. The scoping efforts continued in 2022. The Water Quality Team worked with mine impact experts from Pittsburgh District to further develop data and modeling needs.

National Enterprise Database and Web Application PDT

Water Quality Staff participated on the national Enterprise Database and Web Application PDT. The purpose of the PDT is to assist the Coldwater Regions Research and Engineering Laboratory (CRREL) in the development of an enterprise water quality database application for all USACE Districts. As team members, they worked with other USACE staff from multiple districts to build a user friendly, web-based, application that maintains the same functionality as the current USACE software (DASLER). The result will be a national database usable by all districts and the public for access to water quality data.

STEM

Water Wonders Summer Camp

During the week of 26 July 2021, the Water Quality Team assisted with the West Virginia Science Adventures Camp for Water Wonders at Marshall University. This children's summer camp was hosted by Marshall University and the WV DEP and educated the campers on many aspects water. The Water Quality Team assisted the program for two days discussing watersheds, fish, fish identification, a virtual watershed display, and answering questions.

Project WET Make-A-Splash Water Festival

The Water Quality Team hosted a station at the Make-A-Splash Water Festival at Spring Hill Elementary in partnership with the WVDEP and Project WET. The USACE station involved a discussion of watershed components, precipitation, pollution, and a watershed simulation game. Other topics of discussion at the festival included acid rain, macroinvertebrates, and stormwater runoff. This event took place in lieu of the annual Water Festival at Marshall University due to ongoing Covid-19 restrictions.

Coordination with Other Agencies

Muskingum Watershed Conservancy (MWCD) – The LRH Water Quality Team maintains an ongoing relationship with the MWCD. The MWCD provides the Water Quality Team with assistance in the field during years when a Muskingum basin project falls on the intensive sampling schedule. Where staffing levels permit, the MWCD may opt to perform sampling duties themselves, which lessens the workload of the Water Quality Team, or they may accompany the Water Quality Team during sampling events. The Water Quality Team also coordinates closely with the MWCD during environmental events such as a HAB at a Muskingum basin project. In 2021, Matt Thomas of MWCD assisted Water Quality staff with retrieving lake monitoring buoys from Atwood, Clendening, and Leesville lakes.

Tappan Lake Nutrient Reduction Initiative – The Tappan Lake Nutrient Reduction Initiative (TLNRI) is a multi-agency effort to reduce nutrient loading in Tappan Lake. Tappan Lake is the current source of drinking water for the nearby Village of Cadiz, Ohio, which has been plagued by persistent, low-level concentrations of microcystin at the raw water source. The TLNRI is being designed to eliminate the presence of harmful algal blooms and their resultant water-borne toxins in Tappan Lake water within the next decade. The Water Quality Team has been involved in the data sub-group that is gathering and analyzing available water quality data that will be used to determine future sampling needs within the initiative. The Initiative, currently in Phase 2, is in the process of filling data gaps in the Tappan Lake watershed. Internal loading of nutrients from lake sediment is the suspected source and the focus for future efforts. Nothing much was done with this effort in 2021, likely due to delays and staff reductions caused by COVID-19 restrictions.

WV Division of Natural Resources (WV DNR) – The LRH Water Quality Team often works with the WV DNR during fish collection or mitigation efforts in the LRH District. In 2021, the LRH Water Quality Team partnered with a team led by the WV DNR and the US FWS for lake propagation of native plain pocketbook mussels at Burnsville and Sutton Lakes over the summer.

Harrison and Carroll County Soil and Water Conservation District (SWCD) – The Water Quality Team has been involved in a partnership with the Harrison and Carroll County SWCD since 2015. The Water Quality Team provided SWCD with funding and materials to complete water chemistry sampling in the Muskingum basin as part of an ongoing nutrient monitoring project. Sampling was conducted year-round at Tappan, Atwood, and Leesville lakes in 2021 as a result of intensive monitoring by the Water Quality Team, and a partnership between the SWCD and Youngstown State University. Physical data and water chemistry results have been incorporated into the water quality database as a result of SWCD efforts. The SWCD utilizes the nutrient results to improve watershed management efforts in their counties.

Ohio River Valley Mollusk Group – Postponed until winter 2022 due to COVID-19.

Requests for Data

The Water Quality Team is often called to fulfill Freedom of Information Act (FOIA) requests from outside agencies or individuals, or data requests from other government entities. The following list details requests for LRH Water Quality data in 2021:

- KYDOW – current water quality data for LRH lakes within the state of Kentucky
- WVDEP – current water quality data for LRH lakes within the state of West Virginia
- MWCD – water quality data from Pleasant Hill Lake
- OSU – water quality data from the Scioto River Basin
- Operations Division – water quality data to update Master Plans at various lake projects

Training and Professional Development

In addition to the mandatory USACE training courses, the following training or professional development courses were completed and/or ongoing in 2021 by one or more members of the Water Quality Team:

- Regulatory Developmentals for Josh and Luke
- EcoMapper Training, Xylem Inc., Falls River, MA for Josh and Nathan
- COR Training
- Eurofins-TestAmerica Labs Informational Webinars
- YSI Training Webinars
- Boat Operator Training and Refresher
- ArcGIS Pro Basics

Looking Forward

Watershed land uses and water quality issues are continually changing, providing new challenges for our program. Socioeconomic and environmental needs are in constant flux and are impacting many of our watersheds. Along with resource extraction shifting from coal mining to natural gas hydraulic fracturing, record dry, hot years have impacted water quality throughout the District. This year's activities and findings have emphasized several needs and modifications to the water quality program.

Intake structure modifications at Muskingum Basin Lakes have proven successful. Studies completed at Tappan, Clendening, and Piedmont lakes have yielded highly positive results. Atwood and Leesville lakes are scheduled for modification in the future. Funding has been budgeted for FY21 for studying the modification at Atwood Lake.

Marcellus Shale or deep shale drilling for natural gas is active in much of the District. Ohio, Kentucky, and West Virginia have significant areas of active drilling. Baseline water quality conditions need established and potentially impacted streams need to be monitored in the upcoming years to determine the extent of impacts to District waters. This baselining of environmental data should occur through scrutiny of our existing intensive water quality data and sampling.

Environmental Flows describe the management of water flow needed to sustain or increase wildlife habitat quality and water quality while managing operational needs. The East Lynn Lake environmental flow study implemented in 2013 revealed a great opportunity to manage operations in a way that benefits downstream aquatic communities. By adjusting the period and amount of flow discharged during drawdown and precipitation events, downstream habitat diversity can be increased and extreme temperature variability decreased, benefiting macroinvertebrate and fish communities. The Water Quality Team implemented similar studies at Burnsville and Sutton lakes in 2018 and hope to continue studies at other LRH projects in the future. In 2021, RD Bailey Lake and Burnsville Lake will be studied for e-flow potential.

Partnerships with other agencies and watershed groups are extremely beneficial when planning or implementing a monitoring strategy. Increasing our network of partnerships at the watershed level should continue to be a goal over the next couple of years. This provides us more intimate knowledge of a watershed and more “eyes” on the stream.

Stream restoration or mitigation efforts may benefit project waters experiencing chronic water quality issues, much like the wetland treatment areas at Wills Creek Lake. These wetlands are settling out metals that previously were directly entering Wills Creek Lake and possibly impacting the biota. Chronic environmental issues impacting District lakes and inflows should be prioritized and these sources considered for some type of remediation. Sediment erosion and sedimentation of lake headwaters are a major issue that can potentially benefit from passive treatment such as in-stream structures that will lessen the sediment loads entering the lakes.

Appendix A - Informational Tables

Table 11. Complete list of sampling locations and descriptions for 2021.

PROJECT	SITE NO.	TYPE	STREAM	BASIN	COUNTY	STATE	LAT	LONG
Alum Creek	1ACS0901	Well	ACS Piezometer Well #1	Scioto	Delaware	OH	40.184894	-82.966209
Alum Creek	1ACS0902	Well	ACS Piezometer Well #2	Scioto	Delaware	OH	40.185652	-82.965516
Atwood	1ATI0001	Outflow	Atwood Lake Outflow	Muskingum	Tuscarawas	OH	40.52583333	-81.2875
Atwood	1ATI0002	Lake	Atwood Lake	Muskingum	Tuscarawas	OH	40.52638889	-81.28472222
Atwood	1ATI0003	Stream	Indian Fork	Muskingum	Carroll	OH	40.553649	-81.170377
Atwood	1ATI0012	Stream	Elliot Run	Muskingum	Carroll	OH	40.57816667	-81.21483333
Atwood	1ATI0013	Stream	Willow Run	Muskingum	Carroll	OH	40.57036111	-81.19555556
Atwood	1ATI0014	Stream	Unnamed tributary	Muskingum	Carroll	OH	40.57311111	-81.23127778
Atwood	1ATI0015	Stream	Gantz Creek	Muskingum	Carroll	OH	40.55252778	-81.07605556
Atwood	1ATI0016	Stream	Indian Fork	Muskingum	Carroll	OH	40.55852778	-81.10077778
Atwood	1ATI0017	Stream	Town Creek	Muskingum	Carroll	OH	40.56455556	-81.08369444
Atwood	1ATI0018	Stream	Pleasant Valley Run	Muskingum	Carroll	OH	40.55836111	-81.15541667
Atwood	1ATI0019	Stream	Cold Spring Run	Muskingum	Carroll	OH	40.5745	-81.12116667
Atwood	1ATI0020	Stream	Cold Spring Run	Muskingum	Carroll	OH	40.59525	-81.11575
Atwood	1ATI0021	Stream	Unnamed tributary	Muskingum	Carroll	OH	40.56797222	-81.25725
Atwood	1ATI0022	Stream	Indian Fork	Muskingum	Carroll	OH	40.55130556	-81.17413889
Atwood	1ATI0029	Stream	Unnamed tributary	Muskingum	Carroll	OH	40.553318	-81.170781
Atwood	1ATI0030	Stream	Indian Fork	Muskingum	Carroll	OH	40.554803	-81.153519
Beech Fork	1BBF0101	Outflow	Beech Fork Lake Outflow	Twelvepole	Wayne	WV	38.30388889	-82.41916667
Beech Fork	1BBF0102	Lake	Beech Fork Lake	Twelvepole	Wayne	WV	38.30388889	-82.41444444
Beech Fork	1BBF0107	Stream	Beech Fork	Twelvepole	Wayne	WV	38.30888889	-82.31638889
Beech Fork	1BBF0108	Stream	Long Branch	Twelvepole	Cabell	WV	38.31305556	-82.33944444
Beech Fork	1BBF0110	Stream	Millers Fork	Twelvepole	Wayne	WV	38.25461111	-82.37366667
Charles Mill	1CMB0001	Outflow	Charles Mill Lake Outflow	Muskingum	Ashland	OH	40.737777	-82.363333
Charles Mill	1CMB0002	Lake	Charles Mill Lake	Muskingum	Ashland	OH	40.741944	-82.3625
Charles Mill	1CMB0009	Stream	Black Fork	Muskingum	Ashland	OH	40.817055	-82.416972
Charles Mill	1CMB0010	Stream	Ruffner Run	Muskingum	Ashland	OH	40.775555	-82.371333
Charles Mill	1CMB0011	Stream	Seymour Run	Muskingum	Ashland	OH	40.751944	-82.355222
Dewey	1DEW0001	Outflow	Dewey Lake Outflow	Big Sandy	Floyd	KY	37.737633	-82.731233
Dewey	1DEW0005	Stream	Brushy Fork	Big Sandy	Floyd	KY	37.680555	-82.589722
Dewey	1DEW0024	Stream	Stratton Branch	Big Sandy	Floyd	KY	37.698888	-82.742222
Dewey	1DEW0050	Stream	Buffalo Creek	Big Sandy	Floyd	KY	37.67	-82.650111
East Lynn	1ELT0001	Outflow	East Lynn Lake Outflow	Twelvepole	Wayne	WV	38.146388	-82.381111
East Lynn	1ELT0002	Lake	East Lynn Lake	Twelvepole	Wayne	WV	38.143333	-82.385
East Lynn	1ELT0005	Stream	Lick Creek	Twelvepole	Wayne	WV	38.113333	-82.321388
East Lynn	1ELT0031	Stream	East Fork	Twelvepole	Wayne	WV	38.052222	-82.308055
East Lynn	1ELT0032	Stream	Kiah Creek	Twelvepole	Wayne	WV	38.060277	-82.265277
East Lynn	1ELT0036	Stream	Big Laurel Creek	Twelvepole	Wayne	WV	38.062666	-82.260638
East Lynn	1ELT0064	Stream	Troughs Fork	Twelvepole	Wayne	WV	38.045777	-82.251027

PROJECT	SITE NO.	TYPE	STREAM	BASIN	COUNTY	STATE	LAT	LONG
Fishtrap	1FRL0001	Outflow	Fishtrap Lake Outflow	Big Sandy	Pike	KY	37.429431	-82.415114
Fishtrap	1FRL0021	Stream	Lick Creek	Big Sandy	Pike	KY	37.397134	-82.302839
Fishtrap	1FRL0025	Stream	Grapevine Creek	Big Sandy	Pike	KY	37.43533	-82.348326
J.W. Flannagan	1JWF0001	Outflow	J.W. Flannagan Lake Outflow	Big Sandy	Dickenson	VA	37.236697	-82.344813
J.W. Flannagan	1JWF0025	Stream	Cranesnest River	Big Sandy	Dickenson	VA	37.152138	-82.410083
J.W. Flannagan	1JWF0026	Stream	Pound River	Big Sandy	Dickenson	VA	37.193277	-82.449138
Kanawha River	1KR02912	River	Kanawha River	Kanawha	Putnam	WV	38.535833	-81.945279
Kanawha River	1KR02919	River	Kanawha River	Kanawha	Putnam	WV	38.539475	-81.948706
Kanawha River	1KR03061	River	Kanawha River	Kanawha	Putnam	WV	38.524482	-81.92411
Kanawha River	1KR03069	River	Kanawha River	Kanawha	Putnam	WV	38.525278	-81.922222
Kanawha River	1KR06671	River	Kanawha River	Kanawha	Kanawha	WV	38.262393	-81.573177
Kanawha River	1KR06729	River	Kanawha River	Kanawha	Kanawha	WV	38.256726	-81.568529
Kanawha River	1KR08229	River	Kanawha River	Kanawha	Kanawha	WV	38.19485	-81.372165
Leesville	1LEM0001	Outflow	Leesville Lake Outflow	Muskingum	Carroll	OH	40.470277	-81.196666
Leesville	1LEM0002	Lake	Leesville Lake	Muskingum	Carroll	OH	40.470555	-81.193055
Leesville	1LEM0003	Stream	North Fork McGuire Creek	Muskingum	Carroll	OH	40.511944	-81.126111
Leesville	1LEM0012	Stream	McGuire Creek	Muskingum	Carroll	OH	40.461722	-81.125416
Leesville	1LEM0013	Stream	Unnamed tributary	Muskingum	Carroll	OH	40.466111	-81.141611
Leesville	1LEM0014	Stream	North Fork McGuire Creek	Muskingum	Carroll	OH	40.513166	-81.112805
Leesville	1LEM0015	Stream	Bear Hole Run	Muskingum	Carroll	OH	40.529027	-81.136916
Leesville	1LEM0016	Stream	McGuire Creek	Muskingum	Carroll	OH	40.477694	-81.105805
Leesville	1LEM0017	Stream	North Fork McGuire Creek	Muskingum	Carroll	OH	40.513388	-81.085638
Leesville	1LEM0019	Stream	North Fork McGuire Creek	Muskingum	Carroll	OH	40.511111	-81.072833
N. Br. Kokosing	1NBN0001	Outflow	North Branch Kokosing Lake Outflow	Muskingum	Knox	OH	40.502808	-82.572036
N. Br. Kokosing	1NBN0002	Lake	North Branch Kokosing Lake Outflow	Muskingum	Knox	OH	40.506666	-82.575277
N. Br. Kokosing	1NBN0004	Stream	North Branch Kokosing River	Muskingum	Knox	OH	40.526916	-82.593472
N. Br. Kokosing	1NBN0005	Stream	Unnamed tributary	Muskingum	Knox	OH	40.511472	-82.604972
N. Fk. Pound	1NFP0001	Outflow	North Fork Pound River	Big Sandy	Wise	VA	37.126523	-82.628948
N. Fk. Pound	1NFP0008	Stream	Bad Creek	Big Sandy	Wise	VA	37.10027	-82.677897
N. Fk. Pound	1NFP0009	Stream	North Fork Pound River	Big Sandy	Wise	VA	37.100183	-82.67805
Ohio River	1OR16209	River	Ohio River	Ohio	Pleasants	WV	39.358528	-81.324556
Ohio River	1OR16230	River	Ohio River	Ohio	Pleasants	WV	39.354444	-81.326944
Ohio River	1OR23791	River	Ohio River	Ohio	Mason	WV	38.921111	-81.908333
Ohio River	1OR23809	River	Ohio River	Ohio	Mason	WV	38.921261	-81.905046
Ohio River	1OR27946	River	Ohio River	Ohio	Mason	WV	38.6775	-82.188638
Ohio River	1OR27951	River	Ohio River	Ohio	Mason	WV	38.678166	-82.184222
Ohio River	1OR32108	River	Ohio River	Ohio	Bracken	KY	38.476341	-82.618808
Ohio River	1OR36339	River	Ohio River	Ohio	Adams	OH	38.666944	-83.108333
Pleasant Hill	1PHC0001	Outflow	Pleasant Hill Lake Outflow	Muskingum	Ashland	OH	40.620277	-82.323888
Pleasant Hill	1PHC0002	Lake	Pleasant Hill Lake	Muskingum	Ashland	OH	40.624166	-82.324722
Pleasant Hill	1PHC0005	Stream	Clear Fork	Muskingum	Richland	OH	40.629638	-82.383569
Pleasant Hill	1PHC0006	Stream	Switzer Creek	Muskingum	Richland	OH	40.644166	-82.3755
Tappan	1TAL0001	Outflow	Tappan Lake Outflow	Muskingum	Harrison	OH	40.356833	-81.230333

PROJECT	SITE NO.	TYPE	STREAM	BASIN	COUNTY	STATE	LAT	LONG
Tappan	1TAL0003	Stream	Standingstone Fork	Muskingum	Harrison	OH	40.298694	-81.0855
Tappan	1TAL0013	Stream	Clear Fork	Muskingum	Harrison	OH	40.334972	-81.094638
Tappan	1TAL0014	Stream	Lower Beaverdam Run	Muskingum	Harrison	OH	40.367111	-81.184444
Tappan	1TAL0015	Stream	Beaverdam Run	Muskingum	Harrison	OH	40.346833	-81.126888
Tappan	1TAL0023	Stream	Clear Fork	Muskingum	Harrison	OH	40.341388	-81.090277
Tappan	1TAL0024	Stream	Leiper Run	Muskingum	Harrison	OH	40.346222	-81.137138
Tappan	1TAL0025	Stream	Unnamed tributary	Muskingum	Harrison	OH	40.345944	-81.089583
Tappan	1TAL0026	Stream	Clear Fork	Muskingum	Harrison	OH	40.324638	-81.021972
Tappan	1TAL0027	Stream	Clear Fork	Muskingum	Harrison	OH	40.338111	-81.114222
Tappan	1TAL0028	Stream	Eddington Run	Muskingum	Harrison	OH	40.344083	-81.16525
Tappan	1TAL0045	Stream	Standingstone Fork	Muskingum	Harrison	OH	40.3115839	-81.1153385
Tom Jenkins	1TJE0002	Outflow	Tom Jenkins Dam Outflow	Hocking	Morgan	OH	39.569701	-82.032313
Tom Jenkins	1TJE0009	Stream	East Branch of Sunday Creek	Hocking	Athens	OH	39.540833	-82.059166
Wills Creek	1WEW0001	Outflow	Wills Creek Lake Outflow	Muskingum	Coshocton	OH	40.159166	-81.8475
Wills Creek	1WEW0003	Stream	Wills Creek	Muskingum	Coshocton	OH	40.204472	-81.714388

Table 12. List of state designated 303d streams sampled by USACE in 2021 during intensive surveys.

Project Name	Stream Name	Stations Located on Stream	Station Type	Watershed	Impairment	Possible sources of Impairment
Atwood	Atwood Lake Outflow	1ATI0001	Outflow	Muskingum	Impaired/non attainment	sedimentation/siltation, toxicity, flow regime modification
Atwood	Atwood Lake	1ATI0002	Lake	Muskingum	Impaired	sedimentation/siltation, toxicity, flow regime modification
Atwood	Indian Fork	1ATI0003	Stream	Muskingum	Impaired/partial attainment	sedimentation/siltation, toxicity, flow regime modification
Atwood	Unnamed tributary	1ATI0014	Stream	Muskingum	Impaired	sedimentation/siltation, toxicity, flow regime modification
Atwood	Unnamed tributary	1ATI0021	Stream	Muskingum	Impaired	sedimentation/siltation, toxicity, flow regime modification
Beech Fork	Beech Fork Lake Outflow	1BBF0101	Outflow	Twelvepole	Impaired	iron, fecal coliform
Beech Fork	Beech Fork Lake	1BBF0102	Lake	Twelvepole	Impaired	phosphorus
Beech Fork	Beech Fork	1BBF0107	Stream	Twelvepole	Impaired	DO, fecal coliform, iron, CNA-Biology
Beech Fork	Long Branch	1BBF0108	Stream	Twelvepole	Impaired	fecal coliform, iron, CNA-Biology
Beech Fork	Millers Fork	1BBF0110	Stream	Twelvepole	Impaired	fecal coliform, iron, CNA-Biology
Charles Mill	Charles Mill Lake Outflow	1CMB0001	Outflow	Muskingum	Impaired/partial attainment	dissolved oxygen, nutrient/eutrophication, flow regime modification, suspended algae
Charles Mill	Charles Mill Lake	1CMB0002	Lake	Muskingum	no data	
Charles Mill	Black Fork	1CMB0009	Stream	Muskingum	Impaired/non attainment	dissolved oxygen, nutrient/eutrophication, flow regime modification, suspended algae
Charles Mill	Ruffner Run	1CMB0010	Stream	Muskingum	no data	
Charles Mill	Seymour Run	1CMB0011	Stream	Muskingum	no data	
East Lynn	East Lynn Lake Outflow	1ELT0001	Outflow	Twelvepole	impaired	iron, CNA-Biology
East Lynn	East Lynn Lake	1ELT0002	Lake	Twelvepole	not impaired	
East Lynn	Lick Creek	1ELT0005	Stream	Twelvepole	impaired	iron, DO
East Lynn	East Fork	1ELT0031	Stream	Twelvepole	impaired	fecal coliform, iron
East Lynn	Kiah Creek	1ELT0032	Stream	Twelvepole	impaired	fecal coliform, iron, CNA-Biology
East Lynn	Big Laurel Creek	1ELT0036	Stream	Twelvepole	impaired	fecal coliform, iron
East Lynn	Troughs Fork	1ELT0064	Stream	Twelvepole	impaired	fecal coliform, iron
Leesville	Leesville Lake Outflow	1LEM0001	Outflow	Muskingum	Impaired/non attainment	ammonia
Leesville	Leesville Lake	1LEM0002	Lake	Muskingum	no data	
Leesville	North Fork McGuire Creek	1LEM0003	Stream	Muskingum	Use attaining	
Leesville	McGuire Creek	1LEM0012	Stream	Muskingum	Full attainment	

Project Name	Stream Name	Stations Located on Stream	Station Type	Watershed	Impairment	Possible sources of Impairment
N. Br. Kokosing	North Branch Kokosing Lake Outflow	1NBN0001	Outflow	Muskingum	Use attaining	
N. Br. Kokosing	North Branch Kokosing Lake Outflow	1NBN0002	Lake	Muskingum	Use attaining	
N. Br. Kokosing	North Branch Kokosing River	1NBN0004	Stream	Muskingum	Use attaining	
N. Br. Kokosing	Unnamed tributary	1NBN0005	Stream	Muskingum	Use attaining	
Pleasant Hill	Pleasant Hill Lake Outflow	1PHC0001	Outflow	Muskingum	Use attaining	
Pleasant Hill	Pleasant Hill Lake	1PHC0002	Lake	Muskingum	Use attaining	
Pleasant Hill	Cleark Fork	1PHC0005	Stream	Muskingum	Use attaining	
Pleasant Hill	Switzer Creek	1PHC0006	Stream	Muskingum	Use attaining	

Table 13. Authorized project purposes for LRH lakes.

Project	Operating Purposes	Authorized Purposes	Authorizing Laws
Alum Creek	Water Supply	Water Supply	PL 87-874
	Fish & Wildlife	Fish & Wildlife	PL 87-874
	Flood Control	Flood Control	PL 87-874
	Recreation	Recreation	PL 87-874
Atwood Lake	Flood Control	Flood Control	PL 76-396, PL 73-67
	Recreation	Recreation	PL 76-396, PL 73-67
	Fish & Wildlife	Water Conservation*	PL 76-396, PL 73-67
Beach City Lake	Flood Control	Flood Control	PL 76-396, PL 73-67
	Recreation	Recreation	PL 76-396, PL 73-67
	Fish & Wildlife	Water Conservation*	PL 76-396, PL 73-67
Beech Fork Lake	Recreation	Recreation	PL 87-874, PL 100-676
	Water Quality	Water Quality	PL 87-874
	Flood Control	Flood Control	PL 87-874
	Fish and Wildlife	Fish & Wildlife	PL 87-874
Bluestone Lake	Flood Control	Flood Control	PL 74-738, PL 75-761
		Hydroelectric Power	PL 74-738, PL 75-761
	Recreation	Recreation	PL 78-534, PL 100-676
	Low Flow Augmentation	Low Flow Augmentation	PL 74-738, PL 75-761
	Fish & Wildlife	Fish & Wildlife	PL 74-738
Bolivar Dam	Flood Control	Flood Control	PL 76-396, PL 73-67
Burnsville Lake	Recreation	Recreation	PL 78-534
		Low Flow Augmentation	PL 75-761
	Flood Control	Flood Control	PL 75-761
	Water Quality	Water Quality	PL 87-88
	Fish and Wildlife	Fish and Wildlife	PL 87-874
Charles Mill Lake	Flood Control	Flood Control	PL 76-396, PL 73-67
	Recreation	Recreation	PL 76-396, PL 73-67
	Fish & Wildlife	Water Conservation*	PL 76-396, PL 73-67
Clendening Lake	Flood Control	Flood Control	PL 76-396, PL 73-67
	Recreation	Recreation	PL 76-396, PL 73-67
	Fish & Wildlife	Water Conservation*	PL 76-396, PL 73-67
Deer Creek Lake	Flood Control	Flood Control	PL 75-761
	Low Flow Augmentation	Low Flow Augmentation	PL 75-761
	Recreation	Recreation	PL 78-534
	Fish & Wildlife	Fish & Wildlife	PL 85-624
Delaware Lake	Flood Control	Flood Control	PL 75-761

Project	Operating Purposes	Authorized Purposes	Authorizing Laws
	Low Flow Augmentation	Low Flow Augmentation	PL 75-761
	Recreation	Recreation	PL 78-534
	Fish and Wildlife	Fish and Wildlife	PL 87-874
Dewey Lake	Flood Control	Flood Control	PL 75-761
	Recreation	Recreation	PL 78-534
	Fish & Wildlife	Low Flow Augmentation	PL 75-761
Dillon Lake	Flood Control	Flood Control	PL 75-761
	Recreation	Recreation	PL 78-534
	Low Flow Augmentation	Low Flow Augmentation	PL 75-761
	Fish and Wildlife	Fish and Wildlife	PL 87-874
Dover Dam	Flood Control	Flood Control	PL 76-396, PL 73-67
		Water Conservation*	PL 76-396, PL 73-67
East Lynn Lake	Flood Control	Flood Control	PL 75-761
	Recreation	Recreation	PL 78-534, PL 100-676
	Low Flow Augmentation	Low Flow Augmentation	PL 75-761
	Water Quality	Water Quality	PL 87-88
	Fish and Wildlife	Fish and Wildlife	PL 87-874
Fishtrap Lake	Flood Control	Flood Control	PL 75-761
	Recreation	Recreation	PL 78-534
	Low Flow Augmentation	Low Flow Augmentation	PL 75-761
	Water Quality	Water Quality	PL 87-88
	Fish & Wildlife	Fish & Wildlife	PL 85-624
Grayson Lake	Flood Control	Flood Control	PL 86-645
	Recreation	Recreation	PL 86-645
	Water Quality	Water Quality	PL 87-88
	Fish and Wildlife	Fish and Wildlife	PL 87-874
John W. Flannagan Dam	Flood Control	Flood Control	PL 75-761
	Recreation	Recreation	PL 78-534
	Low Flow Augmentation	Low Flow Augmentation	PL 75-761
	Water Quality	Water Quality	PL 87-88
	Fish & Wildlife	Fish & Wildlife	PL 85-624
	Water Supply	Water Supply	PL 85-500
Leesville Lake	Flood Control	Flood Control	PL 76-396, PL 73-67
	Recreation	Recreation	PL 76-396, PL 73-67
	Fish & Wildlife	Water Conservation*	PL 76-396, PL 73-67
Mohawk Dam	Flood Control	Flood Control	PL 76-396, PL 73-67
Mohicanville Dam	Flood Control	Flood Control	PL 76-396, PL 73-67
North Branch Kokosing River Lake	Flood Control	Flood Control	PL 78-534, PL 87-874

Project	Operating Purposes	Authorized Purposes	Authorizing Laws
	Recreation	Recreation	PL 78-534, PL 87-874
	Fish & Wildlife	Fish & Wildlife	PL 85-624
North Fork of Pound Lake	Flood Control	Flood Control	PL 86-645
	Water Supply	Water Supply	PL 85-500
	Fish & Wildlife	Fish & Wildlife	PL 85-624
	Recreation	Recreation	PL 86-645, PL 85-624
Paint Creek Lake	Flood Control	Flood Control	PL 75-761
	Water Quality	Water Quality	PL 87-88
	Water Supply	Water Supply	PL 85-500
	Low Flow Augmentation	Low Flow Augmentation	PL 75-761
	Recreation	Recreation	PL 78-534
	Fish and Wildlife	Fish and Wildlife	PL 87-874
Paintsville Lake	Flood Control	Flood Control	PL 89-298
	Recreation	Recreation	PL 89-298
	Water Quality	Water Quality	PL 89-298
	Fish and Wildlife	Fish and Wildlife	PL 87-874
Piedmont Lake	Flood Control	Flood Control	PL 76-396, PL 73-67
	Recreation	Recreation	PL 76-396, PL 73-67
	Fish & Wildlife	Water Conservation*	PL 76-396, PL 73-67
Pleasant Hill Lake	Flood Control	Flood Control	PL 76-396, PL 73-67
	Recreation	Recreation	PL 76-396, PL 73-67
	Fish & Wildlife	Water Conservation*	PL 76-396, PL 73-67
R.D. Bailey Lake	Flood Control	Flood Control	PL 87-874
	Recreation	Recreation	PL 87-874, PL 100-676
	Water Quality	Water Quality	PL 87-874
	Fish & Wildlife	Fish & Wildlife	PL 79-732, PL 85-624
Senecaville Lake	Flood Control	Flood Control	PL 76-396, PL 73-67
	Recreation	Recreation	PL 76-396, PL 73-67
	Fish & Wildlife	Water Conservation*	PL 76-396, PL 73-67
Summersville Lake	Flood Control	Flood Control	PL 75-761
	Recreation	Recreation	PL 78-534, PL 100-676
	Low Flow Augmentation	Low Flow Augmentation	PL 75-761
	Water Quality	Water Quality	PL 87-88
	Fish & Wildlife	Fish & Wildlife	PL 79-732
Sutton Lake	Flood Control	Flood Control	PL 75-761
	Recreation	Recreation	PL 78-534, PL 100-676
	Low Flow Augmentation	Low Flow Augmentation	PL 75-761
	Fish & Wildlife	Fish & Wildlife	PL 79-732

Project	Operating Purposes	Authorized Purposes	Authorizing Laws
Tappan Lake	Flood Control	Flood Control	PL 76-396, PL 73-67
	Recreation	Recreation	PL 76-396, PL 73-67
	Fish & Wildlife	Water Conservation*	PL 76-396, PL 73-67
Tom Jenkins Dam	Flood Control	Flood Control	PL 78-534
	Recreation	Low Flow Augmentation	PL 78-534
	Water Supply	Recreation	PL 78-534
	Fish and Wildlife	Water Supply	PL 85-500
		Fish and Wildlife	PL 87-874
Wills Creek Lake	Flood Control	Flood Control	PL 76-396, PL 73-67
	Recreation	Recreation	PL 76-396, PL 73-67
	Fish & Wildlife	Water Conservation*	PL 76-396, PL 73-67
Yatesville Lake	Flood Control	Flood Control	PL 75-761, PL 89-298
	Water Quality	Water Quality	PL 89-298
	Recreation	Recreation	PL 89-298
	Low Flow Augmentation	Low Flow Augmentation	PL 75-761, PL 89-298
	Fish and Wildlife	Fish and Wildlife	PL 87-874

Table 14. Long-term water quality sampling schedule.

