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

Annual Water Quality Report

2019

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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 2019:

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 Little Sandy, Scioto, and Muskingum River basins. Surveys were conducted six times each at Grayson, Alum Creek, Deer Creek, Delaware, Paint Creek, and Senecaville Lakes. Flooding in June caused closures at some Scioto lakes, which prevented sample collection for that month. 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) The Water Quality Team continued to evaluate the potential water quality and ecological benefits of implementing environmental flow (e-flow) operations below East Lynn, Burnsville, and Sutton Lakes. E-flow is an emerging concept that involves managing water quantity, timing, and quality to sustain the ecological integrity of riverine ecosystems. The study was initiated in 2015 with the deployment of temperature loggers below each dam up to 30 km downstream. Data collected in 2017 and 2018 suggest impacts to the downstream temperature from lake operations are still present as far as 75 km downstream of the outflows of Burnsville and Sutton. As a result of these data, HOBO temperature loggers were placed at strategic intervals below East Lynn, Burnsville, and Sutton Dams to the mouths of their respective outflow streams. When compared to 2017, data from 2018 suggest that better operations at Sutton Dam can drastically reduce the magnitude and distance of temperature changes downstream of the dam following high flow events. Drastic temperature swings are known to cause harm and sometimes death to fish and macroinvertebrates living downstream. The goal of this study is to recommend operational modifications to reduce negative environmental impacts downstream while still maintaining project purposes.
3) The Water Quality Team continued to evaluate the potential water quality, ecological, and operational benefits of structural modifications at Muskingum Lakes. Multiples lakes in the Muskingum River basin (namely Atwood, Clendening, Leesville, Piedmont, and Tappan) have had recurring problems with hydrogen sulfide gas being released from their dams in varying concentrations. Hydrogen sulfide production results from chemical reactions at the bottom of a lake and is known to degrade outlet structures and impede tailwater recreation when it is released downstream. A low-cost structural modification to Tappan Dam in 2015 resulted in reduced hydrogen sulfide releases, the return of high quality water downstream, and an increase in the depth of oxygenated water in the lake. Favorable results at Tappan prompted the decision to continue with modifications to the remaining four projects. Water quality buoys were deployed in 2019 to collect "post-modification" data and assess the effectiveness of the modifications at Clendening, Tappan, and Atwood Lakes, but data analysis is incomplete. Results of this multi-year effort have so far demonstrated favorable results at Clendening, Piedmont, and Tappan. The unusual design of the intake structures at Atwood and Leesville have caused delays in scheduling the modifications at those projects. Implementation of this simple, low-cost fix at all five projects will result in a cost savings of $4.8M when compared to retrofitting the dams with more modern selective withdrawal capabilities.

4) 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 Deer Creek, Grayson, Senecaville, and John W. Flannagan Lakes in 2019. The events were handled by the respective State agencies and no significant impacts were reported.

5) The LRH Water Quality Team educated future scientists by partnering with local universities, high schools, and elementary schools to discuss principles of water quality, water management, and the Corps mission as part of the Science, Technology, Engineering, and Mathematics (STEM) program. The Water Quality Team represented the USACE at eight STEM outreach events in 2019 including the USACE Engineers Day, World Scout Jamboree, and the Annual Water Festival at Marshall University. Typical presentations included educational booths, fish tanks, various water quality equipment, PowerPoint presentations, and wildlife exhibits. Water Quality staff discussed the Corps water quality mission, equipment operation and purpose, watershed principles, and career opportunities in biological sciences. The Water Quality Team actively pursues STEM outreach opportunities in order to facilitate educational opportunities for young students and allow them to see potential career paths with the USACE.

6) As part of the Water Quality Program mission, the Water Quality Team regularly provides support for other USACE offices and organizations.

    a) 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.

    b) The Water Quality Team monitored maintenance dredging operations below R.C. Byrd Locks & Dam as required per 401 Water Quality Certification stipulations in 2019. 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.

    c) The Water Quality Team is often called to respond to environmental issues or provide guidance to other USACE offices and lake projects. In 2019, the Team used an EcoMapper and Sontek Acoustic Doppler to collect bathymetry measurements at Dillon Lake in order to update storage curves used by Water Management to make daily operational decisions. Water Quality Staff completed a shoreline mussel assessment at Sutton Lake at the request of Operations Division in order to determine the potential impacts to mussel resources during a deep drawdown of the lake. The Water Quality Team used an acoustic Doppler to map stilling basin velocities below Bluestone Dam in order to assess safe working conditions for Contractors under additional gate openings. 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. Lastly, two members of the Water Quality Team are involved in a national PDT to develop a USACE-wide water quality database. More information can be found in the Situational/Reactionary Support section.

7) 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

> 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.*" - **ER 1110-2-8154**

***Water Quality** – The physical, chemical, and biological characteristics of water as it occurs on or beneath the surface of the earth including its quantity, distribution, movement, sediments, and biological community (including transients).* **ER 1110-2-8154; 5.c**

Figure 1. The definition of water quality as described in ER 1110-2-8154.

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 1). 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

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 creates unique water chemistry and sediment conditions at each project (Figure 2)

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) Establish baseline conditions and identify trends, opportunities, and problems.
(2) Assess compliance with applicable Federal, State, and local water quality standards.
(3) Provide an adequate database for understanding project conditions and facilitate coordination with Federal and state agencies with regard to watershed activities influencing water quality.
(4) Investigate special problems, design and implement modifications, and improve water management procedures.
(5) Provide data to support reservoir regulation elements for effective management and control of water quality and environmental problems.
(6) Provide water quality data required for real-time project regulation.
(7) Evaluate water/sediment interactions and their effects on overall water quality.
(8) Engineer aquatic environments and ecosystems.
(9) Develop and maintain the environmental awareness and sensitivity essential for sound stewardship for the resource.
(10) Monitor swimming beaches and water supplies for priority pollutants.

Figure 3. Objectives that drive water quality data collection per ER 1110-2-8154; section 10.a.

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 five full-time personnel working on the Water Quality Team in 2019: Kamryn Tufts, *Aquatic Biologist*, Thad Tuggle, *Fisheries Biologist*, Josh Daugherty, *Aquatic Biologist*, Luke Sadecky, *Aquatic Biologist*, and Andrew Johnson, *Wildlife Biologist*. In addition, the team was assisted by one part-time student, Nathan Fleshman.

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. However, Water Quality staff maintain offices at the Distict headquarters in Huntington.

Survey Implementation Strategy

A fixed-site sampling program has been implemented in order to monitor a project's long-term water quality. 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 in our 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.
- 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 our 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 LRH's water quality program: 1) assess compliance with state and federal water quality standards by monitoring current water quality conditions affected 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:

- **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 our jurisdiction that may affect data analysis and site monitoring.

2) Provide Support to Water Control, Project Operations, and Navigation Channel Maintenance Section

LRH 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 6). 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 are able to 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. In order 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 for water quality

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 of our 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.

3) 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 business 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 in order to address the source of impairment.

4) 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 3 (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 in order 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 3 (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 the 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 website (water.usace.army.mil) to provide water quality data to the public for compliance with WRDA 2014 which requires public access to USACE water quality data.

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 is 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 the 250 active gaging stations used by the District 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 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 2019

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 fourteen water quality constituents for long term trend analysis and compliance determinations. These fourteen 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 in order 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.

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 6.0 to 9.0. This threshold value is consistent with the water quality standard of Kentucky.

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.

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
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	5 mg/l	5.0 mg/	None	None

Analyte	USACE Threshold	West Virginia	Kentucky	Ohio	Virginia
	6.0 mg/l cold		6.0 mg/l cold		
Iron	1,000 ug/l	1,500 ug/l	4000 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	None
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	None
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 Water Quality Survey Summaries

Intensive surveys were completed at six projects in 2019 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. Table 2 lists parameters and analytes that were tested for in 2019.

A seasonal approach has been implemented for intensive surveys in order 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 are able to bracket the range of “normal” conditions for those water bodies.

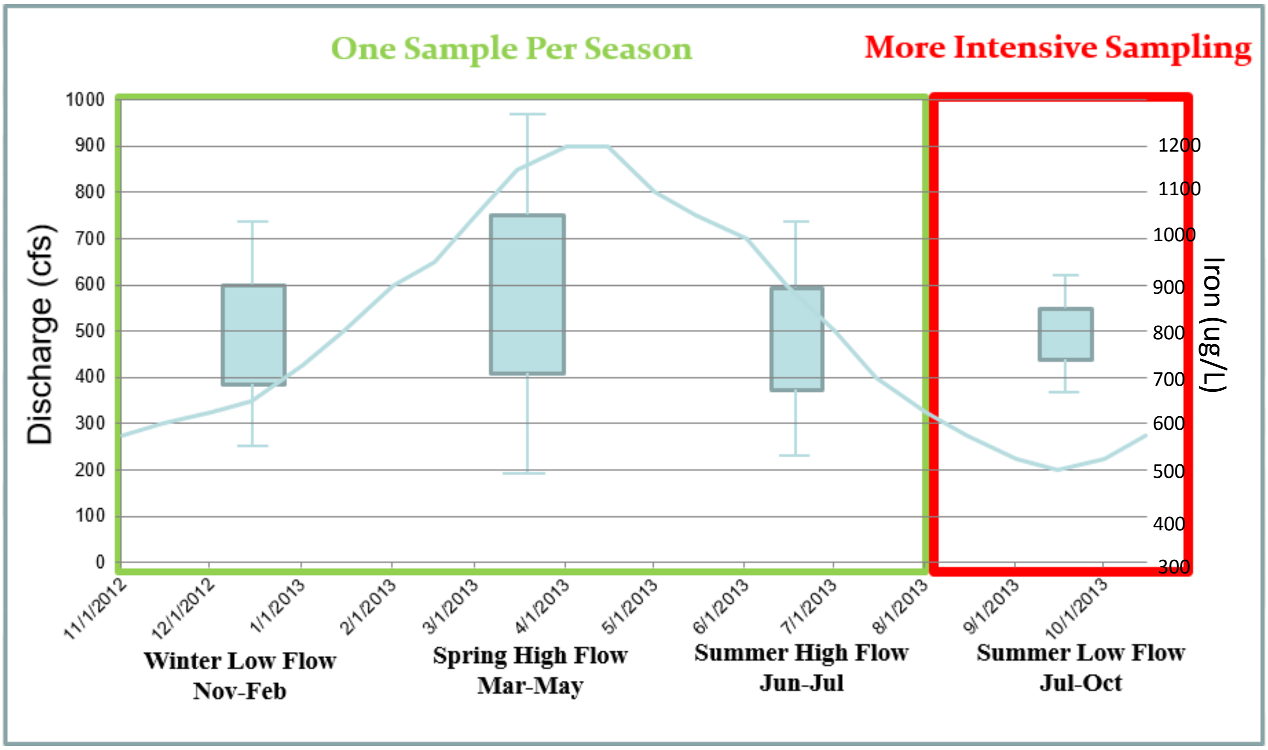

Figure 4. Demonstrates the flow and water quality variability that accompany different seasons of the year.

The Water Quality Team completed intensive water quality surveys at six projects in the Scioto, Little Sandy, and Muskingum River basins. Surveys were conducted six times each at Grayson, Senecaville, Alum Creek, Paint Creek, Delaware, and Deer Creek Lakes. The sections below summarize the most recent information that was collected in 2019. It is important to note that due to differences in flow as a result of impoundment, IBI and Shannon Index scores should not be used to compare outflows to inflows. 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.

Alum Creek Lake: 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.

Deer Creek Lake: 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.

Delaware Lake: 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, whereas 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.

Grayson Lake: 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. No biological data were collected in 2019.

Paint Creek Lake: 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 consituents 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.

Senecaville Lake: 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. No biological data were collected in 2019.

Table 2. Water quality analytes included in current analysis contract and those sampled in 2019.

Water Quality Parameters	Alum Creek	Deer Creek	Delaware	Paint Creek	Grayson	Senecaville
Hot Peroxide Acidity						X
Total Alkalinity	X	X	X	X	X	X
Aluminum	X	X	X	X	X	X
Ammonia as N	X	X	X	X	X	X
Antimony						X
Arsenic	X	X	X	X	X	X
Barium						X
Beryllium						X
Bicarbonate	X	X	X	X	X	X
Boron	X	X	X	X	X	X
Bromide						X
Cadmium	X	X	X	X	X	X
Calcium	X	X	X	X	X	X
Carbon, Organic						
Carbon, Inorganic						
Chloride	X	X	X	X	X	X
Chromium	X	X	X	X	X	X
Cobalt						
Copper	X	X	X	X	X	X
Iron	X	X	X	X	X	X
Total Hardness	X	X	X	X	X	X
Total Kjeldahl Nitrogen	X	X	X	X	X	X
Lead	X	X	X	X	X	X
Magnesium	X	X	X	X	X	X
Manganese	X	X	X	X	X	X
Mercury	X	X	X	X	X	X

Water Quality Parameters	Alum Creek	Deer Creek	Delaware	Paint Creek	Grayson	Senecaville
Nickel	X	X	X	X	X	X
Nitrite + Nitrate as N	X	X	X	X	X	X
Oxygen Saturation	X	X	X	X	X	X
Oxygen Concentration	X	X	X	X	X	X
Total Phosphorus	X	X	X	X	X	X
pH	X	X	X	X	X	X
Potassium	X	X	X	X	X	X
Total Dissolved Solids	X	X	X	X	X	X
Solids, Suspended	X	X	X	X	X	X
Secchi Depth	X	X	X	X	X	X
Selenium	X	X	X	X	X	X
Silver						X
Sodium	X	X	X	X	X	X
Specific Conductance	X	X	X	X	X	X
Strontium	X	X	X	X	X	X
Sulfate	X	X	X	X	X	X
Temperature	X	X	X	X	X	X
Thallium						X
Tin						X
Titanium						X
Turbidity	X	X	X	X	X	X
Vanadium						X
Zinc	X	X	X	X	X	X

Fish Surveys

Electrofishing surveys were conducted at 5 sites in 2019 including the Paint Creek outflow (PCS0001) and Deer Creek outflow (DCS0001), Paint Creek (PCS0002), Rattlesnake Creek (PCS0009), and Deer Creek (DCS0013). Surveys were conducted using the tote barge electrofishing method. Upon completion of survey, 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. Over 7000 specimens were identified and data was input into an Index of Biotic Integrity (IBI) calculator for the state of Ohio. Paint Creek received the best IBI score while the Deer Creek outflow received the lowest score of the sites surveyed in 2019. The criteria for a rating of “good” is a score of anywhere between 36-49. All sites received a rating of “good.” However, the Deer Creek outflow is at the lowest end of the “good” rating. The lower score in relation to the other sites may be explained in part by low dissolved oxygen levels observed at this site in the past, but further research is needed to determine the impairment.

Table 3. Index of Biotic Integrity (IBI) scores resulting from electrofishing surveys conducted in the Scioto River projects in 2019.

Site	IBI Score	Rating
DCS0001	36	Good
DCS0013	47	Good
PCS0001	47	Good
PCS0002	48	Good
PCS0009	45	Good

Environmental Flow Study

Environmental flow (e-flow) is the process of managing water quantity, timing, and quality to sustain ecological integrity of riverine ecosystems. 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. The Water Quality Team first implemented e-flow studies at East Lynn Lake in 2013 and this revealed a great opportunity to manage operations for the benefit of downstream aquatic communities. Studies at Burnsville and Sutton Lakes were added in 2015 and other LRH projects may be added in the future.

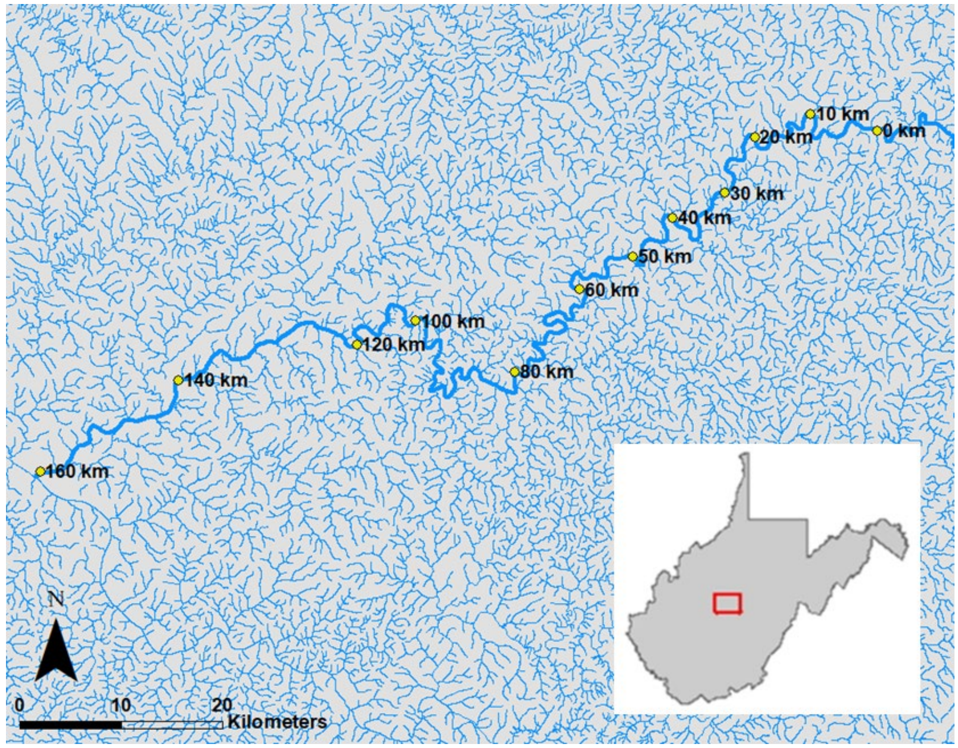

Figure 5. Locations of the HOBO temperature data loggers deployed downstream of Sutton Lake in 2017.

The specific objectives of this study include:

1. Determine temperature characteristics of outflows below Sutton, Burnsville, and East Lynn Lakes.

2. Assess how pulsed flows change the temperature downstream of dams.

3. Assess biological communities and potential temperature impacts from lake operations.

Study Goals: Characterize stream channel morphology, flow dynamics, aquatic communities, and profile sediment types within the watershed. This data will be used in implementing operational changes that balance benefits achieved through environmental flows with existing authorized project purposes.

During the 2013 and 2015 studies, temperature readings were collected, biological community assessments, including fish and benthic macroinvertebrates, were conducted, and in-stream channel characteristics were recorded. However, these analyses were only conducted for up to a maximum distance of 30 km downstream of the lake outflow. Large temperature changes were still recorded 30 km downstream of the outflows. These results led to investigations starting in 2017 which continue to analyze temperatures from the dam to the mouth of the stream to determine how far downstream that impacts to water temperature are occurring.

2019 Activities: Due to extended wet periods of weather, the team was unable to collect the data loggers in 2018 for the 2018 Annual Water Quality Report. As a result, those data will be presented and discussed in this report. The temperature loggers deployed on Twelve Pole Creek below East Lynn Lake were placed at least every 10 km for the first 20 km and then every 20 km until the mouth (69 km). Below Sutton and Burnsville Lakes, temperature loggers were placed every 10 km for the first 50 km and then every 20 km to the mouth in 2018. Data loggers collected temperature readings every 15 minutes throughout summer lake stratification months to determine the extent of downstream temperature impacts due to lake operations.Upon analyzing data collected during the 2018 stratification period, it became apparent there were few instances of significant temperature fluctuations at sites downstream of the dams resulting from sudden discharges. In order to determine if improved temperature fluctuations downstream were a result of operational changes, past large discharge events of similar magnitudes were compared. Specifically, data from similar magnitude discharge events were compared from 2017 and 2018 at Sutton.