WATER QUALITY SAMPLING SCHEDULE HUNTINGTON DISTRICT LAKE PROJECTS Reviewed 18 Sep 2018: Previous Editions Obsolete											
PROJECT	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
ATI			X					X			
BCS				X					X		
BOS											
CLB					X					X	
CMB			X					X			
DOT											
LEM			X					X			
MKW											
MOL											
PES					X					X	
PHC			X					X			
SES	X					X					X
TAL					X					X	
WEW		X					X				
NBN			X					X			
DIL				X					X		
TJE		X					X				
ACS	X					X					X
DCS	X					X					X
DEO	X					X					X
PCS	X					X					X
BLN				X					X		
SUM				X					X		
SUT				X					X		
DEW		X					X				
FRL		X					X				
JWF		X					X				
NFP		X					X				
PIV					X					X	
YBC					X					X	
BBF			X					X			
ELT			X					X			
BUS				X					X		
GRL	X					X					X

Appendix B – Additional Documents and Reports

To access the following reports, please contact the offices specified.

Maintenance Dredging Mitigation Report (2021)

Contact:

Huntington District USACE
Waterways Section
Christopher Blake Chadwick
christopher.b.chadwick@usace.army.mil
304-399-5083

Huntington District USACE
Water Quality Team
Andrew Johnson
andrew.n.johnson@usace.army.mil
304-399-5189

Water Quality Annual Operating Plan (2021)
Water Quality Program Management Plan (2021)

Contact:

Huntington District USACE
Water Quality Team
Andrew Johnson
andrew.n.johnson@usace.army.mil
304-399-5189

Huntington District USACE
Water Management Section
Kamryn Tufts
kamryn.tufts@usace.army.mil

Appendix C – LRH Lake Summaries

Based on the most recent water quality sampling and analysis, some water quality constituents exceed District levels of concern. Constituents exceeding levels of concern include iron, dissolved oxygen, phosphorus, strontium, specific conductance, aluminum, and total Kjeldahl nitrogen. Chloride, sulfate, and specific conductance appear to be on a downward trend. No known operational changes can be made at this time to mitigate elevated levels from the inflow streams. Elevated constituent levels will be reported to the Ohio Environmental Protection Agency to facilitate potential mitigation efforts by the state.

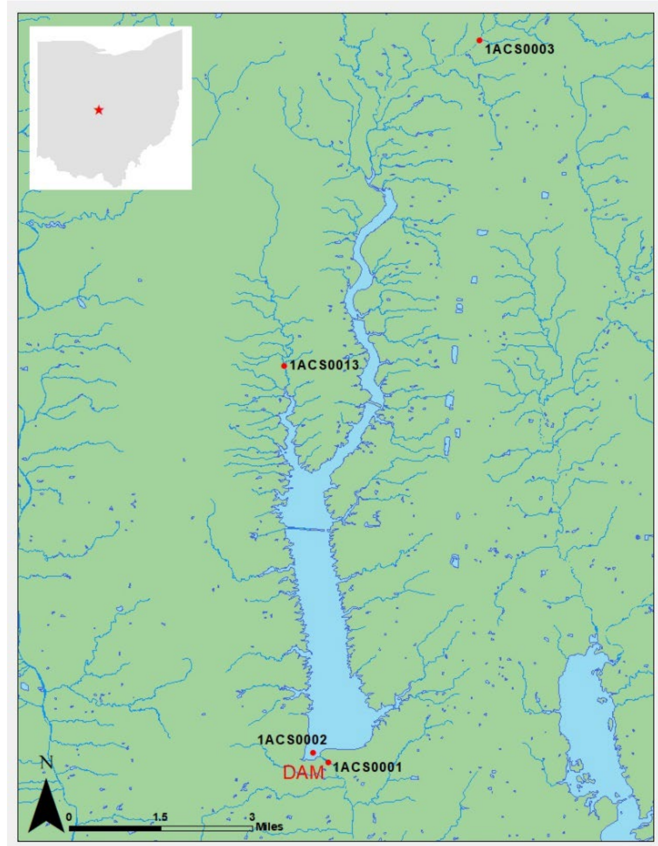


Figure 34. Water quality sampling locations for Alum Creek Lake in 2019.

WATERSHED SUMMARY: Alum Creek Lake is in Delaware County, Ohio, on Alum Creek, a tributary of the Scioto River. It is located 26 miles above the mouth of Alum Creek and 157 miles above the mouth of the Scioto River, a tributary of the Ohio River. The purposes for the project are flood control, recreation, fish and wildlife conservation and water supply. The watershed is 122 squares miles and the main land use within the watershed is agriculture and housing with small forested areas. The lake has a maximum depth of 67 feet with an average retention time of approximately 391 days.

HISTORICAL CONCERNS: Agriculture and land development are the primary sources of watershed degradation resulting in:

- Excessive turbidity and sedimentation
- Increased concentrations of strontium and nutrients
- Increased risk of harmful algae blooms in the lake

2019 ACTIVITIES: Six sampling events were conducted in the Alum Creek Lake watershed in 2019. Two major inflow streams and the outflow were sampled six times each. The lake was sampled four times during stratification at the primary lake station near the dam. All sampling events included the collection of physical water quality parameters via data sonde as well as water sample collection for a predetermined suite of water chemistry parameters. Each lake sampling event included an epilimnion, metalimnion, and hypolimnion sample with the addition of chlorophyll and dissolved metals analyses. Filtered samples were also collected at the outflow site during lake stratification to be analyzed for dissolved metals. Benthic macroinvertebrate sampling was conducted at ACS0003 and ACS0013, but no analysis has been performed. Alum Creek Lake is scheduled to be intensively sampled again in fiscal year 2024.

OBSERVED WATER QUALITY CONCERNS: Water quality analysis revealed elevated inputs of strontium, phosphorus, sulfate, and nitrogen into the lake from the main inflows (1ACS0003 and 1ACS0013). Water quality data from the outflow reveals similar concerns at lesser concentrations showing that the lake is buffering some pollutants. Elevated levels of nitrogen and strontium are being passed downstream but are still within historical ranges. During one sampling trip the inflow streams exceeded several thresholds including those for metals and nutrients. This appears to be an isolated incident due to a flooding event that was occurring at the time of sampling. Concentrations of chloride and sulfate appear to be on a downward trend in the watershed, which is reflected by a downward trend in specific conductance as well. All other constituents of concern appear to be stable.

Ongoing discussions surrounding a proposed relocation of the Delaware County sewer treatment discharge to a new site on Big Run (1ACS0013) prompted the addition of the stream to the intensive sampling schedule in 2019. Big Run is a small tributary of the northwestern end of Alum Creek Lake. The Team included Big Run in the routine monitoring for FY2019 in order to understand baseline conditions should the sewage discharge proposal move forward. Strontium concentrations remain very high in Big Run, especially during periods of low flow.

ADDITIONAL INFORMATION: Alum Creek Lake has a multi-level intake structure for optimization of water quality in the outflow. It is also a water supply reservoir.

All water quality concerns revealed in intensive surveys at ACS have been previously documented in the WCM with no new concerns surfacing, except for the collection of strontium, which began with 2013 sampling. Active agricultural land use is most likely contributing the nutrients to the watershed through runoff of farm fields and poor administration of fertilizers. The main inflows, 1ACS0003 and 1ACS0013, provide most of the nutrient loading into the lake. The lake is acting as a water quality buffer, trapping the sediments, nutrients, metals and ions contributed by the inflow that would ultimately create a larger impact to the watershed. Increased nutrients at Alum Creek Lake make it highly susceptible to Harmful Algal Blooms which can negatively affect water supplies, recreation, and wildlife.

Aquatic macroinvertebrate data from the previous intensive survey at Alum Creek (1ACS0003) indicated a fair community structure. The sample wasn't collected in a manner to which an index can provide an overall score, however, metrics of interest can be used to provide an idea of what the community looks like versus what is considered ideal. Taxa richness was low (24) and although %EPT was high, it mostly consisted of tolerant taxa or those present in nutrient rich conditions. Percent clingers were abundant, indicating that habitat is available for colonization with low sediment runoff.

Trophic State Index (TSI) is an assessment of the level of productivity in a waterbody based on Secchi disk measurements and chlorophyll and total phosphorus concentrations in the water column. Alum Creek Lake scored 47 for average TSI in 2019, which is categorized as mesotrophic. Mesotrophic lakes are usually characterized by having moderate clarity, nutrients, and algal growth. Eutrophic lakes are usually characterized by having low clarity, high nutrients, and high algal growth. Oligotrophic lakes are usually characterized by having high clarity, low nutrients, and low algal growth.

Table 15. Alum Creek Lake samples exceeding state criteria and/or District levels of concern in 2019.

STATION	STATION STYPE	STREAM NAME	ANALYTES W/ELEVATED CONCENTRATIONS	NUMBER OF SAMPLES EXCEEDING SCREENING VALUE	EXCEED NATIVE STATE CRITERIA
1ACS0001	Outflow	Alum Creek	TKN	8	NONE
			Total Phosphorus	1	NONE
			Total Strontium	8	NONE
1ACS0002	Lake	Alum Creek	TKN	10	NONE
			Total Phosphorus	2	NONE
			Total Strontium	12	NONE
1ACS0003	Inflow	Alum Creek	Total Aluminum	1	NONE
			Total Iron	1	NONE
			TKN	2	NONE
			Total Phosphorus	5	NONE
			Sp. Conductance	5	NONE
			Total Strontium	6	NONE
1ACS0013	Inflow	Big Run of Alum Creek	Total Aluminum	1	NONE
			Dissolved Oxygen	1	NONE
			Total Iron	1	NONE
			TKN	5	NONE

	pH	1	Yes
	Total Phosphorus	2	NONE
	Sp. Conductance	4	NONE
	Total Strontium	5	NONE
	Total Sulfate	2	NONE

Based on the most recent water quality sampling and analysis, some water quality constituents exceed District levels of concern, but are within historical ranges. Constituents exceeding levels of concern include bromide, dissolved oxygen, iron, manganese, phosphorus, specific conductance, strontium, and total Kjeldahl nitrogen. New for 2021, Aluminum exceeded levels of concern multiple times at three separate sites (ATI0002, ATI0003, and ATI0014). Samples in 2016 and 2021 from one inflow site (ATI0021) yielded three detections of bromide, which can be an indicator of natural gas fracking activity in the watershed. Instances of low dissolved oxygen and high dissolved metals in the outflow could be rectified in the future with the addition of a trash rack weir. This structural modification could be completed as soon as 2018. Elevated constituent levels will be reported to the Ohio EPA to facilitate potential mitigation efforts by the state.

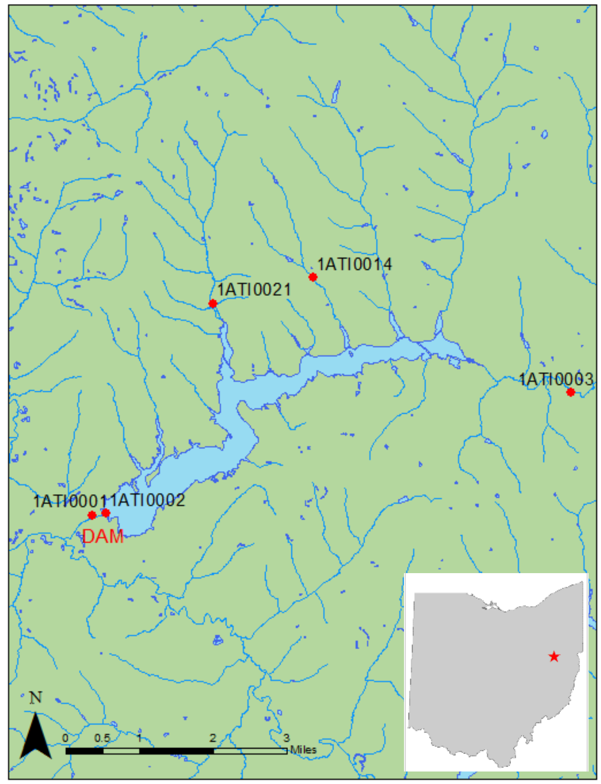


Figure 35. Water quality sampling locations for Atwood Lake in 2021.

WATERSHED SUMMARY: Atwood Lake is located in Carroll and Tuscarawas Counties in Northeastern Ohio. Indian Fork of Conotton Creek is the major stream in the basin. Honey Run and Gantz Creek feed Indian Fork of Conotton Creek and join near the city of Carrollton in the upper end of the basin. The Atwood Lake basin drains about 70 square miles of forest and farmland, with Carrollton in its headwaters. Shale gas extraction is a significant industry in the watershed. The authorized project purposes of the lake are flood control, fish and wildlife, and recreation. The lake has a maximum depth of 42 feet with an average residence time of 113 days.

HISTORICAL WATERSHED CONCERNS: Resource extraction, agriculture, and poor land management are the primary sources of watershed degradation resulting in:

- Elevated levels of aluminum, manganese, iron, specific conductance, and sulfates
- Elevated levels of nutrients

2021 ACTIVITIES: There were six sampling events in the 2021 sampling season. All six events included collecting YSI ambient readings as well as water chemistry parameters. These events include routine water quality sampling of Atwood Lake, select inflows, and the outflow. Macroinvertebrate community samples were collected at two locations. Invertebrate community index (ICI) scores for ATI0014 and ATI0021 were both low fair (18), indicating an somewhat impaired aquatic macroinvertebrate community at these locations. Fish surveys were also conducted at ATI0021. This site received an IBI score of 33 (fair). *NEXT SAMPLING YEAR: 2026*

ADDITIONAL INFORMATION: Similar to Tappan Lake in 2015, structural modifications are scheduled for the outlet structures at Atwood Lake. The purpose of this trash rack modification is to minimize the release of hydrogen sulfide gas that is produced from outflow water originating in the hypolimnion. Additionally, increased phosphorus and nitrogen inputs from the inflows are being passed into the tailwaters without being buffered by the lake. Atwood Lake scored 50 for average TSI in 2021, which is categorized as eutrophic.

Trophic State Index (TSI) is an assessment of the level of productivity in a waterbody based on Secchi disk measurements and chlorophyll and total phosphorus concentrations in the water column. Atwood Lake scored 50 for average TSI in 2021, which is categorized as eutrophic. Eutrophic lakes are usually characterized by having low clarity, high nutrients, and high algal growth.

Table 16. Atwood Lake samples exceeding state criteria and/or District levels of concern in 2016.

STATION	STATION TYPE	STREAM NAME	ANALYTES W/ELEVATED CONCENTRATIONS	NUMBER OF RESULTS THAT EXCEED SCREENING VALUE	EXCEEDED APPLICABLE NATIVE STATE CRITERIA
ATI0001	Outflow	Indian Fork	Iron, Total	3	NONE
			Kjeldahl Nitrogen, Total	7	NONE
			Manganese, Total	3	NONE
			Oxygen, Dissolved	1	NONE
			Phosphorus, Total	2	NONE
ATI0002	Lake	Indian Fork	Aluminum	1	NONE
			pH	3	YES
			Phosphorus, Total	2	NONE
ATI0003	Inflow	Indian Fork	Aluminum	1	NONE
			Kjeldahl Nitrogen, Total	5	NONE
			Phosphorus, Total	7	NONE
			Specific Conductance	4	NONE
			Strontium, Total	1	NONE
ATI0014	Inflow	Grapevine Creek	Aluminum	3	NONE
			Iron, Total	1	NONE
			Kjeldahl Nitrogen, Total	2	NONE
			Phosphorus, Total	5	NONE
			Strontium, Total	2	NONE
ATI0021	Inflow	Indian Fork UT	Bromide, Total	3	NONE
			Iron, Total	1	NONE
			Kjeldahl Nitrogen, Total	2	NONE
			Phosphorus, Total	3	NONE
			Specific Conductance	3	NONE
			Strontium, Total	5	NONE

Based on the most recent water quality sampling and analysis, some water quality constituents exceed District levels of concern, but are within historical ranges. Constituents exceeding levels of concern include aluminum, iron, total Kjeldahl nitrogen, total phosphorus, and specific conductance. Degraded water quality conditions in the lake have resulted in discussions regarding the conversion of Beach City Dam into a dry dam that is impounded only when necessary. No other known operational changes can be made at this current time to mitigate elevated levels of pollutants from the inflow streams. Elevated constituent levels will be reported to the Ohio Environmental Protection Agency to facilitate potential mitigation efforts by the state.

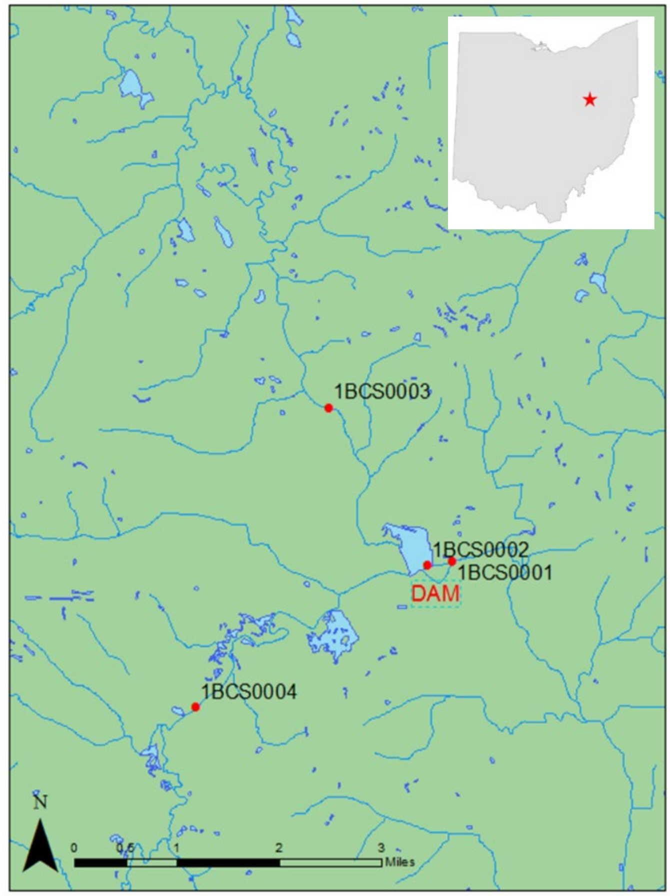


Figure 36. Water quality sampling locations for Beach City Lake in 2017.

WATERSHED SUMMARY: Beach City Dam is located in Tuscarawas County, Ohio, on Sugar Creek, a tributary of the Tuscarawas River in the Muskingum River basin. It is 180 miles upstream of the confluence of the Muskingum and Ohio Rivers at Marietta, Ohio. Beach City Lake has a drainage area of 300 square miles. The lake project's authorized purposes include flood control, recreation, and fish and wildlife conservation. Due to the small size of the impoundment, the hydraulic residence time of the lake averages 0.1 days. The watershed is dominated by agriculture. With a maximum depth of only 18 feet, nearly the entire conservation pool for Beach City has been lost due to sedimentation.

HISTORICAL CONCERNS: Agriculture and poor land management are the primary sources of watershed degradation resulting in:

- Excessive turbidity and sedimentation
- Increased nutrient concentrations
- Increased temperature and frequency of harmful algal blooms

2017 ACTIVITIES: There were five sampling events in the 2017 sampling season. These events included collection of routine water samples from Beach City Lake (only 4 of 5 events), select inflows (all events), and the outflow (all events). Water samples were analyzed for a pre-determined suite of chemical analytes and chlorophyll a, b, and c. Physical water quality measurements were collected simultaneously using a multiparameter datasonde during all five sampling events. No benthic macroinvertebrate or fish samples were collected in 2017 due to staffing limitations. *NEXT SAMPLING YEAR: 2022*

ADDITIONAL INFORMATION: Inflow water into Beach City Lake is characteristic of the calcareous nature of the watershed. Ionic concentrations and buffering capacity (alkalinity) are high. Nutrient levels are fairly high, but over productivity seems to be kept in check by pollution sources. Beach City Lake receives domestic pollution from the Sugar Creek Waste Water Treatment Plant and non-point discharges from agricultural runoff. In the upper reaches of Sugar Creek there are several food processors and clay mining operations which may contribute to the low pH and other related problems. Continual sedimentation has resulted in a shallow impoundment, increased sunlight penetration, increased temperatures, and more frequent HABs. Beach City provides little recreational value due to a diminished conservation pool as a result of significant sedimentation. It is recommended that USACE and MWCD coordinate to convert Beach City into a dry dam which in turn would likely mitigate water quality issues in the lake. As a dry dam

Beach City would be impounded only during high water events to reduce downstream flooding; however, conservation pool would be lost completely.

Trophic State Index (TSI) is an assessment of the level of productivity in a waterbody based on Secchi disk measurements and chlorophyll and total phosphorus concentrations in the water column. A TSI score has not been calculated for Beach City Lake.

Table 17. Beach City Lake samples exceeding state criteria and/or District levels of concern in 2017.

STATION	STATION TYPE	STREAM NAME	ANALYTES W/ELEVATED CONCENTRATIONS	NUMBER OF SAMPLES EXCEEDING SCREENING VALUE	EXCEEDED APPLICABLE NATIVE STATE CRITERIA
1BCS0001	Outflow	Sugar Creek	Aluminum, Total	1	NONE
			Iron, Total	1	NONE
			Kjeldahl Nitrogen, Total	1	NONE
			Phosphorus, Total	1	NONE
			Specific Conductance	1	NONE
1BCS0002	Lake	Beach City Lake	Specific Conductance	3	NONE
1BCS0003	Inflow	Sugar Creek	Aluminum, Total	1	NONE
			Iron, Total	1	NONE
			Kjeldahl Nitrogen, Total	1	NONE
			Phosphorus, Total	1	NONE
			Specific Conductance	1	NONE
1BCS0004	Inflow	South Fork of Sugar Creek	Aluminum, Total	1	NONE
			Iron, Total	1	NONE
			Kjeldahl Nitrogen, Total	1	NONE
			Phosphorus, Total	1	NONE
			Specific Conductance	1	NONE

Based on the most recent water quality sampling and analysis, some water quality constituents exceed District levels of concern, but are within historical ranges. Constituents exceeding levels of concern include aluminum, specific conductance, dissolved oxygen, iron, manganese, phosphorus, and TKN; new to 2021, strontium exceeded once at BBF0108. No known operational changes can be made at this current time to mitigate elevated levels from the inflow streams. Elevated constituent levels will be reported to the West Virginia Department of Environmental Protection to facilitate potential mitigation efforts by the state.

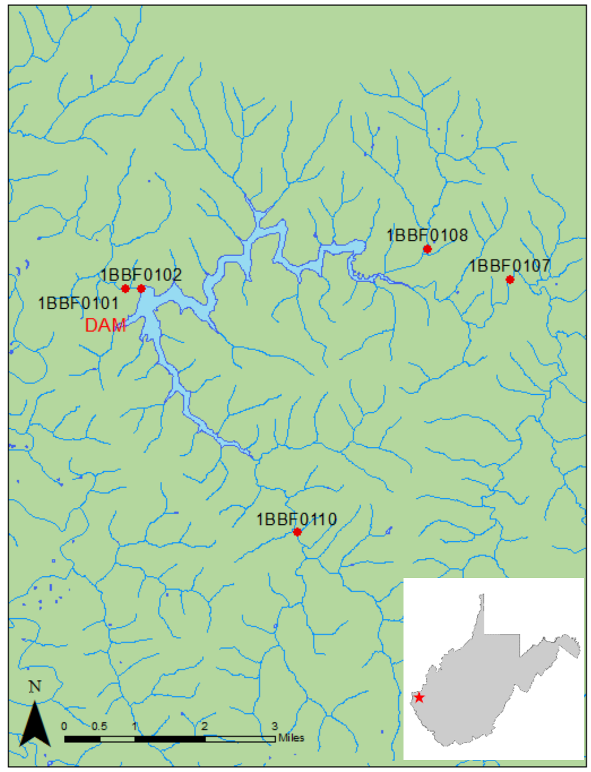


Figure 37. Water quality sampling locations for Beech Fork Lake in 2021.

WATERSHED SUMMARY: Beech Fork Lake is located in Wayne and Cabell Counties in western West Virginia. The authorized project purposes for Beech Fork Lake are flood control, recreation, enhanced recreation (whitewater), fish and wildlife conservation, and water quality control. The Beech Fork drainage basin is roughly 78 square miles of mountains and rugged hills. Beech Fork is a small tributary of Twelvepole Creek and the largest tributary of Beech Fork is Millers Fork, which drains about 26% of the area within the Beech Fork basin. The maximum depth of the lake is 40 feet with an average residence time of approximately 40 days.

HISTORICAL CONCERNS: Agriculture, silviculture and poor land management are the primary sources of watershed degradation resulting in:

- Excessive turbidity and sedimentation

2021 ACTIVITIES: There were six sampling events in the 2021 sampling season. All six events included collecting YSI ambient readings as well as water chemistry parameters. These events include routine water quality sampling of Beech Fork Lake, select inflows, and the outflow. Macroinvertebrate community samples and fish surveys were collected at four locations. The Kentucky Index of Biotic Integrity (KYIBI) was used because West Virginia does not have an IBI for fish. The KYIBI is the most compatible with West Virginia streams in the Huntington District.

West Virginia Stream Condition Index (WVSCI) scores: BBF0101 – 59.4 (slightly impaired), BBF0107 – 69.4 (unimpaired-good), BBF0108 – 63 (impaired-gray zone), and BBF0110 69.6 (unimpaired-good).

Kentucky Index of Biotic Integrity (KYIBI) Scores: 1BBF0101 – 47 (Fair), 1BBF0107 – 47 (Fair),

1BBF0108 – 61 (Fair/Good), 1BBF0110 - 63 (Good).

NEXT SAMPLING YEAR: 2026

ADDITIONAL INFORMATION: Fine suspended sediments block light penetration throughout the lake reducing the depth of the epilimnion and decreasing primary production. Decreased primary production limits food sources for fish, and as a result, the sport fishery in Beech Fork Lake is negatively impacted. Marshall University is in the early stages of developing a study to determine the causes and impacts of the high levels of suspended sediments in the lake.

Trophic State Index (TSI) is an assessment of the level of productivity in a waterbody based on Secchi disk measurements and chlorophyll and total phosphorus concentrations in the water column. Beech Fork Lake scored 50 for average TSI in 2021, which is categorized as eutrophic. Eutrophic lakes are usually characterized by having low clarity, high nutrients, and high algal growth.

Table 18. Beech Fork Lake samples exceeding state criteria and/or District levels of concern in 2021.

STATION	STATION TYPE	STREAM NAME	ANALYTES W/ELEVATED CONCENTRATIONS	NUMBER OF SAMPLES EXCEEDING SCREENING VALUE	EXCEEDED APPLICABLE NATIVE STATE CRITERIA
BBF0101	Outflow	Beech Fork	Aluminum, Total	7	7
			Iron, Total	9	5
			Kjeldahl Nitrogen, Total	3	NONE
			Manganese, Total	2	NONE
			Phosphorus, Total	1	NONE
BBF0102	Lake	Beech Fork Lake	Aluminum, Total	3	3
			Kjeldahl Nitrogen, Total	1	NONE
			Iron, Total	8	6
			Phosphorus, Total	1	NONE
BBF0107	Inflow	Beech Fork	Aluminum, Total	3	3
			Iron, Total	3	3
			Kjeldahl Nitrogen, Total	1	NONE
			Phosphorus, Total	3	NONE
BBF0108	Inflow	Long Branch	Aluminum, Total	4	4
			Iron, Total	4	2
			Phosphorus, Total	2	NONE
			Strontium	1	NONE
BBF0110	Inflow	Millers Fork	Aluminum, Total	3	3
			Iron, Total	3	1
			Kjeldahl Nitrogen, Total	1	NONE
			Phosphorus, Total	1	NONE

Based on the most recent water quality sampling and analysis, some water quality constituents exceed District levels of concern. Constituents exceeding levels of concern include aluminum, iron, total Kjeldahl nitrogen, strontium, and phosphorus. High nutrient loadings from the watershed have the potential to exacerbate algal blooms. No known operational changes can be made at this current time to mitigate elevated levels from the inflow streams. Elevated constituent levels will be reported to the West Virginia Department of Environmental Protection to facilitate potential mitigation efforts by the state.

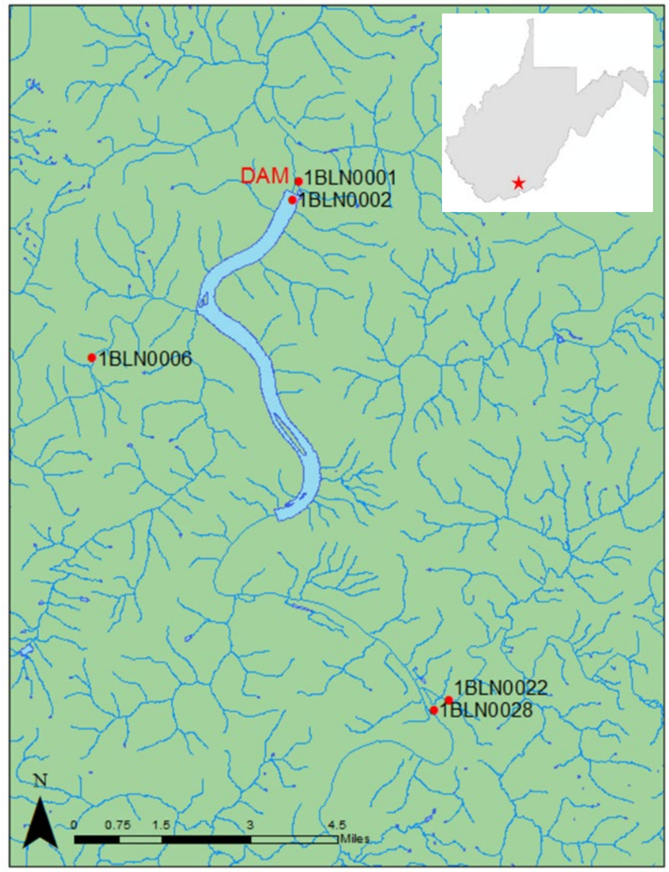


Figure 38. Water quality sampling locations for Bluestone Lake in 2017.

WATERSHED SUMMARY: Bluestone Lake is located in Summers County, West Virginia. The dam is located on the New River, a tributary of the Kanawha River, 162 miles upstream of its confluence with the Ohio River in Pt. Pleasant, West Virginia. Bluestone Lake has the largest drainage area in the Huntington District at 4,565 square miles. The lake project's authorized purposes include flood control, hydroelectric power, recreation, enhanced recreation (whitewater), low flow augmentation, and fish and wildlife conservation. The lake has a maximum depth of 42 feet with a hydraulic residence time averaging 2 days. The watershed is dominated by forested lands. The section of the river just downstream of Bluestone Dam is known as the "Miracle Mile" because it provides one of the best wadeable, large river, smallmouth bass fisheries for anglers. This section is also considered irreplaceable habitat according to the US Fish and Wildlife Service as a result of its rocky habitat and high water quality.

HISTORICAL CONCERNS: Mining, timbering, and poor land management are the primary sources of watershed degradation resulting in:

- Excessive turbidity and sedimentation

2017 ACTIVITIES: There were six sampling events in the 2017 sampling season. These events included collection of routine water samples from Bluestone Lake (only 4 of 6 events), select inflows (all events), and the outflow (all events). Samples were collected from the epilimnion, metalimnion, and hypolimnion during each lake sampling event. Water samples were analyzed for a pre-determined suite of chemical analytes and chlorophyll *a*, *b*, and *c*. Physical water quality measurements were collected simultaneously using a multiparameter datasonde during all six sampling events. No benthic macroinvertebrate or fish samples were collected in 2017 due to staffing limitations. *NEXT SAMPLING YEAR: 2022*

ADDITIONAL INFORMATION: Excessive productivity is the most significant problem in Bluestone Lake. High nutrient loadings from the watershed were the result of both point and non-point source loadings.

Trophic State Index (TSI) is an assessment of the level of productivity in a waterbody based on Secchi disk measurements and chlorophyll and total phosphorus concentrations in the water column. A TSI score has not been calculated for Bluestone Lake.

Table 19. Bluestone Lake samples exceeding state criteria and/or District levels of concern in 2017.

STATION	STATION TYPE	STREAM NAME	ANALYTES W/ELEVATED CONCENTRATIONS	NUMBER OF SAMPLES EXCEEDING SCREENING VALUE	EXCEEDED APPLICABLE NATIVE STATE CRITERIA
1BLN0001	Outflow	New River	None	-	-
1BLN0002	Lake	New River	Total Kjeldahl Nitrogen	2	NONE
			Phosphorus, total	9	9
1BLN0006	Inflow	Bluestone River	Aluminum, total	1	1
			Iron, total	1	1
			Strontium, total	1	-
			Total Kjeldahl Nitrogen	1	-
			Phosphorus, total	4	4
1BLN00022	Inflow	Indian Creek	Aluminum, Total	1	1
			Iron, Total	1	0
			Phosphorus, Total	1	NONE
1BLN00028	Inflow	New River	Phosphorus, Total	2	NONE

Based on the most recent water quality sampling and analysis, some water quality constituents exceed District levels of concern, but are within historical ranges. Constituents exceeding levels of concern include aluminum, iron, and total Kjeldahl nitrogen. No known operational changes can be made at this current time to mitigate elevated levels from the inflow streams. Elevated constituent levels will be reported to the West Virginia Department of Environmental Protection to facilitate potential mitigation efforts by the state. Burnsville Lake's watershed has seen an increase in hydraulic fracturing for oil and gas which could alter water quality.

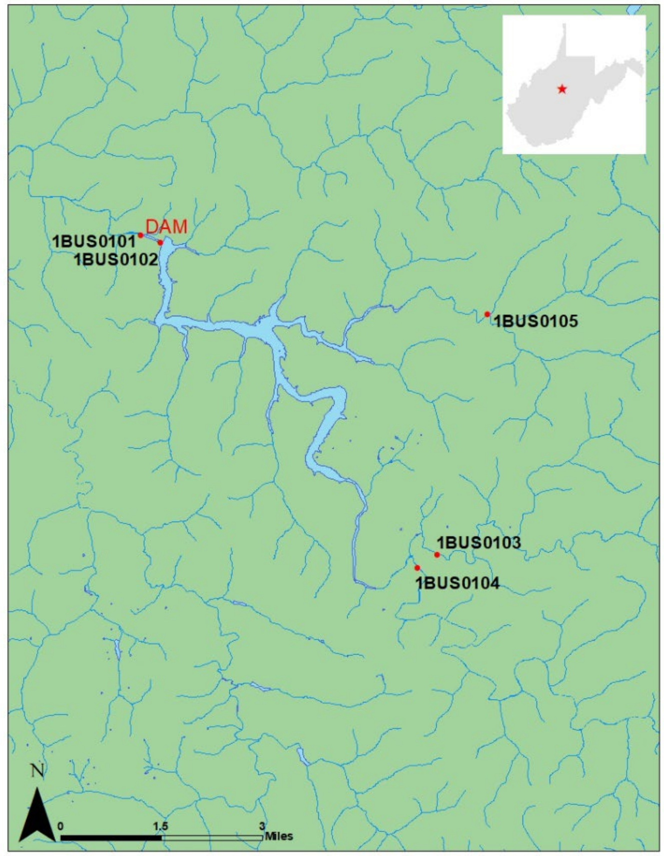


Figure 39. Water quality sampling locations for Burnsville Lake in 2017.

WATERSHED SUMMARY: Burnsville Lake is located in Braxton County, West Virginia. The dam is on the Little Kanawha River, 124 miles upstream of its confluence with the Ohio River. The drainage area of the impoundment is 165 square miles. The lake project's authorized purposes include flood control, recreation, enhanced recreation (whitewater), water quality, and fish and wildlife conservation. The lake has a maximum depth of 34 feet with a hydraulic residence time averaging 23 days. The land use of the watershed is dominated by forested land, but hydraulic fracturing is an emerging concern. Water quality in the basin is generally favorable but could be impacted by an increase in local oil and gas extraction.

HISTORICAL CONCERNS: Mining and oil and gas extraction are the primary sources of watershed degradation resulting in:

- Excessive turbidity and sedimentation
- Elevated levels of specific conductance, sulfates, chlorides, and metals

2017 ACTIVITIES: There were six sampling events in the 2017 sampling season. These events included collection of routine water samples from Burnsville Lake (only 4 of 6 events), select inflows (all events), and the outflow (all events). Samples were collected from the epilimnion, metalimnion, and hypolimnion during each lake sampling event. Water samples were analyzed for a pre-determined suite of chemical analytes and chlorophyll *a*, *b*, and *c*. Physical water quality measurements were collected simultaneously using a multiparameter datasonde during all six sampling events. No benthic macroinvertebrate or fish samples were collected in 2017 due to staffing limitations. *NEXT SAMPLING YEAR: 2022*

ADDITIONAL INFORMATION: Burnsville Lake stratifies seasonally with warm, oxygenated water on the top of the lake and cold, de-oxygenated water on the bottom of the lake. The Little Kanawha River watershed has very good water quality. In addition, Burnsville Lake has a selective withdrawal outflow that allows it to regulate the downstream water temperature and oxygen levels. As a result, the downstream reaches of the Little Kanawha River are home to endangered mussels and a very diverse fishery. However, increased gas extraction could negatively affect the water resources in the watershed.

Trophic State Index (TSI) is an assessment of the level of productivity in a waterbody based on Secchi disk measurements and chlorophyll and total phosphorus concentrations in the water column. A TSI score has not been calculated for Burnsville Lake.

Table 20. Burnsville Lake samples exceeding state criteria and/or District levels of concern in 2017.

STATION	STATION TYPE	STREAM NAME	ANALYTES W/ELEVATED CONCENTRATIONS	NUMBER OF SAMPLES EXCEEDING SCREENING VALUE	EXCEEDED APPLICABLE NATIVE STATE CRITERIA
1BUS0101	Outflow	Little Kanawha River	Aluminum, Total	1	1
1BUS0102	Lake	Little Kanawha River	Iron, total Total Kjeldahl Nitrogen	4 4	4 NONE
1BUS0103	Inflow	Falls Run	None	-	-
1BUS0104	Inflow	Little Kanawha River	None	-	-
1BUS0105	Inflow	Knawl Creek	None	-	-

Based on the most recent water quality sampling and analysis, some water quality constituents exceed District levels of concern. Constituents exceeding levels of concern include, aluminum, dissolved oxygen, iron, pH, phosphorus, specific conductance, strontium, and TKN. New for 2021, Aluminum exceeded levels of concern at CBM0001 (4x), CMB0002 (2x), and CMB0011 (1x). No known operational changes can be made at this time to mitigate elevated levels from the inflow streams. Elevated constituent levels will be reported to the Ohio Environmental Protection Agency to facilitate potential mitigation efforts by the state.

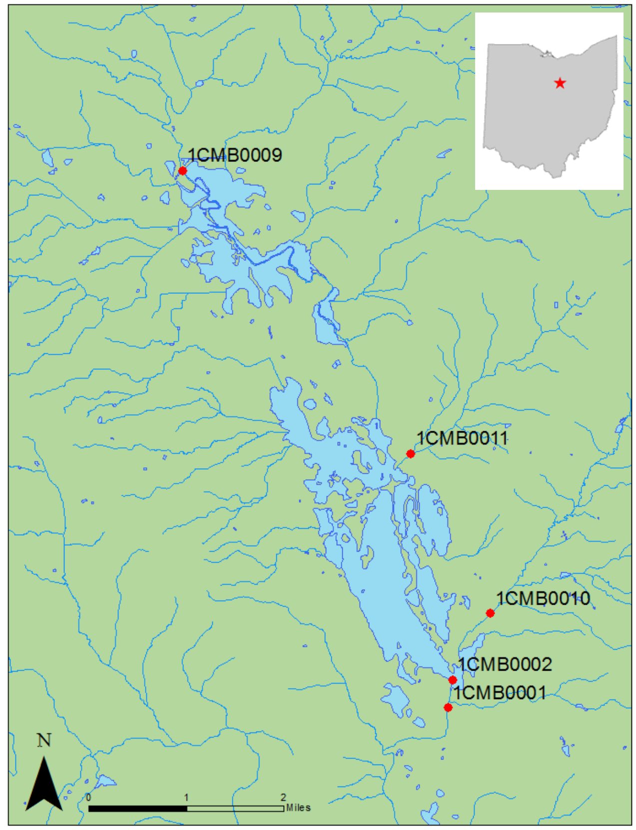


Figure 40. Water quality sampling locations for Charles Mill Lake in 2021.

WATERSHED SUMMARY: Charles Mill Lake is located in Ashland and Richland Counties in northeastern Ohio. The Black Fork of the Mohican River is the main stream in this 215 square mile, crescent shaped basin. The authorized purposes of this project are flood control and fish and wildlife enhancement. The Black Fork is one of the three main forks of the Mohican River, which combines with the Kokosing River to form the Walhonding River. The watershed is mainly comprised of woodland and farmland with little industry located within the basin. The lake has a maximum depth of 17 feet and an average residence time of approximately 12 days.

HITORICAL CONCERNS: Agriculture and poor land management are primary sources of watershed degradation resulting in:

- Excessive turbidity and sedimentation
- Increased nutrient concentrations

2021 ACTIVITIES: There were six sampling events in the 2021 sampling season. All six events included collecting YSI ambient readings as well as water chemistry parameters. These events include routine water quality sampling of Charles Mill Lake, select inflows, and the outflow. Macroinvertebrate community samples were collected at one location (Table 13). Invertebrate community index (ICI) scores for CMB0009 and CMB0009 was low-fair (16), indicating an somewhat impaired aquatic macroinvertebrate community. Fish surveys were also conducted at one site CMB0011. It received a score of 34 (fair).

NEXT SAMPLING YEAR: 2026

ADDITIONAL INFORMATION: Concentrations of TKN, phosphorus, and specific conductance have been steadily increasing since 1985. Charles Mill Lake scored 77 for average TSI in 2021, which is categorized as hypereutrophic. Hypereutrophic lakes are usually characterized by having the lowest clarity, highest nutrients, and highest algal growth.

Table 21. Charles Mill Lake samples exceeding state criteria and/or District levels of concern in 2021.

STATION	STATION TYPE	STREAM NAME	ANALYTES W/ELEVATED CONCENTRATIONS	NUMBER OF SAMPLES EXCEEDING SCREENING VALUE	EXCEEDED APPLICABLE NATIVE STATE CRITERIA
CMB0001	Outflow	Black Fork Mohican River	Aluminum, Total	4	NONE
			Iron, Total	5	NONE

STATION	STATION TYPE	STREAM NAME	ANALYTES W/ELEVATED CONCENTRATIONS	NUMBER OF SAMPLES EXCEEDING SCREENING VALUE	EXCEEDED APPLICABLE NATIVE STATE CRITERIA
			Kjeldahl Nitrogen, Total	7	NONE
			Phosphorus, Total	6	NONE
			Strontium, Total	9	NONE
CMB0002	Lake	Charles Mill Lake	Aluminum, Total	2	NONE
			Iron, Total	5	NONE
			Kjeldahl Nitrogen, Total	4	NONE
			Phosphorus, Total	4	NONE
			Strontium, Total	8	NONE
CMB0009	Inflow	Black Fork Mohican River	Aluminum, Total	6	NONE
			Iron, Total	6	NONE
			Kjeldahl Nitrogen, Total	5	NONE
			Oxygen, Dissolved	3	NONE
			Phosphorus, Total	5	NONE
			Specific Conductance	4	NONE
			Strontium, Total	5	NONE
CMB0010	Inflow	Ruffner Run	Phosphorus, Total	1	NONE
CMB0011	Inflow	Seymour Run	Aluminum, Total	1	NONE
			Iron, Total	1	NONE
			Kjeldahl Nitrogen, Total	1	NONE
			Phosphorus, Total	1	NONE
			Specific Conductance	1	NONE

Based on the most recent water quality sampling and analysis, some water quality constituents exceed District levels of concern, but are within historical ranges. Constituents exceeding levels of concern include specific conductance, iron, strontium, sulfates, phosphorus, and total Kjeldahl nitrogen. Elevated constituent levels will be reported to the Ohio Environmental Protection Agency to facilitate potential mitigation efforts by the state. Data analysis revealed that a structural modification completed in 2017 minimized hydrogen sulfide gas emissions, increased dissolved oxygen, and decreased dissolved metals in the outflow, improving overall water quality to the downstream area.

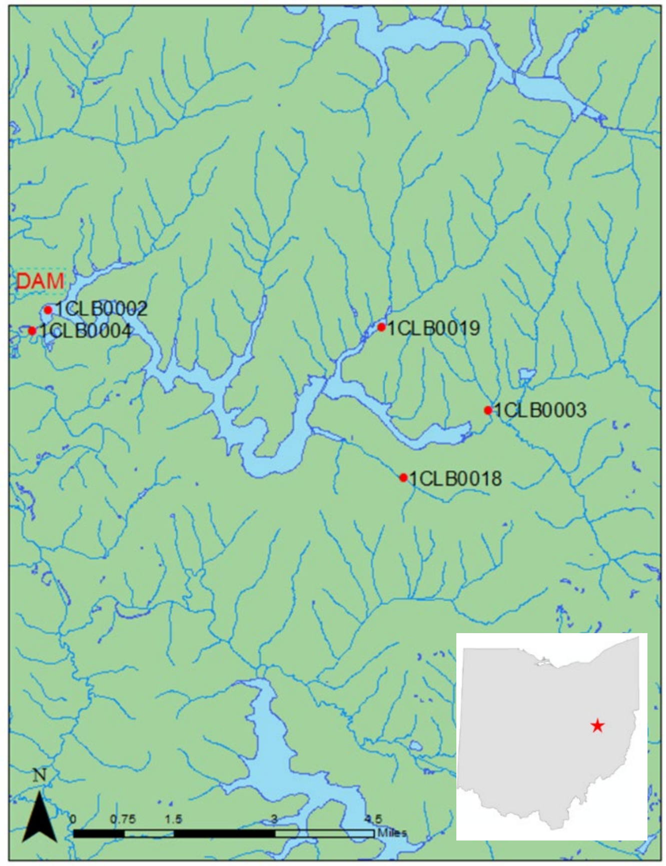


Figure 41. Water quality sampling locations for Clendening Lake in 2013.

WATERSHED SUMMARY: Clendening Lake is located in Harrison County, Ohio. The dam is located on Brushy Fork of Stillwater Creek, which is a tributary of the Tuscarawas River in the Muskingum River basin. Clendening Dam is 184 miles upstream of the confluence of the Muskingum River with the Ohio River. Clendening Lake has a drainage of 69 square miles. The lake project's authorized purposes include flood control, recreation, and fish and wildlife conservation. The lake has a maximum depth of 40 feet with a hydraulic residence time averaging 129 days. The watershed is dominated by agriculture, forest, and surface mining.

HISTORICAL CONCERNS: Mining and agriculture are the primary sources of watershed degradation resulting in:

- Elevated levels of sedimentation, specific conductance, sulfates, chlorides, and metals
- Dangerous emissions of hydrogen sulfide gas from the outlet structure

2018 ACTIVITIES: Five sampling events were conducted in the Clendening Lake watershed in 2018. High flows prevented collection of the late summer/early fall sample. Three major inflow streams and the outflow were sampled five times each. The lake was sampled four times during stratification at the primary lake station near the dam. All sampling events included the collection of physical water quality parameters via data sonde as well as water sample collection for a predetermined suite of water chemistry parameters. Each lake sampling event included an epilimnion, metalimnion, and hypolimnion sample with the addition of chlorophyll and dissolved metals analyses. Filtered samples were also collected at the outflow site during lake stratification to be analyzed for dissolved metals. No benthic macroinvertebrate sampling was conducted due to staffing limitations and high flows during the index period. Clendening Lake is scheduled to be intensively sampled again in fiscal year 2023

ADDITIONAL INFORMATION: In the fall of 2017 the intake structure at Clendening Lake was retrofitted with a steel plate that allowed high quality surface water to be discharged downstream, with the intention of mitigating long-standing problems caused by hydrogen sulfide (H_2S) gas releases. As part of an ongoing study of the intake modification, vertical water quality profiles were collected throughout the lake in the summer of 2018 to identify any post-modification impacts to the downstream and/or lake fishery. A continuous monitoring buoy was also deployed at the dam site, which collected physical water quality data during the summer and early fall. Subsequent data analysis has shown no negative impacts to the downstream and/or lake fisheries at Clendening Lake, and overall water quality has significantly improved in the tailwaters. See the Muskingum Area Structural Modification Impact Study Section or Appendix B for more information.

Trend analysis revealed that increased phosphorus and nitrogen inputs from the inflows were being passed into the tailwaters without being buffered by the lake. Elevated levels of nutrients in a waterbody are thought to increase the occurrence of harmful algae blooms (HABs). HABs are comprised of toxin-producing cyanobacteria that can threaten human and animal health, recreation, and drinking water supplies. Other constituents exceeding levels of concern included specific conductance, iron, strontium, and sulfates. Elevated constituent levels will be reported to the Ohio Environmental Protection Agency to facilitate potential mitigation efforts by the state.

Elevated levels of ions (such as calcium, magnesium, sulfate, etc.) and strontium were observed in Brushy Fork at site 1CLB0003, the main tributary to Clendening Lake, during the July and August sampling events. Flows were low during these sampling events, during which conditions dissolved constituents become more concentrated. This is further demonstrated by elevated specific conductance and total dissolved solids levels. Otherwise water chemistry analyses revealed no new concerns.

Trophic State Index (TSI) is an assessment of the level of productivity in a waterbody based on Secchi disk measurements and chlorophyll and total phosphorus concentrations in the water column. A TSI score has not been calculated for Clendening Lake.

Table 22. Clendening Lake samples exceeding state criteria and/or District levels of concern in 2018.

STATION	STATION TYPE	STREAM NAME	ANALYTES W/ELEVATED CONCENTRATIONS	NUMBER OF SAMPLES EXCEEDING SCREENING VALUE	EXCEEDED APPLICABLE NATIVE STATE CRITERIA
1CLB0002	Lake	Brushy Fork of Stillwater	Kjeldahl Nitrogen, Total	2	NONE
			Sp. Conductance	3	NONE
			Strontium	3	NONE
			Sulfate	3	NONE
1CLB0003	Inflow	Brushy Fork of Stillwater	Iron	2	NONE
			Specific Conductance	8	NONE
			Strontium	5	NONE
			Sulfate	6	NONE
			Kjeldahl Nitrogen, Total	2	NONE
			Phosphorus, Total	2	NONE
1CLB0004	Outflow	Brushy Fork of Stillwater	Kjeldahl Nitrogen, Total	5	NONE
			Phosphorus	3	NONE
			Sp. Conductance	5	NONE
			Strontium	5	NONE
			Sulfate	5	NONE
1CLB0018	Inflow	Huff Run of Brushy Fork	Kjeldahl Nitrogen, Total	1	NONE
			Phosphorus	1	NONE
			Specific Conductance	3	NONE
			Strontium	3	NONE
1CLB0019	Inflow	McFadden Run of Brushy Fork	Iron	1	NONE
			Phosphorus	1	NONE

Based on the most recent water quality sampling and analysis, some water quality constituents exceed District levels of concern including dissolved oxygen, iron, phosphorus, strontium, specific conductivity, aluminum, and total Kjeldahl nitrogen. No known operational changes can be made at this time to mitigate elevated levels from the inflow streams. Elevated constituent levels will be reported to the Ohio Environmental Protection Agency to facilitate potential mitigation efforts by the state. The Deer Creek inflow scored a 47 on the Ohio IBI, which is a rating of "good", and a 1.66 on the Shannon Index. The Deer Creek outflow scored a 36 on the Ohio IBI, which is a rating of "good", and a 0.49 on the Shannon Index.

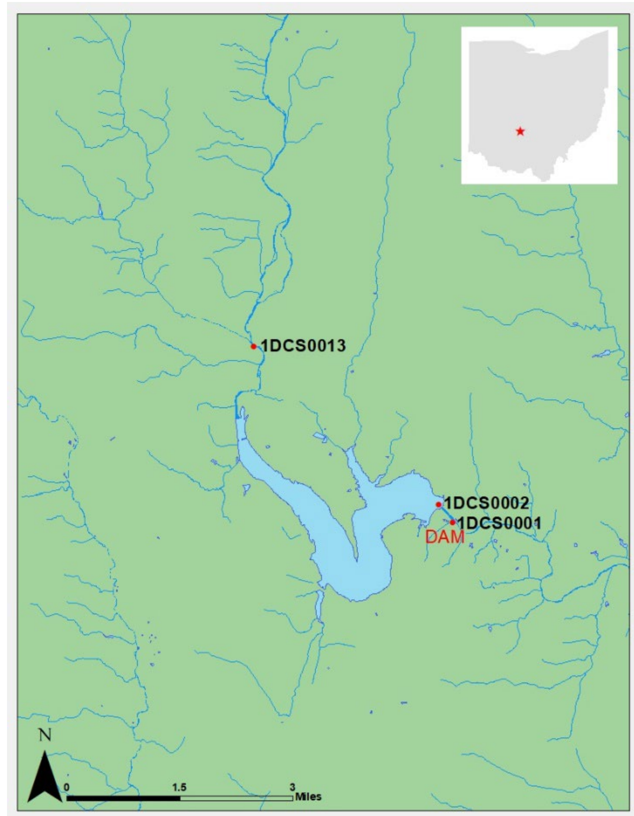


Figure 42. Water quality sampling locations for Deer Creek Lake in 2019.

WATERSHED SUMMARY: Deer Creek Lake is located in Pickaway and Fayette Counties, Ohio in a 277 square mile watershed. Major land uses are agriculture with light residential use. The lake is considered eutrophic with high productivity. Surface waters are considered hard with high sulfate concentrations creating an ionic imbalance. The lake's authorized project purposes are flood control, recreation, fish and wildlife conservation and low flow augmentation. The lake has a maximum depth of 40 feet with an average retention time of 51 days.

HISTORICAL CONCERNS: Agriculture and poor land management are the primary sources of watershed degradation resulting in:

- Excessive turbidity and sedimentation
- Increased concentrations of strontium and nutrients
- Increased risk of harmful algae blooms in the lake

2019 ACTIVITIES: Six sampling events were conducted in the Deer Creek Lake watershed in 2019. One major inflow stream and the outflow were sampled six times each. The lake was sampled three times during stratification at the primary lake station near the dam. A lake sampling event was missed in June due to a flooding event during which the lake was closed to boaters. All sampling events included the collection of physical water quality parameters via data sonde as well as water sample collection for a predetermined suite of water chemistry parameters. Each lake sampling event included an epilimnion, metalimnion, and hypolimnion sample with the addition of chlorophyll and dissolved metals analyses. Filtered samples were also collected at the outflow site during lake stratification to be analyzed for dissolved metals. Benthic macroinvertebrate sampling was conducted at DCS0001 and DCS0013, but no analysis has been performed. Deer Creek Lake is scheduled to be intensively sampled again in fiscal year 2024. Fish community surveys were conducted at the inflow and outflow sites.

OBSERVED WATER QUALITY CONCERNS: Water quality analysis revealed high inputs of TKN, phosphorus, and strontium into the lake from the primary inflow. During one sampling trip the inflow streams exceeded the aluminum and iron thresholds, however this was an isolated incident due to a flooding event. Water quality data from the outflow reveals many of the same concerns as the inflows. In many instances the outflow concentrations are higher, whereas in other instances the lake is acting as a water quality buffer. Concentrations of sulfate appear to be on a downward trend, which is reflected in a slight downward trend in specific conductance. Conversely, concentrations of phosphorus appear to be on an upward trend with many values above historical ranges. Strontium continues to be at elevated levels, but concentrations are within historical ranges at a stable trend.

Fish community surveys were completed at the Deer Creek inflow and lake outflow. The Deer Creek inflow scored a 47 on the Ohio IBI, which is a rating of “good”, and a 1.66 on the Shannon Index. The Deer Creek outflow scored a 36 on the Ohio IBI, which is a rating of “good”, and a 0.49 on the Shannon Index. Low dissolved oxygen levels at the time of survey could explain the lower score at the outflow.

ADDITIONAL INFORMATION: Deer Creek Lake has minimal flexibility for outflow water quality. A low flow valve is located at a lake elevation that provides oxygenated water in the early summer. In the late summer, the low flow valve exists in the hypolimnion and does not provide adequate oxygen to the tailwater. Project staff have developed an aerator that seats within a sluice gate and provides a source of valuable oxygenation to the tailwater.

All water quality concerns revealed in the most recent intensive surveys at DCS have been previously documented in the WCM with no new concerns surfacing. Active agricultural land use is most likely contributing the nutrients to the watershed through runoff of farm fields and over use of fertilizers. Increased nutrients from the inflows of Deer Creek Lake make it susceptible to harmful algal blooms. A HAB occurred in July of 2013 but did not result in any closures or impacts to recreation.