2017 Discharge Event: The rain event in 2017 resulted in a discharge of approximately 5,000 cfs above minimum flows. As shown in the graph, temperatures varied greatly with larger magnitudes occurring closer to the dam and becoming smaller downstream.

Temperature fluctuation downstream of the dam was minimal prior to the discharge event. Significant fluctuations are observed beginning around 12:00 on 7/23/17. As discharge volume increases, magnitude of temperature change from the previous hour increases as well. Magnitudes are greatest at the first monitoring site directly below the dam (S1) and generally decrease with distance from dam. Fluctuations in temperature appear to greatly diminish as discharge volume decreases and becomes more stable as time passes after the storm event.

As discussed in Table 3, magnitudes are greatest at the first monitoring site directly below the dam (S1) and generally decrease with distance from dam. Largest temperature fluctuations also occur later in the event as colder water makes its way downstream.

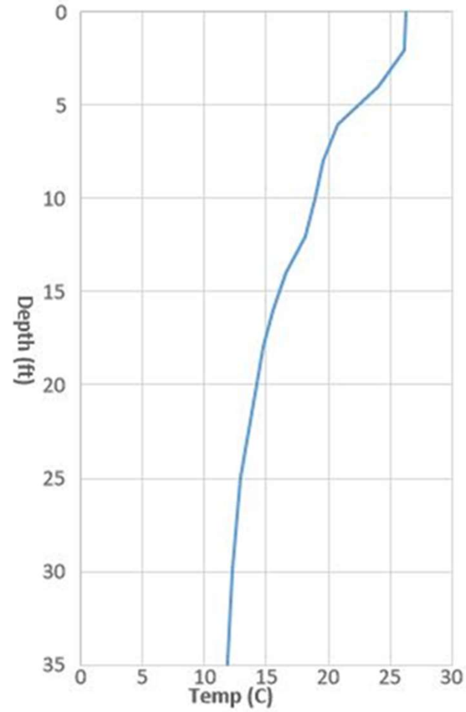

Figure 6. Vertical Temperature Profile of Sutton Lake collected on 7/11/2017.

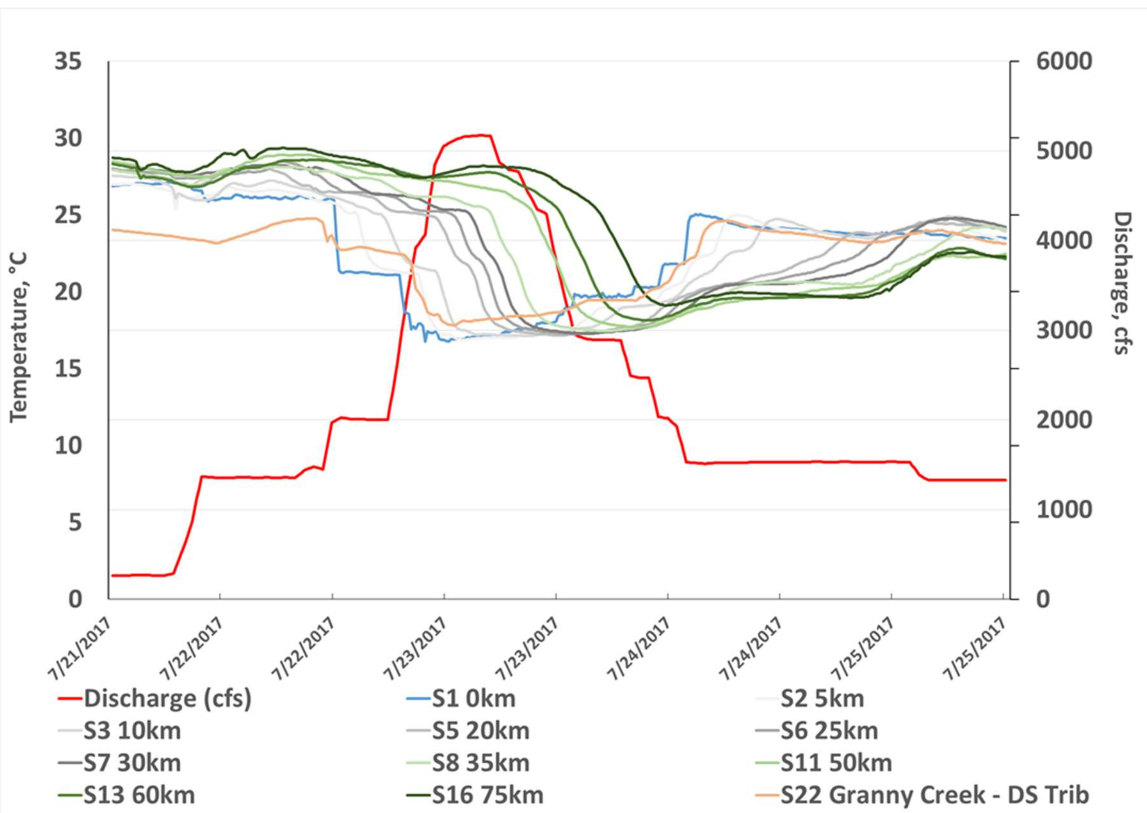

Figure 7. Temperature (°C) of the Sutton Lake outflow, the Elk River up to 75 km downstream of the outflow, and a downstream tributary (Granny Creek) compared to the lake discharge (cfs) in July 2017.

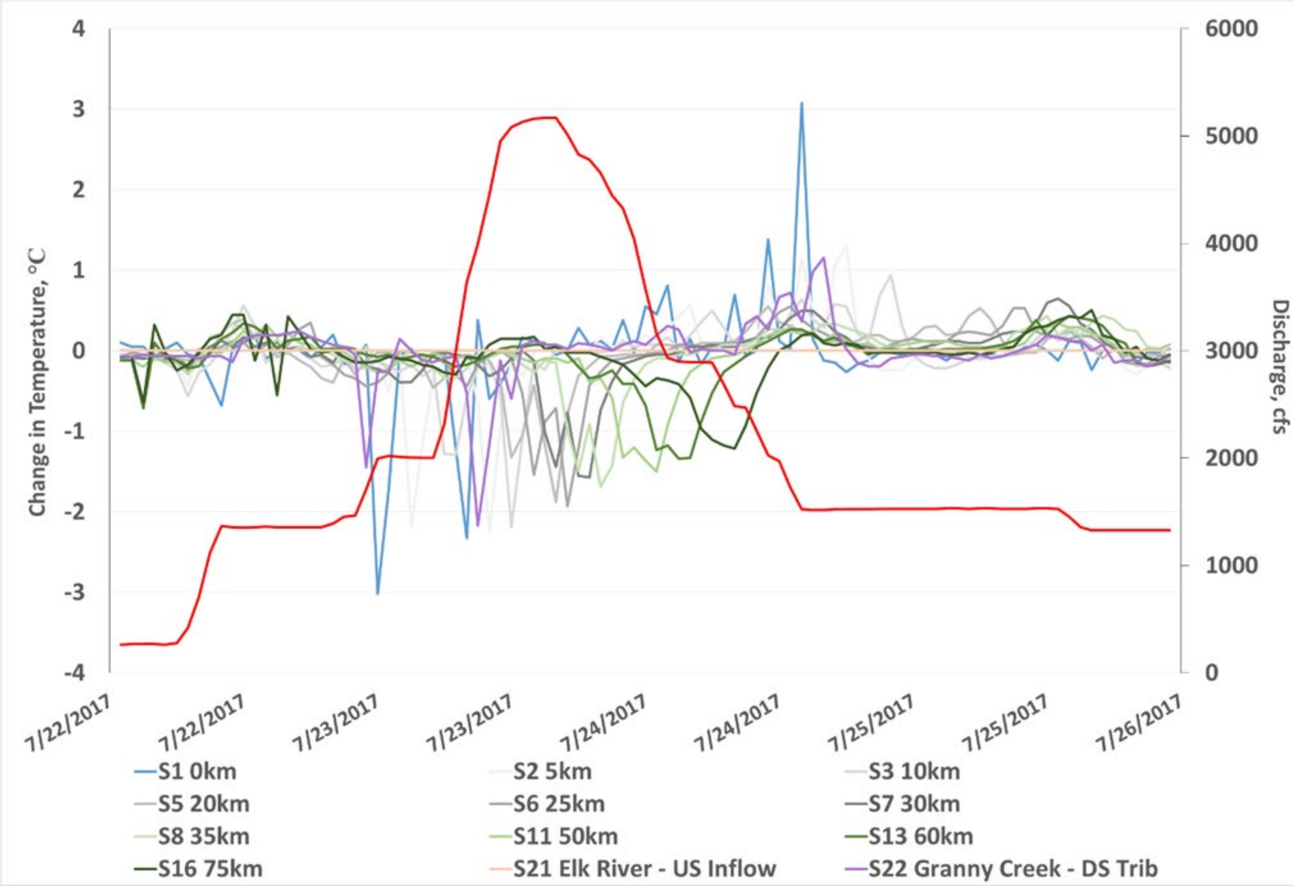

Figure 8. Change in temperature (°C) from previous hour of the Sutton Lake outflow, the Elk River up to 75 km downstream of the outflow, and a downstream tributary (Granny Creek) compared to the lake discharge (cfs) in July 2017.

2018 Discharge Event: As compared to the 2017 event shown in figures 7 & 8, downstream temperatures in figure 10 are much more steady and consistent even though the discharge of the event is almost identical in 2018 (nearly 5,000cfs). Although these flow events occurred at different times of the year, the discharges followed similar trends. The 2017 event began with flow around 270 cfs and climbed to roughly 5,100 cfs over the course of 32 hours, while the 2018 event began with flow around 288 cfs and climbed to roughly 4,700 cfs over the course 11 hours. Due to these similarities, it is reasonable to compare the effects to temperature downstream. It is apparent upon comparing the events that the event in 2018 experienced much less fluctuation in temperature at all monitoring sites downstream. This can likely be partially attributed to better operation during storm events and may also be due in part to warmer temperatures at the bottom of the lake in comparison to the 2017 event. Profile data from the time of the event was unavailable so the next closest data was utilized for figure 9.

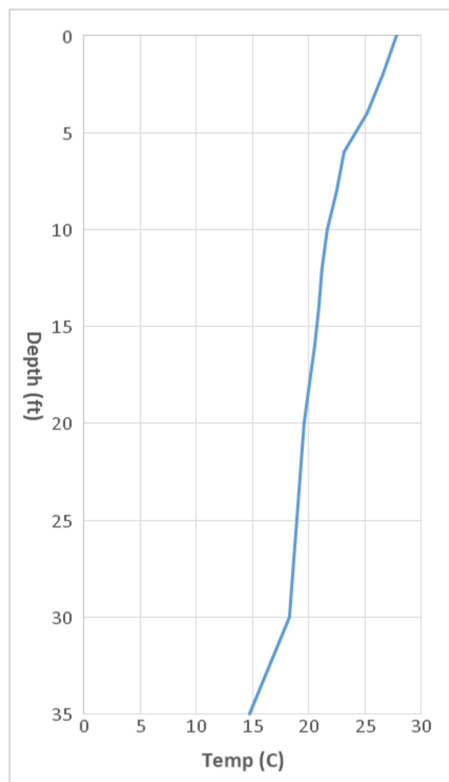

Figure 9. Vertical Temperature Profile of Sutton Lake collected on 8/30/2018.

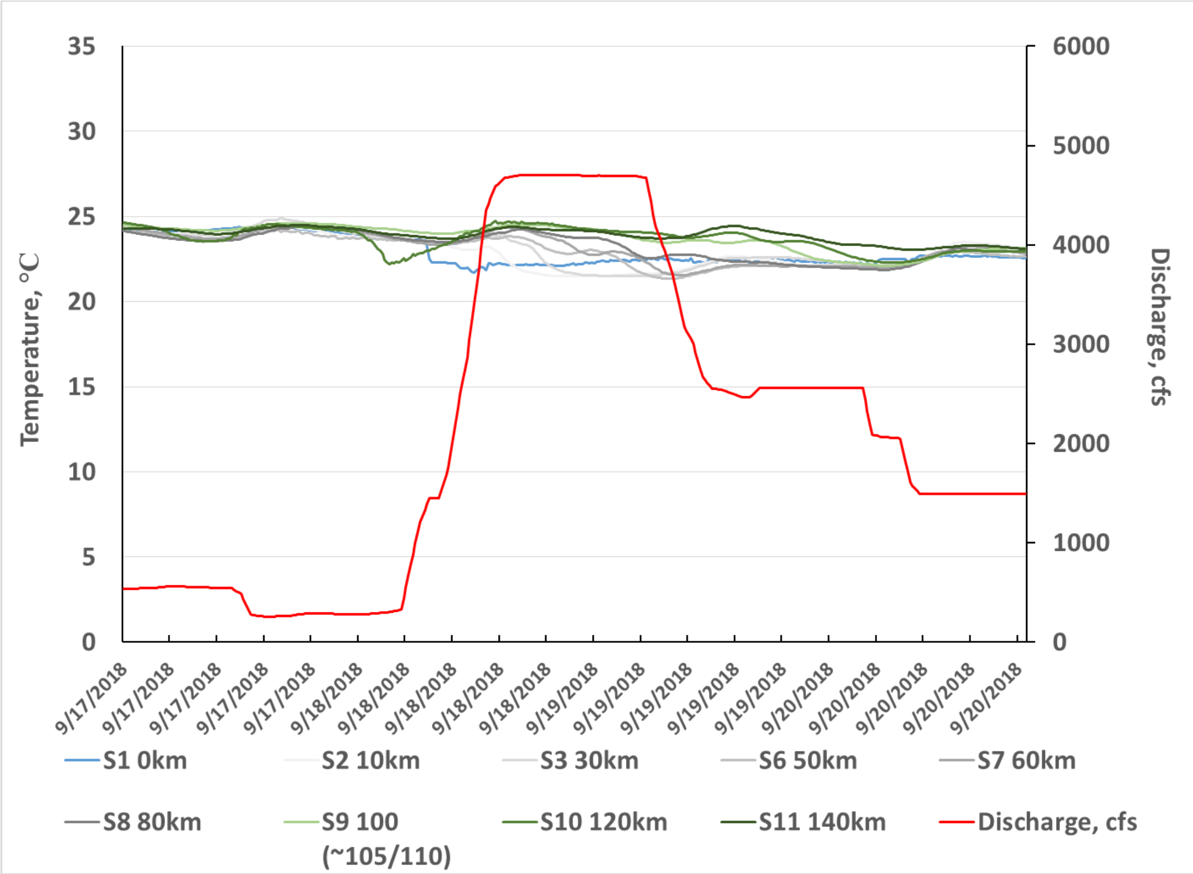

Figure 10. Temperature (°C) of the Sutton Lake outflow, the Elk River up to 140 km downstream of the outflow, and a downstream tributary (Granny Creek) compared to the lake discharge (cfs) in Sept. 2018.

Figure 11. Change in temperature (°C) from previous hour of the Sutton Lake outflow, the Elk River up to 140 km downstream of the outflow, compared to the lake discharge (cfs) in Sept. 2018.

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 along with creating a dead zone for aquatic life downstream. In response to this major issue, in the spring of 2015, a structural modification was completed to the outlet structure at Tappan Lake (Figure 12). The purpose of this structure was to minimize the release of hydrogen sulfide gas that is produced from outflow water originating in the hypolimnion. Concerns were raised of the impact this modification would have on the fishery in the lake by reduction of high water quality and depth of the epilimnion. Chemical data collected as part of this study has shown the release of hydrogen sulfide gas from the outfall of Tappan Lake has been significantly reduced from above 60 ppm to below levels of concern and there were no negative impacts to the depth of the epilimnion. During 2016, extensive studies similar to 2015 were conducted at Clendening, Piedmont, and Atwood Lakes to provide baseline data prior to structural modifications. With positive study results, similar modifications were made at Clendening and Piedmont Lake in the fall of 2017.

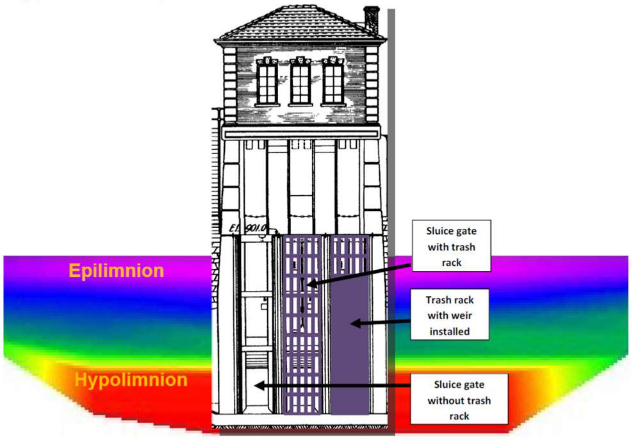

Figure 12. A structural drawing depicting the modifications made to Tappan Dam in 2015.

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. Along with the buoy data, profile data throughout the lakes were collected regularly. 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. Additionally, random sites were monitored within the lake to show the potential of lake-wide impacts (Figure 13).

The study showed release of hydrogen sulfide gas from the outfall of Tappan Lake has been significantly reduced to levels below 3ppm since the trash rack weirs have been put into operation. This modification had additional benefits of returning high quality water to downstream habitats, expanding the available fish habitat within the lakes by increasing the size of the oxygen rich epilimnion, and reducing the public health risk.

Clendening and Piedmont both showed similar benefits to the tailwaters during 2018. No perceivable impacts were noted to the lake or the fishery of either lake as a result of the modifications.

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. This means greater benefits to the human environment, solving a public safety issue, and increasing recreational opportunities. Structural modifications are tentatively planned at Atwood and Leesville Lakes, but these projects require additional considerations due to design differences of their intake structures.

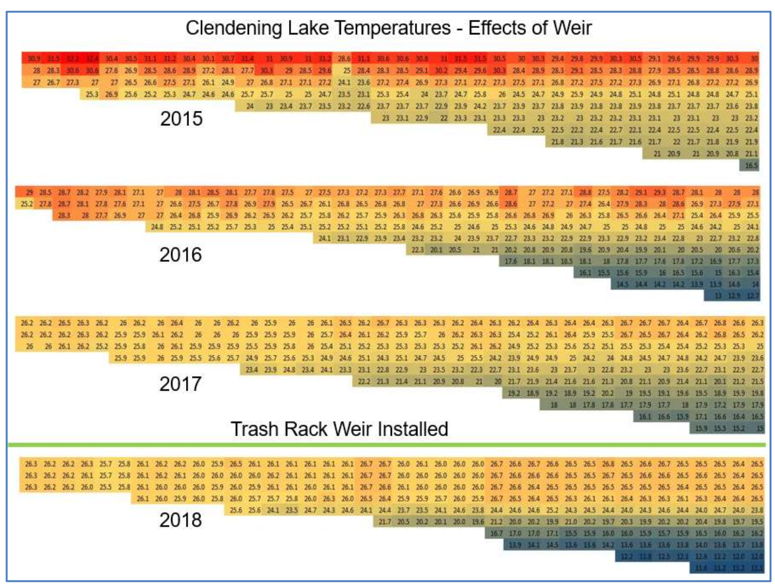

Figure 13. Temperature stratification maps of Clendening Lake before and after the structural modification were implemented.