Trophic State Index (TSI) is an assessment of the level of productivity in a waterbody based on Secchi disk measurements and chlorophyll and total phosphorus concentrations in the water column. Deer Creek Lake scored 69 for average TSI in 2019, which is categorized as eutrophic. Eutrophic lakes are usually characterized by having low clarity, high nutrients, and high algal growth.

Table 23. Deer Creek Lake samples exceeding state criteria and/or District levels of concern in 2019.

STATION	STATION STYPE	STREAM NAME	ANALYTES W/ELEVATED CONCENTRATIONS	NUMBER OF SAMPLES EXCEEDING SCREENING VALUE	EXCEED NATIVE STATE CRITERIA
1DCS0001	Outflow	Deer Creek	Dissolved Oxygen	1	NONE
			Total Aluminum	2	NONE
			Total Iron	3	NONE
			TKN	6	NONE
			Total Phosphorus	6	NONE
			Sp. Conductance	4	NONE
			Total Strontium	6	NONE
1DCS0002	Lake	Deer Creek	Total Iron	1	NONE
			TKN	9	NONE
			Total Phosphorus	9	NONE
			Total Strontium	9	NONE
1DCS0013	Inflow	Deer Creek	Total Aluminum	1	NONE
			Total Iron	1	NONE
			TKN	2	NONE
			Total Phosphorus	6	NONE
			Sp. Conductance	5	NONE
			Total Strontium	6	NONE

Based on the most recent water quality sampling and analysis, some water quality constituents exceed District levels of concern including iron, strontium, aluminum, specific conductivity, phosphorus, and total Kjeldahl nitrogen. Nutrient levels in the lake and outflow were mostly above historical ranges, where as levels in the inflow streams were within historical ranges. Concentrations of sulfate appear to be on a downward trend, which is reflected in a slight downward trend in specific conductance. No known operational changes can be made at this time to mitigate elevated levels from the inflow streams. Elevated constituent levels will be reported to the Ohio Environmental Protection Agency to facilitate potential mitigation efforts by the state.

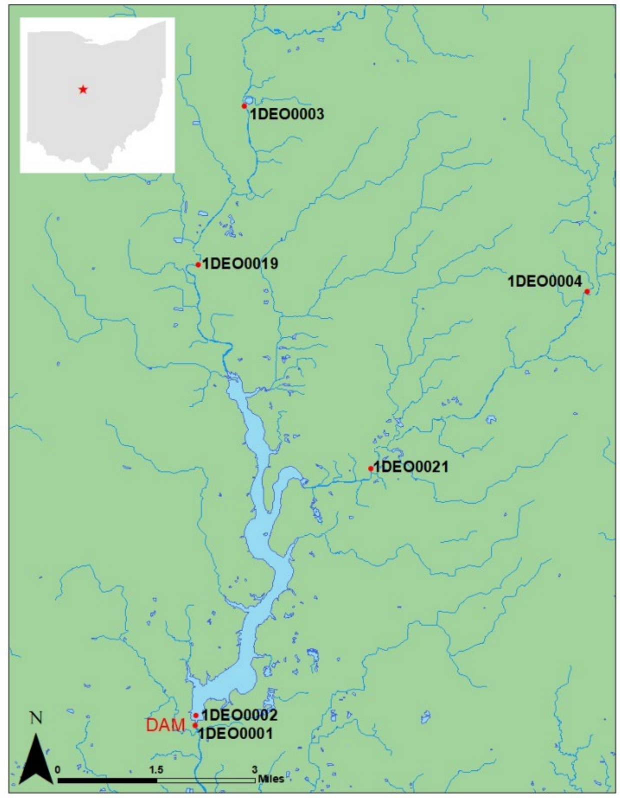


Figure 43. Water quality sampling locations for Delaware Lake in 2019.

WATERSHED SUMMARY: Delaware Lake is located in Delaware County, Ohio, on the Olentangy River, 32 miles upstream from the confluence with the Scioto River at Columbus, Ohio. Delaware Lake has a watershed size of 386 square miles. Land use in the basin is predominantly agricultural with some mining and quarrying. Moderate levels of nutrient concentrations in the basin result in normal productivity in the lake. Water hardness is classified as moderately hard. The purposes of the project are flood control, recreation, low flow augmentation and fish and wildlife conservation. The lake has a maximum depth of 35 feet and an average retention time of approximately 17 days.

HISTORICAL CONCERNS: Agriculture, mining/quarrying, and poor land management are the primary sources of watershed degradation resulting in:

- Excessive turbidity and sedimentation
- Increased concentrations of aluminum, manganese, iron, specific conductance, and sulfates
- Increased concentrations of nutrients

2019 ACTIVITIES: Six sampling events were conducted in the Delaware Lake watershed in 2019. Two major inflow streams and the outflow were sampled six times each. The lake was sampled three times during stratification at the primary lake station near the dam. During a flooding event in June the inflows had to be sampled further upstream at the historical sites and the lake was closed to boaters. All sampling events included the collection of physical water quality parameters via data sonde as well as water sample collection for a predetermined suite of water chemistry parameters. Each lake sampling event included an epilimnion, metalimnion, and hypolimnion sample with the addition of chlorophyll and dissolved metals analyses. Filtered samples were also collected at the outflow site during lake stratification to be analyzed for dissolved metals. Benthic macroinvertebrate sampling was conducted at DEO0019 and DEO0021, but no analysis has been performed. Delaware Lake is scheduled to be intensively sampled again in fiscal year 2024.

OBSERVED WATER QUALITY CONCERNS: Water quality analysis revealed high inputs of aluminum, iron, TKN, phosphorus, and strontium into the lake from the primary inflows, the Olentangy River (1DEO0003, 1DEO0019) and Whetstone Creek (1DEO0004, 1DEO0021). The outflow contained high levels of aluminum, iron, TKN, phosphorus, and strontium, indicating that the lake is not acting as a buffer to the above sources. Nutrient levels in the lake and outflow were mostly above historical ranges, where as levels in the inflow streams were within historical ranges. Concentrations of sulfate appear to be on a downward trend, which is reflected in a slight downward trend in specific conductance. All other consituents appear to be stable in the watershed.

ADDITIONAL INFORMATION:

All water quality concerns revealed in the most recent intensive surveys at DEO have been previously documented in the WCM with no new concerns surfacing. Active agricultural land use is most likely contributing the nutrients to the watershed through runoff of farm fields and poor administration of fertilizers, while resource extraction is contributing to the metals observed in water quality samples.

Trophic State Index (TSI) is an assessment of the level of productivity in a waterbody based on Secchi disk measurements and chlorophyll and total phosphorus concentrations in the water column. Delaware Lake scored 68 for average TSI in 2019, which is categorized as eutrophic. Eutrophic lakes are usually characterized by having low clarity, high nutrients, and high algal growth.

Table 24. Delaware Lake samples exceeding state criteria and/or District levels of concern in 2019.

STATION	STATION STYPE	STREAM NAME	ANALYTES W/ELEVATED CONCENTRATIONS	NUMBER OF SAMPLES EXCEEDING SCREENING VALUE	EXCEED NATIVE STATE CRITERIA
1DEO0001	Outflow	Olentangy River	Total Aluminum	5	NONE
			Total Iron	5	NONE
			TKN	6	NONE
			Total Phosphorus	6	NONE
			Total Strontium	5	NONE
1DEO0002	Lake	Olentangy River	Total Aluminum	3	NONE
			Total Iron	5	NONE
			TKN	9	NONE
			Total Phosphorus	9	NONE
			Total Strontium	9	NONE
1DEO0019 & 1DEO0003	Inflow	Olentangy River	Total Aluminum	4	NONE
			Total Iron	4	NONE
			TKN	6	NONE
			Total Phosphorus	6	NONE
			Sp. Conductance	2	NONE
			Total Strontium	5	NONE
1DEO0021 & 1DEO0004	Inflow	Whetstone Creek	Total Aluminum	2	NONE
			Total Iron	3	NONE
			TKN	5	NONE
			Total Phosphorus	5	NONE
			Sp. Conductance	4	NONE
			Total Strontium	6	NONE

Based on the most recent water quality sampling and analysis, some water quality constituents exceed District levels of concern, but are within historical ranges. Constituents exceeding levels of concern include specific conductance, aluminum, iron, total Kjeldahl nitrogen, strontium, manganese, and sulfates. Some levels of total iron exceeded Kentucky state criteria. All constituents are buffered within the lake, except aluminum; however, no operational changes can be made at this time to mitigate elevated levels from the inflow streams. Sites that exceeded state criteria will be reported to the Kentucky Division of Water to facilitate potential mitigation efforts by the state.

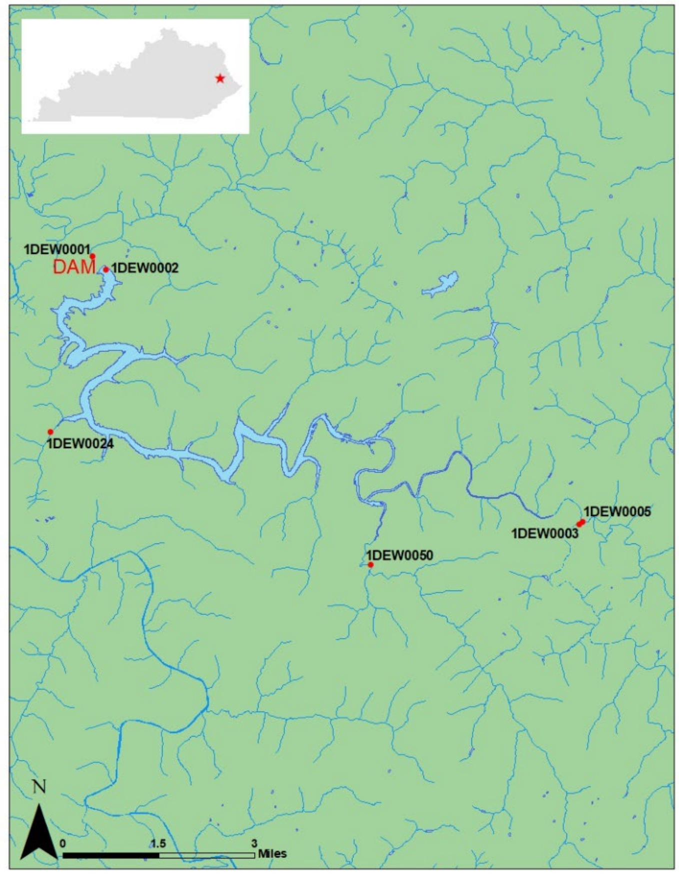


Figure 44. Water quality sampling locations for Dewey Lake in 2020.

WATERSHED SUMMARY: Dewey Lake is located in Floyd County, Kentucky on Johns Creek, a tributary of Levisa Fork of the Big Sandy River. Dewey Lake's authorized purposes are flood control, recreation, water quality, and fish and wildlife conservation. Dewey Lake is located 5.4 miles upstream of the mouth of Johns Creek, 79.4 miles above the mouth of the Big Sandy River, and is situated approximately 5 miles northeast of Prestonsburg, Kentucky. The Johns Creek watershed is long and narrow, extending approximately 36 miles from the headwaters to the mouth and has an average width of about 6 miles. The total drainage area is 225 square miles. The lake has a maximum depth of 50 feet and a water retention time of 27.8 days.

HISTORICAL WATERSHED CONCERNS: Mining and poor land management are the primary sources of watershed degradation resulting in:

- Excessive turbidity and sedimentation
- Increased concentrations of aluminum, manganese, iron, specific conductance, and sulfates

2020 ACTIVITIES: Six sampling events were conducted in the Dewey Lake watershed in 2020. Four major inflow streams and the outflow were sampled six times each. The lake was sampled four times during stratification at the primary lake station near the dam. All sampling events included the collection of physical water quality parameters via data sonde as well as water sample collection for a predetermined suite of water chemistry parameters. Each lake sampling event included an epilimnion, metalimnion, and hypolimnion sample with the addition of chlorophyll and dissolved metals analyses. Filtered samples were also collected at the outflow site during lake stratification and analyzed for dissolved metals. Benthic macroinvertebrate samples were collected but samples were inadvertently discarded by the contracted lab prior to analysis. In 2021, macroinvertebrates were surveyed again and results were received. Kentucky Macroinvertebrate Bioassessment Scores (KYMBI): DEW0001 – 52.7 (Fair), DEW0005 – 46.8 (Poor), DEW0024 – 52.0 (Fair), DEW0050 – 47.7 (Poor). These scores indicate an overall somewhat impaired macroinvertebrate community. Dewey Lake is scheduled to be intensively sampled again in fiscal year 2025.

ADDITIONAL INFORMATION: During lake stratification, outflow conditions are managed through use of a water quality weir upstream of a sluice gate to meet downstream dissolved oxygen and temperature targets. The lake is also managed by the Kentucky Division of Fish & Wildlife for the presence of invasive zebra mussels and excessive aquatic plant growth. Recent history has shown this watershed is susceptible to accidental discharges of coal mine waste. There were no operational changes or further sampling required to minimize impacts.

Elevated levels of strontium, sulfate, and specific conductance were present throughout the watershed but were within historical ranges. Chloride concentrations were also elevated but did not exceed state criteria. Levels were within historical ranges. Sulfate and chloride concentrations are likely driving the elevated specific conductance levels found throughout the watershed, which appear to be trending upward. The water appears to be getting more basic in pH throughout the watershed, though the cause is unknown.

Stratton Branch (1DEW0024) is a small tributary of Dewey Lake that has consistently had elevated sulfate concentrations that are several times greater than other sites in the watershed. This stream drains a reclaimed surface mine and valley fill area, which may account for the elevated sulfate concentrations. Areas of resource extraction are often linked to elevated levels of metals, sulfates, and sedimentation due to land disturbance. Because Stratton Branch is a very small tributary, its sulfate levels do not appear to affect Dewey Lake. Concentrations in the lake remain below screening thresholds.

Trophic State Index (TSI) is an assessment of the level of productivity in a waterbody based on Secchi disk measurements and chlorophyll and total phosphorus concentrations in the water column. Dewey Lake scored 44 for average TSI in 2020, which is categorized as mesotrophic. Mesotrophic lakes are usually characterized by having moderate clarity, nutrients, and algal growth.

Table 25. Dewey Lake samples exceeding state criteria and/or District levels of concern in 2020.

STATION	STATION TYPE	STREAM NAME	ANALYTES W/ELEVATED CONCENTRATIONS	NUMBER OF SAMPLES EXCEEDING SCREENING VALUE	EXCEED NATIVE STATE CRITERIA
1DEW0001	Outflow	Johns Creek	Strontium, Total	9	None
			Sp. Conductance	3	None
1DEW0002	Lake	Johns Creek	Sulfate	2	None
			Strontium	12	None
			TKN	2	None
			Manganese	4	None
1DEW0003	Inflow	Johns Creek	Iron	1	None
			Sp. Conductance	4	None
			Strontium, Total	6	None
			Sulfate	3	None
1DEW0005	Inflow	Brushy Fork	Sp. Conductance	6	None
			Strontium, Total	6	None
			Sulfate, Total	4	None
			Iron	1	No
1DEW0024	Inflow	Stratton Branch	Total Iron	1	Yes
			TKN	1	None
			Sp. Conductance	6	None
			Strontium, Total	7	None
			Sulfate, Total	7	None
1DEW0050	Inflow	Buffalo Creek	Iron	1	No

	Sp. Conductance	5	None
	Strontium, Total	6	None
	Sulfate, Total	4	None

Based on the most recent water quality sampling and analysis, some water quality constituents exceed District levels of concern, but are within historical ranges. Constituents exceeding levels of concern include aluminum, specific conductance, iron, phosphorus, strontium, and total Kjeldahl nitrogen. No known operational changes can be made at this current time to mitigate elevated levels from the inflow streams. Elevated constituent levels will be reported to the Ohio Environmental Protection Agency to facilitate potential mitigation efforts by the state.

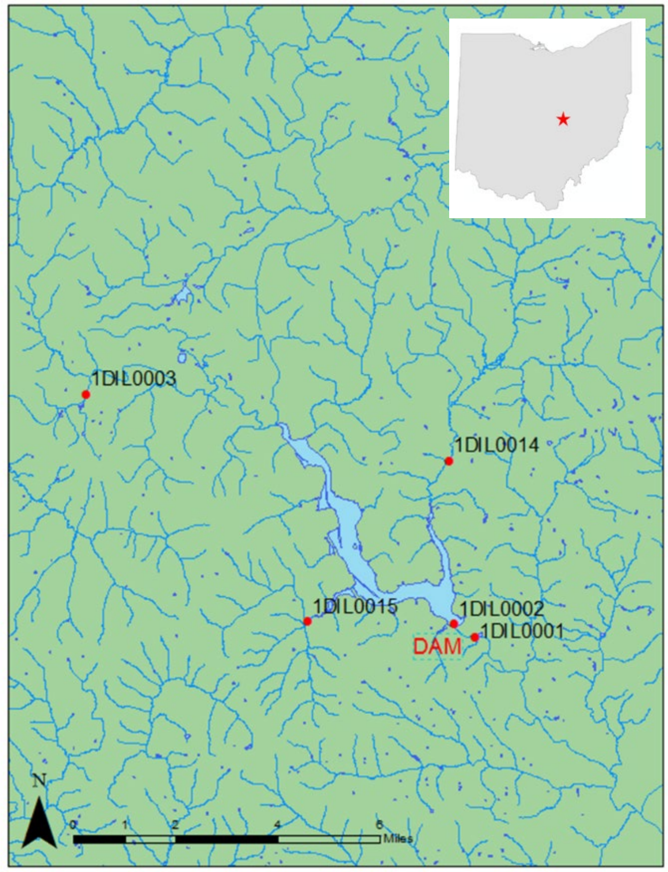


Figure 45. Water quality sampling locations for Dillon Lake in 2017.

WATERSHED SUMMARY: Dillon Lake is located in Muskingum County, Ohio on the Licking River, a tributary of the Muskingum River, of the Ohio River. The dam is located 83 miles upstream of the confluence of the Muskingum and Ohio Rivers. The drainage area of the lake is 742 square miles. The lake project's authorized purposes are flood control, recreation, and low flow augmentation. The lake has a maximum depth of 32 feet and a hydraulic residence time averaging 6 days. There is development and heavy residential use surrounding the lake.

HISTORICAL CONCERNS: Agriculture, forestry, mining, and land development are the primary sources of watershed degradation resulting in:

- Excessive turbidity and sedimentation
- Increased nutrient concentrations

2017 ACTIVITIES: There were five sampling events in the 2017 sampling season. These events included collection of routine water samples from Dillon Lake (only 4 of 5 events), select inflows (all events), and the outflow (all events). Samples were collected from the epilimnion, metalimnion, and hypolimnion during each lake sampling event. Water samples were analyzed for a pre-determined suite of chemical analytes and chlorophyll *a*, *b*, and *c*. Physical water quality measurements were collected simultaneously using a multiparameter datasonde during all five sampling events. No benthic macroinvertebrate or fish samples were collected in 2017 due to staffing limitations. *NEXT SAMPLING YEAR: 2022*

ADDITIONAL INFORMATION: Water is released from the lake through an outflow structure with three gated sluices. The structure was designed to release water from the bottom of the lake at all times. Therefore the quality of release water cannot be regulated.

Trophic State Index (TSI) is an assessment of the level of productivity in a waterbody based on Secchi disk measurements and chlorophyll and total phosphorus concentrations in the water column. A TSI score has not been calculated for Dillon Lake.

Table 26. Dillon Lake samples exceeding state criteria and/or District levels of concern in 2017.

STATION	STATION TYPE	STREAM NAME	ANALYTES W/ELEVATED CONCENTRATIONS	NUMBER OF SAMPLES EXCEEDING SCREENING VALUE	EXCEEDED APPLICABLE NATIVE STATE CRITERIA
1DIL0001	Outflow	Licking River	Aluminum, Total	1	NONE

STATION	STATION TYPE	STREAM NAME	ANALYTES W/ELEVATED CONCENTRATIONS	NUMBER OF SAMPLES EXCEEDING SCREENING VALUE	EXCEEDED APPLICABLE NATIVE STATE CRITERIA
			Iron, Total	1	NONE
			Kjeldahl Nitrogen, Total	1	NONE
			Phosphorus, Total	1	NONE
			Strontium, Total	1	NONE
1DIL0002	Lake	Licking River	Aluminum, total	1	NONE
			Iron, total	1	NONE
			Total Kjeldahl Nitrogen	14	NONE
			Phosphorus, total	14	NONE
			Specific Conductance	35	NONE
1DIL0003	Inflow	Licking River	Aluminum, Total	1	NONE
			Iron, Total	1	NONE
			Kjeldahl Nitrogen, Total	1	NONE
			Phosphorus, Total	1	NONE
			Strontium, Total	1	NONE
1DIL0014	Inflow	Big Run	Iron, Total	1	NONE
			Kjeldahl Nitrogen, Total	1	NONE
			Phosphorus, Total	1	NONE
1DIL0015	Inflow	Unnamed Tributary of Licking River	None	-	-

Based on the most recent water quality sampling and analysis, some water quality constituents exceed District levels of concern. Constituents exceeding levels of concern include aluminum, dissolved oxygen, iron, manganese, phosphorus, and strontium. There was a noticeable reduction in the number of constituents exceeding levels of concern for ELT0001 (outflow). However, Kiah Creek (ELT0036) and Trough Fork (ELT0064) showed a noticeable increase in constituents exceeding levels of concern. No known operational changes can be made at this time to mitigate elevated levels from the inflow streams. Elevated constituent levels will be reported to the West Virginia Department of Environmental Protection facilitate potential mitigation efforts by the state.

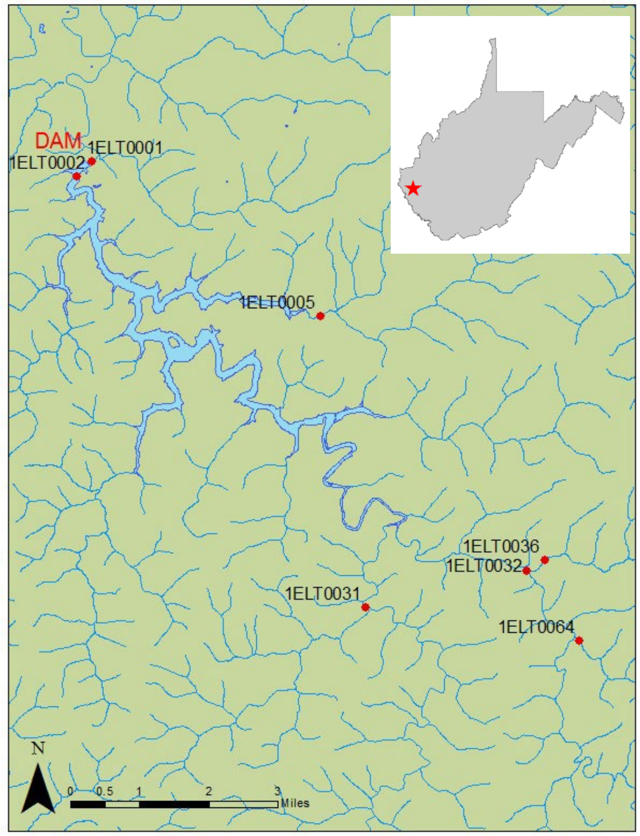


Figure 46. Water quality sampling locations for East Lynn Lake in 2021.

WATERSHED SUMMARY: East Lynn Lake lies in the southeastern portion of the Twelvepole Creek Basin in Wayne and Mingo Counties, West Virginia and drains 133 square miles. The authorized purposes of this lake are flood control, water quality, low flow augmentation, enhanced recreation (whitewater), and recreation. The major industry within the watershed is coal mining, while others include gas and oil extraction, timbering, and farming. The lake has a maximum depth of 50 feet and a residence time of approximately 42 days.

HISTORICAL CONCERNS: Mining and poor land management are the primary sources of watershed degradation resulting in:

- Elevated levels of aluminum, manganese, specific conductance and sulfates

2021 ACTIVITIES: There were six sampling events in the 2021 sampling season. All six events included collecting YSI ambient readings as well as water chemistry parameters. These events include routine water quality sampling of East Lynn Lake, select inflows, and the outflow. Macroinvertebrate community samples were collected at four locations. West Virginia Stream Condition Index (WVSCI) scores were ELT0001 – 32.1 (moderately impaired), ELT0031 – 80.5 (unimpaired-very good), ELT0032 - 75.2 (unimpaired-good), and ELT0064 - 75.6 (unimpaired-good) indicating a healthy aquatic macroinvertebrate community at three of the four locations. Fish surveys were conducted at six sites. The Kentucky Index of Biotic Integrity (KYIBI) was used because West Virginia does not have an IBI for fish. The KYIBI is the most compatible with West Virginia streams in the Huntington District. KYIBI scores were ELT0001 – 64 (Good), ELT0005 -54 (Fair), ELT0031 – 73 (Excellent), ELT0032 – 39 (Poor), ELT0036 -86 (Excellent), ELT0064 – 71 (Excellent) indicating an overall healthy fish community at five out of six sites. *NEXT SAMPLING YEAR: 2026*

ADDITIONAL INFORMATION: East Lynn Lake is functioning as a buffer by protecting downstream water quality against pollutants originating from the headwaters. Kiah Creek continues to be the major source of those pollutants to the lake. Currently, the selective withdrawal outflow tower has lost the use of a water quality gate. This has limited the ability of the project to control for downstream temperature and oxygen targets. This will result in warmer discharges from the lake until the gate has been fixed.

Trophic State Index (TSI) is an assessment of the level of productivity in a waterbody based on Secchi disk measurements and chlorophyll and total phosphorus concentrations in the water column. East Lynn Lake scored 44 for average TSI in 2021, which is categorized as mesotrophic. Mesotrophic lakes are usually characterized by having moderate clarity, nutrients, and algal growth.

Table 27. East Lynn Lake samples exceeding state criteria and/or District levels of concern in 2021.

STATION	STATION TYPE	STREAM NAME	ANALYTES W/ELEVATED CONCENTRATIONS	NUMBER OF SAMPLES EXCEEDING SCREENING VALUE	EXCEEDED APPLICABLE NATIVE STATE CRITERIA
ELT0001	Inflow	East Fork of Twelvepole Creek	Iron, Total	2	2
			Kjeldahl Nitrogen, Total	1	NONE
			Manganese, Total	2	NONE
ELT0002	Lake	East Fork of Twelvepole Creek	Aluminum, Total	1	1
			Kjeldahl Nitrogen, Total	1	NONE
ELT0005	Inflow	Lick Creek	Aluminum, Total	2	2
			Iron, Total	2	2
			Phosphorus, Total	1	1
ELT0031	Inflow	East Fork of Twelvepole Creek	Strontium, Total	1	NONE
ELT0032	Inflow	Kiah Creek	Kjeldahl Nitrogen, Total	1	NONE
			Specific Conductance	5	NONE
			Strontium, Total	3	NONE
			Sulfate, Total	3	NONE
ELT0036	Inflow	Big Laurel Creek	Aluminum, Total	1	1
			Iron, Total	1	1
			Phosphorus, Total	1	NONE
			Specific Conductance	5	NONE
ELT0064	Inflow	Trough Fork	Strontium, Total	8	NONE
			Sulfate, Total	6	NONE

Based on the most recent water quality sampling and analysis, some water quality constituents exceed District levels of concern, but are within historical ranges. Constituents exceeding levels of concern include specific conductance, aluminum, strontium, manganese, iron, phosphorus, bromide, and sulfates. Levels of *e. coli* bacteria exceeded state criteria at multiple locations. No known operational changes can be made at this current time to mitigate elevated levels from the inflow streams. The Kentucky Division of Water is already aware of the exceedances for *e. coli*.

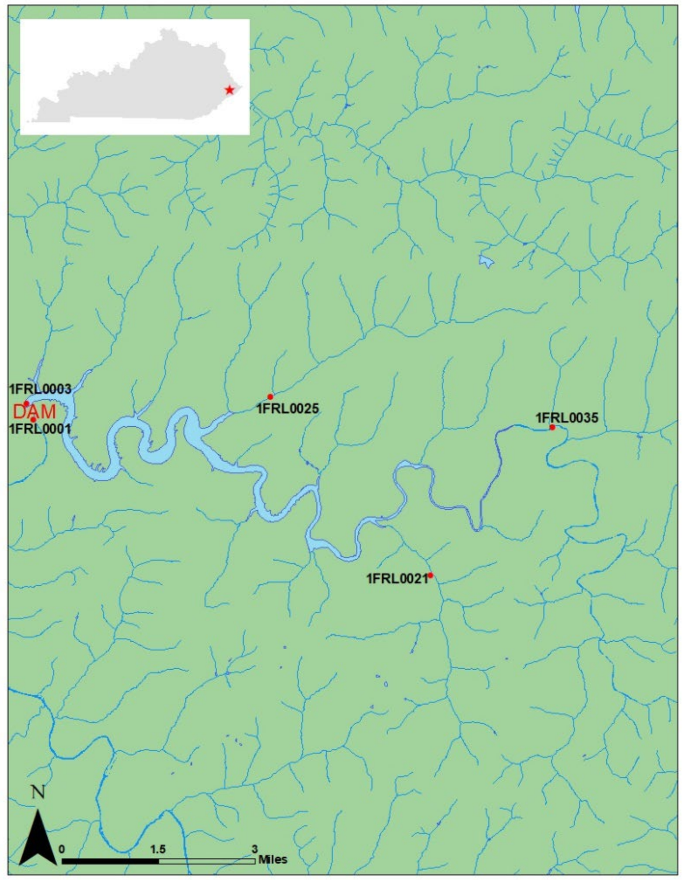


Figure 47. Water quality sampling locations for Fishtrap Lake in 2020.

WATERSHED SUMMARY: Fishtrap Lake is located entirely in Pike County, Kentucky on the Levisa Fork of the Big Sandy River near the states of Virginia and West Virginia. The authorized purposes for Fishtrap Lake are flood control, recreation, water quality and fish and wildlife conservation. The dam is located on Levisa Fork of Big Sandy River, a tributary of the Ohio River, 130 miles from its mouth and approximately 7 miles above the City of Pikeville, Kentucky. The dam is also 3 miles above the confluence of Russell and Levisa Forks, 103 miles upstream from the mouth of Levisa Fork. The lake drains 392 square miles of Kentucky and Virginia. The lake has a maximum depth of 83 feet and an average retention time of 24 days.

HISTORICAL WATERSHED CONCERNS: Mining and poor land management are the primary sources of watershed degradation resulting in:

- Excessive turbidity and sedimentation
- Increased concentrations of *E.coli*, aluminum, phosphorous, manganese, bromide, iron, specific conductance, and sulfates

2020 ACTIVITIES: Six sampling events were conducted in the Fishtrap Lake watershed in 2020. Three major inflow streams and the outflow were sampled six times each. The lake was sampled four times during stratification at the primary lake station near the dam. All sampling events included the collection of physical water quality parameters via data sonde as well as water sample collection for a predetermined suite of water chemistry parameters. Each lake sampling event included an epilimnion, metalimnion, and hypolimnion sample with the addition of chlorophyll and dissolved metals analyses. Filtered samples were also collected at the outflow site during lake stratification and analyzed for dissolved metals. Kentucky DOW requested additional *E. coli* sampling as part of our normal intensive routine. Benthic macroinvertebrate samples were collected but samples were inadvertently discarded by the contracted lab prior to analysis. In 2021, macroinvertebrates were surveyed again and results were received. Kentucky Macroinvertebrate Bioassessment Scores (KYMBI): FRL0001 – 39.2 (poor), FRL0021 – 52.8 (fair), FRL0025 – 70.3 (fair). These indicate an overall slightly impaired macroinvertebrate community. Fishtrap Lake is scheduled to be intensively sampled again in fiscal year 2025.

ADDITIONAL INFORMATION: Fishtrap Lake has a multi-level intake structure for optimization of water quality in the outflow. Debris and trash buildup continue to be a problem for the staff at Fishtrap Lake. Stretches of river downstream of Fishtrap Lake have been proposed as critical habitat for the Big Sandy crayfish, which has also been proposed as a federally threatened species. No operational changes were required for water quality.

Strontium and sulfate levels were elevated throughout the watershed, which is common in watersheds affected by land disturbance such as mineral extraction. Sulfate appears to be on an upward trend at the Lick Creek sample location (1FRL0021). Analyte concentrations were within historical ranges. Specific conductance levels were also high throughout the watershed, which are likely being driven by the high sulfate concentrations.

Grapevine Creek (1FRL0025) is a small tributary of Fishtrap Lake that is characterized by poor water quality and unsightly habitat. Concentrations of aluminum, iron, manganese, and sulfate were elevated at this location, which is the likely cause of the white precipitate that covers its substrate. *E. coli* bacteria exceeded state standards suggesting improper discharge of human or animal waste along Lick Creek and Grapevine Creek.

Trophic State Index (TSI) is an assessment of the level of productivity in a waterbody based on Secchi disk measurements and chlorophyll and total phosphorus concentrations in the water column. Fishtrap Lake scored 40 for average TSI in 2020, which is categorized as mesotrophic. Mesotrophic lakes are usually characterized by having moderate clarity, nutrients, and algal growth.

Table 28. Fishtrap Lake samples exceeding state criteria and/or District levels of concern in 2020.

STATION	STATION TYPE	STREAM NAME	ANALYTES W/ELEVATED CONCENTRATIONS	NUMBER OF RESULTS THAT EXCEED SCREENING VALUE	EXCEEDED APPLICABLE NATIVE STATE CRITERIA
1FRL0001	Outflow	Levisa Fork	Sp. Conductance	4	None
			Strontium, Total	9	None
1FRL0003	Lake	Fishtrap Lake	Aluminum	1	None
			Iron	1	No
			Manganese	4	None
			Phosphorus	1	None
			Strontium	12	None
1FRL0021	Inflow	Lick Creek	E. coli	1	Yes
			Sp. Conductance	6	None
			Strontium	7	None
			Sulfate	7	None
1FRL0025	Inflow	Grapevine Creek	E. coli	4	Yes
			Aluminum	6	None
			Iron	1	No
			Sp. Conductance	6	None
			Strontium	6	None
			Sulfate	4	None
1FRL0035	Inflow	Levisa Fork	Bromide	1	None
			Sp. Conductance	6	None
			Strontium	6	None

Based on the most recent water quality sampling and analysis, some water quality constituents exceed District levels of concern, but are within historical ranges. Constituents exceeding levels of concern include iron, aluminum, strontium, manganese, total Kjeldahl nitrogen, and phosphorus. All constituents of interest appear to be stable in the watershed. No known operational changes can be made at this time to mitigate elevated levels from the inflow streams. Elevated constituent levels will be reported to the Kentucky Division of Water to facilitate potential mitigation efforts by the state.

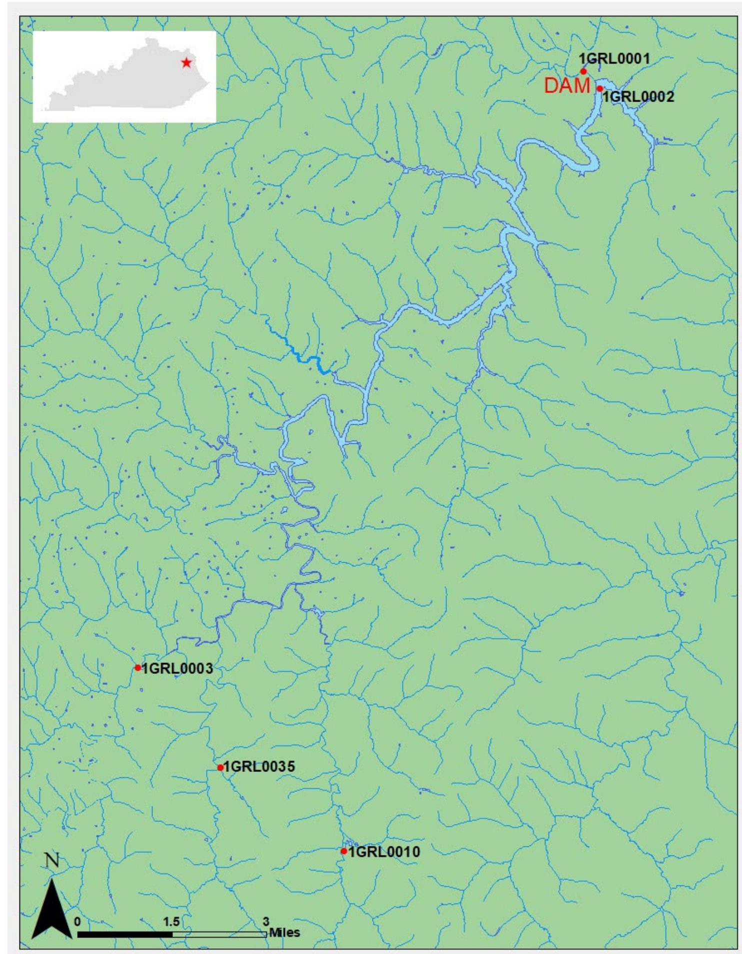


Figure 48. Water quality sampling locations for Grayson Lake in 2019.

WATERSHED SUMMARY: Grayson Lake lies within Carter and Elliott Counties, Kentucky. The dam site is located in Carter County, on the Little Sandy River, a tributary of the Ohio River. It is located 51.2 miles above the mouth of the Little Sandy River, 1.3 miles above the mouth of Big Sinking Creek, and about 6.5 road miles south of the town of Grayson, Kentucky. Grayson Lake drains 721 square miles of watershed. Most of the basin is forested and the main land uses are resource extraction (coal, gas/oil, timber) with light agriculture and residential impacts. The lake has a maximum depth of 60 feet and an average hydraulic retention time of 52 days.

HISTORICAL CONCERNS: Mining, agriculture, and poor land management are the primary sources of watershed degradation resulting in:

- Excessive turbidity and sedimentation
- Increased concentrations of manganese, iron, and specific conductance
- Increased concentrations of nutrients

2019 ACTIVITIES: Six sampling events were conducted in the Grayson Lake watershed in 2019. Three major inflow streams and the outflow were sampled six times each. The lake was sampled four times during stratification at the primary lake station near the dam. All sampling events included the collection of physical water quality parameters via data sonde as well as water sample collection for a predetermined suite of water chemistry parameters. Each lake sampling event included an epilimnion, metalimnion, and hypolimnion sample with the addition of chlorophyll and dissolved metals analyses. Filtered samples were also collected at the outflow site during lake stratification to be analyzed for dissolved metals. No benthic macroinvertebrate sampling was conducted at the inflow sites in 2019. Grayson Lake is scheduled to be intensively sampled again in fiscal year 2024.

OBSERVED WATER QUALITY CONCERNS: Water quality analysis revealed fair water quality throughout the year in the Grayson Lake watershed. The inflow streams exceeded the screening threshold once for iron, strontium, and phosphorus during a high flow event, which can be expected during times when streams are heavy with sediment. The lake exceeded screening thresholds multiple times throughout the year for iron, TKN, and manganese at lower depths, which is typical during stratification. The outflow exceeded thresholds for aluminum, iron, and TKN once each suggesting the lake is acting as a water quality buffer, trapping the sediments, nutrients, metals, and ions contributed by the inflows that would ultimately create a larger impact to the watershed if not contained.

Data analysis from Newcombe Creek show that chloride and specific conductance appear to be on a downward trend. This is likely caused by high concentrations in the mid-1980s that have since stabilized. All other parameters appear stable in the watershed.

Aquatic macroinvertebrate community data collected in 2014 from the Little Sandy River (1GRL0003), Middle Fork of the Little Sandy River (1GRL0035), and Rocky Branch (1GRL0036) all indicated a fair community structure with the Kentucky Macroinvertebrate Biotic Index (MBI) scores of 61, 70, and 56, respectively. Lower taxa percentages of sensitive individuals (EPT) and higher percentages and taxa of tolerant individuals were present in all samples showing impacts from reduced water quality.

ADDITIONAL INFORMATION: Grayson Lake has a multi-level intake structure for optimization of water quality in the outflow. Although it is not an authorized project purpose, the lake serves as water supply for local residents. Despite presenting a low-risk for harmful algae blooms (HABs) a toxin producing HAB was present in summer 2015.

Trophic State Index (TSI) is an assessment of the level of productivity in a waterbody based on Secchi disk measurements and chlorophyll and total phosphorus concentrations in the water column. Grayson Lake scored 45 for average TSI in 2019, which is categorized as mesotrophic. Mesotrophic lakes are usually characterized by having moderate clarity, nutrients, and algal growth.

Table 29. Grayson Lake samples exceeding state criteria and/or District levels of concern in 2019.

STATION	STATION STYPE	STREAM NAME	ANALYTES W/ELEVATED CONCENTRATIONS	NUMBER OF SAMPLES EXCEEDING SCREENING VALUE	EXCEED NATIVE STATE CRITERIA
1GRL0001	Outflow	Little Sandy River	Total Aluminum	1	None
			Total Iron	1	No
			TKN	1	None
1GRL0002	Lake	Little Sandy River	Total Iron	2	No
			Dissolved Iron	2	None
			Total Manganese	3	None
			Diss. Manganese	3	None
			TKN	4	None
1GRL0003	Inflow	Little Sandy River	Total Phosphorus	1	None
1GRL0010	Inflow	Newcombe Creek	Total Iron	1	No
			Total Strontium	1	None
1GRL0035	Inflow	Middle Fork of Little Sandy River	Total Iron	1	No
			Total Phosphorus	1	None

Based on the most recent water quality sampling and analysis, some water quality constituents exceed District levels of concern, but are within historical ranges. Constituents exceeding levels of concern include specific conductance, strontium, TKN, manganese, bromide, and sulfates. No known operational changes can be made at this current time to mitigate elevated levels from the inflow streams.

This project is currently Licensed by the Federal Energy Regulatory Commission for the addition of non-Federal hydropower, which could potentially alter water quality at the project. The District is working together with the agency and the Licensee to determine the best options for the project.

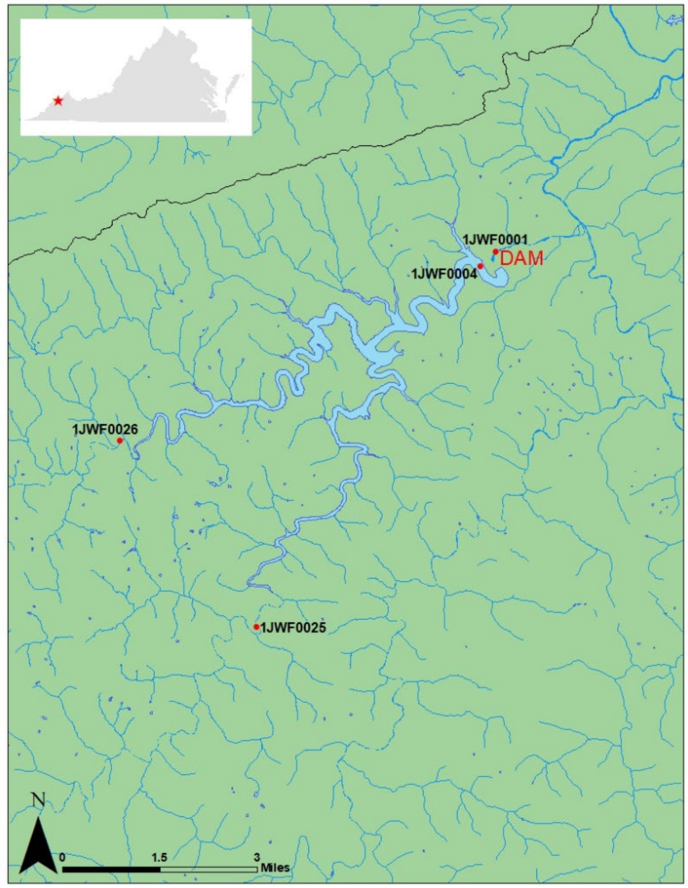


Figure 49. Water quality sampling locations for J.W. Flannagan Lake in 2020.

WATERSHED SUMMARY: John W. Flannagan Lake is located on Pound River, a tributary of Russell Fork, of Levisa Fork of the Big Sandy River, 150 river miles above the confluence of the Big Sandy and Ohio Rivers. The authorized purposes of the lake are flood control, recreation and fish and wildlife conservation. The project is located about 80 miles south of Huntington, WV. The reservoir drains an area of 204 square miles. The lake has a maximum depth of 186 feet and an average hydraulic retention time of 111 days.

HISTORICAL CONCERNS: Mining and poor land management are the primary sources of watershed degradation resulting in:

- Excessive turbidity and sedimentation
- Increased concentrations of aluminum, manganese, iron, bromide, specific conductance, and sulfates

2020 ACTIVITIES: Six sampling events were conducted in the John W. Flannagan Lake watershed in 2020. Two major inflow streams and the outflow were sampled six times each. The lake was sampled four times during stratification at the primary lake station near the dam. All sampling events included the collection of physical water quality parameters via data sonde as well as water sample collection for a predetermined suite of water chemistry parameters. Each lake sampling event included an epilimnion, metalimnion, and hypolimnion sample with the addition of chlorophyll and dissolved metals analyses. Filtered samples were also collected at the outflow site during lake stratification and analyzed for dissolved metals. Benthic macroinvertebrate samples were collected but samples were inadvertently discarded by the contracted lab prior to analysis. In 2021, macroinvertebrates were surveyed again and results were received. Virginia Stream Condition Index (VSCI) scores: JWF0001 – 50.0 (impaired), JWF0025 – 64.8 (similar to reference), JWF0026 – 68.2 (similar to reference). These scores indicate a healthy macroinvertebrate community at two of three sites surveyed. John W. Flannagan Lake is scheduled to be intensively sampled again in fiscal year 2025.

ADDITIONAL INFORMATION: Water from J.W. Flannagan Lake is discharged from the hypolimnion resulting in cold, deoxygenated outflows. However, these discharges are quickly oxygenated downstream leading to a high quality trout stream. The Virginia Department of Environmental Quality has re-classified the Pound River downstream of J. W. Flannagan Lake to a “natural reproducing trout water”. The Federal Energy Regulatory Commission has issued a license for the construction of a non-federal hydroelectric power plant at the dam. Construction of the plant could impact water quality downstream of the lake. Stretches of river within the impounded reservoir and downstream of J.W. Flannagan Lake have been proposed as critical habitat for the Big Sandy crayfish, which has also been proposed as a federally threatened species. Additionally, J.W. Flannagan Lake frequently has harmful algal blooms during both the cold winter season and the summer recreation season despite low nutrient concentrations and low productivity.

Elevated levels of strontium, sulfate, and specific conductance were seen in the inflow streams, though concentrations were within historical ranges. Specific conductance appears to trend upward throughout the watershed until about 2010, which could be driven by concentrations of sulfate. Elevated levels of these constituents are commonly found in watersheds subjected to land disturbances such as mining.

Trophic State Index (TSI) is an assessment of the level of productivity in a waterbody based on Secchi disk measurements and chlorophyll and total phosphorus concentrations in the water column. John W. Flannagan Lake scored 39 for average TSI in 2020, which is categorized as oligotrophic. Oligotrophic lakes are usually characterized by having high clarity, low nutrients, and low algal growth.

Table 30. J.W. Flannagan Lake samples exceeding state criteria and/or District levels of concern in 2020.

STATION	STATION TYPE	STREAM NAME	ANALYTES W/ELEVATED CONCENTRATIONS	NUMBER OF SAMPLES EXCEEDING SCREENING VALUE	EXCEEDED APPLICABLE NATIVE STATE CRITERIA
1JWF0001	Outflow	Pound River	Sp. Conductance	2	None
			Manganese	1	None
			Strontium	6	None
			Sulfate	2	None
1JWF0004	Lake	Cranes Nest River	Manganese	2	None
			pH	4	None
			Strontium	10	None
			Sulfate	1	None
			TKN	1	None
1JWF0025	Inflow	Cranes Nest River	Bromide	1	None
			Sp. Conductance	4	None
			Strontium	6	None
			Sulfate	4	None
1JWF0026	Inflow	Pound River	Bromide	1	None
			Sp. Conductance	6	None
			Strontium	6	None
			Sulfate	4	None

Based on the most recent water quality sampling and analysis, some water quality constituents exceed District levels of concern. Constituents exceeding levels of concern include aluminum, dissolved oxygen, iron, manganese, phosphorus, and TKN. New for 2021, Aluminum and Iron exceeded levels of concern multiple times at LEM0012; these constituents did not exceed levels of concern during the last sampling round in 2016Instances of low dissolved oxygen and high dissolved metals in the outflow could be rectified in the future with the addition of a trash rack weir. This structural modification could be completed as soon as 2018. Elevated constituent levels will be reported to the Ohio Environmental Protection Agency to facilitate potential mitigation efforts by the state.

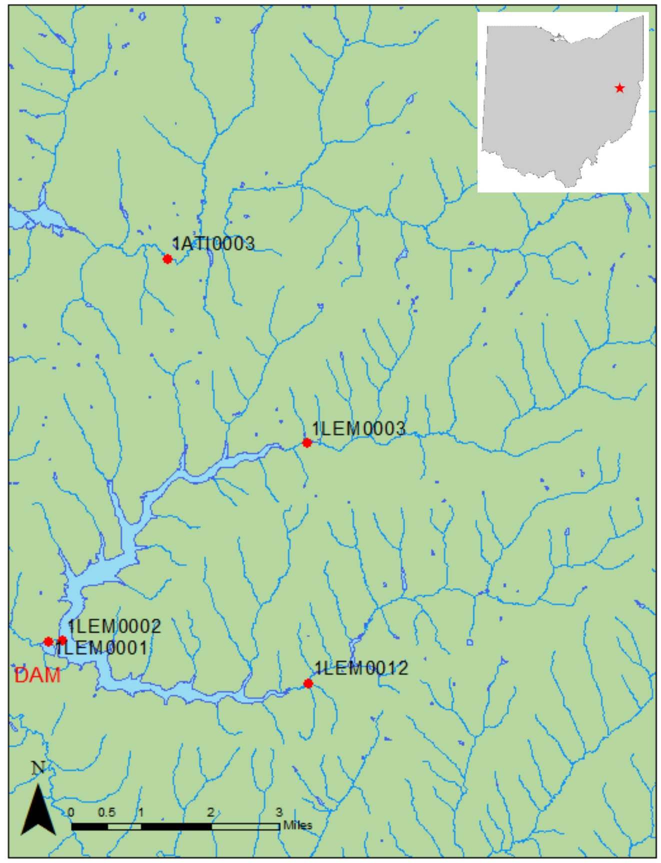


Figure 50. Water quality sampling locations for Leesville Lake in 2021.

WATERSHED SUMMARY: Leesville Lake is located in Carroll County in northeastern Ohio. The authorized project purposes for Leesville Lake are flood control, fish and wildlife, and recreation. The lake is supplied by two forks of Conotton Creek: McGuire Creek and North Fork of McGuire Creek. Together they drain roughly 48 square miles of forest and farm land. Shale gas extraction is a significant industry in the watershed. The lake has a maximum depth of 48 feet and a residence time of about 134 days.

HISTORICAL CONCERNS: Resource extraction, agriculture, and poor land management are the primary sources of watershed degradation resulting in:

- Elevated levels of aluminum, manganese, iron, sulfates, and nutrients

2021 ACTIVITIES: There were six sampling events in the 2021 sampling season. All six events included collecting physical chemistry as well as water quality samples. These events include routine sampling of Leesville Lake, select inflows, and the outflow. Macroinvertebrate community samples were collected at three locations. Invertebrate community index (ICI) scores: LEM0001 – 12 (low-fair), LEM0003 – 24 (fair), LEM0012 – 18 (low-fair), indicating an overall somewhat impaired aquatic macroinvertebrate community at these locations. Fish surveys were also conducted at two sites. Ohio Index of Biotic Integrity (OHIBI) scores: LEM0003 – 34 (fair), LEM0012 – 34 (fair). *NEXT SAMPLING YEAR: 2026*

ADDITIONAL INFORMATION: Modifications are scheduled for the outlet structures at Leesville and Atwood Lakes, however the unusual design of the intakes are causing delays in the project. The purpose of the trash rack modifications are to minimize the release of hydrogen sulfide gas that is produced from outflow water originating in the hypolimnion. While Leesville and Atwood Lakes produce hydrogen sulfide to a lesser extent than Tappan, Clendening, or Piedmont, the gas is still negatively affecting the structures and human health. Additionally, increased phosphorus and nitrogen inputs from the inflows are being passed into the tailwaters without being buffered by the lake.

Trophic State Index (TSI) is an assessment of the level of productivity in a waterbody based on Secchi disk measurements and chlorophyll and total phosphorus concentrations in the water column. Leesville Lake scored 42 for average TSI in 2021, which is categorized as mesotrophic. Mesotrophic lakes are usually characterized by having moderate clarity, nutrients, and algal growth.

Table 31. Leesville Lake samples exceeding state criteria and/or District levels of concern in 2021.

STATION	STATION TYPE	STREAM NAME	ANALYTES W/ELEVATED CONCENTRATIONS	NUMBER OF SAMPLES EXCEEDING SCREENING VALUE	EXCEEDED APPLICABLE NATIVE STATE CRITERIA
LEM0001	Outflow	McGuire Creek	Iron, Total	4	NONE
			Kjeldahl Nitrogen, Total	2	NONE
			Manganese, Total	8	NONE
			Phosphorus, Total	2	NONE
LEM0002	Lake	Leesville Lake	Iron, Total	2	NONE
			Kjeldahl Nitrogen, Total	1	NONE
LEM0003	Inflow	North Fork McGuire Creek	Aluminum, Total	1	NONE
			Iron, Total	1	NONE
			Phosphorus, Total	1	NONE
LEM0012	Inflow	McGuire Creek	Aluminum, Total	4	NONE
			Iron, Total	5	NONE
			Kjeldahl Nitrogen, Total	4	NONE
			Phosphorus, Total	1	NONE

Based on the most recent water quality sampling and analysis, some water quality constituents exceed District levels of concern. Constituents exceeding levels of concern include aluminum, dissolved oxygen, iron, phosphorus, strontium, specific conductivity, and TKN. New for 2021, there is a noticeable increase in strontium exceeding levels of concern for NBN0001. No known operational changes can be made at this time to mitigate elevated levels from the inflow streams. Elevated constituent levels will be reported to the Ohio Environmental Protection Agency to facilitate potential mitigation efforts by the state.

Figure 51. Water quality sampling locations for North Branch of Kokosing Lake in 2021.

WATERSHED SUMMARY: North Branch of Kokosing Lake is located in Knox County, in north central Ohio. The North Branch of the Kokosing River is located in the northwest portion of the much larger Kokosing River basin, which spans five counties. The North Branch basin drains roughly 45 square miles of gently rolling farm land. North Branch of Kokosing Lake is the smallest flood control lake in the Huntington District, and its authorized project purposes are flood control, fish and wildlife, and recreation. The lake has a maximum depth of 23 feet and a residence time of approximately 5 days.

HISTORICAL CONCERNS: Agriculture and poor land management are the primary sources of watershed degradation resulting in:

- Excessive turbidity and sedimentation
- Increased concentrations of nutrients

2021 ACTIVITIES: There were six sampling events in the 2021 sampling season. All six events included collecting physical chemistry and water quality samples. These events include routine sampling of North Branch of Kokosing Lake, select inflows, and the outflow. Macroinvertebrate community samples were collected at three locations. Invertebrate community index (ICI) scores: NBN0001 – 20 (low-fair), NBN0004 – 42 (very good), NBN0005 – 30 (marginally good) indicating an overall healthy aquatic macroinvertebrate community at these locations. Fish Surveys were also conducted at three sites. Ohio Index of Biotic Integrity (OHIBI) scores: NBN0001 – 34 (fair), NBN0004 – 46 (good), NBN0005 – 46 (good).

NEXT SAMPLING YEAR: 2026

ADDITIONAL INFORMATION: Concentrations of TKN, phosphorus, and specific conductance have been steadily increasing since 1985. Elevated levels of nutrients have contributed to increased algal growth and a shallow epilimnion due to reduced light penetration.

Trophic State Index (TSI) is an assessment of the level of productivity in a waterbody based on Secchi disk measurements and chlorophyll and total phosphorus concentrations in the water column. North Branch of Kokosing Lake scored 69 for average TSI in 2021, which is categorized as eutrophic. Eutrophic lakes are usually characterized by having low clarity, high nutrients, and high algal growth.

Table 32. North Branch of Kokosing Lake samples exceeding state criteria and/or District levels of concern in 2021.

STATION	STATION STYPE	STREAM NAME	ANALYTES W/ELEVATED CONCENTRATIONS	NUMBER OF SAMPLES EXCEEDING SCREENING VALUE	EXCEED NATIVE STATE CRITERIA
NBN0001	Outflow	Kokosing River	Aluminum, Total	3	NONE
			Iron, Total	3	NONE
			Kjeldahl Nitrogen, Total	8	NONE
			Oxygen, Dissolved	2	NONE
			Phosphorus, Total	7	NONE
			Strontium, Total	9	NONE
NBN0002	Lake	Kokosing Lake	Aluminum, Total	1	NONE
			Iron, Total	1	NONE
			Kjeldahl Nitrogen, Total	4	NONE
			Phosphorus, Total	4	NONE
			Strontium, Total	8	NONE
NBN0004	Inflow	North Branch of Kokosing River	Aluminum, Total	3	NONE
			Iron, Total	2	NONE
			Phosphorus, Total	3	NONE
			Specific Conductance	4	NONE
			Strontium, Total	5	NONE
NBN0005	Inflow	UT to North Branch of Kokosing River	Phosphorus, Total	1	NONE
			Specific Conductance	3	NONE
			Strontium, Total	5	NONE

Based on the most recent water quality sampling and analysis, some water quality constituents exceed District levels of concern. Constituents exceeding levels of concern include iron, strontium, manganese, TKN, and specific conductance. No known operational changes can be made at this time to mitigate elevated levels from the inflow streams.

WATERSHED SUMMARY: North Fork of Pound Dam is located on North Fork of Pound River, VA, a tributary of Pound River, of Russell Fork, of Levisa Fork, of the Big Sandy River. The dam is 184 river miles above the confluence of the Big Sandy and Ohio Rivers. The authorized purposes for the dam are flood control, recreation, water quality, and fish and wildlife conservation. The watershed is 17.2 square miles and is generally mountainous. The lake has a maximum depth of 61 feet and a water retention time of 59 days.

HISTORICAL CONCERNS: Based on District data, North Fork of Pound Lake has few water quality concerns.

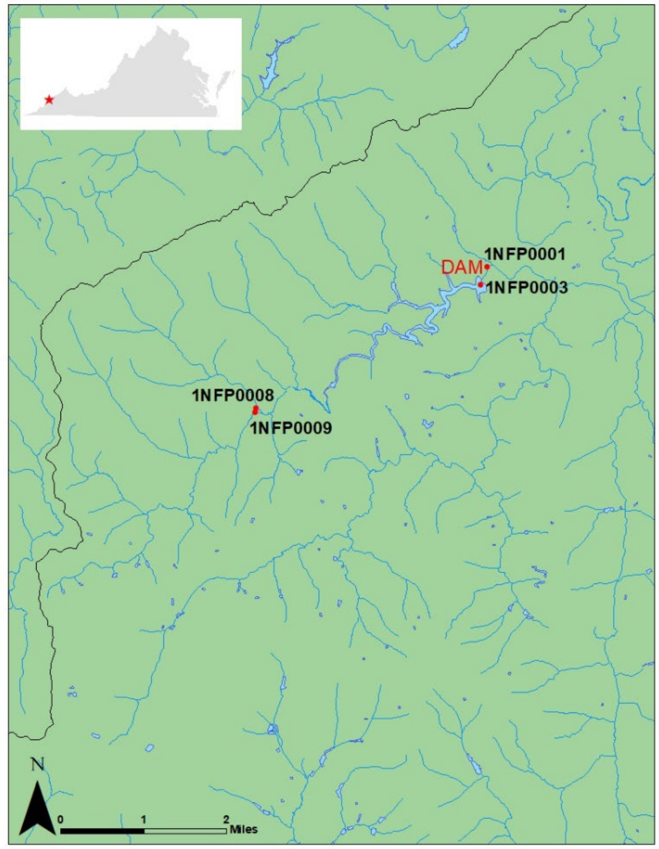


Figure 52. Water quality sampling locations for North Fork of Pound Lake in 2020.