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 Deer Creek, Grayson, Senecaville, and John W. Flannagan Lakes in 2019. John W. Flannagan Lake had a contact advisory posted for about a week, and the event was handled primarily by the VA DEQ. No other significant events occurred in 2019.

Support for Other USACE Elements

Dredge Mission at R.C. Byrd Locks and Dam in 2019

Figure 14. 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 in order 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 from the RCB dam in order to direct dredge disposal plumes away from endangered mussels. Lock operators create steering currents by opening and closing a combination of gates to control the direction and magnitude of flow over the dam. Turbidity, sedimentation, and dissolved oxygen levels are intensely monitored downstream of the dredge disposal area and adjacent to valuable mussel beds. Recently, the monitoring platform was upgraded to provide real-time data transmissions to the District in order to monitor 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 15. Velocity vectors demonstrating the effectiveness of steering currents employed below R.C. Byrd Dam.

Flows at R.C. Byrd were, once again, higher than normal during the dredge season. This resulted in multiple mobilizations and demobilizations of the dredge. It also resulted in ambient conditions which minimized any impacts resulting from dredge and disposal. Those conditions included higher turbidity and laminar flow from the dam (Figure 15). Figure 14 shows the WIZARD monitoring platform that monitors our mussel beds for impacts from dredge disposal. The WIZARD is a realtime platform measuring sedimentation, dissolved oxygen, and turbidity. Due to the high water conditions, no WIZARDS were deployed in 2019. Flows were greater than 60,000 cfs during the entire summer dredge period. This required a minimum of 14 feet of gate opening. Flows were as high as 160,000 cfs requiring 107 feet of gate opening. Steering currents are not applicable in flows of this magnitude. In addition, these flows were high enough to minimize any impacts related to dredge disposal. Figure 16 shows the flow, stage, and dates of R.C. Byrd dredging. Dredging operations were stopped early as a result of the continuous high water.

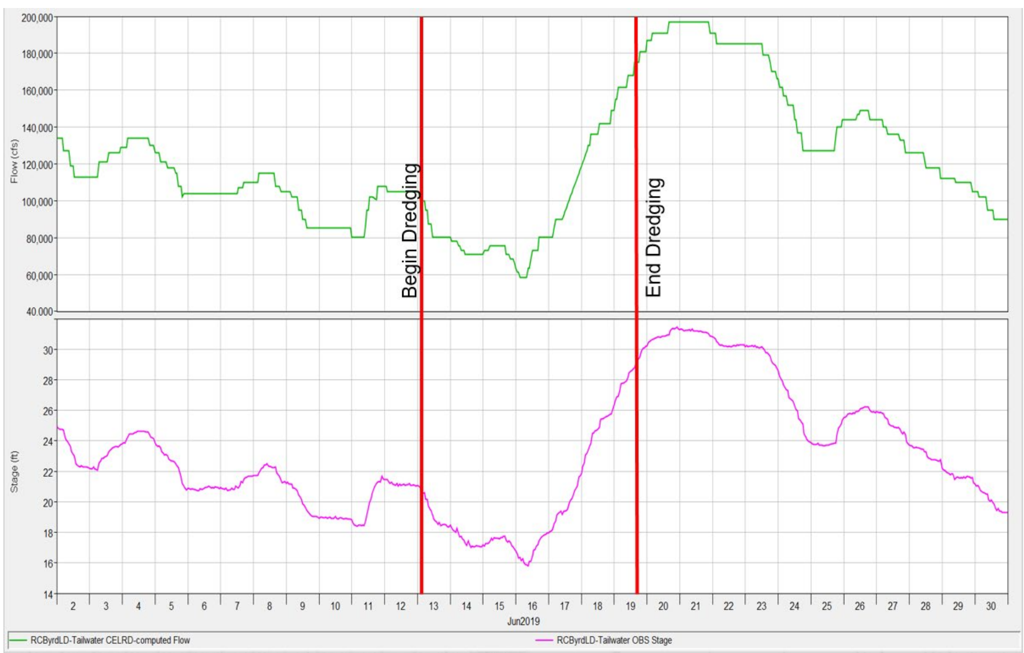

Figure 16. Flows, stages and dredge dates for R.C. Byrd dredging in 2019.

Dredge Mission Sediment Analysis

In order to maintain proper 401 Water Quality certification, the District is required to sample sediment and raw water from dredging and receiving locations at least once every 3 years. The LRH Water Quality Team conducts these sampling efforts on behalf of the Waterways Section on a 3-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. 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 4 provides a summary of the locations where sampling was conducted in 2019 and lists any constituents that exceeded state criteria or an EPA recommendation. For more detailed information, see the Maintenance Dredging Program Mitigation Reports for 2019 (Appendix B).

Table 4. Summary of locations sampled for the Maintenance Dredging Program in 2019 and constituents that exceeded state criteria or EPA recommendation.

River	Dredge Location	Constituents that Exceeded One or More State Criteria or EPA Recommendations
Ohio	Belleville Locks Lower Approach	aluminum, chromium, copper, iron, lead, manganese, PCBs, benzo[a]anthracene, benzo[b]pyrene, benzo[b]fluoranthene, benzo[k]fluoranthene, chrysene, indeno[1,2,3-cd]pyrene
Ohio	Meldahl Locks Lower Approach	aluminum, chromium, copper, iron, lead, manganese

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. However, R.C. Byrd and C.A. Meldahl Locks and Dam surveys are conducted more regularly and include quantitative surveys once every five years.

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 2019, semi-quantitative survey plans and cost estimates were developed for mussel beds downstream of C.A. Meldahl, Witcher Island, Old Lock 31, and Lower Bonanza Bar. These surveys were developed for comparison of previous semi-quantitative surveys. Task orders were awarded to Lewis Environmental Consulting on the regional IDIQ contract. The results of the Old Lock 31 site and the Lower Bonanza Bar site showed that very little has changed near these dredge disposal areas. At C.A. Meldahl, the 2019 survey showed that there are no longer mussel beds below the dam. Populations have thinned out, likely as a result of the redirected discharge from the hydropower project. The survey at Witcher Island shows increased mussel recruitment within and surrounding the disposal area. A species that is currently proposed for federal protection under the Endangered Species Act (*O. subrotunda*) now makes up more than 24% of that population. Continued use of the Witcher Island site will require significant coordination with US FWS and WV DNR.

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.

In order 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. Profiling equipment is distributed to selective withdrawal projects and subsequently retrieved by Water Quality personnel following fall mixing in the lakes.

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.

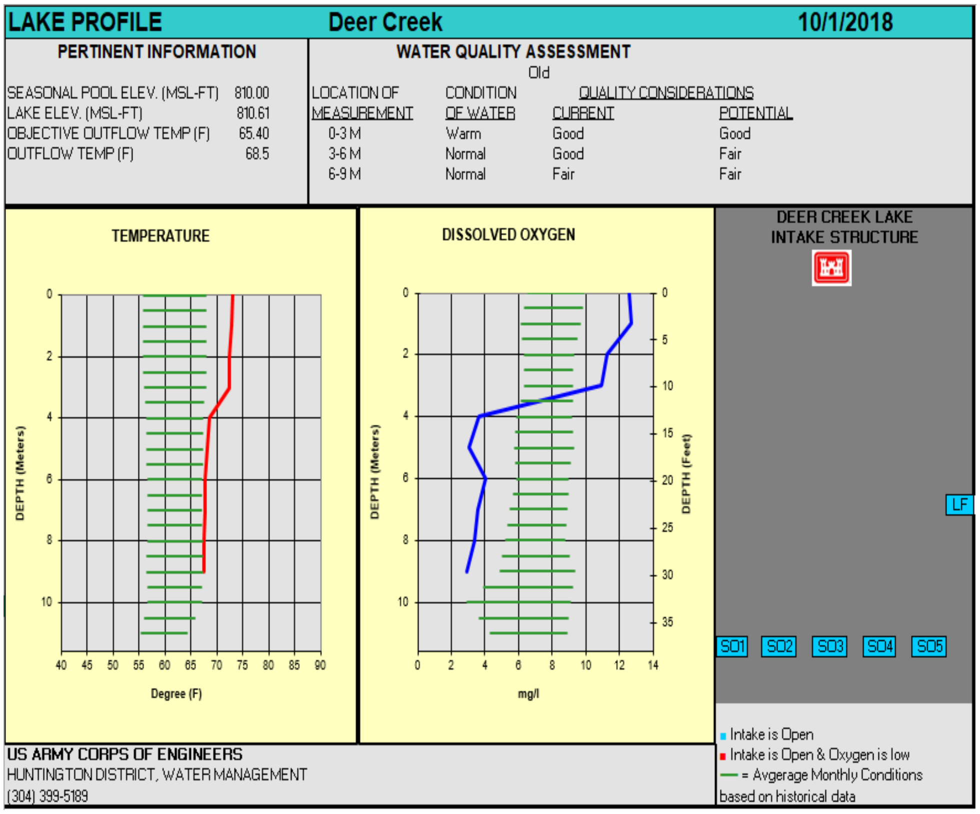

Figure 17. An example of the informational plots featured on the District Water Management public website. The plots are an output of the LRH lake profiling program.

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 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 17). 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 revised winter drawdown schedule took not only water quality into consideration, but also other competing projects purposes such as water supply, recreation, and fish and wildlife conservation. The schedule had no impact on flood control and allowed for improved management of the project overall.

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 WCM. 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.

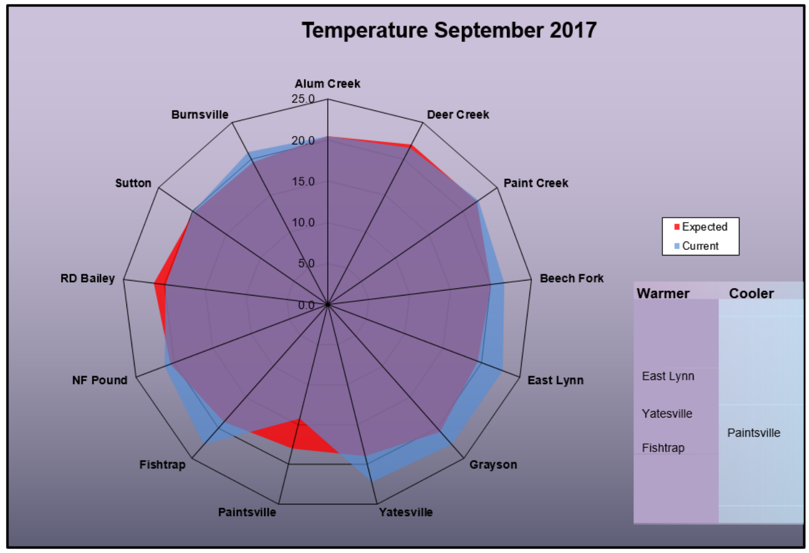

Figure 18. Average water temperatures at LRH lakes in 2017. Average conditions for each lake are compared to what would normally be expected for the time of year. Temperatures for most lakes were near normal.

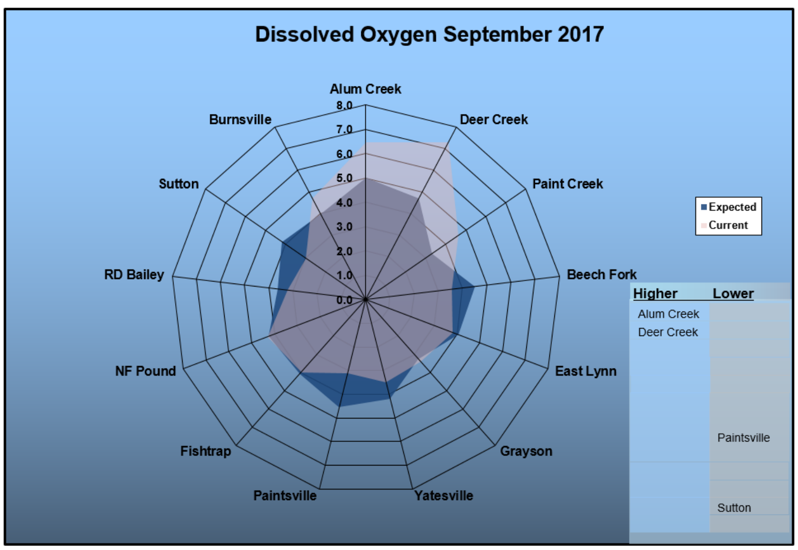

Figure 19. Average dissolved oxygen conditions at LRH Lakes in 2017. Average conditions for each lake are compared to what would normally be expected for the time of year. Dissolved oxygen levels were better than normal for most of the lakes.

Spider web charts (Figures 18 & 19) are a convenient way for the District to view trends in temperature and dissolved oxygen during periods of lake stratification. These charts are developed using water quality profile data from each of the selective withdrawal projects. These charts show September data from the 2017 season. Historical monthly profile data are used to determine the expected condition of each lake. Monthly comparisons can be made to explain existing lake conditions, yearly summaries, and to provide recommendations on outflow gate operations.

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 in order to meet water quality targets developed in coordination with the West Virginia Department of Environmental Protection. Weather and flow conditions during 2019 allowed the river to maintain adequate oxygen levels and temperatures. As a result, no augmentation was necessary for Kanawha River flows.

ISO Certification

Water Quality staff continue to meet ISO Certification procedures. The ISO process covers documentation and calibration process for maintenance of multiparameter datasondes. Being ISO certified improves accuracy and ensures quality of data collected by the Water Quality Team.

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 2019.

Sutton deep drawdown – In November 2019, USACE Water Quality Staff and the West Virginia DNR completed a shoreline mussel assessment between winter pool elevation (895') and summer pool elevation (922') at Sutton Lake. This assessment was required as part of a request by Operations to conduct an unplanned deviation from normal operations. The concern was that healthy mussel beds could be exposed to air and freezing temperatures during a deep drawdown. This additional drawdown was needed in order to allow divers to remove debris from in front of the sluice gates that prevented the bulkheads from closing. Staff assessed multiple areas in the headwaters of the lake. Three people searched in the Bakers Run campground area, and two people searched in the Freeman campground area. Additionally, three people searched the mainstem of the lake using a boat. A total of 20 man hours was spent searching the banks for mussels and shell material. No significant mussel resources and no living mussels were encountered. Our determination was that there was very little potential for significant mussel resources to exist within the lake between the deep drawdown target elevation (865') and the winter pool elevation (895'). As a result, no further surveys were needed and the project was able to initiate the deep drawdown operation.

Dillon bathymetry and storage calculation – In September and October 2019, the Water Quality Team used the EcoMapper AUV and Sontek Acoustic Doppler Profiler to collect bathymetry measurements at Dillon Lake. This survey was needed for Water Management to update the storage capacity curve used in daily modeling. The Water Quality Team covered approximately 62% of the lake in less than two days in September using the bathymetry equipment (Figure 1). This data was TIN modeled to create a bathymetric mesh of the lake (Figure 2). Individual depths were also measured in a randomized approach to cover the remaining shallow regions of the lake where bathymetry equipment could not be used (Figure 3). This data was used to develop storage estimates for the shallow lake areas. All data was combined in order to update the storage curves and sedimentation tables for the lake (Figure 4). Additionally, a Standard Operating Procedure was developed to streamline and maximize this new capability for potential use at other projects. The Water Quality Team was able to quickly process and analyze the data, resulting in informed decision making for our flood fighting program while reducing expense to the District.

National Enterprise Database and Web Application PDT – Kamryn Tufts and Andrew Johnson, EC-GW-W, 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 a water quality database application for all USACE Districts. Kamryn was a requested team member because of her national expertise in the use of the Aquarius water quality database software. Kamryn and the Huntington District have developed the largest Aquarius database in the USACE, which was displayed in a national demonstration of Aquarius to the PDT. Andrew was selected as a team member based on his previous experience with the CWMS Betterment Sub-PDT of WMIST and his participation on the National Water Quality Committee. As team members, they will work 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 final result will be a national database usable by all districts and the public to access water quality data.

Bluestone Stilling basin velocities – Jeff Jacquez, Thad Tuggle, Kamryn Tufts, and Nathan Fleshman, and Steve Foster (Water Quality Team, EC-GW-W) utilized an M9 Acoustic Doppler to measure velocities and currents within the Bluestone Dam stilling basin. Contract specifications have limited the DSA project contractor's stilling basin work to times when Bluestone does not exceed the operation of 5 outflow gates. However, the contractor designed their work barge mooring system to withstand the operation of 6-7 gates. The Water Quality Team partnered with the contractor to measure velocities using the contractor's boat and the District's Doppler during the operation of 5, 6, and 7 gates. All data was processed through HydroSurveyor, ArcGIS, and HYPACK software packages. The results showed that velocities were generally higher during the operation of 7 gates and that peak velocities were 4.6 ft/second. The data and exhibits were made available to the contractor for further analysis. The Water Quality team was able to quickly deploy this state of the art equipment and analyze the data, resulting in informed decision making for our dam safety program and contractors.

Mussel propagation – Andy Johnson and Josh Daugherty (Water Quality Team, EC-GW-W) partnered 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. This is the second consecutive year that District lakes have been used for the rearing of native mussels. Last year's successful propagation at Sutton Lake resulted in a record size class for propagated mussels in West Virginia. The process involves the inoculation of bass with the parasitic larva of the plain pocketbook and the black sandshell mussels. These bass are released into floating cages at the lakes where the larvae will mature and fall from the fish to a sand filled tray beneath the cage. The mussels spend three months filter feeding and growing in the lake water. The Water Quality Team will monitor water quality at the propagation sites and provide historical lake data to our partners. Before winter, the mature mussels will be harvested from the cages and reintroduced to the rivers and streams of the state or kept for use in further propagation studies. This project provides a fantastic cooperation opportunity between USACE and our resource agencies.

STEM

The STEM program and educational outreach opportunities are important because they facilitate educational opportunities for young students, and allow them to see potential career paths. As part of the Huntington District's STEM program, the Water Quality Team:

Presented to students from Pikeville Elementary School at Dewey Lake in October 2018. The talk included discussion of water quality related topics, showcasing specimens, and a demonstration of electrofishing techniques. The STEM program and educational outreach opportunities are important because they facilitate educational opportunities for young students, and allow them to see potential career paths.

Participated in U.S. Army Corps of Engineers day at Marshall University in February 2018. The talk included our responsibilities as biologists, water quality sampling, and a demonstration of the common fish and mussels found in West Virginia. The STEM program and educational outreach opportunities are important because they facilitate educational opportunities for young students, and allow them to see potential career paths.

Presented to Ashton Elementary students in April 2019. This included an overview of USACE as a whole as well as the mission of the Water Quality Team. Students were educated about various water quality and environmental related topics and were given the chance to ask questions and look at fish and bug specimens as well as equipment used by the Water Quality Team.

Represented the USACE LRH during the July 2019 International Scout Jamboree at the Summit Bechtel Scout Reserve in Fayette County, West Virginia. An educational booth was displayed which included an operational fish tank with various native fish species, an EXO multiparameter data sonde, underwater camera, acoustic Doppler profiler, PowerPoint presentation, as well as fish, mussel, and benthic macroinvertebrate specimens. Water Quality staff were available to discuss the Corps water quality mission, equipment operation and purpose, watershed principles, and career opportunities in biological sciences. A total of 47,000 scouts, leaders, and presenters were in attendance representing 133 countries.

Presented at the Kanawha County Make-A-Splash Water Festival in Dunbar, WV, St. Albans Water Festival, and Morris Creek Water Festival in September 2019. A total of over 550 students from at least 12 different elementary schools were in attendance at these festivals. Topics discussed included the basics of watersheds, stream ecology, and hydrology. Students were also able to learn more about these topics through an interactive activity.

Presented the Huntington District Water Quality Mission at the Marshall University Water Festival to 5th grade students and teachers from schools located in Cabell County in September 2019. The event highlighted Science, Technology, Engineering, and Math (STEM) opportunities in biology, chemistry, hydrologic, and physical sciences. The festival allowed students and teachers to gain an understanding of the USACE mission and increased awareness of how water quality impacts project purposes. The Team demonstrated watershed and topographic principals to enhance understanding of how communities influence water management. Teachers and students gained an insight into how the Corps of Engineers operates projects to provide for sustainable human uses while conserving the environmental value of the resource by focusing on physical, chemical, hydrologic and biological processes

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.

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 is in Phase 2, and is in the process of filling data gaps in the Tappan Lake watershed.

WV Division of Natural Resources (WVDNR) – The LRH Water Quality Team often works with the WVDNR during fish collection or mitigation efforts in the LRH District. In 2019, the District and the Water Quality Team partnered with a team led by the WVDNR and the US Fish and Wildlife Service for lake propagation of native mussels at Burnsville and Sutton Lakes over the summer. Although the projects share a similar headwater area, the projects showed significant growth differences in mussel propagation. The efforts at Sutton led to the first propagation of taggable sized mussels in a single season. Burnsville was able to propagate similar numbers of mussels, but they did not reach taggable size. Stonewall Jackson Lake showed below average potential for size class and recruitment of propagated mussels. Water quality staff assisted with long term monitoring of water chemistry at the site and evaluations of historic data. The Water Quality team also partnered with the WVDNR to collect fish downstream of Sutton Dam during a periodic inspection. This resulted in the collection of valuable biological data that can be utilized by both agencies.

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 Kristy Dickey of the 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 at Clendening, Tappan, Atwood, and Leesville Lakes in 2019 during the spring and fall seasons. Physical data and water chemistry results have been incorporated into the water quality database as a result of Kristy's efforts.

Ohio River Valley Mollusk Group – The LRH Water Quality Team presented accomplishments at the Ohio River Valley Mollusk Group meeting in Hamilton, OH. Topics included mussel bed monitoring at R.C. Byrd Lock and Dam during maintenance dredging and results from implementation of the new WIZARD sediment monitoring platform. Future plans to evaluate dam operations on the Ohio River to maximize dissolved oxygen using the EcoMapper Autonomous Underwater Vehicle were also discussed. Both items were well received and spurred numerous discussion with regulating and monitoring agencies on potential benefits.

Big Sandy River Basin Team – The Water Quality Team is becoming involved in the Big Sandy River Basin Team, which is a collaboration between the KDOW and various public groups aimed at protecting, remediating, and restoring watersheds within the Big Sandy River basin. The first annual meeting was held in 2019 after a long hiatus and involved discussion of restarting the program, TMDLs, and funding sources for watershed restoration projects. The Water Quality Team offered assistance in the form of furnishing water quality data and involvement in projects within the Huntington District.

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 2019:

- MWCD – Physical profile data from Muskingum Lakes.
- ATC Group Services – Polycyclic Aromatic Hydrocarbon data on the Ohio River
- OR-BLN – outflow data for Bluestone Lake
- WV DEP – outflow data for R.D. Bailey Lake
- Harrison Soil and Water Conservation District – historic water quality data for certain Muskingum area lakes

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 2019 by one or more members of the Water Quality Team:

- Leadership Development Program
- Fish Identification
- Macroinvertebrate Identification
- YSI Training Webinars
- Boat Operator Training and Refresher

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. Modifying the intake structure of Tappan, Clendening, and Piedmont Lakes have greatly reduced the negative impacts of poor water quality discharging from the lake, and similar results are expected at other projects receiving this benefit.

Marcellus shale or deep shale drilling for natural gas is active in much of the District now. Ohio, Kentucky and West Virginia have significant areas of active drilling. Baseline water quality conditions need established and possible impacted streams need to be monitored in the upcoming years to determine the extent of impacts to District waters. Over the next couple of years, active areas need prioritized and a monitoring strategy including physical and biological sampling should be implemented. Burnsville Lake and the Little Kanawha watershed were sampled for bromide in 2017, which yielded no detections. Bromide is a known indicator of fracking activity in a watershed.

Harmful Algae Blooms Historical data indicate that many LRH lakes are perfect candidates for harboring a HAB. Though eutrophic type lakes are most susceptible to these blooms, HABs can occur rapidly anywhere, at any time, and can dissipate just as quickly. This is demonstrated by the fact that Grayson and R.D. Bailey Lakes experienced HABs, yet both lakes are categorized as "low risk" for HABs. The erratic nature of HABs makes them difficult to study, predict, and respond to. They can cause safety issues, health issues and operational disruptions which make this issue a priority. Response plans have been developed for each state in Huntington District, allowing the district to take a more reactionary role in the event of a HAB. The Huntington USACE will continue to provide support in the form of sample collection and bloom reporting when necessary.

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.

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 5. Complete list of sampling locations and descriptions for 2019.

PROJECT	SITE NO.	TYPE	STREAM	BASIN	COUNTY	STATE	LAT	LONG
Alum Creek	ACS0001	Outflow	Alum Creek of Scioto River	Scioto River	Delaware	OH	40 11 03	82 57 50
Alum Creek	ACS0002	Lake	Alum Creek of Scioto River	Scioto River	Delaware	OH	40 11 11	82 58 07
Alum Creek	ACS0003	Inflow	Alum Creek of Scioto River	Scioto River	Delaware	OH	40 21 21	82 55 19
Alum Creek	ACS0013	Inflow	Big Run of Alum Creek	Scioto River	Delaware	OH	40 16 40	82 58 49
Atwood	ATI0001	Outflow	Indian Fork of Conotton Creek	Muskingum	Tuscarawas	OH	40.5258333	-81.2875
Atwood	ATI0012	Inflow	Elliot Run of Indian Fork	Muskingum	Carroll	OH	40.5781667	-81.2148333
Atwood	ATI0013	Inflow	Willow Run of Indian Fork	Muskingum	Carroll	OH	40.5703611	-81.1955556
Atwood	ATI0014	Inflow	Unnamed trib of Indian Fork	Muskingum	Carroll	OH	40.5731111	-81.2312778
Atwood	ATI0015	Inflow	Gantz Creek of Indian Fork	Muskingum	Carroll	OH	40.5525278	-81.0760556
Atwood	ATI0016	Inflow	Indian Fork of Conotton Creek	Muskingum	Carroll	OH	40.5585278	-81.1007778
Atwood	ATI0017	Inflow	Town Creek of Honey Run	Muskingum	Carroll	OH	40.5645556	-81.0836944
Atwood	ATI0018	Inflow	Pleasant Valley of Indian Fork	Muskingum	Carroll	OH	40.5583611	-81.1554167
Atwood	ATI0019	Inflow	Cold Spring Run of Indian Fork	Muskingum	Carroll	OH	40.5745	-81.1211667
Atwood	ATI0020	Inflow	Cold Spring Run of Indian Fork	Muskingum	Carroll	OH	40.59525	-81.11575
Atwood	ATI0021	Inflow	Unnamed trib to Atwood Lake	Muskingum	Carroll	OH	40.5679722	-81.25725
Atwood	ATI0022	Inflow	Indian Fork of Conotton Creek	Muskingum	Carroll	OH	40.5513056	-81.1741389
Atwood	ATI0028	Inflow	Unnamed Tributary to Atwood Lake	Muskingum	Carroll	OH	40.567	-81.258
Big Sandy River	BSR0235	River	Big Sandy River of Ohio River	Big Sandy	Wayne	WV	38.384722	-82.596111
Big Sandy River	BSR0635	River	Big Sandy River of Ohio River	Big Sandy	Wayne	WV	38.335556	-82.585278
Clendening	CLB0003	Inflow	Brushy Fork of Stillwater Creek	Muskingum	Harrison	OH	40.250555	-81.151944
Clendening	CLB0004	Outflow	Brushy Fork of Stillwater Creek	Muskingum	Harrison	OH	40.2675	-81.281111
Clendening	CLB0007	Inflow	Elk Run of Brushy Fork	Muskingum	Harrison	OH	40.246777	-81.145361
Clendening	CLB0015	Inflow	Colman Run of Brushy Fork	Muskingum	Harrison	OH	40.282388	-81.215722
Clendening	CLB0020	Inflow	Unnamed trib of Brushy Fork	Muskingum	Harrison	OH	40.271166	-81.138166
Clendening	CLB0021	Inflow	Brushy Fork of Stillwater Creek	Muskingum	Harrison	OH	40.241861	-81.073611
Clendening	CLB0022	Inflow	Brushy Fork of Stillwater Creek	Muskingum	Harrison	OH	40.251666	-81.104777
Clendening	CLB0023	Inflow	Hefling Run of Brushy Fork	Muskingum	Harrison	OH	40.283277	-81.250111
Deer Creek	DCS0001	Outflow	Deer Creek of Scioto River	Scioto River	Pickaway	OH	39 37 10	83 12 44
Deer Creek	DCS0002	Lake	Deer Creek of Scioto River	Scioto River	Pickaway	OH	39 37 15	83 12 53
Deer Creek	DCS0013	Inflow	Deer Creek of Scioto River	Scioto River	Fayette	OH	39 39 08.4	83 15 46.6
Delaware	DEO0001	Outflow	Olentangy River of Scioto River	Scioto River	Delaware	OH	40 21 29.3	83 04 09.2
Delaware	DEO0002	Lake	Olentangy River of Scioto River	Scioto River	Delaware	OH	40 21 34.9	83 04 08.9
Delaware	DEO0019	Inflow	Olentangy River of Scioto River	Scioto River	Marion	OH	40 27 35	83 04 17
Delaware	DEO0021	Inflow	Whetstone Creek of Olentangy River	Scioto River	Delaware	OH	40 24 56	83 01 13
Grayson	GRL0001	Outflow	Little Sandy River of Ohio River	Little Sandy River	Carter	KY	38 15 17	82 59 21
Grayson	GRL0002	Lake	Little Sandy River of Ohio River	Little Sandy River	Carter	KY	38 15 03	82 59 03
Grayson	GRL0003	Inflow	Little Sandy River of Ohio River	Little Sandy River	Elliott	KY	38 06 52.8	83 06 56.2
Grayson	GRL0010	Inflow	Newcombe Crk of Little Sandy River	Little Sandy River	Elliott	KY	38 04 25	83 03 15
Grayson	GRL0035	Inflow	Middle Fork of Little Sandy River	Little Sandy River	Elliott	KY	38 05 31.7	83 05 27.1

PROJECT	SITE NO.	TYPE	STREAM	BASIN	COUNTY	STATE	LAT	LONG
Kanawha River	KR02912	River	Kanawha River of Ohio River	Kanawha	Putnam	WV	38.535833	-81.945279
Kanawha River	KR02919	River	Kanawha River of Ohio River	Kanawha	Putnam	WV	38.539475	-81.948706
Kanawha River	KR03069	River	Kanawha River of Ohio River	Kanawha	Putnam	WV	38.525278	-81.922222
Kanawha River	KR06671	River	Kanawha River of Ohio River	Kanawha	Kanawha	WV	38.262393	-81.573177
Leesville	LEM0001	Outflow	McGuire Creek of Conotton Creek	Muskingum	Carroll	OH	40.470277	-81.196666
Leesville	LEM0012	Inflow	McGuire Creek of Conotton Creek	Muskingum	Carroll	OH	40.461722	-81.125416
Leesville	LEM0013	Inflow	Unnamed trib of McGuire Creek	Muskingum	Carroll	OH	40.466111	-81.141611
Leesville	LEM0014	Inflow	North Fork of McGuire Creek	Muskingum	Carroll	OH	40.513166	-81.112805
Leesville	LEM0015	Inflow	Bear Hole Run of North Fork McGuire Creek	Muskingum	Carroll	OH	40.529027	-81.136916
Leesville	LEM0016	Inflow	McGuire Creek of Conotton Creek	Muskingum	Carroll	OH	40.477694	-81.105805
Leesville	LEM0017	Inflow	North Fork of McGuire Creek	Muskingum	Carroll	OH	40.513388	-81.085638
Leesville	LEM0019	Inflow	North Fork of McGuire Creek	Muskingum	Carroll	OH	40.511111	-81.072833
Ohio River	OR20429	River	Ohio River	Ohio	Meigs	OH	39.114444	-81.742777
Ohio River	OR20440	River	Ohio River	Ohio	Wood	WV	39.114444	-81.738888
Ohio River	OR32108	River	Ohio River	Ohio	Boyd	KY	38.476341	-82.618808
Ohio River	OR43659	River	Ohio River	Ohio	Clermont	OH	38.798111	-84.175917
Ohio River	OR43685	River	Ohio River	Ohio	Bracken	KY	38.796111	-84.178889
Paint Creek	PCS0001	Outflow	Paint Creek of Scioto River	Scioto River	Highland	OH	39 15 09.9	83 20 54.6
Paint Creek	PCS0002	Inflow	Paint Creek of Scioto River	Scioto River	Highland	OH	39 19 11.9	83 23 10
Paint Creek	PCS0009	Inflow	Rattlesnake Creek of Paint Creek	Scioto River	Highland	OH	39 17 27	83 27 23
Paint Creek	PCS0014	Lake	Paint Creek of Scioto River	Scioto River	Highland	OH	39 14 55	83 21 21
Senecaville	SES0001	Outflow	Seneca Fork of Wills Creek	Muskingum River	Guernsey	OH	39 55 27.9	81 26 16.7
Senecaville	SES0002	Lake	Seneca Fork of Wills Creek	Muskingum River	Guernsey	OH	39 55 32.4	81 25 57.5
Senecaville	SES0010	Inflow	Beaver Creek of Seneca Fork	Muskingum River	Noble	OH	39 54 04.3	81 19 10.4
Senecaville	SES0013	Inflow	Seneca Fork of Wills Creek	Muskingum River	Noble	OH	39 51 59.7	81 19 52.6
Senecaville	SES0014	Inflow	Glady Run of Seneca Fork	Muskingum River	Noble	OH	39 51 33.9	81 20 42.7
Senecaville	SES0015	Inflow	Mud Run of Seneca Fork	Muskingum River	Noble	OH	39 52 51.4	81 22 12.8
Tappan	TAL0001	Outflow	Little Stillwater Creek of Stillwater Creek	Muskingum	Harrison	OH	40.356833	-81.230333
Tappan	TAL0003	Inflow	Standingstone Fork of Little Stillwater Creek	Muskingum	Harrison	OH	40.298694	-81.0855
Tappan	TAL0014	Inflow	Lower Beaverdam Run of Little Stillwater Creek	Muskingum	Harrison	OH	40.367111	-81.184444
Tappan	TAL0015	Inflow	Beaverdam Run of Little Stillwater Creek	Muskingum	Harrison	OH	40.346833	-81.126888
Tappan	TAL0023	Inflow	Clear Fork of Little Stillwater Creek	Muskingum	Harrison	OH	40.341388	-81.090277
Tappan	TAL0024	Inflow	Leiper Run of Beaverdam Run	Muskingum	Harrison	OH	40.346222	-81.137138
Tappan	TAL0025	Inflow	Unnamed trib of Clear Fork	Muskingum	Harrison	OH	40.345944	-81.089583
Tappan	TAL0026	Inflow	Clear Fork of Little Stillwater Creek	Muskingum	Harrison	OH	40.324638	-81.021972
Tappan	TAL0027	Inflow	Clear Fork of Little Stillwater Creek	Muskingum	Harrison	OH	40.338111	-81.114222
Tappan	TAL0028	Inflow	Eddington Run of Little Stillwater Creek	Muskingum	Harrison	OH	40.344083	-81.16525
Tappan	TAL0045	Inflow	Standingstone Fork of Little Stillwater Creek	Muskingum	Harrison	OH	40.3115839	-81.1153385
Tappan	TAL0046	Inflow	Unnamed Tributary to Tappan Lake	Muskingum	Harrison	OH	40.338	-81.16

Table 6. List of state designated 303d streams sampled by USACE in 2019 during intensive surveys.

Project Name	Stream Name	Stations Located on Stream	Station Type	Watershed	Impairment	Possible sources of Impairment
Alum Creek	Alum Creek of Scioto	ACS0001	Outflow	Scioto	Habitat alterations, flow alterations, organic enrichment/DO, sedimentation	URBANIZATION/INDUSTRY - suburbanization, urban runoff/storm sewers; LAND DEVELOPMENT - channelization, impoundment
Alum Creek	Alum Creek of Scioto River	ACS0003	Inflow	Scioto	Habitat alterations, flow alterations, flow alterations, high nutrients	AGRICULTURE - nonirrigated crop production, channelization, removal of riparian vegetation
Alum Creek	Big Run of Alum Creek	ACS0013	Inflow	Scioto	Habitat alterations, flow alterations, high nutrients	AGRICULTURE - nonirrigated crop production, channelization, removal of riparian vegetation
Deer Creek	Deer Creek of Scioto River	DCS0001	Outflow	Scioto	Dissolved oxygen, nutrient/eutrophication biological indicators	Dam/impoundment
Deer Creek	Deer Creek of Scioto River	DCS0002	Lake	Scioto	Nutrient/eutrophication biological indicators	Agriculture, septic systems
Deer Creek	Deer Creek of Scioto River	DCS0013	Inflow	Scioto	Nutrient/eutrophication biological indicators	Agriculture, septic systems
Delaware	Olentangy River of Scioto River	DEO0001	Outflow	Scioto	Habitat alterations, flow alterations, high nutrients, sedimentation	AGRICULTURE - range grazing (riparian), nonirrigated crop production, channelization; LAND DEVELOPMENT - flow regulation, removal of riparian vegetation; URBANIZATION/INDUSTRY - septic systems
Delaware	Olentangy River of Scioto River	DEO0019	Inflow	Scioto	Flow alterations, sedimentation	Dam/impoundment
Delaware	Whetstone Creek of Olentangy River	DEO0021	Inflow	Scioto	Habitat alterations, flow alterations, high nutrients, thermal modifications, sedimentation	AGRICULTURE - nonirrigated crop production, removal of riparian vegetation, streambank modification/destabilization; URBANIZATION/INDUSTRY - municipal point sources, septic tanks; LAND DEVELOPMENT - dam/impoundment, flow regulation

Table 7. 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
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
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
	Low Flow Augmentation	Low Flow Augmentation	PL 75-761
	Recreation	Recreation	PL 78-534
Dewey Lake	Flood Control	Flood Control	PL 75-761
	Recreation	Recreation	PL 78-534

Project	Operating Purposes	Authorized Purposes	Authorizing Laws
	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
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
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
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
	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

Project	Operating Purposes	Authorized Purposes	Authorizing Laws
	Low Flow Augmentation	Low Flow Augmentation	PL 75-761
	Recreation	Recreation	PL 78-534
Paintsville Lake	Flood Control	Flood Control	PL 89-298
	Recreation	Recreation	PL 89-298
	Water Quality	Water Quality	PL 89-298
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
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
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
		Low Flow Augmentation	PL 78-534
	Recreation	Recreation	PL 78-534
	Water Supply	Water Supply	PL 85-500
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

Project	Operating Purposes	Authorized Purposes	Authorizing Laws
	Low Flow Augmentation	Low Flow Augmentation	PL 75-761, PL 89-298

Table 8. 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 (2019)

Contact:

Huntington District USACE
Waterways Section
Brian Collins
brian.s.collins@usace.army.mil
304-399-5398

Huntington District USACE
Water Management Section
Andrew Johnson
Andrew.n.johnson@usace.army.mil
304-399-5189

Water Quality Annual Operating Plan (2019)
Water Quality Program Management Plan (2019)

Contact:

Huntington District USACE
Water Quality Operations Center
Andrew Johnson
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Huntington District USACE
Water Quality Operations Center
Steve Foster
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304-399-5542

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.