2020 ACTIVITIES: Six sampling events were conducted in the North Fork of Pound Lake watershed in 2020. Two major inflow streams and the outflow were sampled six times each. The lake was sampled four times during stratification at the primary lake station near the dam. All sampling events included the collection of physical water quality parameters via data sonde as well as water sample collection for a predetermined suite of water chemistry parameters. Each lake sampling event included an epilimnion, metalimnion, and hypolimnion sample with the addition of chlorophyll and dissolved metals analyses. Filtered samples were also collected at the outflow site during lake stratification and analyzed for dissolved metals. Benthic macroinvertebrate samples were collected but samples were inadvertently discarded by the contracted lab prior to analysis. In 2021, macroinvertebrates were surveyed again and results were received. Virginia Stream Condition Index (VSCI) scores: NFP0001 – 65.1 (similar to reference), NFP0008 – 63.4 (similar to reference), NFP0009 – 75.9 (similar to reference). These scores indicate a healthy macroinvertebrate community. North Fork of Pound Lake is scheduled to be intensively sampled again in fiscal year 2025.

ADDITIONAL INFORMATION: North Fork of Pound Lake has a multi-level intake structure for optimization of water quality in the outflow. Water quality in this watershed is generally good, likely due to its forested areas, and lack of major land disturbances such as agriculture or resource extraction.

Sample results from 2016 and 2020 confirm that an anomalous phosphorus result that exceeded the district threshold in 2015 was not an upward trend.

Trophic State Index (TSI) is an assessment of the level of productivity in a waterbody based on Secchi disk measurements and chlorophyll and total phosphorus concentrations in the water column. North Fork of Pound Lake scored 33 for average TSI in 2020, which is categorized as oligotrophic. Oligotrophic lakes are usually characterized by having high clarity, low nutrients, and low algal growth.

Table 33. North Fork of Pound Lake samples exceeding state criteria and/or District levels of concern in 2020.

STATION	STATION TYPE	STREAM NAME	ANALYTES W/ELEVATED CONCENTRATIONS	NUMBER OF SAMPLES EXCEEDING SCREENING VALUE	EXCEEDED APPLICABLE NATIVE STATE CRITERIA
1NFP0001	Outflow	North Fork of Pound	None	-	-
1NFP0003	Lake	North Fork of Pound	Iron	1	None
			Manganese	8	None
			TKN	1	None
1NFP0008	Inflow	Bad Creek	None	-	-
1NFP0009	Inflow	North Fork of Pound	Sp. Conductance	2	None
			Strontium	4	None

Based on the most recent water quality sampling and analysis, some water quality constituents exceed District levels of concern including aluminum, iron, strontium, specific conductivity, phosphorus, and total Kjeldahl nitrogen. Trends analysis revealed a downward trend in sulfate concentrations in the watershed, and all other constituents appear stable. No known operational changes can be made at this time to mitigate elevated levels from the inflow streams. Elevated constituent levels will be reported to the Ohio Environmental Protection Agency to facilitate potential mitigation efforts by the state. The Paint Creek inflow scored a 48 on the Ohio IBI, which is a rating of "good", and a 2.13 on the Shannon Index. The Rattlesnake Creek inflow scored a 45 on the Ohio IBI, which is a rating of "good", and a 2.05 on the Shannon Index. The Paint Creek outflow scored a 47 on the Ohio IBI, which is a rating of "good", and a 1.63 on the Shannon Index.

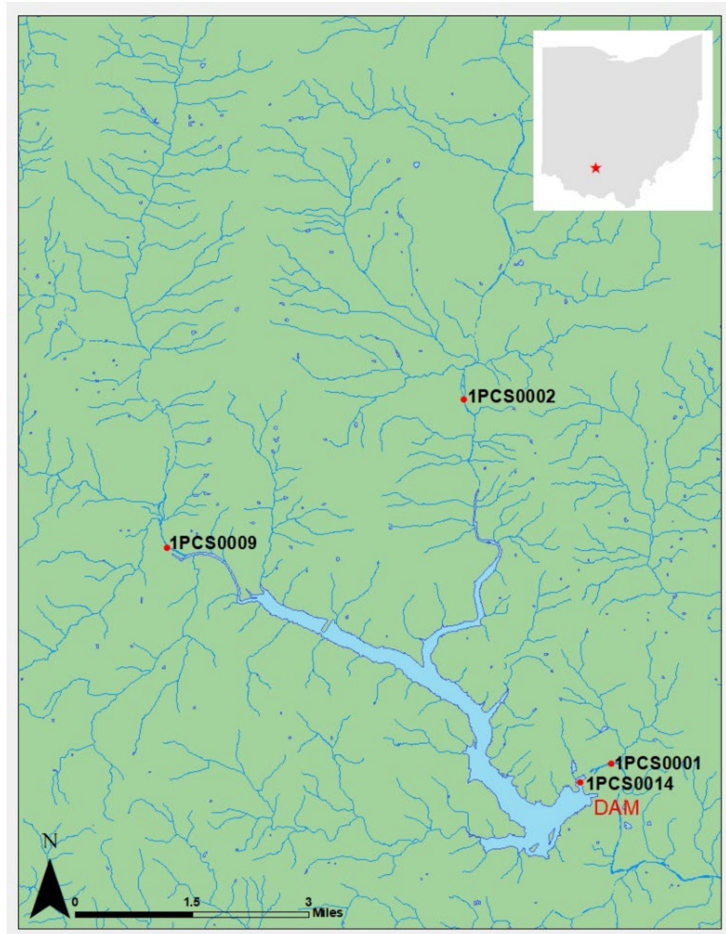


Figure 53. Water quality sampling locations for Paint Creek Lake in 2019.

WATERSHED SUMMARY: Paint Creek Lake is located in Ross and Highland Counties, Ohio on Paint Creek, a tributary of the Scioto River. The dam site is 16 miles above the town of Bourneville, 36.8 miles above the mouth. Paint Creek Lake drains 570 square miles of watershed. The main land uses are agriculture and residential. The inflow water is characterized as calcium-chloride type representing an unbalanced condition. High concentrations of nutrients result in a high productivity in the lake. The lake has a maximum depth of 50 feet and an average retention time of 16 days.

HISTORICAL CONCERNS: Agriculture, residential, and poor land management are the primary sources of watershed degradation resulting in:

- Excessive turbidity and sedimentation
- Increased concentrations of strontium and nutrients
- Increased risk of harmful algae blooms in the lake

2019 ACTIVITIES: Six sampling events were conducted in the Paint Creek Lake watershed in 2019. Two major inflow streams and the outflow were sampled six times each, with the exception of Paint Creek (1PCS0002) which was sampled only five times. The lake was sampled three times during stratification at the primary lake station near the dam. A flooding event in June prevented sampling at the lake and the Paint Creek inflow due to the sites being inaccessible. All successful sampling events included the collection of physical water quality parameters via data sonde as well as water sample collection for a predetermined suite of water chemistry parameters. Each lake sampling event included an epilimnion, metalimnion, and hypolimnion sample with the addition of chlorophyll and dissolved metals analyses. Filtered samples were also collected at the outflow site during lake stratification to be analyzed for dissolved metals. Electrofishing surveys were conducted in both inflow streams and the outflow. Benthic macroinvertebrate sampling was conducted at 1PCS0002 and 1PCS0009, but no analysis has been performed. Paint Creek Lake is scheduled to be intensively sampled again in fiscal year 2024.

OBSERVED WATER QUALITY CONCERNS: Water quality analysis revealed high inputs of nitrogen, phosphorus, and strontium into the lake from the primary inflows, Paint Creek (1PCS0002) and Rattlesnake Creek (1PCS0009). The outflow contained high levels of nitrogen, phosphorus, and strontium, indicating that the lake is not acting as a buffer to the above sources. One sampling event yielded high concentrations of iron, aluminum, manganese, and nutrients that were outside of historical ranges, but this is likely due to a flooding event occurring at the time. Trend analysis revealed a downward trend in sulfate, and nutrient levels remain consistently high at all locations. All other parameters of interest appear stable in the watershed.

The Paint Creek inflow scored a 48 on the Ohio IBI, which is a rating of “good”, and a 2.13 on the Shannon Index. The Rattlesnake Creek inflow scored a 45 on the Ohio IBI, which is a rating of “good”, and a 2.05 on the Shannon Index. The Paint Creek outflow scored a 47 on the Ohio IBI, which is a rating of “good”, and a 1.63 on the Shannon Index.

All water quality concerns revealed in the most recent intensive surveys at Paint Creek Lake have been previously documented in the WCM with no new concerns surfacing. Active agricultural land use is most likely contributing the nutrients to the watershed through runoff of farm fields and overuse of fertilizers.

ADDITIONAL INFORMATION: Paint Creek Lake has a multi-level intake structure for optimization of water quality in the outflow.

Aquatic macroinvertebrate data from 2014 from Paint Creek (1PCS0002) indicates a fair community structure based on standard assessment tools. Macroinvertebrate metrics of interest can be used to provide an idea of what the aquatic insect community looks like versus what is considered ideal.

The increased nutrient loading from the inflows make it susceptible to HABs. A HAB occurred in July of 2013 but did not result in any closures or impacts to recreation. In 2017 a HAB occurred on Little Pond, which is a small body of water adjacent to Paint Creek Lake. While not part of the main lake, Little Pond is an active recreation area managed by the Corps of Engineers. Signage has been placed to alert the public of the risks of contact with HABs.

Trophic State Index (TSI) is an assessment of the level of productivity in a waterbody based on Secchi disk measurements and chlorophyll and total phosphorus concentrations in the water column. Paint Creek Lake scored 67 for average TSI in 2019, which is categorized as eutrophic. Eutrophic lakes are usually characterized by having low clarity, high nutrients, and high algal growth.

Table 34. Paint Creek Lake samples exceeding state criteria and/or District levels of concern in 2019.

STATION	STATION STYPE	STREAM NAME	ANALYTES W/ELEVATED CONCENTRATIONS	NUMBER OF SAMPLES EXCEEDING SCREENING VALUE	EXCEED NATIVE STATE CRITERIA
1PCS0001	Outflow	Paint Creek	Total Aluminum	2	NONE
			Total Iron	2	NONE
			TKN	6	NONE
			Total Phosphorus	6	NONE
			Sp. Conductance	2	NONE
			Total Strontium	6	NONE
1PCS0002	Inflow	Paint Creek	Total Aluminum	1	NONE
			Total Iron	1	NONE
			TKN	3	NONE
			Total Phosphorus	5	NONE
			Sp. Conductance	4	NONE
			Total Strontium	5	NONE

STATION	STATION STYPE	STREAM NAME	ANALYTES W/ELEVATED CONCENTRATIONS	NUMBER OF SAMPLES EXCEEDING SCREENING VALUE	EXCEED NATIVE STATE CRITERIA
1PCS0009	Inflow	Rattlesnake Creek	Total Aluminum	1	NONE
			Total Iron	1	NONE
			TKN	3	NONE
			Total Phosphorus	5	NONE
			Sp. Conductance	4	NONE
			Total Strontium	5	NONE
1PCS0014	Lake	Paint Creek	Total Aluminum	1	NONE
			Total Iron	2	NONE
			Dissolved Iron	1	NONE
			TKN	9	NONE
			Total Phosphorus	9	NONE
			Total Strontium	9	NONE

Based on the most recent water quality sampling and analysis, some water quality constituents exceed District levels of concern, but are within historical ranges. Constituents exceeding levels of concern include manganese, selenium, strontium, iron, and phosphorus. No known operational changes can be made at this current time to mitigate elevated levels from the inflow streams. Elevated constituent levels will be reported to the Kentucky Division of Water to facilitate potential mitigation efforts by the state.

Figure 54. Water quality sampling locations for Paintsville Lake in 2018.

WATERSHED SUMMARY: Paintsville Lake is located primarily in Johnson County, Kentucky. The dam is on Paint Creek, a tributary of the Levisa Fork, of the Big Sandy River. The drainage area of the lake is approximately 92 square miles. The lake project's authorized purposes are flood control, recreation, and water quality. The tailwater of the lake is designated as a cold water fishery by the Commonwealth of Kentucky and it is managed year round for trout. The lake has a maximum depth of 112 feet and a hydraulic residence time of about 126 days. The watershed is dominated by forested land.

HISTORICAL CONCERNS: Mining and natural gas extraction are the primary sources of watershed degradation resulting in:

- Excessive turbidity and sedimentation
- Excessive levels of iron and manganese in the lake during times of stratification

2018 ACTIVITIES: Six sampling events were conducted in the Paintsville Lake watershed in 2018. Four major inflow streams and the outflow were sampled six times each. The lake was sampled four times during stratification at the primary lake station near the dam. All sampling events included the collection of physical water quality parameters via data sonde as well as water sample collection for a predetermined suite of water chemistry parameters. Each lake sampling event included an epilimnion, metalimnion, and hypolimnion sample with the addition of chlorophyll and dissolved metals analyses. Filtered samples were also collected at the outflow site during lake stratification to be analyzed for dissolved metals. No benthic macroinvertebrate sampling was conducted due to staffing limitations and high flows during the index period. Paintsville Lake is scheduled to be intensively sampled again in fiscal year 2023.

ADDITIONAL INFORMATION: Water quality analysis did not reveal many new concerns. Selenium, strontium, manganese, and iron exceeded levels of concern in Little Paint Creek and Big Mine Fork. Metals were elevated in hypolimnion samples of Paintsville Lake, but these metals settle and become latent in the lake sediments, buffering any downstream impacts. The lake does heavily stratify leaving an anoxic hypolimnion with high metal concentrations, but water control manages flows to minimally impact downstream water quality and aquatic communities. The headwaters of the lake are experiencing heavy sedimentation from the increased solids input caused by upstream land uses and erosion. Phosphorus exceeded its level of concern once in Little Paint Creek but productivity is generally not an issue within the lake.

During the summer stratification period, the outflow is managed for the maintenance of the trout stream below our discharge. The use of selective withdrawal gates is also managed for the lake fishery because use of some gates can lead to insufficient water quality for pelagic game fish species.

Trophic State Index (TSI) is an assessment of the level of productivity in a waterbody based on Secchi disk measurements and chlorophyll and total phosphorus concentrations in the water column. Paintsville Lake scored 38 for average TSI in 2018, which is categorized as oligotrophic. Oligotrophic lakes are usually characterized by having high clarity, low nutrients, and low algal growth.

Table 35. Paintsville Lake samples exceeding state criteria and/or District levels of concern in 2018.

STATION	STATION TYPE	STREAM NAME	ANALYTES W/ELEVATED CONCENTRATIONS	NUMBER OF SAMPLES EXCEEDING SCREENING VALUE	EXCEEDED APPLICABLE NATIVE STATE CRITERIA
1PIV0001	Outflow	Paint Creek	None	-	-
1PIV0002	Lake	Paint Creek	None	-	-
1PIV0003	Inflow	Little Paint Creek	Iron, Total	1	No
			Phosphorus, Total	1	NONE
1PIV0009	Inflow	Big Mine Fork	Selenium	2	NONE
			Strontium	3	NONE
1PIV0010	Inflow	Open Fork	None	-	-
1PIV0101	Inflow	Patoker Branch of Open Fork	None	-	-

Based on the most recent water quality sampling and analysis, some water quality constituents exceed District levels of concern, but are within historical ranges. Constituents exceeding levels of concern include specific conductance, pH, sulfates, phosphorus, total Kjeldahl nitrogen, strontium, manganese, aluminum, and iron. Elevated constituent levels will be reported to the Ohio Environmental Protection Agency to facilitate potential mitigation efforts by the state. Data analysis revealed that a structural modification completed in 2017 minimized hydrogen sulfide gas emissions, increased dissolved oxygen, and decreased dissolved metals in the outflow, improving overall water quality to the downstream area.

WATERSHED SUMMARY: Piedmont Lake is located in Harrison County, Ohio on Stillwater Creek, a tributary of the Tuscarawas River, of the Muskingum River. The dam is located 198 miles upstream of the confluence of the Muskingum River and the Ohio River. The drainage area of the lake is approximately 86 square miles. The lake project's authorized purposes are flood control, recreation, and fish and wildlife conservation. The lake has a maximum depth of 38 feet with an average residence time of 144 days. The watershed is dominated by surface mining, forest, and agriculture.

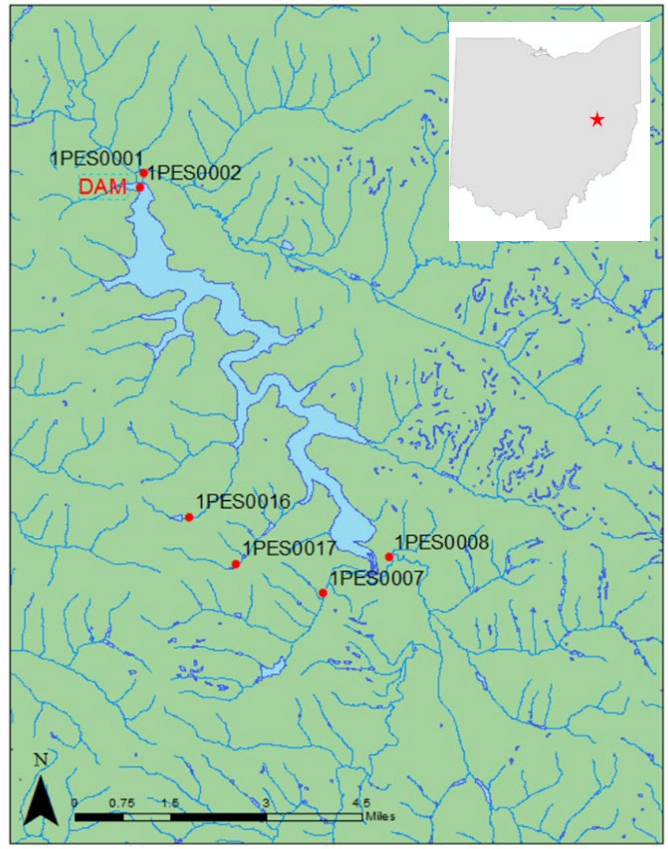


Figure 55. Water quality sampling locations for Piedmont Lake in 2018.

HISTORICAL CONCERNS: Mining and agriculture are the primary sources of watershed degradation resulting in:

- Elevated levels of specific conductance, sulfates, chlorides, and metals

2018 ACTIVITIES: Five sampling events were conducted in the Piedmont Lake watershed in 2018. High flows prevented collection of the late summer/early fall sample. Four major inflow streams and the outflow were sampled five times each. The lake was sampled four times during stratification at the primary lake station near the dam. All sampling events included the collection of physical water quality parameters via data sonde as well as water sample collection for a predetermined suite of water chemistry parameters. Each lake sampling event included an epilimnion, metalimnion, and hypolimnion sample with the addition of chlorophyll and dissolved metals analyses. Filtered samples were also collected at the outflow site during lake stratification to be analyzed for dissolved metals. No benthic macroinvertebrate sampling was conducted due to staffing limitations and high flows during the index period. Piedmont Lake is scheduled to be intensively sampled again in fiscal year 2023.

ADDITIONAL INFORMATION: In the fall of 2017 the intake structure at Piedmont Lake was retrofitted with a steel plate that allowed high quality surface water to be discharged downstream, with the intention of mitigating long-standing problems caused by hydrogen sulfide (H2S) gas releases. Lake buoy data showed no perceivable impacts to the water quality of the lake as a result of the structural modification.

Project personnel from Piedmont Lake receive a considerable amount of reports from boaters regarding a white precipitate flowing into the Lick Run arm of the lake. Lick Run is comprised of a series of old retention ponds that discharge directly into Piedmont Lake and are the source of the white material. Lick Run (1PES0017) was intensively sampled in 2018 at the uppermost pond from the lake (due to accessibility issues). Analysis results show that high concentrations of metals (primarily aluminum, cobalt, iron, and manganese) and sulfates are discharged regularly from the pond. Additional sampling of the discharge at the confluence with Piedmont Lake would determine whether the subsequent ponds were buffering any of the metals prior to discharge into the lake. However, given the white coloration of the water in the upper end of the Lick Creek arm of the lake, this seems unlikely. Additional constituents exceeding levels of concern within the Piedmont Lake watershed include specific conductance, pH, sulfates, phosphorus, total Kjeldahl nitrogen, strontium, manganese, aluminum, and iron. Elevated constituent levels will be reported to the Ohio Environmental Protection Agency to facilitate potential mitigation efforts by the state.

In 2016, the Water Quality Team was called to investigate another pond discharging into Piedmont Lake that appeared blue in color. Analysis of samples collected from both the pond itself and its discharge showed high concentrations of metals and sulfates in the pond itself, but much lower concentrations in the pond's discharge. The pond discharges adjacent to the previously described series of retention ponds on Lick Creek, but ultimately ends up in the same arm of the lake.

Trophic State Index (TSI) is an assessment of the level of productivity in a waterbody based on Secchi disk measurements and chlorophyll and total phosphorus concentrations in the water column. A TSI score has not been calculated for Piedmont Lake.

Table 36. Piedmont Lake samples exceeding state criteria and/or District levels of concern in 2018.

STATION	STATION TYPE	STREAM NAME	ANALYTES W/ELEVATED CONCENTRATIONS	NUMBER OF SAMPLES EXCEEDING SCREENING VALUE	EXCEEDED APPLICABLE NATIVE STATE CRITERIA
1PES0001	Outflow	Stillwater Creek	Kjeldahl Nitrogen, Total	1	NONE
			Manganese	1	NONE
			Phosphorus, Total	1	NONE
			Specific Conductance	5	NONE
			Strontium	5	NONE
			Sulfate	5	NONE
1PES0002	Lake	Stillwater Creek	Specific Conductance	3	NONE
			Strontium	3	NONE
			Sulfate	3	NONE
1PES0007	Inflow	Robinson Creek	Kjeldahl Nitrogen, Total	1	NONE
			Phosphorus, Total	1	NONE
			Specific Conductance	5	NONE
			Strontium	5	NONE
			Sulfate	5	NONE
1PES0008	Inflow	Stillwater Creek	Aluminum	1	NONE
			Iron	1	NONE
			Kjeldahl Nitrogen, Total	2	NONE
			Phosphorus, Total	4	NONE
			Strontium	4	NONE
			Sulfate	5	NONE
1PES0016	Inflow	Indian Run	Aluminum	2	NONE
			Manganese	1	NONE
			pH	3	Yes

STATION	STATION TYPE	STREAM NAME	ANALYTES W/ELEVATED CONCENTRATIONS	NUMBER OF SAMPLES EXCEEDING SCREENING VALUE	EXCEEDED APPLICABLE NATIVE STATE CRITERIA
			Phosphorus, Total	1	NONE
			Specific Conductance	3	NONE
			Strontium	2	NONE
			Sulfate	2	NONE
1PES0017	Inflow	Lick Run	Aluminum	4	NONE
			Iron	5	NONE
			Kjeldahl Nitrogen, Total	2	NONE
			Manganese	4	NONE
			pH	5	Yes
			Phosphorus	1	NONE
			Selenium	1	NONE
			Specific Conductance	5	NONE
			Strontium	5	NONE
			Sulfate	5	NONE

Based on the most recent water quality sampling and analysis, some water quality constituents exceed District levels of concern including dissolved oxygen, phosphorus, strontium, specific conductivity, and TKN. New for 2021, strontium has exceeded levels on concern multiple times at PHC0001, PHC0002, and PHC0005. No known operational changes can be made at this time to mitigate elevated levels from the inflow streams. Elevated constituent levels will be reported to the Ohio Environmental Protection Agency to facilitate potential mitigation efforts by the state.

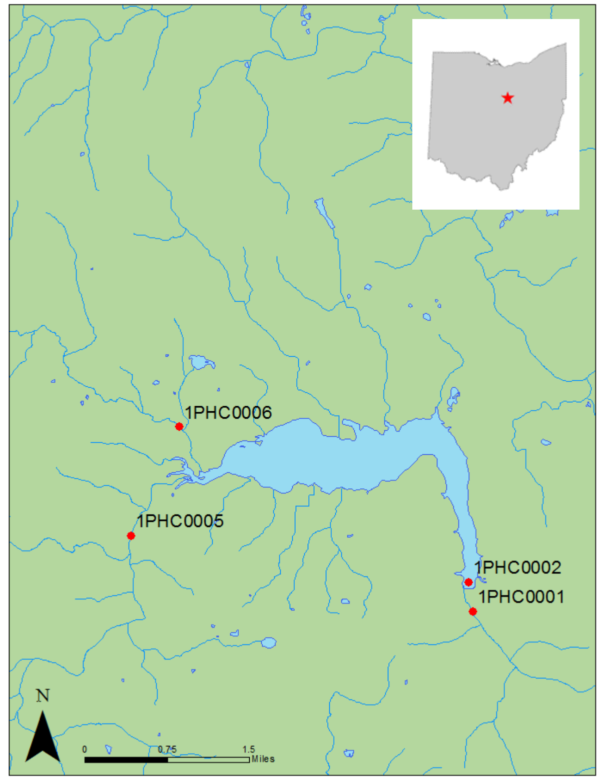


Figure 56. Water quality sampling locations for Pleasant Hill Lake in 2021.

WATERSHED SUMMARY: The Pleasant Hill Lake drainage basin lies within portions of Ashland, Richland, Knox, and Morrow Counties in the north central portion of Ohio. Clear Fork of Mohican River is the major tributary in the basin. The lake drains approximately 197 square miles of forest and farmland southeast of Mansfield. The authorized project purposes for the lake are flood control, fish and wildlife, and recreation. The lake has a maximum depth of 55 feet and a residence time of approximately 24 days.

HISTORICAL CONCERNS: Agriculture and poor land management are the primary sources of watershed degradation resulting in:

- Increased concentrations of nutrients

2021 ACTIVITIES: There were six sampling events in the 2022 sampling season. All six events included assessing physical chemistry as well as the collection of water chemistry samples. These events assessed Pleasant Hill Lake, select inflows, and the outflow. Macroinvertebrate community samples were collected at three locations. Invertebrate community index (ICI) scores for PHC0001, PHC0005, and PHC0006 were all 42 (very good), indicating a healthy aquatic macroinvertebrate community at these locations. Fish surveys were conducted in 2020 and 2021. PHC0001 was surveyed during a 2020 periodic inspection and scored 38 (good) and PHC0006 was surveyed in 2021 and received a score of 42 (good) indicating an overall healthy fish community. *NEXT SAMPLING YEAR: 2026*

ADDITIONAL INFORMATION: Like many other watersheds in the region, the Clear Fork has impacts resulting from increased nutrients. However, relative to other Huntington District lakes in the Muskingum River basin, Pleasant Hill Lake has relatively high water quality.

Trophic State Index (TSI) is an assessment of the level of productivity in a waterbody based on Secchi disk measurements and chlorophyll and total phosphorus concentrations in the water column. Pleasant Hill Lake scored 56 for average TSI in 2021, which is categorized as eutrophic. Eutrophic lakes are usually characterized by having low clarity, high nutrients, and high algal growth.

Table 37. Pleasant Hill Lake samples exceeding state criteria and/or District levels of concern in 2021.

STATION	STATION STYPE	STREAM NAME	ANALYTES W/ELEVATED CONCENTRATIONS	NUMBER OF SAMPLES EXCEEDING SCREENING VALUE	EXCEED NATIVE STATE CRITERIA
PHC0001	Outflow	Clear Fork of Mohican River	Aluminum, Total	1	NONE
			Iron, Total	3	NONE
			Kjeldahl Nitrogen, Total	2	NONE
			Phosphorus, Total	5	NONE
			Strontium, Total	6	NONE
PHC0002	Lake	Pleasant Hill Lake	Kjeldahl Nitrogen, Total	2	NONE
			Phosphorus, Total	1	NONE
			Strontium	9	NONE
PHC0005	Inflow	Clear Fork of Mohican River	Iron, Total	1	NONE
			Phosphorus, Total	7	NONE
			Specific Conductance	1	NONE
			Strontium, Total	8	NONE
PHC0006	Inflow	Switzer Creek	None	-	-

Based on the most recent water quality sampling and analysis, some water quality constituents exceed District levels of concern, but are within historical ranges. Constituents exceeding levels of concern include specific conductance, iron, strontium, and sulfate. No known operational changes can be made at this current time to mitigate elevated levels from the inflow streams. Elevated constituent levels will be reported to the West Virginia Department of Environmental Protection to facilitate potential mitigation efforts by the state.

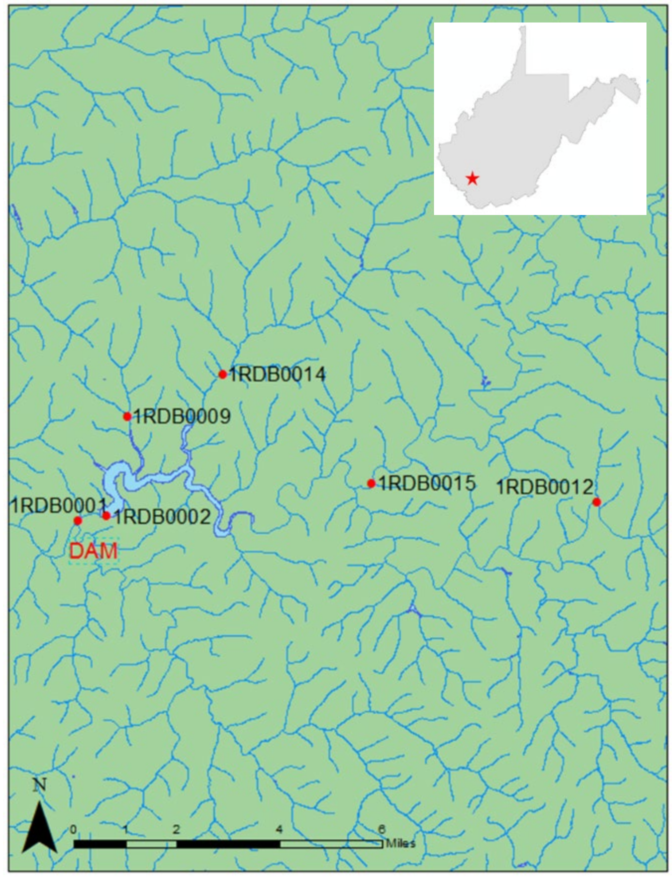


Figure 57. Water quality sampling locations for R.D. Bailey Lake in 2018.