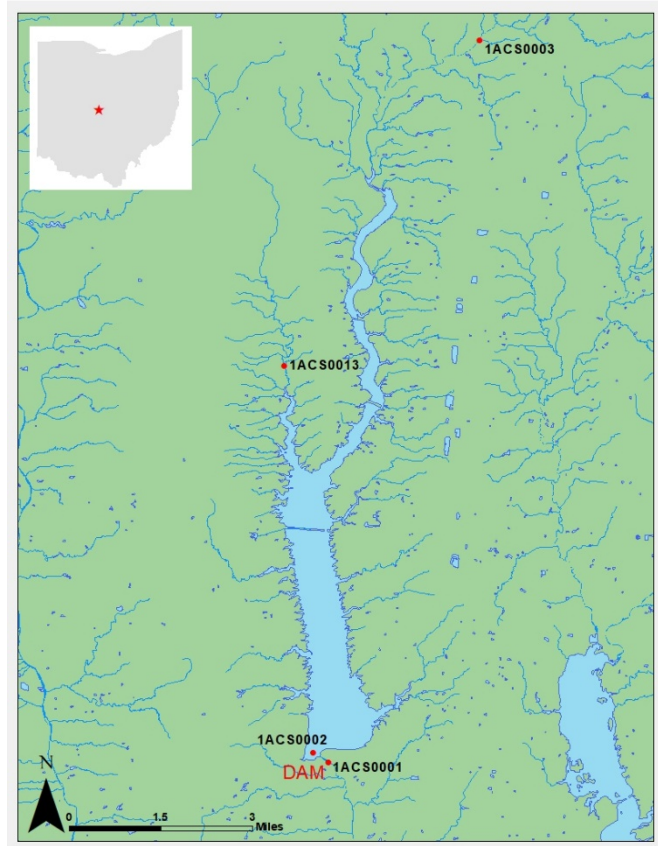

Figure 20. Water quality sampling locations for Alum Creek Lake in 2019.

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.

Table 9. 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	NO CRITERIA
			Total Phosphorus	1	NO CRITERIA
			Total Strontium	8	NO CRITERIA
1ACS0002	Lake	Alum Creek	TKN	10	NO CRITERIA
			Total Phosphorus	2	NO CRITERIA
			Total Strontium	12	NO CRITERIA
1ACS0003	Inflow	Alum Creek	Total Aluminum	1	NO CRITERIA
			Total Iron	1	NO CRITERIA
			TKN	2	NO CRITERIA
			Total Phosphorus	5	NO CRITERIA
			Sp. Conductance	5	NO CRITERIA
			Total Strontium	6	NO CRITERIA
1ACS0013	Inflow	Big Run of Alum Creek	Total Aluminum	1	NO CRITERIA
			Dissolved Oxygen	1	NO CRITERIA
			Total Iron	1	NO CRITERIA
			TKN	5	NO CRITERIA
			pH	1	<6.5 or >9.0
			Total Phosphorus	2	NO CRITERIA
			Sp. Conductance	4	NO CRITERIA
			Total Strontium	5	NO CRITERIA
			Total Sulfate	2	NO CRITERIA

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. Samples in 2016 from one inflow site 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.

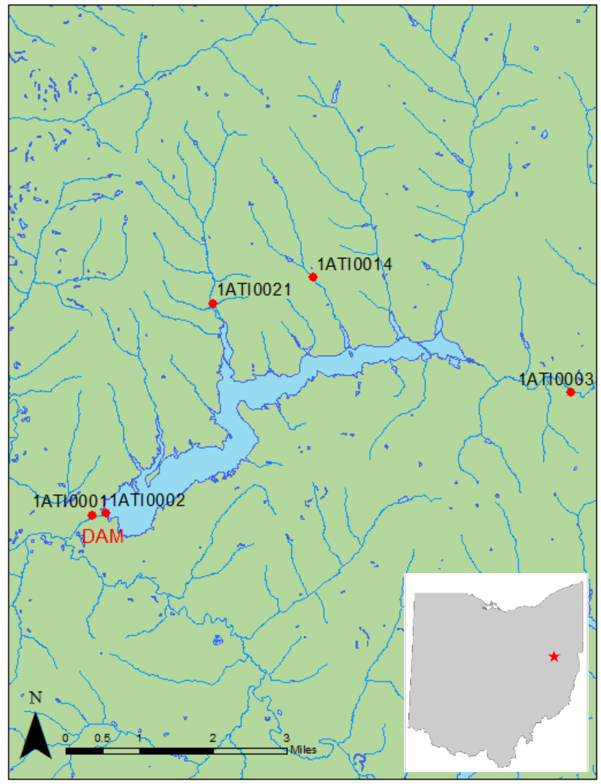

Figure 21. Water quality sampling locations for Atwood Lake in 2016.

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

2016 ACTIVITIES: There were six sampling events in the 2016 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 ATI0003 and ATI0021 were marginally good (34) and fair (24), respectively, indicating an overall healthy aquatic macroinvertebrate community at these locations. *NEXT SAMPLING YEAR: 2021*

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.

Table 10. 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	NO CRITERIA
			Kjeldahl Nitrogen, Total	7	NO CRITERIA

STATION	STATION TYPE	STREAM NAME	ANALYTES W/ELEVATED CONCENTRATIONS	NUMBER OF RESULTS THAT EXCEED SCREENING VALUE	EXCEEDED APPLICABLE NATIVE STATE CRITERIA
			Manganese, Total	3	NO CRITERIA
			Oxygen, Dissolved	1	NO CRITERIA
			Phosphorus, Total	8	NO CRITERIA
ATI0002	Lake	Indian Fork	Kjeldahl Nitrogen, Total	4	NO CRITERIA
			Phosphorus, Total	2	NO CRITERIA
ATI0003	Inflow	Indian Fork	Kjeldahl Nitrogen, Total	5	NO CRITERIA
			Phosphorus, Total	6	NO CRITERIA
			Specific Conductance	4	NO CRITERIA
			Strontium, Total	3	NO CRITERIA
ATI0014	Inflow	Grapevine Creek	Iron, Total	1	NO CRITERIA
			Kjeldahl Nitrogen, Total	2	NO CRITERIA
			Phosphorus, Total	3	NO CRITERIA
			Strontium, Total	2	NO CRITERIA
ATI0021	Inflow	Indian Fork UT	Bromide, Total	3	NO CRITERIA
			Iron, Total	1	NO CRITERIA
			Kjeldahl Nitrogen, Total	2	NO CRITERIA
			Phosphorus, Total	6	NO CRITERIA
			Specific Conductance	3	NO CRITERIA
			Strontium, Total	4	NO CRITERIA

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.

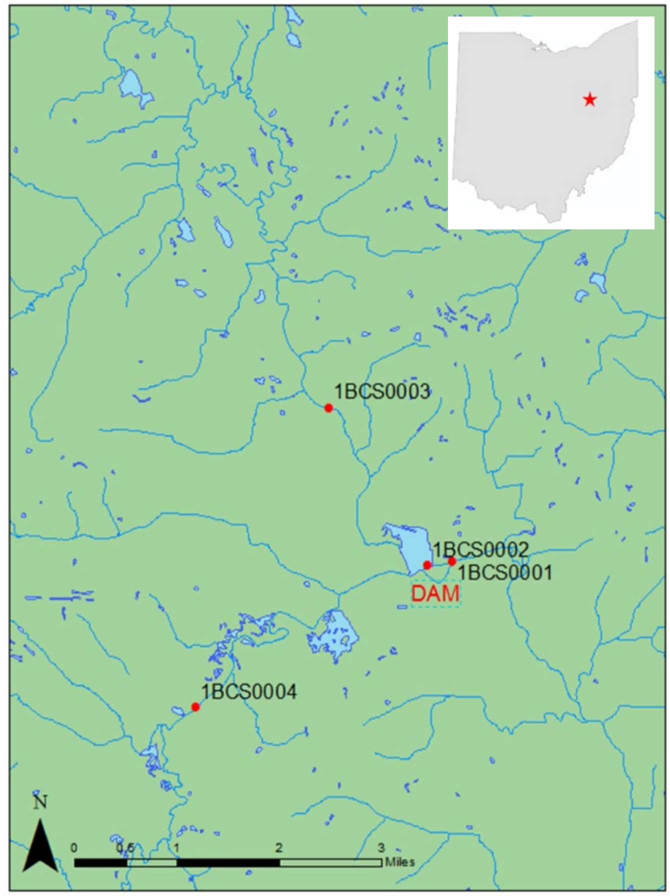

Figure 22. Water quality sampling locations for Beach City Lake in 2017.

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.

Table 11. 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	NO CRITERIA
			Iron, Total	1	NO CRITERIA
			Kjeldahl Nitrogen, Total	1	NO CRITERIA
			Phosphorus, Total	1	NO CRITERIA
			Specific Conductance	1	NO CRITERIA
1BCS0002	Lake	Beach City Lake	Specific Conductance	3	NO CRITERIA
1BCS0003	Inflow	Sugar Creek	Aluminum, Total	1	NO CRITERIA
			Iron, Total	1	NO CRITERIA
			Kjeldahl Nitrogen, Total	1	NO CRITERIA
			Phosphorus, Total	1	NO CRITERIA
			Specific Conductance	1	NO CRITERIA
1BCS0004	Inflow	South Fork of Sugar Creek	Aluminum, Total	1	NO CRITERIA
			Iron, Total	1	NO CRITERIA
			Kjeldahl Nitrogen, Total	1	NO CRITERIA
			Phosphorus, Total	1	NO CRITERIA
			Specific Conductance	1	NO CRITERIA

Beech Fork Lake (BBF) Water Quality Summary

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. 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.

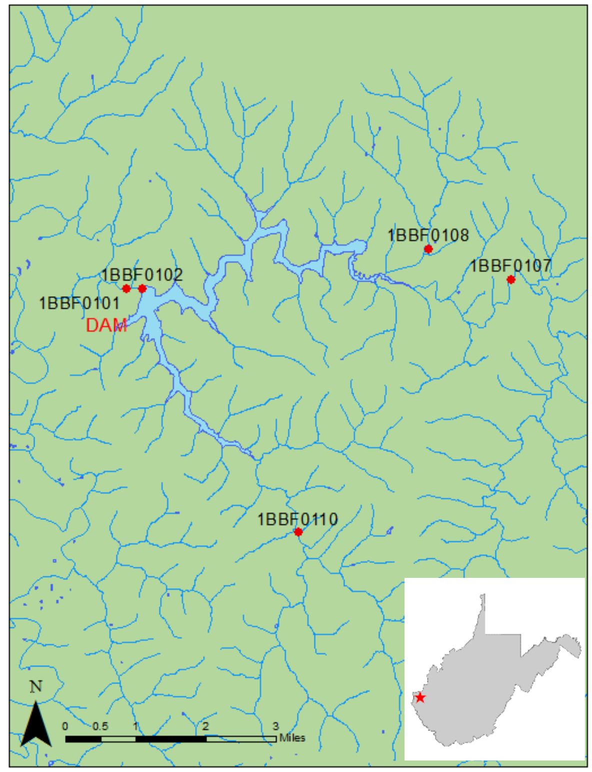

Figure 23. Water quality sampling locations for Beech Fork Lake in 2016.

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

2016 ACTIVITIES: There were six sampling events in the 2016 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 were collected at two locations. West Virginia Stream Condition Index (WVSCI) scores for BBF0107 and BBF0110 were very good (82.38) and good (70.51), respectively, indicating a healthy aquatic macroinvertebrate community at both locations. *NEXT SAMPLING YEAR: 2021*

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.

Table 12. Beech Fork Lake samples exceeding state criteria and/or District levels of concern in 2016.

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	2	2
			Iron, Total	3	2
			Kjeldahl Nitrogen, Total	4	NO CRITERIA
			Manganese, Total	1	NO CRITERIA
			Phosphorus, Total	4	NO CRITERIA
BBF0102	Lake	Beech Fork Lake	Kjeldahl Nitrogen, Total	2	NO CRITERIA

STATION	STATION TYPE	STREAM NAME	ANALYTES W/ELEVATED CONCENTRATIONS	NUMBER OF SAMPLES EXCEEDING SCREENING VALUE	EXCEEDED APPLICABLE NATIVE STATE CRITERIA
BBF0107	Inflow	Beech Fork	Aluminum, Total	1	1
			Iron, Total	2	1
			Kjeldahl Nitrogen, Total	1	NO CRITERIA
			Phosphorus, Total	3	NO CRITERIA
BBF0108	Inflow	Long Branch	Aluminum, Total	1	1
			Iron, Total	1	0
			Oxygen, Dissolved	1	1
			Phosphorus, Total	2	NO CRITERIA
BBF0110	Inflow	Millers Fork	Aluminum, Total	2	2
			Iron, Total	2	1
			Kjeldahl Nitrogen, Total	2	NO CRITERIA
			Phosphorus, Total	2	NO CRITERIA

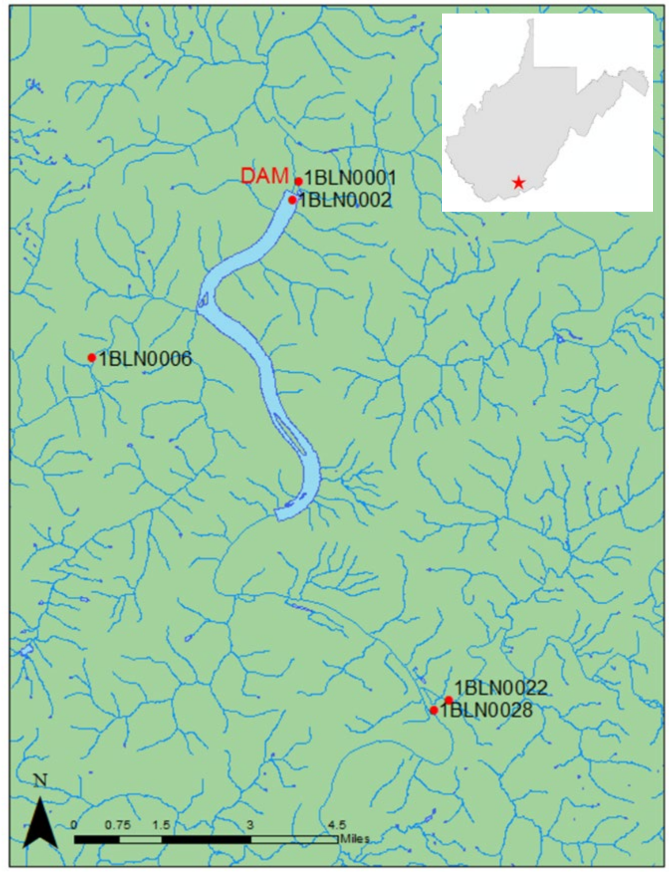

Figure 24. Water quality sampling locations for Bluestone Lake in 2017.

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.

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.

Table 13. 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	No Criteria
			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	NO CRITERIA
1BLN00028	Inflow	New River	Phosphorus, Total	2	NO CRITERIA

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.

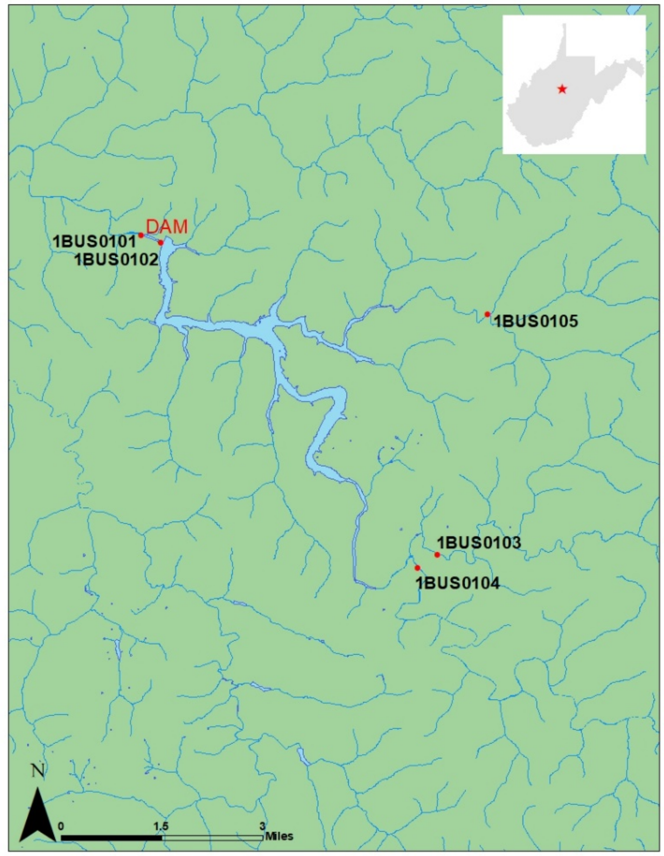

Figure 25. Water quality sampling locations for Burnsville Lake in 2017.

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.

Table 14. 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 No Criteria
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. 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.

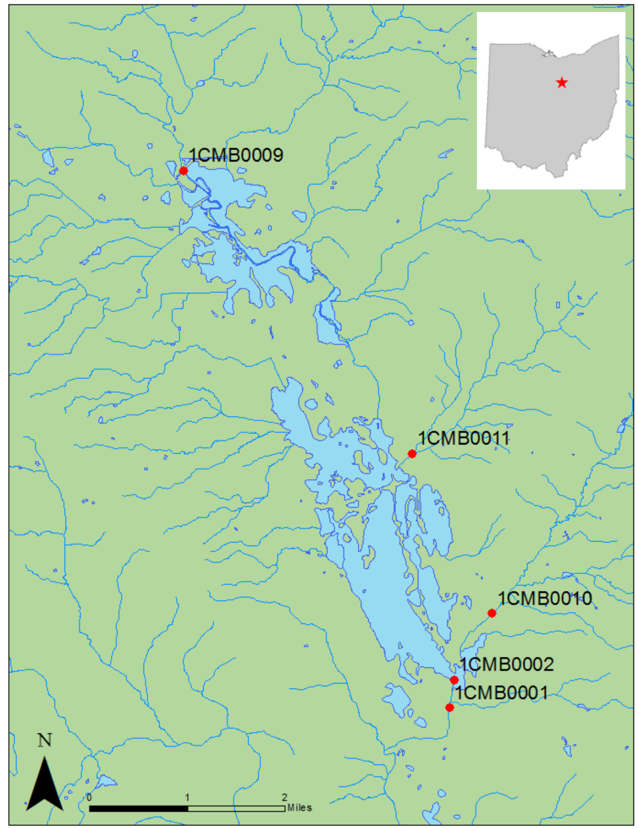

Figure 26. Water quality sampling locations for Charles Mill Lake in 2016.

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

2016 ACTIVITIES: There were six sampling events in the 2016 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 two locations (Table 13). Invertebrate community index (ICI) scores for CMB0009 and CMB0011 were fair (26) and exceptional (46), respectively, indicating an overall healthy aquatic macroinvertebrate community. *NEXT SAMPLING YEAR: 2021*

ADDITIONAL INFORMATION: Concentrations of TKN, phosphorus, and specific conductance have been steadily increasing since 1985.

Table 15. Charles Mill Lake samples exceeding state criteria and/or District levels of concern in 2016.

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	Iron, Total	2	NO CRITERIA
			Kjeldahl Nitrogen, Total	5	NO CRITERIA
			Oxygen, Dissolved	2	NO CRITERIA
			Phosphorus, Total	6	NO CRITERIA
			Specific Conductance	4	NO CRITERIA

STATION	STATION TYPE	STREAM NAME	ANALYTES W/ELEVATED CONCENTRATIONS	NUMBER OF SAMPLES EXCEEDING SCREENING VALUE	EXCEEDED APPLICABLE NATIVE STATE CRITERIA
			Strontium, Total	5	NO CRITERIA
CMB0002	Lake	Charles Mill Lake	Iron, Total	3	NO CRITERIA
			Kjeldahl Nitrogen, Total	4	NO CRITERIA
			Oxygen, Dissolved	1	NO CRITERIA
			Phosphorus, Total	4	NO CRITERIA
			Specific Conductance	3	NO CRITERIA
			Strontium, Total	4	NO CRITERIA
CMB0009	Inflow	Black Fork Mohican River	Aluminum, Total	2	NO CRITERIA
			Iron, Total	3	NO CRITERIA
			Kjeldahl Nitrogen, Total	6	NO CRITERIA
			Oxygen, Dissolved	2	NO CRITERIA
			Phosphorus, Total	6	NO CRITERIA
			Specific Conductance	5	NO CRITERIA
			Strontium, Total	6	NO CRITERIA
CMB0010	Inflow	Ruffner Run	pH	1	NO CRITERIA
			Specific Conductance	2	NO CRITERIA
CMB0011	Inflow	Seymour Run	Phosphorus, Total	1	NO CRITERIA
			Specific Conductance	4	NO CRITERIA

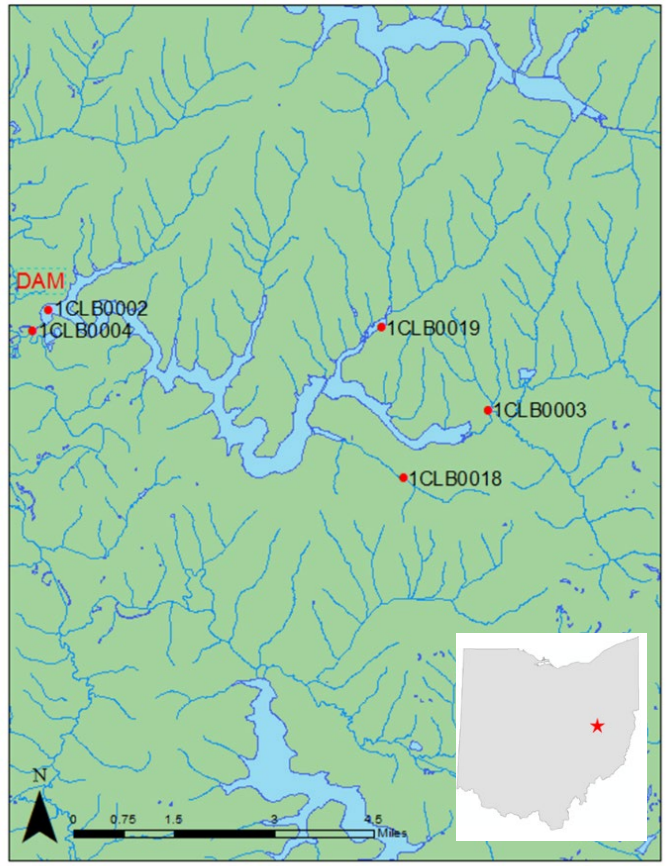

Figure 27. Water quality sampling locations for Clendening Lake in 2013.

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.

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.

Table 16. 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	NO CRITERIA
			Sp. Conductance	3	NO CRITERIA
			Strontium	3	NO CRITERIA
			Sulfate	3	NO CRITERIA
1CLB0003	Inflow	Brushy Fork of Stillwater	Iron	2	NO CRITERIA
			Specific Conductance	8	NO CRITERIA
			Strontium	5	NO CRITERIA
			Sulfate	6	NO CRITERIA
			Kjeldahl Nitrogen, Total	2	NO CRITERIA
			Phosphorus, Total	2	NO CRITERIA
1CLB0004	Outflow	Brushy Fork of Stillwater	Kjeldahl Nitrogen, Total	5	NO CRITERIA
			Phosphorus	3	NO CRITERIA
			Sp. Conductance	5	NO CRITERIA
			Strontium	5	NO CRITERIA
			Sulfate	5	NO CRITERIA
1CLB0018	Inflow	Huff Run of Brushy Fork	Kjeldahl Nitrogen, Total	1	NO CRITERIA
			Phosphorus	1	NO CRITERIA
			Specific Conductance	3	NO CRITERIA
			Strontium	3	NO CRITERIA
1CLB0019	Inflow	McFadden Run of Brushy Fork	Iron	1	NO CRITERIA
			Phosphorus	1	NO CRITERIA

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.

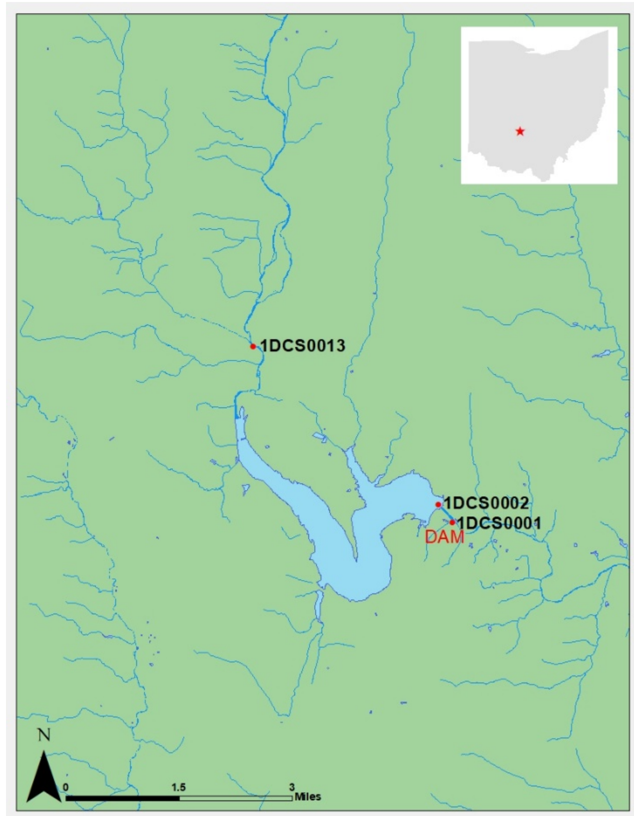

Figure 28. Water quality sampling locations for Deer Creek Lake in 2019.

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.

Table 17. 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	NO CRITERIA
			Total Aluminum	2	NO CRITERIA
			Total Iron	3	NO CRITERIA
			TKN	6	NO CRITERIA
			Total Phosphorus	6	NO CRITERIA
			Sp. Conductance	4	NO CRITERIA
			Total Strontium	6	NO CRITERIA
1DCS0002	Lake	Deer Creek	Total Iron	1	NO CRITERIA
			TKN	9	NO CRITERIA
			Total Phosphorus	9	NO CRITERIA
			Total Strontium	9	NO CRITERIA
1DCS0013	Inflow	Deer Creek	Total Aluminum	1	NO CRITERIA
			Total Iron	1	NO CRITERIA
			TKN	2	NO CRITERIA
			Total Phosphorus	6	NO CRITERIA
			Sp. Conductance	5	NO CRITERIA
			Total Strontium	6	NO CRITERIA

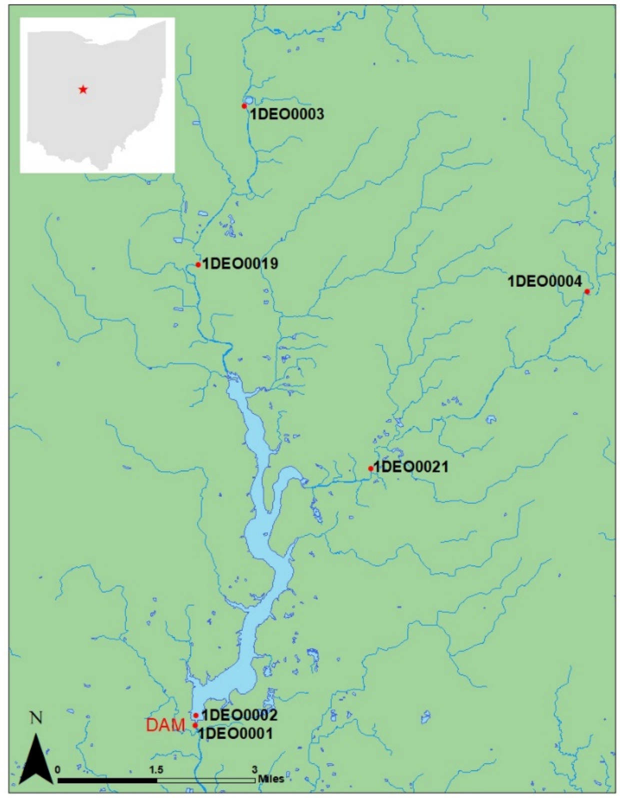

Figure 29. Water quality sampling locations for Delaware Lake in 2019.

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.

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.

Table 18. 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	NO CRITERIA
			Total Iron	5	NO CRITERIA
			TKN	6	NO CRITERIA
			Total Phosphorus	6	NO CRITERIA
			Total Strontium	5	NO CRITERIA
1DEO0002	Lake	Olentangy River	Total Aluminum	3	NO CRITERIA
			Total Iron	5	NO CRITERIA
			TKN	9	NO CRITERIA
			Total Phosphorus	9	NO CRITERIA
			Total Strontium	9	NO CRITERIA
1DEO0019 & 1DEO0003	Inflow	Olentangy River	Total Aluminum	4	NO CRITERIA
			Total Iron	4	NO CRITERIA
			TKN	6	NO CRITERIA
			Total Phosphorus	6	NO CRITERIA
			Sp. Conductance	2	NO CRITERIA
			Total Strontium	5	NO CRITERIA
1DEO0021 & 1DEO0004	Inflow	Whetstone Creek	Total Aluminum	2	NO CRITERIA
			Total Iron	3	NO CRITERIA
			TKN	5	NO CRITERIA
			Total Phosphorus	5	NO CRITERIA
			Sp. Conductance	4	NO CRITERIA
			Total Strontium	6	NO CRITERIA

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, manganese, total Kjeldahl nitrogen, strontium, sulfates, and phosphorus. 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. Elevated constituent levels will be reported to the Kentucky Division of Water to facilitate potential mitigation efforts by the state.cd

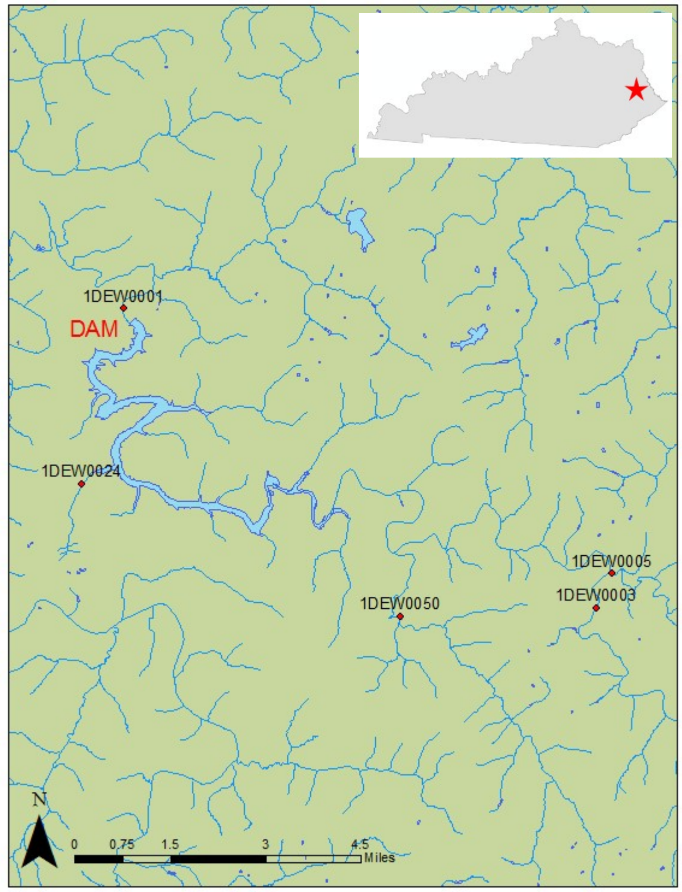

Figure 30. Water quality sampling locations for Dewey Lake in 2015.

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

2015 ACTIVITIES: There were four sampling events that occurred at Dewey Lake in the 2015 sampling season. Due to contracting issues, only one of the sampling events included all water chemistry parameters. The last three events were conducted through ambient YSI readings. These events include routine water quality sampling of inflows and outflows at all locations. *NEXT SAMPLING YEAR: 2020*

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. In August 2017, a coal slurry was discharged from Scott Branch into Johns Creek, approximately 17.5 miles upstream of the lake. Discharge booms and turbidity curtains were deployed by the mine company on Johns Creek to slow the material down. Water quality analysis showed that this event did not significantly raise ambient levels of metals, ions, and solids above historical conditions. There were no operational changes or further sampling required to minimize impacts.

Table 19. Dewey Lake samples exceeding state criteria and/or District levels of concern in 2015.

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

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.

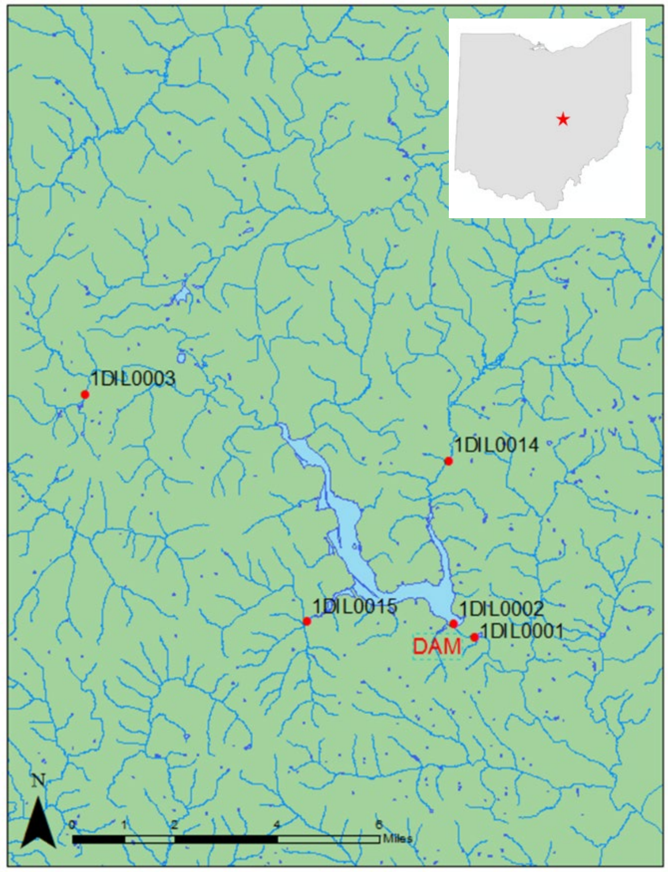

Figure 31. Water quality sampling locations for Dillon Lake in 2017.

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.

Table 20. 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	NO CRITERIA
			Iron, Total	1	NO CRITERIA
			Kjeldahl Nitrogen, Total	1	NO CRITERIA

STATION	STATION TYPE	STREAM NAME	ANALYTES W/ELEVATED CONCENTRATIONS	NUMBER OF SAMPLES EXCEEDING SCREENING VALUE	EXCEEDED APPLICABLE NATIVE STATE CRITERIA
			Phosphorus, Total	1	NO CRITERIA
			Strontium, Total	1	NO CRITERIA
1DIL0002	Lake	Licking River	Aluminum, total	1	NO CRITERIA
			Iron, total	1	NO CRITERIA
			Total Kjeldahl Nitrogen	14	NO CRITERIA
			Phosphorus, total	14	NO CRITERIA
			Specific Conductance	35	NO CRITERIA
1DIL0003	Inflow	Licking River	Aluminum, Total	1	NO CRITERIA
			Iron, Total	1	NO CRITERIA
			Kjeldahl Nitrogen, Total	1	NO CRITERIA
			Phosphorus, Total	1	NO CRITERIA
			Strontium, Total	1	NO CRITERIA
1DIL0014	Inflow	Big Run	Iron, Total	1	NO CRITERIA
			Kjeldahl Nitrogen, Total	1	NO CRITERIA
			Phosphorus, Total	1	NO CRITERIA
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. 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.

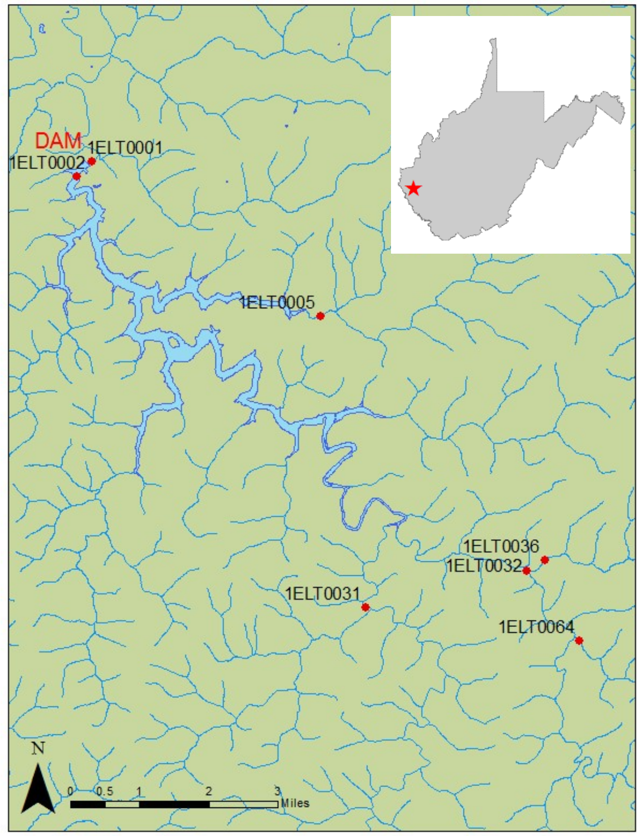

Figure 32. Water quality sampling locations for East Lynn Lake in 2016.

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

2016 ACTIVITIES: There were six sampling events in the 2016 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 for ELT0005, ELT0031, ELT0032, and ELT006 were very good (81.34), impaired-gray zone (67.80), good (71.14), and good (77.14), respectively, indicating a healthy aquatic macroinvertebrate community at three of the four locations. *NEXT SAMPLING YEAR: 2021*

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.

Table 21. East Lynn Lake samples exceeding state criteria and/or District levels of concern in 2016.