WATERSHED SUMMARY: R.D. Bailey Lake is located in Wyoming and Mingo Counties, West Virginia. The dam site is 112 miles upstream of the mouth of the Guyandotte River with the Ohio River. The drainage area of the lake is 540 square miles. The lake project's authorized purposes include flood control, recreation, enhanced recreation (whitewater), fish and wildlife conservation, and water quality. The lake has a maximum depth of 145 feet and a hydraulic residence time averaging 18 days. The watershed is dominated by second-growth forested land. Water quality in the watershed is generally fair despite resource extraction activity.

HISTORICAL CONCERNS: Coal mining, natural gas extraction, and timbering are the primary sources of watershed degradation resulting in:

- Excessive turbidity and sedimentation
- Elevated specific conductance
- Elevated sulfates and metals

2018 ACTIVITIES: Six sampling events were conducted in the R.D. Bailey Lake watershed in 2018. Four major inflow streams and the outflow were sampled six times each with the exception of Leatherwood Creek (1RDB0009). A sample was not collected from Leatherwood Creek during the July trip because a fallen tree was blocking access to the site and could not be removed at the time. The lake was sampled four times during stratification at the primary lake station near the dam. All sampling events included the collection of physical water quality parameters via data sonde as well as water sample collection for a predetermined suite of water chemistry parameters. Each lake sampling event included an epilimnion, metalimnion, and hypolimnion sample with the addition of chlorophyll and dissolved metals analyses. Filtered samples were also collected at the outflow site during lake stratification to be analyzed for dissolved metals. No benthic macroinvertebrate sampling was conducted due to staffing limitations and high flows during the index period. Piedmont Lake is scheduled to be intensively sampled again in fiscal year 2023.

ADDITIONAL INFORMATION: R.D. Bailey Dam was constructed with a selective withdrawal system that allows for temperature and dissolved oxygen regulation as well as low-flow augmentation downstream. The WV Department of Environmental Protection classifies R.D. Bailey as a cool water lake, therefore it is subject to stricter water quality criteria. Despite historically low concentrations of nutrients, multiple harmful algal blooms have occurred on the lake in recent years but did not result in any closures or impacts to recreation. Due to changes in the sampling schedule, this project was not intensively sampled between 2008 and 2018.

The Bureau of Land Management is currently reviewing a proposal to allow mining of coal on federal property surrounding R.D. Bailey Lake in the Leatherwood Creek watershed. This could result in increases of sediment and pollutants in the lake. Streams impacted by mining activities generally have elevated levels of metals, sulfate, dissolved solids, and sediment. The Water Quality Team began collecting samples from Leatherwood Creek in 2018 to establish baseline conditions in the event that coal mining should take place. Data analysis revealed favorable water quality conditions in the stream thus far, i.e. clear with adequate flow, low sedimentation, and relatively low levels of pollutants.

Big Cub Creek continues to input high concentrations of strontium and sulfate into the lake. There are also clear increasing trends in sulfate, strontium, and selenium, which can be an indication of mining activities in a watershed. A coal operation exists along Big Cub Creek, which drains directly into the lake, however other parameters of interest are within historical ranges in comparison with the main inflow streams Clear Fork (1RDB0015) and the Guyandotte River (1RDB0012).

Trophic State Index (TSI) is an assessment of the level of productivity in a waterbody based on Secchi disk measurements and chlorophyll and total phosphorus concentrations in the water column. A TSI score has not been calculated for R.D. Bailey Lake.

Table 38. R.D. Bailey Lake samples exceeding state criteria and/or District levels of concern in 2018.

STATION	STATION TYPE	STREAM NAME	ANALYTES W/ELEVATED CONCENTRATIONS	NUMBER OF SAMPLES EXCEEDING SCREENING VALUE	EXCEEDED APPLICABLE NATIVE STATE CRITERIA
1RDB0001	Outflow	Guyandotte River	Iron	1	No
			Strontium	3	NONE
1RDB0002	Lake	Guyandotte River	Strontium	4	NONE
1RDB0012	Inflow	Guyandotte River	Specific Conductance	1	NONE
			Strontium	5	NONE
1RDB0014	Inflow	Big Cub Creek	Specific Conductance	4	NONE
			Strontium	10	NONE
			Sulfate	7	NONE
1RDB0015	Inflow	Clear Fork	Strontium	4	NONE

Based on the most recent water quality sampling and analysis, some water quality constituents exceed District levels of concern including iron, aluminum, strontium, manganese, specific conductivity, dissolved oxygen, phosphorus, and total Kjeldahl nitrogen. Consituents were within or below historical ranges. No known operational changes can be made at this time to mitigate elevated levels from the inflow streams. Elevated constituent levels will be reported to the Ohio Environmental Protection Agency to facilitate potential mitigation efforts by the state.

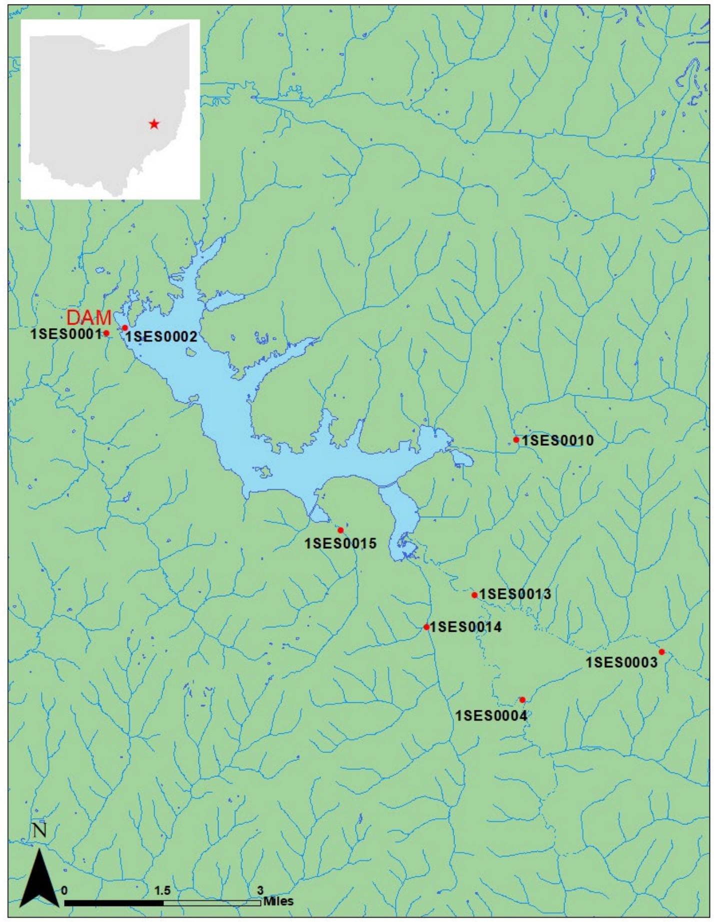


Figure 58. Water quality sampling locations for Senecaville Lake in 2019.

WATERSHED SUMMARY: The drainage basin contributing to Senecaville Lake has headwaters beginning in Noble, Belmont and Monroe Counties. The Senecaville dam site is located in Guernsey County, Ohio on Seneca Fork of Wills Creek, a tributary of the Muskingum River. Senecaville Dam is approximately 1.5 miles upstream from the town of Senecaville and 10 miles southeast of Cambridge, Ohio. The lake drains 118 square miles of watershed. Sources of pollution in the drainage basin which might influence water quality are rural domestic, local industry, and active and inactive mining operations. The lake headwaters are characteristic of the calcareous nature of the watershed. Buffering capacity (alkalinity) is high, as well as nutrients, but over-productivity in the lake does not appear to be a problem. The lake has a maximum depth of 29 feet and an average retention time of 132 days.

HISTORICAL CONCERNS: Senecaville Lake has fewer water quality concerns than many of the other District lakes. However, mining, agriculture, and poor land management are sources of watershed degradation resulting in:

- Excessive turbidity and sedimentation
- Increased concentrations of manganese, iron, and specific conductance
- Increased concentrations of nutrients

2019 ACTIVITIES: Six sampling events were conducted in the Senecaville Lake watershed in 2019. Five major inflow streams and the outflow were sampled six times each. Initially samples were collected on Seneca Fork above the lake at 1SES0013, which combined the two major inflows. However, it was determined that this location was lake impacted, and the inflow sites were split into the historical sites 1SES0003 (Seneca Fork) and 1SES0004 (South Fork of Seneca Fork). The lake was sampled four times during stratification at the primary lake station near the dam. All sampling events included the collection of physical water quality parameters via data sonde as well as water sample collection for a predetermined suite of water chemistry parameters. Each lake sampling event included an epilimnion, metalimnion, and hypolimnion sample with the addition of chlorophyll and dissolved metals analyses. Filtered samples were also collected at the outflow site during lake stratification to be analyzed for dissolved metals. No benthic macroinvertebrate sampling was conducted at the inflow sites in 2019. Senecaville Lake is scheduled to be intensively sampled again in fiscal year 2024.

OBSERVED WATER QUALITY CONCERNS: Water quality analysis of the project's main inflows revealed high inputs of nitrogen, phosphorus, and strontium throughout the sampling year. The lake showed high levels of phosphorus and strontium, which were being passed to the outflow, suggesting the lake is not buffering inputs from the inflows. The lake also showed high concentrations of kjeldahl nitrogen, which were not present in the inflow streams in high concentrations, suggesting that nitrogen is being internally loaded in the lake and passed downstream. One sample was above historical ranges for total and dissolved iron at the lake site at the bottom depth, which is common when the lake stratifies and dissolved oxygen levels approach zero. All other consituents were within or below historical ranges. Sulfate concentrations in the primary inflows (1SES0003, 1SES0004) appear to be trending downward, while other consituents are stable in the watershed. All water quality concerns revealed in the most recent intensive surveys at Senecaville Lake have been previously documented in the WCM with no new concerns surfacing.

ADDITIONAL INFORMATION: Historically, elevated concentrations of phosphorus, aluminum, iron and strontium and TKN were observed from the inflow stations. If the nutrient loading continues, the project may see an increase in productivity and could be more susceptible to HABs.

Trophic State Index (TSI) is an assessment of the level of productivity in a waterbody based on Secchi disk measurements and chlorophyll and total phosphorus concentrations in the water column. Senecaville Lake scored 59 for average TSI in 2019, which is categorized as eutrophic. Eutrophic lakes are usually characterized by having low clarity, high nutrients, and high algal growth.

Table 39. Senecaville Lake samples exceeding state criteria and/or District levels of concern in 2019.

STATION	STATION STYPE	STREAM NAME	ANALYTES W/ELEVATED CONCENTRATIONS	NUMBER OF SAMPLES EXCEEDING SCREENING VALUE	EXCEED NATIVE STATE CRITERIA
1SES0001	Outflow	Seneca Fork	Total Aluminum	1	
			Total Iron	1	NONE
			TKN	4	NONE
			Total Phosphorus	5	NONE
			Total Strontium	4	
1SES0002	Lake	Seneca Fork	Total Iron	1	
			TKN	12	
			Total Manganese	1	NONE
			Dissolved Manganese	1	NONE
			Total Phosphorus	7	
			Total Strontium	12	
1SES0003	Inflow	Seneca Fork	TKN	1	
			Total Phosphorus	1	
			Total Strontium	4	
1SES0004	Inflow	South Fork	Total Aluminum	1	
			Total Iron	1	
			TKN	1	
			Total Phosphorus	2	
			Total Strontium	4	
1SES0010	Inflow	Beaver Creek	Total Iron	1	NONE
			Total Phosphorus	2	NONE
			Sp. Conductance	6	NONE

STATION	STATION STYPE	STREAM NAME	ANALYTES W/ELEVATED CONCENTRATIONS	NUMBER OF SAMPLES EXCEEDING SCREENING VALUE	EXCEED NATIVE STATE CRITERIA
			Total Strontium	6	
1SES0013	Inflow	Seneca Fork	Total Aluminum	1	NONE
			Total Iron	1	NONE
			TKN	1	NONE
			Total Phosphorus	1	NONE
			Total Strontium	2	NONE
1SES0014	Inflow	Glady Run	Total Iron	1	NONE
			Total Strontium	6	
			Dissolved Oxygen	1	
			Total Phosphorus	3	
			Specific Conductance	1	
1SES0015	Inflow	Mud Run	Total Aluminum	1	NONE
			Total Iron	1	NONE
			TKN	1	NONE
			Total Phosphorus	3	NONE
			Total Strontium	6	NONE
			Specific Conductance	1	

Based on the most recent sampling and analysis, there were no water quality constituents that exceeded District levels of concern. Water quality in the watershed is generally high, and all results were within historical ranges. Any future elevated constituent levels will be reported to the West Virginia Department of Environmental Protection to facilitate potential mitigation efforts by the state.

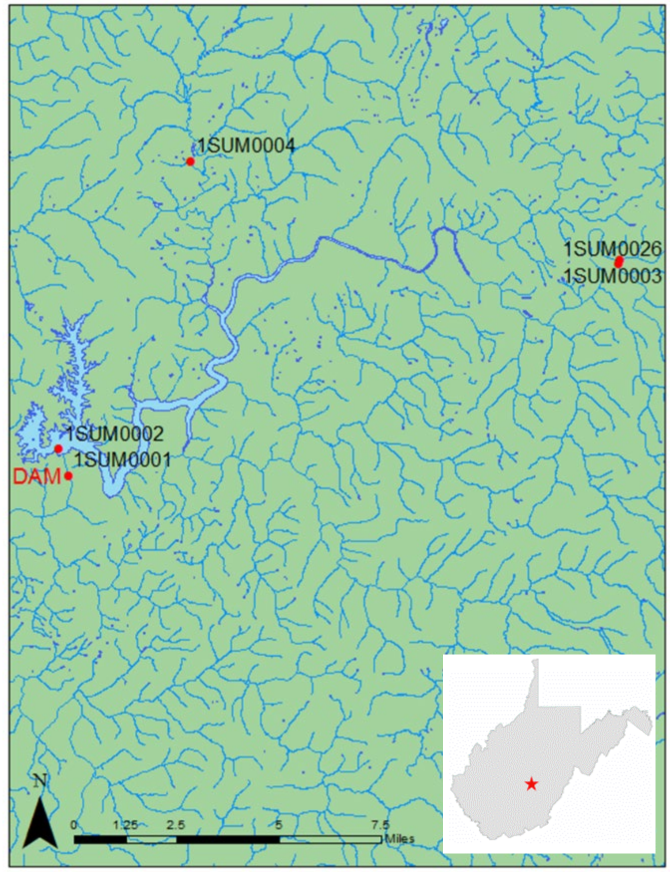


Figure 59. Water quality sampling locations for Summersville Lake in 2017.

WATERSHED SUMMARY: Summersville Lake is located in Nicholas County, West Virginia. The dam is located on the Gauley River, a tributary of the Kanawha River; 131 miles above the confluence of the Kanawha River with the Ohio River. Summersville Lake has a drainage area of 803 square miles. The lake project's authorized purposes include flood control, recreation, enhanced recreation (whitewater), low flow augmentation, water quality, and fish and wildlife conservation. The lake has a maximum depth of 267 feet and a hydraulic residence time averaging 45 days. The watershed is dominated by forested mountains and, as a result, the Gauley River has some of the highest water quality within the Huntington District.

HISTORICAL CONCERNS: Based on historical data, Summersville Lake has few water quality concerns. Despite favorable water quality conditions, several problems still exist: (1) Acid rain in the headwaters of the Gauley River is linked to the burning of fossil fuels and coal-fired power plants. If left unchecked, acid rain could prove detrimental to the sensitive species that are present in the watershed. (2) While over-production is a common issue in many Huntington District lakes, Summersville has been historically plagued by low productivity. A moderate level of production in a lake is necessary to maintain a healthy fishery, yet not so much as to encourage nuisance algae blooms. (3) Cold water pollution is perhaps an unavoidable problem surrounding Summersville Lake. Due to the extreme depth of the lake and all-sluice withdrawal system, discharges from the dam are constantly cold even in the hottest months of the year. Cold water pollution disrupts the natural temperature regimes in a riverine system and negatively affect the biota that live within it. Because of the cold nature of our discharge, West Virginia has listed the tailwaters of Summersville Lake as a "Trout Waters". This area is now managed for trout and trout fishing.

2017 ACTIVITIES: There were six sampling events in the 2017 sampling season. These events included collection of routine water samples from Summersville Lake (only 4 of 6 events), select inflows (all events), and the outflow (all events). Samples were collected from the epilimnion, metalimnion, and hypolimnion during each lake sampling event. Water samples were analyzed for a pre-determined suite of chemical analytes and chlorophyll *a*, *b*, and *c*. Physical water quality measurements were collected simultaneously using a multiparameter datasonde during all six sampling events. No benthic macroinvertebrate or fish samples were collected in 2017 due to staffing limitations. *NEXT SAMPLING YEAR: 2022*

ADDITIONAL INFORMATION: Basin geology, morphology, and land use determine the quality of water within the basin. Geological considerations are the most important because rock types in the drainage basin determine, to a great extent, the inorganic composition of the water. Rocks in the Summersville Lake Basin consist of sandstones, shales, and coal. Basin morphology is that of steep topography which indicates that the potential for erosion and sedimentation is high.

However, most of the basin is generally covered by second growth timber and wild vegetation. In addition, the invert of the outlet tunnel is located 83 feet above the streambed, creating a dead storage pool of about 6,900 acre-feet capacity. For these reasons, the possibility of greater than average sedimentation in the basin is believed to be of little consequence. The major industries in the basin are coal mining and some timbering. A mountain stream with rugged terrain create a potential for excellent water quality and the quality of the water at Summersville Lake is known as the best in Huntington District.

Trophic State Index (TSI) is an assessment of the level of productivity in a waterbody based on Secchi disk measurements and chlorophyll and total phosphorus concentrations in the water column. A TSI score has not been calculated for Summersville Lake.

Table 40. Summersville Lake samples exceeding state criteria and/or District levels of concern in 2017.

STATION	STATION TYPE	STREAM NAME	ANALYTES W/ELEVATED CONCENTRATIONS	NUMBER OF SAMPLES EXCEEDING SCREENING VALUE	EXCEEDED APPLICABLE NATIVE STATE CRITERIA
1SUM0001	Outflow	Gauley River	None	-	-
1SUM0002	Lake	Gauley River	None	-	-
1SUM0003	Inflow	Gauley River	None	-	-
1SUM0004	Inflow	Muddlety Creek	Aluminum, Total	1	1
			Iron, Total	1	1
			Phosphorus, Total	1	1
1SUM0026	Inflow	Cherry River	None	-	-

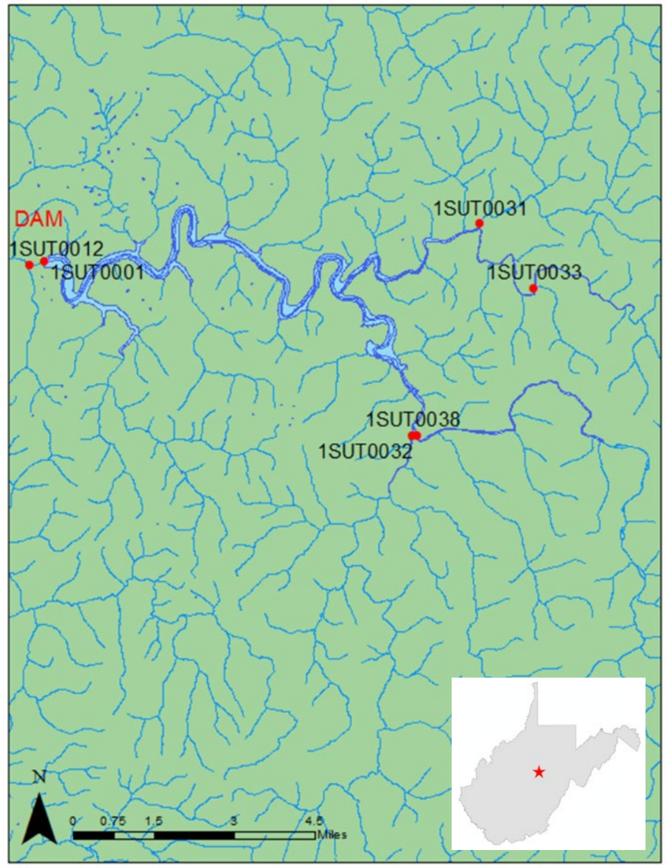


Figure 60. Water quality sampling locations for Sutton Lake in 2017.

Based on the most recent water quality sampling and analysis, some water quality constituents exceed District levels of concern, but are within historical ranges. Constituents exceeding levels of concern include specific conductance, manganese, phosphorus, strontium, sulfate, and total Kjeldahl nitrogen. Laurel Creek is contributing high concentrations of sulfate to the Elk River but concentrations are being diluted before reaching Sutton Lake. No known operational changes can be made at this current time to mitigate elevated levels from the inflow streams. Elevated constituent levels will be reported to the West Virginia Department of Environmental Protection to facilitate potential mitigation efforts by the state.

WATERSHED SUMMARY: Sutton Lake is located in Braxton County, West Virginia. The dam is located on the Elk River, a tributary of the Kanawha River; 100 miles upstream of the confluence of the Kanawha River with the Ohio River. Sutton Lake has a drainage area of 537 square miles. The lake project's authorized purposes include flood control, recreation, enhanced recreation (whitewater), low flow augmentation, and fish and wildlife conservation. The lake has a maximum depth of 110 feet and a hydraulic residence time averaging 22 days. The watershed is dominated by forested mountains and has maintained good water quality. Federally endangered mussels and a diverse fishery exist throughout the tailwater on the Elk River.

HISTORICAL CONCERNS: Mining, silviculture, and poor land management are the primary sources of watershed degradation resulting in:

- Excessive turbidity and sedimentation
- Coldwater pollution discharges

2017 ACTIVITIES: There were six sampling events in the 2017 sampling season. These events included collection of routine water samples from Sutton Lake (only 4 of 6 events), select inflows (all events), and the outflow (all events). Samples were collected from the epilimnion, metalimnion, and hypolimnion during each lake sampling event. Water samples were analyzed for a pre-determined suite of chemical analytes and chlorophyll *a*, *b*, and *c*. Physical water quality measurements were collected simultaneously using a multiparameter datasonde during all six sampling events. No benthic macroinvertebrate or fish samples were collected in 2017 due to staffing limitations. *NEXT SAMPLING YEAR: 2022*

ADDITIONAL INFORMATION: Historically, sulfate levels, chloride, specific conductance, and total dissolved solids were low in the watershed, the lake, and in the water released from the lake. The system has a low inherent capacity to resist shifts in pH as indicated by low alkalinity values and water hardness classifications of "soft". This indicates a potential for watershed problems if land use is not managed properly. Laurel Creek is a small tributary of the Elk River above Sutton Lake and is characterized by high specific conductance driven by high sulfate. High concentrations of sulfate are likely being supplied by the surface coal mine that is in the headwaters of the creek. However, substantial flows from the Elk River and its other tributaries dilute sulfate concentrations before reaching Sutton Lake.

As a result of declining communities of endangered mussels downstream of the dam, operational changes were made in order to increase the wintertime passage of sediments through the lake and decrease the summertime discharges of cold water pollution. These cold water discharges can severely impact the reproductive success of mussels on the Elk River. It is anticipated that these new operations will result in more successful mussel reproduction in the watershed. However, these operations may also have an impact to the turbidity and quality of the lake itself. The District will be monitoring for such impacts.

Since 2015, the District has been studying the impacts of environmental flow operations (e-flows) on the downstream reaches of the Elk River. The goal of this study is to determine the benefit of operating Sutton Dam for more seasonally appropriate flows and assessing the extent of impacts from cold water discharges. For more information, see the 2017 Water Quality Annual Report.

Trophic State Index (TSI) is an assessment of the level of productivity in a waterbody based on Secchi disk measurements and chlorophyll and total phosphorus concentrations in the water column. A TSI score has not been calculated for Sutton Lake.

Table 41. Sutton Lake samples exceeding state criteria and/or District levels of concern in 2017.

STATION	STATION TYPE	STREAM NAME	ANALYTES W/ELEVATED CONCENTRATIONS	NUMBER OF SAMPLES EXCEEDING SCREENING VALUE	EXCEEDED APPLICABLE NATIVE STATE CRITERIA
1SUT0001	Lake	Elk River	Manganese	2	NONE
			Total Kjeldahl Nitrogen	1	NONE
			Total Phosphorus	1	1
1SUT0012	Outflow	Elk River	None	-	-
1SUT0031	Inflow	Left Fork Holly River	None	-	-
1SUT0032	Inflow	Elk River	None	-	-
1SUT0033	Inflow	Right Fork Holly River	None	-	-
1SUT0038	Inflow	Laurel Creek	Specific Conductance	4	NONE
			Strontium	4	NONE
			Sulfate	3	NONE

Based on the most recent water quality sampling and analysis, some water quality constituents exceed District levels of concern, but are within historical ranges. Constituents exceeding levels of concern include specific conductance, aluminum, iron, strontium, sulfate, phosphorus, and total Kjeldahl nitrogen. A structural modification was completed in 2015 to reduce hydrogen sulfate releases from the dam during lake stratification. The new operation yielded favorable results by returning higher quality water to the downstream area. No other operational changes can be made at this current time to mitigate elevated levels from the inflow streams. Elevated constituent levels will be reported to the Ohio Environmental Protection Agency to facilitate potential mitigation efforts by the state.

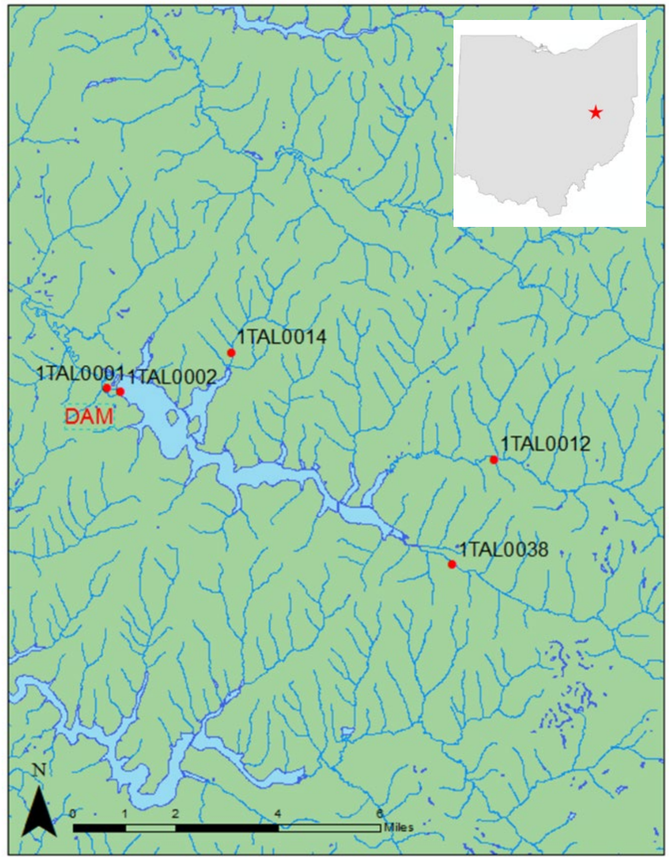


Figure 61. Water quality sampling locations for Tappan Lake in 2018.

WATERSHED SUMMARY: Tappan Lake is located in Harrison County, Ohio. The dam is located on Little Stillwater Creek, a tributary of Stillwater Creek, of the Tuscarawas River, of the Muskingum River; 174 miles above the confluence of the Muskingum River with the Ohio River. Tappan Lake has a drainage area of 71 square miles. The lake project's authorized purposes include flood control, recreation, and fish and wildlife conservation. The lake has a maximum depth of 34 feet and a hydraulic residence time that averages 190 days. The watershed is dominated by agriculture, forest, and surface mining.

HISTORICAL CONCERNS: Agriculture and mining are the primary sources of watershed degradation resulting in:

- Elevated levels of sedimentation, specific conductance, sulfates, chlorides, nutrients, and metals
- Dangerous concentrations of hydrogen sulfide gas discharges from the outlet structure

2018 ACTIVITIES: Five sampling events were conducted in the Tappan Lake watershed in 2018. High flows prevented collection of the late summer/early fall sample. Three major inflow streams and the outflow were sampled five times each. The lake was sampled four times during stratification at the primary lake station near the dam. All sampling events included the collection of physical water quality parameters via data sonde as well as water sample collection for a predetermined suite of water chemistry parameters. Each lake sampling event included an epilimnion, metalimnion, and hypolimnion sample with the addition of chlorophyll and dissolved metals analyses. Filtered samples were also collected at the outflow site during lake stratification to be analyzed for dissolved metals. No benthic macroinvertebrate sampling was conducted due to staffing limitations and high flows during the index period. Piedmont Lake is scheduled to be intensively sampled again in fiscal year 2023.

ADDITIONAL INFORMATION: In the spring of 2015, a structural modification was made to the outlet structure at Tappan Lake. The purpose of this structure was to minimize the release of hydrogen sulfide gas that was produced from outflow water originating in the hypolimnion. The chemical and biological data collected as part of this study has shown that the release of hydrogen sulfide gas from the outfall of Tappan Lake has been significantly reduced. This modification had an additional benefit of returning high quality water to the habitat downstream of Tappan Lake while likely expanding the available fish habitat within Tappan Lake by increasing the size of the oxygen rich epilimnion. It appears from 2018 data, that the phosphorus buffering capacity of the lake could be diminished as a result of the structural modification. As a result, the water quality team will increase monitoring of phosphorus in the lake and at the outflow. Phosphorus levels are also elevated above our screening values in all three of the inflows to Tappan Lake.