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	Aluminum, Total	1	1
			Iron, Total	2	2
			Kjeldahl Nitrogen, Total	4	NO CRITERIA
			Manganese, Total	1	NO CRITERIA

STATION	STATION TYPE	STREAM NAME	ANALYTES W/ELEVATED CONCENTRATIONS	NUMBER OF SAMPLES EXCEEDING SCREENING VALUE	EXCEEDED APPLICABLE NATIVE STATE CRITERIA
			Phosphorus, Total	3	NO CRITERIA
ELT0005	Inflow	Lick Creek	Oxygen, Dissolved	2	2
ELT0031	Inflow	East Fork of Twelvepole Creek	Aluminum, Total	2	2
			Iron, Total	3	2
			Phosphorus, Total	3	NO CRITERIA
			Strontium, Total	2	NO CRITERIA
ELT0032	Inflow	Kiah Creek	Specific Conductance	2	NO CRITERIA
			Strontium, Total	2	NO CRITERIA
			Sulfate, Total	3	NO CRITERIA
ELT0036	Inflow	Big Laurel Creek	None	-	-
ELT0064	Inflow	Trough Fork	Specific Conductance	1	NO CRITERIA
			Strontium, Total	1	NO CRITERIA
			Sulfate, Total	1	NO CRITERIA

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, and sulfates. 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.

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.

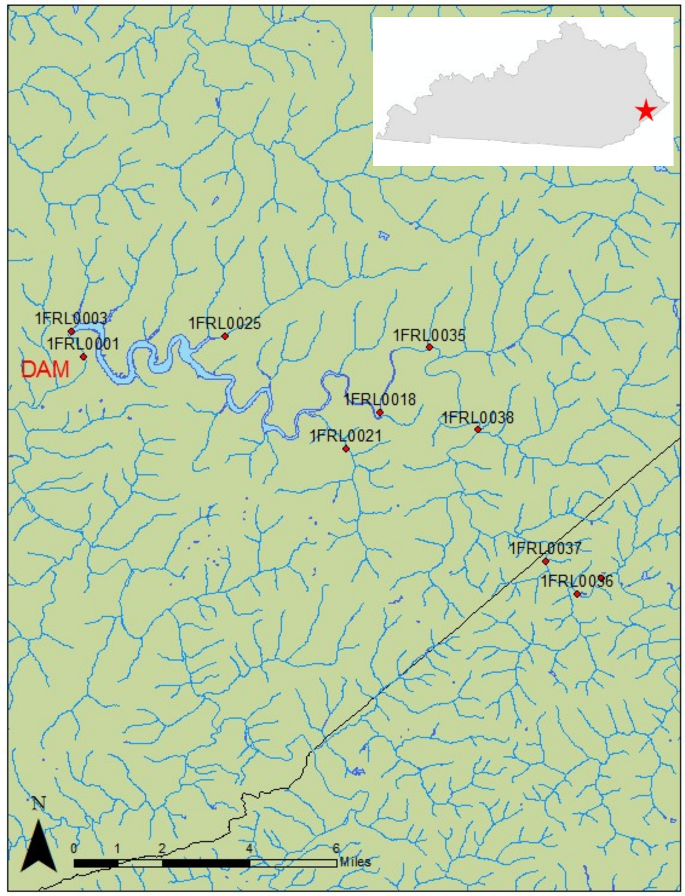

Figure 33. Water quality sampling locations for Fishtrap Lake in 2015.

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

2015 ACTIVITIES: Five sampling events were completed at all ten locations at Fish Trap Lake in the 2015 sampling season. Only two of the sampling events included all water chemistry parameters. The remaining three events only assessed physical chemistry using a multiparameter data sonde. These events include routine water quality analysis of inflows and outflows at all locations. *NEXT SAMPLING YEAR: 2020*

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. In 2015, the District met with lake personnel, politicians, and concerned citizens in an attempt to begin to solve the issue. No resolution to the problem has been put forth at this time. Additionally in 2015, a sewage main was damaged on the Levisa Fork in Grundy, VA upstream of the lake. Although no state criteria were exceeded as a result of the spill, the public perception resulted in a decrease in recreation on the lake. No operational changes were required for water quality.

Table 22. Fishtrap Lake samples exceeding state criteria and/or District levels of concern in 2015.

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	3	None

STATION	STATION TYPE	STREAM NAME	ANALYTES W/ELEVATED CONCENTRATIONS	NUMBER OF RESULTS THAT EXCEED SCREENING VALUE	EXCEEDED APPLICABLE NATIVE STATE CRITERIA
			Strontium, Total	2	
1FRL0002	Inflow	Levisa Fork	Sp. Conductance	1	None
1FRL0003	Inflow	Fish Trap Lake	None	0	None
1FRL0018	Inflow	Levisa Fork	None	0	None
1FRL0021	Inflow	Lick Creek	Sp. Conductance	3	None
			Strontium, Total	2	
			Sulfate, Total	2	
1FRL0025	Inflow	Grapevine Creek	Aluminum, Total	1	None
			Sp. Conductance	3	
			Strontium, Total	2	
			Sulfate, Total	1	
1FRL0035	Inflow	Levisa Fork	Sp. Conductance	5	None
			Strontium, Total	2	
1FRL0036	Inflow	Levisa Fork	Sp. Conductance	1	None
1FRL0037	Inflow	Levisa Fork	Sp. Conductance	1	None
1FRL0038	Inflow	Levisa Fork	Sp. 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 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.

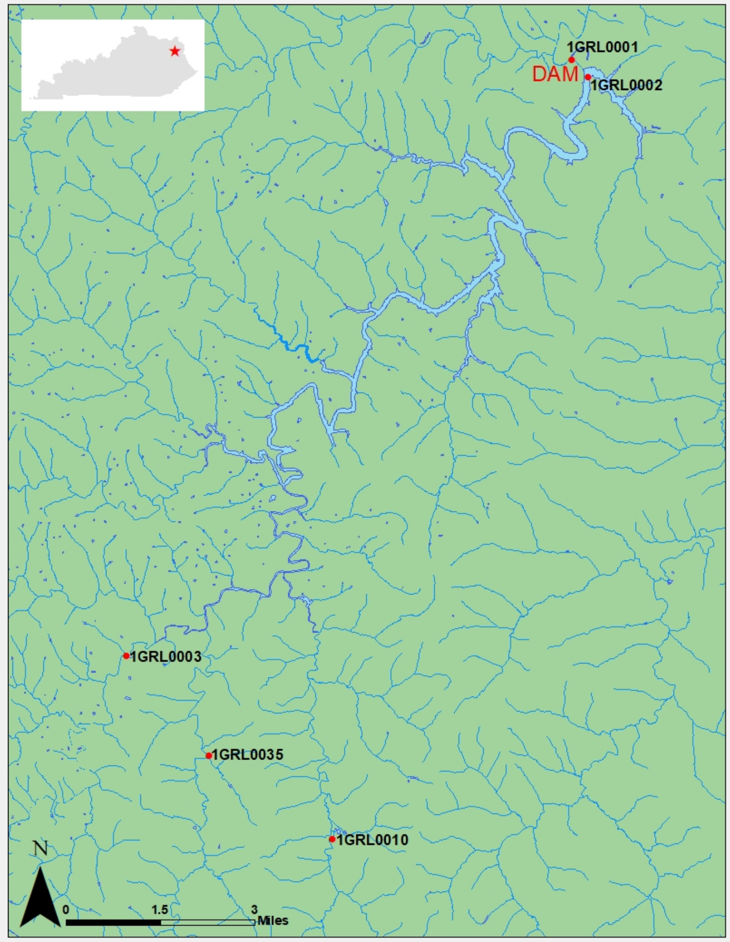

Figure 34. Water quality sampling locations for Grayson Lake in 2019.

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.

Table 23. 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, and sulfates. 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 Virginia Department of Environmental Quality to facilitate potential mitigation efforts by the state.

This project is currently in the Federal Energy Regulatory Commission (FERC) licensing phase for the addition of non-Federal hydropower, which could potentially alter water quality at the project.

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.

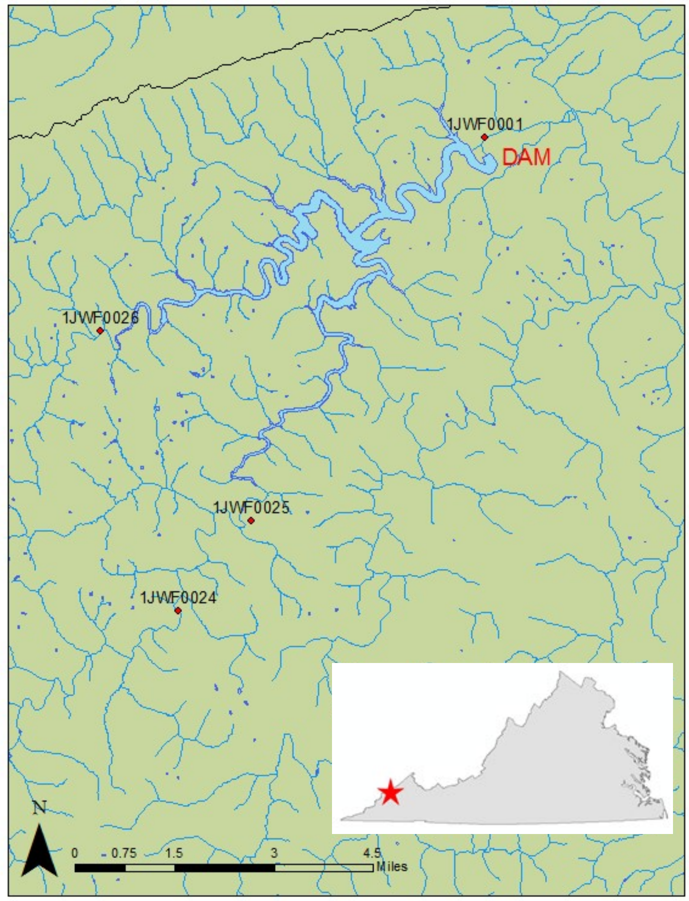

Figure 35. Water quality sampling locations for J.W. Flannagan Lake in 2015.

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, specific conductance, and sulfates

2015 ACTIVITIES: Three sampling events were completed at four locations at J.W. Flannagan Lake. Only two of the sampling events included all water chemistry parameters. The remaining sampling events assessed physical chemistry using a multiparameter data sonde. These events include routine water quality analysis of inflows and outflow. *NEXT SAMPLING YEAR: 2020*

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 is currently reviewing 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.

J.W. Flannagan Lake has recently had frequent harmful algal blooms during both the cold winter season and the summer recreation season. As a result, Virginia has initiated a study to help determine some of the causes of the problematic blooms.

Table 24. J. W. Flannagan Lake samples exceeding state criteria and/or District levels of concern in 2015.

STATION	STATION TYPE	STREAM NAME	ANALYTES W/ELEVATED CONCENTRATIONS	NUMBER OF SAMPLES EXCEEDING SCREENING VALUE	EXCEEDED APPLICABLE NATIVE STATE CRITERIA
1JWF0001	Outflow	Pound River	TKN	1	None
			Sp. Conductance	3	
			Strontium, Total	2	
			Sulfate, Total	1	
1JWF0024	Inflow	Cranes Nest River	Sp. Conductance	1	None
			Strontium, Total	1	
1JWF0025	Inflow	Cranes Nest River	Sp. Conductance	2	None
			Strontium, Total	1	
			Sulfate, Total	1	
1JWF0026	Inflow	Pound River	Sp. Conductance	3	None
			Strontium, Total	2	
			Sulfate, Total	2	

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. 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 Environmental Protection Agency to facilitate potential mitigation efforts by the state.

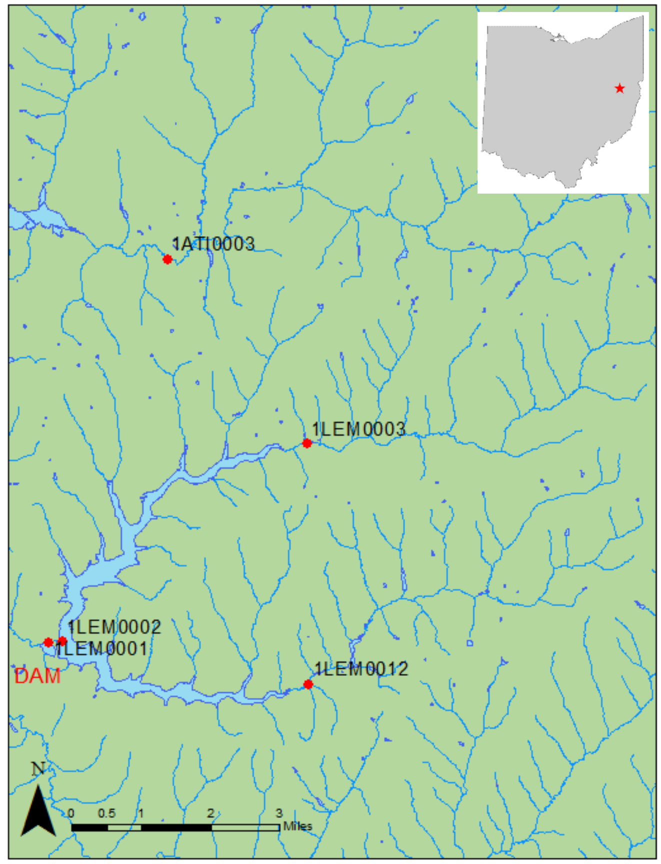

Figure 36. Water quality sampling locations for Leesville Lake in 2016.

WATERSHED SUMMARY: The Leesville Lake drainage basin 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

2016 ACTIVITIES: There were six sampling events in the 2016 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 two locations. Invertebrate community index (ICI) scores for LEM0003 and LEM0012 were fair (28) and fair (26), respectively, indicating an overall healthy aquatic macroinvertebrate community at these locations. *NEXT SAMPLING YEAR: 2021*

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.

Table 25. Leesville Lake samples exceeding state criteria and/or District levels of concern in 2016.

STATION	STATION TYPE	STREAM NAME	ANALYTES W/ELEVATED CONCENTRATIONS	NUMBER OF SAMPLES EXCEEDING SCREENING VALUE	EXCEEDED APPLICABLE NATIVE STATE CRITERIA
LEM0001	Outflow	McGuire Creek	Aluminum, Total	1	NO CRITERIA
			Iron, Total	2	NO CRITERIA
			Kjeldahl Nitrogen, Total	6	NO CRITERIA
			Manganese, Total	3	NO CRITERIA
			Phosphorus, Total	5	NO CRITERIA
LEM0002	Lake	Leesville Lake	Kjeldahl Nitrogen, Total	1	NO CRITERIA
			pH	2	NO CRITERIA
LEM0003	Inflow	North Fork McGuire Creek	Aluminum, Total	1	NO CRITERIA
			Iron, Total	2	NO CRITERIA
			Kjeldahl Nitrogen, Total	2	NO CRITERIA
			Phosphorus, Total	5	NO CRITERIA
LEM0012	Inflow	McGuire Creek	Kjeldahl Nitrogen, Total	4	NO CRITERIA
			Oxygen, Dissolved	2	NO CRITERIA
			Phosphorus, Total	7	NO CRITERIA

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. 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 37. Water quality sampling locations for North Branch of Kokosing Lake in 2016.

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

2016 ACTIVITIES: There were six sampling events in the 2016 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 two locations. Invertebrate community index (ICI) scores for NBN0004 and NBN0005 were very good (42) and fair (22), respectively, indicating an overall healthy aquatic macroinvertebrate community at these locations. *NEXT SAMPLING YEAR: 2021*

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.

Table 26. North Branch of Kokosing Lake samples exceeding state criteria and/or District levels of concern in 2016.

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	1	NO CRITERIA
			Iron, Total	1	NO CRITERIA
			Kjeldahl Nitrogen, Total	6	NO CRITERIA
			Oxygen, Dissolved	3	NO CRITERIA
			Phosphorus, Total	6	NO CRITERIA
			Strontium, Total	2	NO CRITERIA

STATION	STATION STYPE	STREAM NAME	ANALYTES W/ELEVATED CONCENTRATIONS	NUMBER OF SAMPLES EXCEEDING SCREENING VALUE	EXCEED NATIVE STATE CRITERIA
NBN0002	Lake	Kokosing Lake	Kjeldahl Nitrogen, Total	4	NO CRITERIA
			Oxygen, Dissolved	4	NO CRITERIA
			Strontium, Total	1	NO CRITERIA
NBN0004	Inflow	North Branch of Kokosing River	Kjeldahl Nitrogen, Total	1	NO CRITERIA
			Phosphorus, Total	1	NO CRITERIA
			Specific Conductance	4	NO CRITERIA
			Strontium, Total	5	NO CRITERIA
NBN0005	Inflow	UT to North Branch of Kokosing River	Kjeldahl Nitrogen, Total	2	NO CRITERIA
			Phosphorus, Total	5	NO CRITERIA
			Specific Conductance	3	NO CRITERIA
			Strontium, Total	5	NO CRITERIA

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 specific conductance and phosphorus. 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 Virginia Department of Environmental Quality to facilitate potential mitigation efforts by the state. Future sampling will allow the District to further evaluate phosphorus levels at the project.

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.

2015 ACTIVITIES: Three sampling events occurred at three sites in FY 2015. Due to contracting issues, only two of the sampling events included all water chemistry parameters, the last event assessed physical chemistry only. These events included routine water quality sampling of inflows and outflow. *NEXT SAMPLING YEAR: 2020*

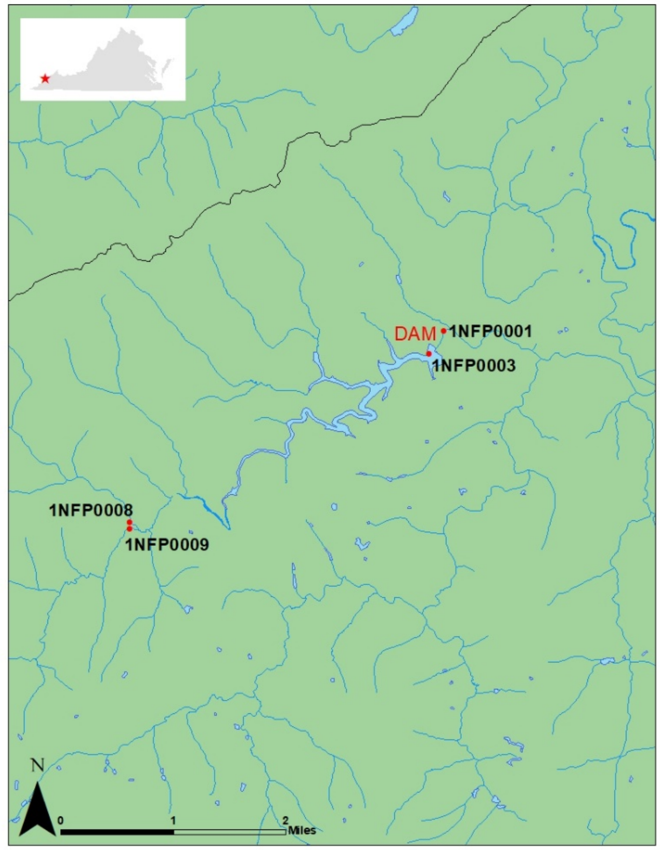

Figure 38. Water quality sampling locations for North Fork of Pound Lake in 2015.

ADDITIONAL INFORMATION: North Fork of Pound Lake has a multi-level intake structure for optimization of water quality in the outflow. In 2015 a phosphorus result exceeded the threshold of concern (0.05 mg/L). Upon subsequent analysis in 2016 it was determined that the previous sample was likely an anomaly and not an upward trend. The LRH Water Quality Team has determined that no further monitoring is necessary, and North Fork of Pound will be sampled on schedule in 2020 under the routine Intensive Water Quality Survey Program.