Tappan Lake is a source of drinking water for the nearby town of Cadiz, OH. The lake has consistently high levels of microcystins, which must be constantly monitored by the Town of Cadiz to ensure public safety. A newly formed nutrient reduction initiative in 2018 may help alleviate the issues caused by nuisance algae blooms on Tappan Lake.

Trophic State Index (TSI) is an assessment of the level of productivity in a waterbody based on Secchi disk measurements and chlorophyll and total phosphorus concentrations in the water column. A TSI score has not been calculated for Tappan Lake.

Table 42. Tappan Lake samples exceeding state criteria and/or District levels of concern in 2018.

STATION	STATION TYPE	STREAM NAME	ANALYTES W/ELEVATED CONCENTRATIONS	NUMBER OF SAMPLES EXCEEDING SCREENING VALUE	EXCEEDED APPLICABLE NATIVE STATE CRITERIA
1TAL0001	Outflow	Little Stillwater Creek	Dissolved Oxygen	2	NONE
			Specific Conductance	4	NONE
			Strontium	5	NONE
			Sulfate	2	NONE
			Kjeldahl Nitrogen, Total	5	NONE
			Phosphorus, Total	6	NONE
1TAL0002	Lake	Little Stillwater Creek	Kjeldahl Nitrogen, Total	2	NONE
			Specific Conductance	3	NONE
			Strontium	3	NONE
			Sulfate	2	NONE
1TAL0027	Inflow	Clear Fork	Aluminum	2	NONE
			Iron	3	NONE
			Kjeldahl Nitrogen, Total	1	NONE
			Phosphorus, Total	4	NONE
			Specific Conductance	6	NONE
			Strontium	5	NONE
			Sulfate	5	NONE
1TAL0014	Inflow	Lower Beaverdam Run	Aluminum	1	NONE
			Iron	3	NONE
			Phosphorus, Total	4	NONE
			Specific Conductance	2	NONE
1TAL0045	Inflow	Standingstone Fork	Iron	1	NONE
			Phosphorus, Total	1	NONE
			Specific Conductance	7	NONE
			Strontium	7	NONE
			Sulfate	8	NONE

Based on the most recent water quality sampling and analysis, some water quality constituents exceed District levels of concern. Constituents exceeding levels of concern include aluminum, dissolved oxygen, iron, phosphorus, and total kjeldahl nitrogen. No known operational changes can be made at this time to mitigate elevated levels from the inflow streams.

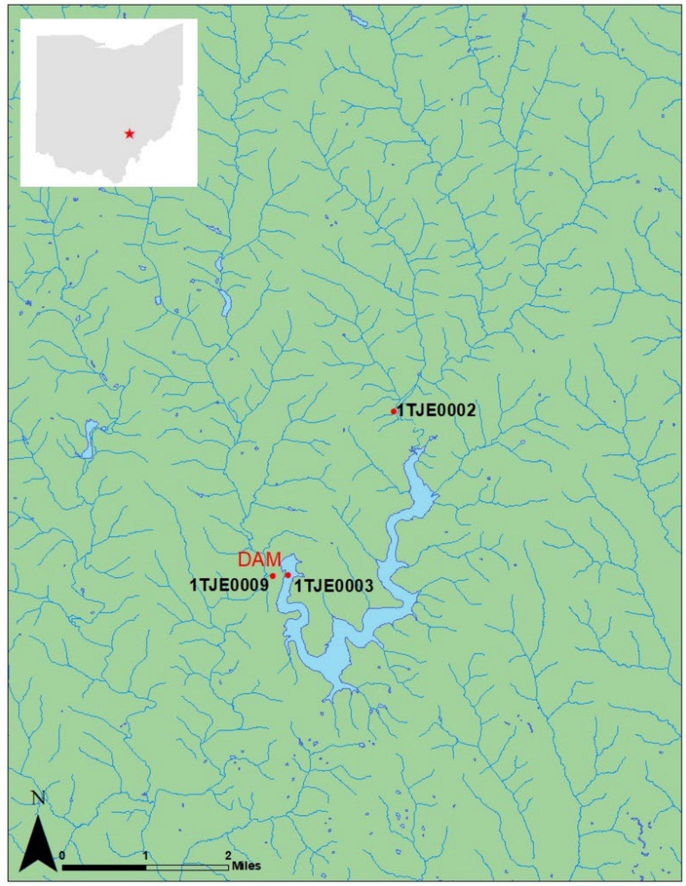


Figure 62. Water quality sampling locations for Tom Jenkins Dam in 2020.

WATERSHED SUMMARY: Tom Jenkins Dam (Burr Oak Lake) is in Athens County, Ohio on East Branch of Sunday Creek, a tributary of Sunday Creek of the Hocking River. The East Branch of Sunday Creek drains the northwestern segment of the Hocking River Basin, including portions of Athens, Morgan, and Perry counties in Ohio. The Burr Oak Lake watershed drains an area of 33 square miles. The project purposes are flood control, water conservation for recreation, water quality, water supply, and fish and wildlife conservation. The lake has a maximum depth of 30 feet and a water retention time of 99 days.

HISTORICAL CONCERNS: Mining, agriculture, and poor land management are the primary sources of watershed degradation resulting in:

- Excessive turbidity and sedimentation
- Increased concentrations of aluminum, manganese, iron, specific conductance, and sulfates
- Increased concentrations of nutrients

2020 ACTIVITIES: Six sampling events were conducted in the Tom Jenkins watershed in 2020. One major inflow stream and the outflow were sampled six times each. The lake was sampled four times during stratification at the primary lake station near the dam. All sampling events included the collection of physical water quality parameters via data sonde as well as water sample collection for a predetermined suite of water chemistry parameters. Each lake sampling event included an epilimnion, metalimnion, and hypolimnion sample with the addition of chlorophyll and dissolved metals analyses. Filtered samples were also collected at the outflow site during lake stratification and analyzed for dissolved metals. Benthic macroinvertebrate samples were collected from the inflow using Hester-Dendy samplers. Tom Jenkins (Burr Oak Lake) is scheduled to be intensively sampled again in fiscal year 2025.

ADDITIONAL INFORMATION: Low dissolved oxygen reading at 1TJE0002 was a result of collecting sample during critical low flow period. Average lake inflows during that time were regularly below 10 cfs.

Tom Jenkins frequently saw exceedances in concentrations of iron, manganese, phosphorus, and TKN in the lake and outflow. Exceedances were not as frequent in the inflow stream suggesting there is internal loading occurring in the lake that is being discharged downstream.

Benthic macroinvertebrate survey results from 2020 are still being reviewed.

Trophic State Index (TSI) is an assessment of the level of productivity in a waterbody based on Secchi disk measurements and chlorophyll and total phosphorus concentrations in the water column. Burr Oak Lake scored 38 for average TSI in 2019 to 2020, which is categorized as oligotrophic. Oligotrophic lakes are usually characterized by having high clarity, low nutrients, and low algal growth.

Table 43. Tom Jenkins Dam samples exceeding state criteria and/or District levels of concern in 2020.

STATION	STATION TYPE	STREAM NAME	ANALYTES W/ELEVATED CONCENTRATIONS	NUMBER OF SAMPLES EXCEEDING SCREENING VALUE	EXCEEDED APPLICABLE NATIVE STATE CRITERIA
1TJE0002	Inflow	East Branch of Sunday Creek	Aluminum	2	None
			Dissolved Oxygen	1	None
			Iron	2	None
			Phosphorus	1	None
			TKN	1	None
1TJE0003	Lake	East Branch of Sunday Creek	Aluminum	2	None
			Iron	2	None
			Manganese	8	None
			Phosphorus	4	None
			TKN	8	None
1TJE0009	Outflow	East Branch of Sunday Creek	Aluminum	3	None
			Iron	6	None
			Manganese	6	None
			Phosphorus	4	None
			TKN	4	None

Based on the most recent water quality sampling and analysis, some water quality constituents exceed District levels of concern. Constituents exceeding levels of concern include bromide, dissolved oxygen, phosphorus, specific conductivity, strontium, iron, aluminum, manganese, sulfate, pH, and total Kjeldahl nitrogen. Some sampling locations exceeded the state of Ohio's criteria for pH. No known operational changes can be made at this time to mitigate elevated levels from the inflow streams. Sites that exceeded state criteria will be reported to the Ohio Environmental Protection Agency to facilitate potential mitigation efforts by the state.

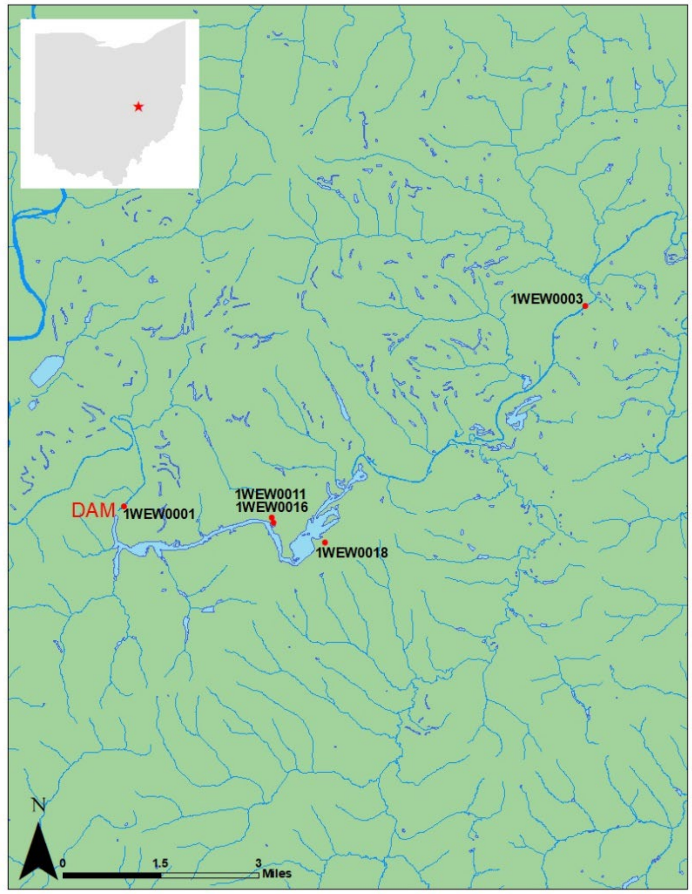


Figure 63. Water quality sampling locations for Wills Creek Lake in 2020.

WATERSHED SUMMARY: Wills Creek, a major tributary of the Muskingum River, is located in eastern Ohio and extends in a general northwesterly direction from its headwaters in northwestern Monroe County and northeastern Noble County, Ohio. Wills Creek Lake is located in Coshocton County, Ohio 6 miles above the mouth of Wills Creek and 108 miles above the mouth of the Muskingum River, a tributary of the Ohio River. The purposes for the project are flood control, water conservation for recreation, and fish and wildlife conservation. The lake drains approximately 724 square miles and the water retention time for the lake averages 0.6 days. The lake had a maximum depth of 22 feet, but most of the pool has been lost to sedimentation.

HISTORICAL CONCERNS: Mining, agriculture, and poor land management are the primary sources of watershed degradation resulting in:

- Excessive turbidity and sedimentation
- Increased concentrations of aluminum, manganese, iron, specific conductance, and sulfates
- Increased concentrations of nutrients

2020 ACTIVITIES: Six sampling events were conducted in the Wills Creek Lake watershed in 2020. One major inflow stream, two mine discharges, a treatment pond outflow, and the lake outflow were sampled six times each. The lake was sampled four times during stratification at the primary lake station near the dam. All sampling events included the collection of physical water quality parameters via data sonde as well as water sample collection for a predetermined suite of water chemistry parameters. Each lake sampling event included an epilimnion sample with the addition of chlorophyll and dissolved metals analyses. The entire water column was not sampled due to lake accessibility issues. Filtered samples were also collected at the outflow site during lake stratification and analyzed for dissolved metals. Only one Hester-Dendy macroinvertebrate sampler was recovered from the treatment pond outflow. In 2021, a Hester-Dendy was placed at WEW0003 where it was lost in 2020. This time, it was able to be retrieved and received an Invertebrate Community Index (ICI) score of 12 (poor). Wills Creek Lake is scheduled to be intensively sampled again in fiscal year 2025.

ADDITIONAL INFORMATION: A series of ponds were constructed to retain and treat mine water discharge flowing into the lake. Discharges from the pond regularly exceed water quality criteria despite treatment efforts. Additionally, this lake has lost significant capacity in the conservation pool due to excessive sedimentation. Sedimentation has impacted the recreation mission on the lake. LRH is reviewing existing authorities to determine if the water quality issues can be further mitigated.

Elevated levels of metals, nutrients, and sulfates are being passed downstream of Wills Creek Dam, suggesting that pollutants are not being buffered by the lake. Pollutant loading appears to come from the inflow streams and various mine discharges around the lake.

Benthic macroinvertebrate survey results from 2020 are still being reviewed.

Trophic State Index (TSI) is an assessment of the level of productivity in a waterbody based on Secchi disk measurements and chlorophyll and total phosphorus concentrations in the water column. Wills Creek Lake scored 57 for average TSI in 2020, which is categorized as eutrophic. Eutrophic lakes are usually characterized by having low clarity, high nutrients, and high algal growth.

Table 44. Wills Creek Lake samples exceeding state criteria and/or District levels of concern in 2020.

STATION	STATION TYPE	STREAM NAME	ANALYTES W/ELEVATED CONCENTRATIONS	NUMBER OF SAMPLES EXCEEDING SCREENING VALUE	EXCEEDED APPLICABLE NATIVE STATE CRITERIA
1WEW0001	Outflow	Wills Creek	Aluminum	4	NONE
			Bromide	2	NONE
			Conductance	3	NONE
			Iron	6	NONE
			TKN	5	NONE
			Phosphorus, Total	6	NONE
			Strontium, Total	5	NONE
			Sulfate	1	NONE
1WEW0002	Lake	Wills Creek	Aluminum	1	NONE
			Bromide	3	NONE
			Conductance	2	NONE
			Iron	1	NONE
			Phosphorus, Total	2	NONE
			Strontium, Total	3	NONE
			Sulfate	1	NONE
			TKN	2	NONE
1WEW0003	Inflow	Wills Creek	Aluminum	4	NONE
			Bromide	4	NONE
			Conductance	4	NONE
			Iron	5	NONE
			Phosphorus, Total	5	NONE
			Strontium, Total	5	NONE
			Sulfate	2	NONE
			TKN	2	NONE
1WEW0011	Inflow	Mine Discharge into treatment pond	Aluminum	2	NONE
			Conductance	6	NONE

STATION	STATION TYPE	STREAM NAME	ANALYTES W/ELEVATED CONCENTRATIONS	NUMBER OF SAMPLES EXCEEDING SCREENING VALUE	EXCEEDED APPLICABLE NATIVE STATE CRITERIA
			Iron	7	NONE
			Manganese	6	NONE
			pH	6	YES
			Strontium, Total	6	NONE
			Sulfate	7	NONE
			TKN	7	NONE
1WEW0016	Inflow	Discharge from treatment pond	Aluminum	1	NONE
			Bromide	1	NONE
			Conductance	6	NONE
			Iron	6	NONE
			Manganese	4	NONE
			pH	1	Yes
			Phosphorus	2	NONE
			Strontium, Total	6	NONE
			Sulfate	6	NONE
			TKN	2	NONE
1WEW0018	Inflow	Mine Discharge	Aluminum	4	NONE
			Conductance	6	NONE
			Dissolved Oxygen	6	NONE
			Iron	6	NONE
			Manganese	5	NONE
			pH	6	Yes
			Strontium, Total	6	NONE
			Sulfate	6	NONE
			TKN	6	NONE

Based on the most recent water quality sampling and analysis, some water quality constituents exceed District levels of concern, but are within historical ranges. Constituents exceeding levels of concern include aluminum, iron, strontium, manganese, sulfate, phosphorus, total Kjeldahl nitrogen, dissolved oxygen, and specific conductance. No known operational changes can be made at this current time to mitigate elevated levels from the inflow streams. Elevated constituent levels will be reported to the Kentucky Division of Water to facilitate potential mitigation efforts by the state.

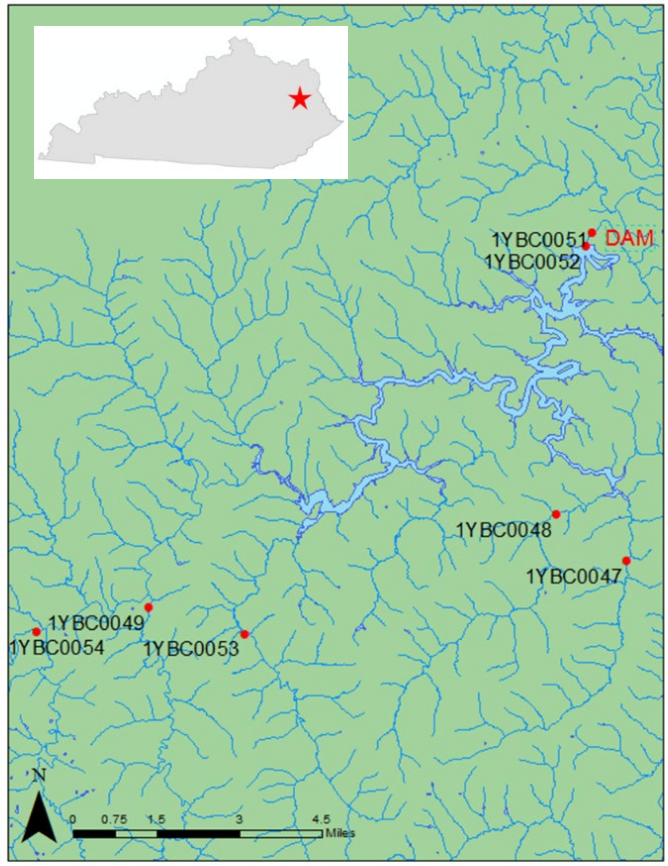


Figure 64. Water quality sampling locations for Yatesville Lake in 2018.

WATERSHED SUMMARY: Yatesville Lake is located in Lawrence County, Kentucky on Blaine Creek, a tributary of the Big Sandy River, of the Ohio River. The dam is located 18.1 miles upstream of the mouth of Blaine Creek. The drainage area of the lake is 208 square miles. The lake project's authorized purposes include flood control, recreation, fish and wildlife conservation, and water quality. The outflow structure at the dam is the best example of a high functioning selective withdrawal structure within the District. The lake has a maximum depth of 57 feet and a hydraulic residence time of about 71 days. The watershed is dominated by forest with mineral and gas extraction industries present.

HISTORICAL CONCERNS: Oil and gas extraction and poor land management are the primary sources of watershed degradation resulting in:

- High levels of iron and manganese in the inflow streams are compounded in the lake because of anoxic conditions in the hypolimnion
- High Total Dissolved Solids (TDS) levels in the inflow streams cause layering in the lake which in-turn cause fall turnover to be later than expected
- Naturally Occurring Radioactive Materials (NORMs) are entering the watershed as a result of oil and gas extraction

2018 ACTIVITIES: Six sampling events were conducted in the Yatesville Lake watershed in 2018. Five major inflow streams and the outflow were sampled six times each. The lake was sampled four times during stratification at the primary lake station near the dam. All sampling events included the collection of physical water quality parameters via data sonde as well as water sample collection for a predetermined suite of water chemistry parameters. Each lake sampling event included an epilimnion, metalimnion, and hypolimnion sample with the addition of chlorophyll and dissolved metals analyses. Filtered samples were also collected at the outflow site during lake stratification to be analyzed for dissolved metals.

ADDITIONAL INFORMATION: The sampling event in January showed high concentrations of aluminum, iron, and nutrients in the inflows. These samples were collected during a high flow event in which stream turbidity was very high. This could account for the elevated constituents, since some metals and nutrients tend to bind to sediment. Results from the outflow were within historical ranges.

Chloride levels have continued to rise in the inflows but remain below our screening values for the analyte. Left Fork and Right Fork Little Blaine Creeks contributed high metals and sulfate concentrations to the lake throughout the year. There are active mine sites within the Little Blaine Creek watershed that is the likely source of these impairments. Additionally aluminum, iron, manganese, and total Kjeldahl nitrogen concentrations were elevated in the hypolimnion of Yatesville Lake during several sampling events, suggesting that these constituents are accumulating in the sediment at the lake's bottom. The outflow also showed slightly elevated concentrations of these analytes, suggesting staff were making use of the project's selective withdrawal capabilities to improve water quality conditions downstream. Yatesville Lake boasts the District's most modern selective withdrawal system, regular use of which can help alleviate low oxygen and high metals issues that develop during summer stratification.

Trophic State Index (TSI) is an assessment of the level of productivity in a waterbody based on Secchi disk measurements and chlorophyll and total phosphorus concentrations in the water column. Yatesville Lake scored 42 for average TSI in 2018, which is categorized as mesotrophic. Mesotrophic lakes are usually characterized by having moderate clarity, nutrients, and algal growth.

Table 45. Yatesville Lake samples exceeding state criteria and/or District levels of concern in 2018.

STATION	STATION TYPE	STREAM NAME	ANALYTES W/ELEVATED CONCENTRATIONS	NUMBER OF SAMPLES EXCEEDING SCREENING VALUE	EXCEEDED APPLICABLE NATIVE STATE CRITERIA
1YBC0047	Inflow	Left Fork Little Blaine Creek	Aluminum	1	NONE
			Iron	1	Yes
			Specific Conductivity	3	NONE
			Strontium	3	NONE
			Sulfate	2	NONE
			Kjeldahl Nitrogen, Total	1	NONE
			Phosphorus, Total	1	NONE
1YBC0048	Inflow	Right Fork Little Blaine Creek	Aluminum	1	NONE
			Iron	1	Yes
			Kjeldahl Nitrogen, Total	1	NONE
			Manganese	2	NONE
			Phosphorus, Total	1	NONE
			Specific Conductivity	3	NONE
			Strontium	4	NONE
			Sulfate	3	NONE
1YBC0049	Inflow	Hood Creek	Aluminum	1	NONE
			Dissolved Oxygen	1	Yes
			Iron	4	No
			Kjeldahl Nitrogen, Total	1	NONE
			Phosphorus, Total	1	NONE
1YBC0050	Lake	Blaine Creek	None	-	-
1YBC0051	Outflow	Blaine Creek	None	-	-
1YBC0053	Inflow	Brushy Creek	Aluminum	1	NONE
			Dissolved Oxygen	1	Yes
			Iron	2	Yes
			Kjeldahl Nitrogen	3	NONE

STATION	STATION TYPE	STREAM NAME	ANALYTES W/ELEVATED CONCENTRATIONS	NUMBER OF SAMPLES EXCEEDING SCREENING VALUE	EXCEEDED APPLICABLE NATIVE STATE CRITERIA
			Phosphorus, Total	1	NONE
1YBC0054	Inflow	Blaine Creek	Iron	1	No
			Phosphorus, Total	1	NONE
			Specific Conductance	3	NONE
			Strontium	5	NONE

Dry Dams: Bolivar (BOS), Dover (DOT), Mohawk (MKW), and Mohicanville (MOL)

There are currently four dry dams managed by the Huntington District: Bolivar, Dover, Mohawk, and Mohicanville Dams. Dry dams do not maintain a permanent pool or impoundment behind the dam, and therefore are operated as run-of-the-river for the majority of the time. The dams will be operated to reduce downstream flooding only during times of excessive rain, so any resulting inundation behind the dam is only temporary. Additionally, there is no hydraulic residence time calculated for these projects. Water Quality sampling at these projects has historically been infrequent due to the nature of their operation, with Mohawk Dam receiving the most attention.

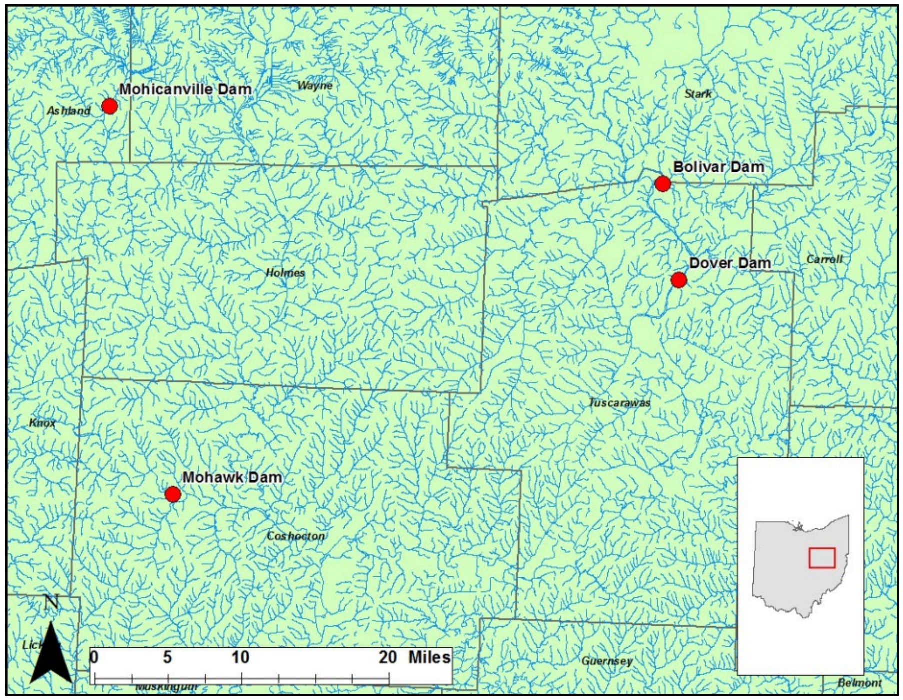


Figure 65. The locations of the four dry dams managed by the Huntington District USACE.

WATERSHED SUMMARY:

Bolivar: Bolivar Dam is located in Stark and Tuscarawas Counties, Ohio, on Sandy Creek, a tributary of the Tuscarawas River, of the Muskingum River; 183 miles upstream of the confluence of the Muskingum and Ohio Rivers. The lake's authorized project purpose includes only flood control. The watershed is dominated by agriculture and drains 502 square miles.

Dover: Dover Dam is located in Tuscarawas County, Ohio on the Tuscarawas River, a tributary of the Muskingum River, of the Ohio River. The dam is located 174 miles upstream of the confluence of the Muskingum and Ohio Rivers. The drainage are of the impoundment is 782 square miles. The authorized project purposes for Dover Dam include flood control and water conservation. Land use in the watershed is a mix of agriculture, housing, and forested land.

Mohawk: Mohawk Dam is located in Coshocton County, Ohio on the Walhonding River, a tributary of the Muskingum River. The dam is 130 miles upstream of the confluence of the Muskingum and Ohio Rivers. The drainage area of the impoundment is 821 square miles. The only authorized project purpose for Mohawk Dam is flood control. Land use in the watershed is mostly agriculture and forested land.

Mohicanville: Mohicanville Dam is located in Ashland County, Ohio on the Lake Fork of Mohican River, a tributary of the Walhonding River, of the Muskingum River, of the Ohio River. The dam is 171 miles upstream of the confluence of the Muskingum and Ohio Rivers. The drainage area of the impoundment is 271 square miles. The only authorized project purpose for Mohicanville Dam is flood control.

HISTORICAL CONCERNS:

Bolivar: Industrial, agricultural, livestock, and wastewater treatment runoff are the primary sources of high nutrient levels, metals, and sedimentation in the Sandy Creek watershed.

Dover: Industrial, agricultural, livestock, and resource extraction runoff are the primary sources of high nutrient levels, metals, and sedimentation in the Tuscarawas River watershed. A large drainage area behind the dam leads to many potential sources of pollutants. The original plans for Dover Dam provided for a permanent impoundment, but industrial waste and heavy sediment loads from the Tuscarawas River initiated the decision to operate the project as a dry dam only.

Mohawk: Industrial, agricultural, livestock, and resource extraction runoff are the primary sources of high nutrient levels, metals, and sedimentation in the Walhonding River watershed. A large drainage area behind the dam leads to many potential sources of pollutants.

Mohicanville: Agricultural, livestock, and resource extraction runoff are the primary sources of high nutrient levels and metals in the Lake Fork watershed. The majority of the watershed is devoted to agriculture, which can potentially introduce large amounts of sediment to the stream, especially during the winter months when soils are bare.

RECENT ACTIVITIES:

Bolivar: Water chemistry samples were last collected from the Bolivar Dam outflow in June of 2011 and analyzed for total and dissolved metals, nutrients, solids, ions, and physical parameters as part of the ambient sampling program. Additional sampling in the same fashion occurred in 2009, 1975, and 1974 at various times of the year.

Dover: Water chemistry samples were last collected from the Dover Dam outflow in June of 2011 and analyzed for total and dissolved metals, nutrients, solids, ions, and physical parameters as part of the ambient sampling program. Additional sampling in the same fashion occurred in 2009, 1975, and 1974 at various times of the year.

Mohawk: More extensive water chemistry sampling has been conducted at Mohawk Dam in both the outflow and the inflow. Samples were last collected from the outflow in June of 2011 and analyzed for total and dissolved metals, nutrients, solids, ions, and physical parameters as part of the ambient sampling program. Considerable amounts of sampling were conducted in 1974 to 1975 and 1992 to 1993.

Mohicanville: Water chemistry samples were last collected from the Mohicanville Dam outflow in June of 2011 and analyzed for total and dissolved metals, nutrients, solids, ions, and physical parameters as part of the ambient sampling program. Additional sampling in the same fashion occurred in 2009, 1975, and 1974 at various times of the year.

ADDITIONAL INFORMATION: There are currently no plans to conduct routine sampling as part of the intensive sampling program at any of the dry dam projects. Because these projects are only operated for flood damage reduction, which would supersede any water quality benefit, there is little value to be gained by monitoring them for water quality. Sampling may be conducted on an ad hoc basis should the need arise.