Table 27. North Fork of Pound Lake samples exceeding state criteria and/or District levels of concern in 2015.

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	Phosphorus, Total	2	None
1NFP0008	Inflow	Bad Creek	None	-	-
1NFP0009	Inflow	North Fork of Pound	Sp. Conductance	1	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 consituents 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.

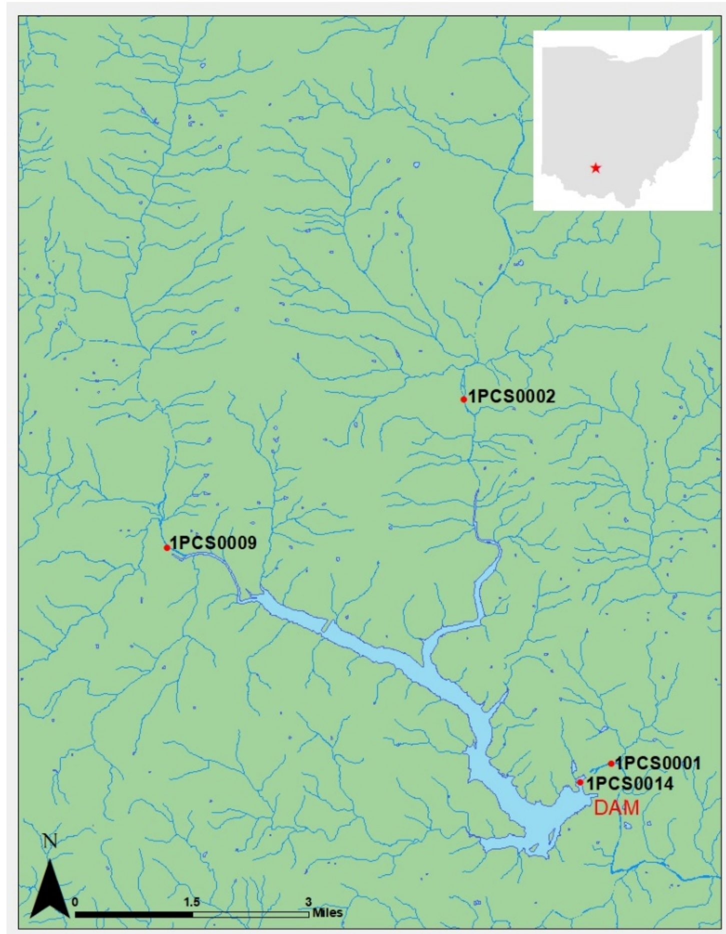

Figure 39. Water quality sampling locations for Paint Creek Lake in 2019.

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.

Table 28. 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	NO CRITERIA
			Total Iron	2	NO CRITERIA
			TKN	6	NO CRITERIA
			Total Phosphorus	6	NO CRITERIA
			Sp. Conductance	2	NO CRITERIA
			Total Strontium	6	NO CRITERIA
1PCS0002	Inflow	Paint Creek	Total Aluminum	1	NO CRITERIA
			Total Iron	1	NO CRITERIA
			TKN	3	NO CRITERIA
			Total Phosphorus	5	NO CRITERIA
			Sp. Conductance	4	NO CRITERIA
			Total Strontium	5	NO CRITERIA
1PCS0009	Inflow	Rattlesnake Creek	Total Aluminum	1	NO CRITERIA
			Total Iron	1	NO CRITERIA
			TKN	3	NO CRITERIA
			Total Phosphorus	5	NO CRITERIA
			Sp. Conductance	4	NO CRITERIA
			Total Strontium	5	NO CRITERIA

STATION	STATION STYPE	STREAM NAME	ANALYTES W/ELEVATED CONCENTRATIONS	NUMBER OF SAMPLES EXCEEDING SCREENING VALUE	EXCEED NATIVE STATE CRITERIA
1PCS0014	Lake	Paint Creek	Total Aluminum	1	NO CRITERIA
			Total Iron	2	NO CRITERIA
			Dissolved Iron	1	NO CRITERIA
			TKN	9	NO CRITERIA
			Total Phosphorus	9	NO CRITERIA
			Total Strontium	9	NO CRITERIA

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.

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.

Figure 40. Water quality sampling locations for Paintsville Lake in 2013.

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.

Table 29. 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	NO CRITERIA
1PIV0009	Inflow	Big Mine Fork	Selenium	2	NO CRITERIA
			Strontium	3	NO CRITERIA
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.

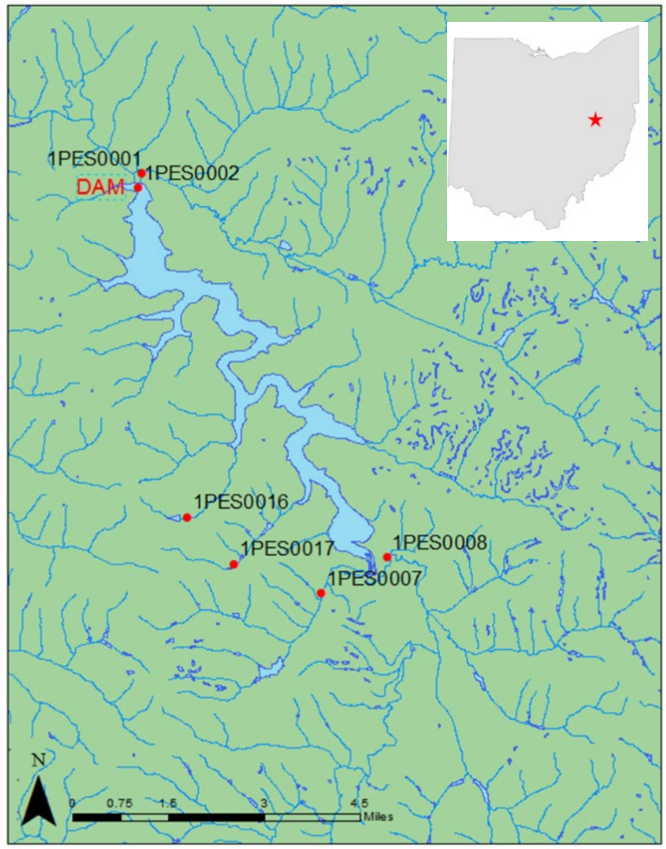

Figure 41. Water quality sampling locations for Piedmont Lake in 2013.

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.

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.

Table 30. 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	NO CRITERIA
			Manganese	1	NO CRITERIA
			Phosphorus, Total	1	NO CRITERIA
			Specific Conductance	5	NO CRITERIA
			Strontium	5	NO CRITERIA
			Sulfate	5	NO CRITERIA
1PES0002	Lake	Stillwater Creek	Specific Conductance	3	NO CRITERIA
			Strontium	3	NO CRITERIA
			Sulfate	3	NO CRITERIA
1PES0007	Inflow	Robinson Creek	Kjeldahl Nitrogen, Total	1	NO CRITERIA
			Phosphorus, Total	1	NO CRITERIA
			Specific Conductance	5	NO CRITERIA
			Strontium	5	NO CRITERIA
			Sulfate	5	NO CRITERIA
1PES0008	Inflow	Stillwater Creek	Aluminum	1	NO CRITERIA
			Iron	1	NO CRITERIA
			Kjeldahl Nitrogen, Total	2	NO CRITERIA
			Phosphorus, Total	4	NO CRITERIA
			Strontium	4	NO CRITERIA
			Sulfate	5	NO CRITERIA
1PES0016	Inflow	Indian Run	Aluminum	2	NO CRITERIA
			Manganese	1	NO CRITERIA
			pH	3	Yes
			Phosphorus, Total	1	NO CRITERIA
			Specific Conductance	3	NO CRITERIA
			Strontium	2	NO CRITERIA
			Sulfate	2	NO CRITERIA
1PES0017	Inflow	Lick Run	Aluminum	4	NO CRITERIA

STATION	STATION TYPE	STREAM NAME	ANALYTES W/ELEVATED CONCENTRATIONS	NUMBER OF SAMPLES EXCEEDING SCREENING VALUE	EXCEEDED APPLICABLE NATIVE STATE CRITERIA
			Iron	5	NO CRITERIA
			Kjeldahl Nitrogen, Total	2	NO CRITERIA
			Manganese	4	NO CRITERIA
			pH	5	Yes
			Phosphorus	1	NO CRITERIA
			Selenium	1	NO CRITERIA
			Specific Conductance	5	NO CRITERIA
			Strontium	5	NO CRITERIA
			Sulfate	5	NO CRITERIA

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. 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.

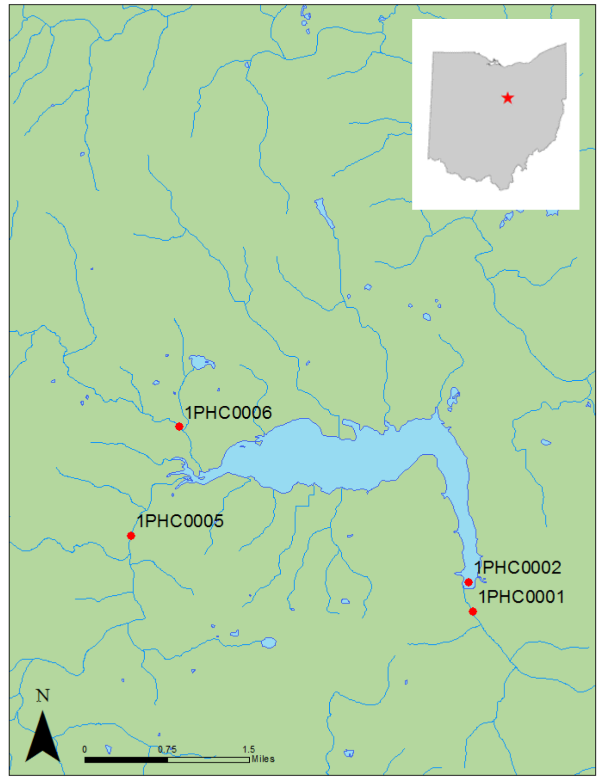

Figure 42. Water quality sampling locations for Pleasant Hill Lake in 2016.

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

2016 ACTIVITIES: There were six sampling events in the 2016 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 two locations. Invertebrate community index (ICI) scores for PHC0005 and PHC0006 were marginally good (32) and exceptional (50), respectively, indicating a healthy aquatic macroinvertebrate community at these locations. *NEXT SAMPLING YEAR: 2021*

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.

Table 31. Pleasant Hill Lake samples exceeding state criteria and/or District levels of concern in 2016.

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	Kjeldahl Nitrogen, Total	5	NO CRITERIA
			Oxygen, Dissolved	2	NO CRITERIA
			Phosphorus, Total	5	NO CRITERIA
			Strontium, Total	1	NO CRITERIA
PHC0002	Lake	Pleasant Hill Lake	Kjeldahl Nitrogen, Total	4	NO CRITERIA
			Phosphorus, Total	3	NO CRITERIA
PHC0005	Inflow	Clear Fork of Mohican River	Phosphorus, Total	5	NO CRITERIA
			Specific Conductance	3	NO CRITERIA

			Strontium, Total	4	NO CRITERIA
PHC0006	Inflow	Switzer Creek	Phosphorus, Total	2	NO CRITERIA

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.

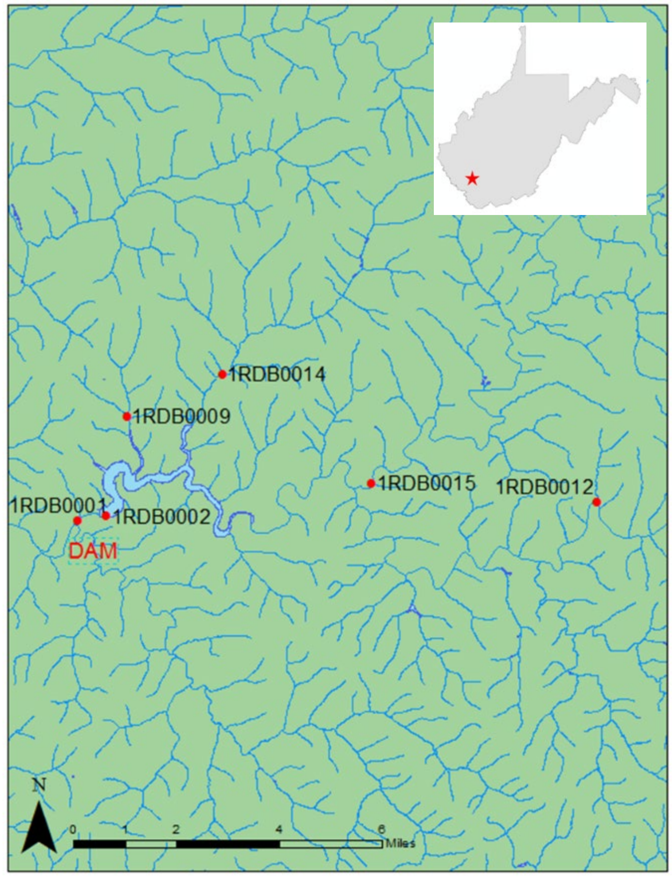

Figure 43. Water quality sampling locations for R.D. Bailey Lake in 2008.

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).

Table 32. 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	NO CRITERIA
1RDB0002	Lake	Guyandotte River	Strontium	4	NO CRITERIA
1RDB0012	Inflow	Guyandotte River	Specific Conductance	1	NO CRITERIA
			Strontium	5	NO CRITERIA
1RDB0014	Inflow	Big Cub Creek	Specific Conductance	4	NO CRITERIA
			Strontium	10	NO CRITERIA
			Sulfate	7	NO CRITERIA
1RDB0015	Inflow	Clear Fork	Strontium	4	NO CRITERIA

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.

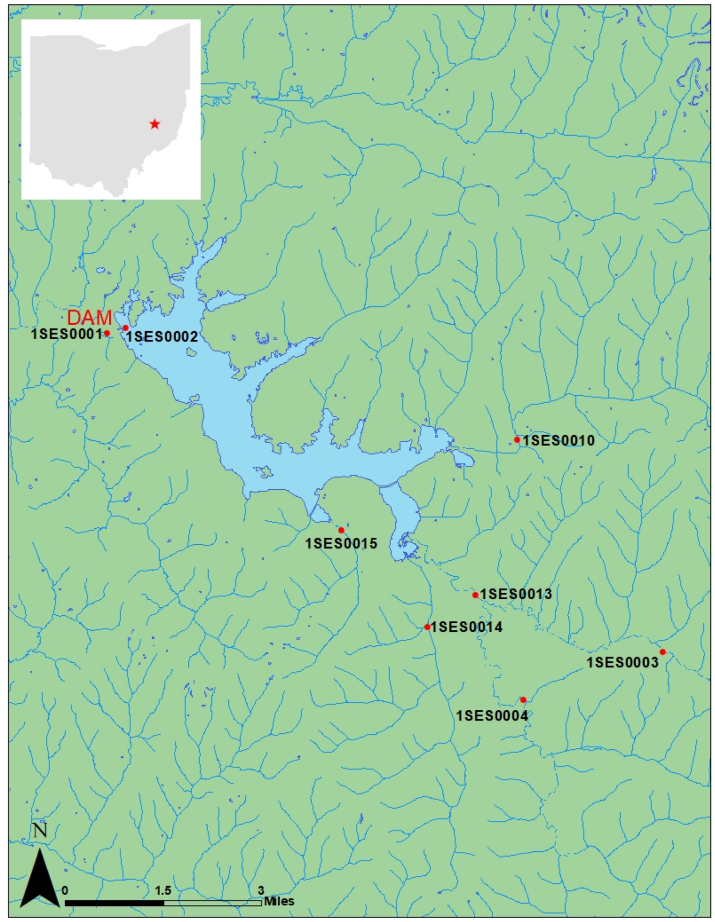

Figure 44. Water quality sampling locations for Senecaville Lake in 2019.

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. Senecaville 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.

Table 33. 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	NO CRITERIA
			TKN	4	NO CRITERIA
			Total Phosphorus	5	NO CRITERIA
			Total Strontium	4	
1SES0002	Lake	Seneca Fork	Total Iron	1	
			TKN	12	
			Total Manganese	1	NO CRITERIA
			Dissolved Manganese	1	NO CRITERIA
			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	NO CRITERIA
			Total Phosphorus	2	NO CRITERIA
			Sp. Conductance	6	NO CRITERIA
			Total Strontium	6	
1SES0013	Inflow	Seneca Fork	Total Aluminum	1	NO CRITERIA
			Total Iron	1	NO CRITERIA
			TKN	1	NO CRITERIA
			Total Phosphorus	1	NO CRITERIA
			Total Strontium	2	NO CRITERIA

STATION	STATION STYPE	STREAM NAME	ANALYTES W/ELEVATED CONCENTRATIONS	NUMBER OF SAMPLES EXCEEDING SCREENING VALUE	EXCEED NATIVE STATE CRITERIA
1SES0014	Inflow	Glady Run	Total Iron	1	NO CRITERIA
			Total Strontium	6	
			Dissolved Oxygen	1	
			Total Phosphorus	3	
			Specific Conductance	1	
1SES0015	Inflow	Mud Run	Total Aluminum	1	NO CRITERIA
			Total Iron	1	NO CRITERIA
			TKN	1	NO CRITERIA
			Total Phosphorus	3	NO CRITERIA
			Total Strontium	6	NO CRITERIA
			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.

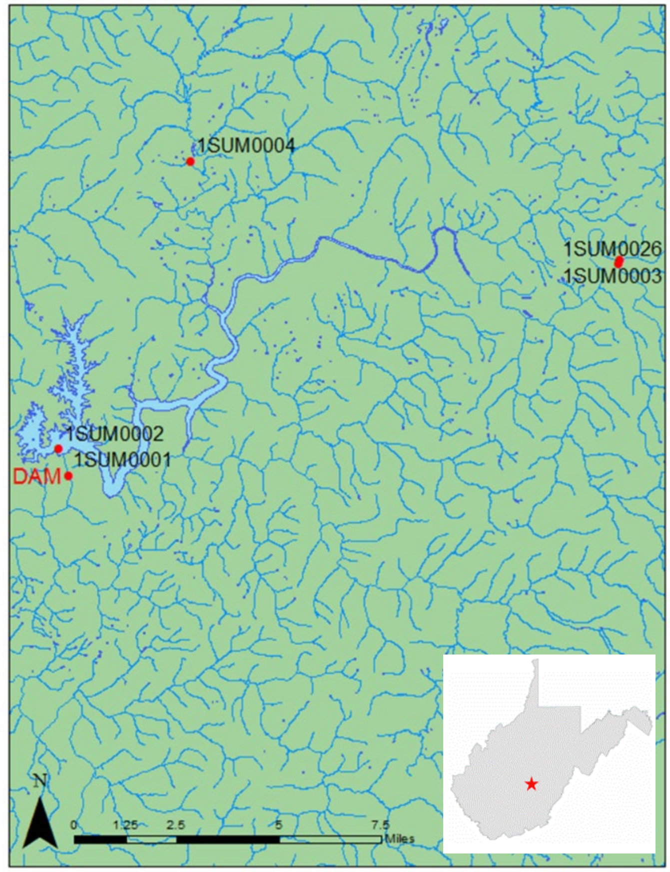

Figure 45. Water quality sampling locations for Summersville Lake in 2017.

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.

Table 34. 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	-	-

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.

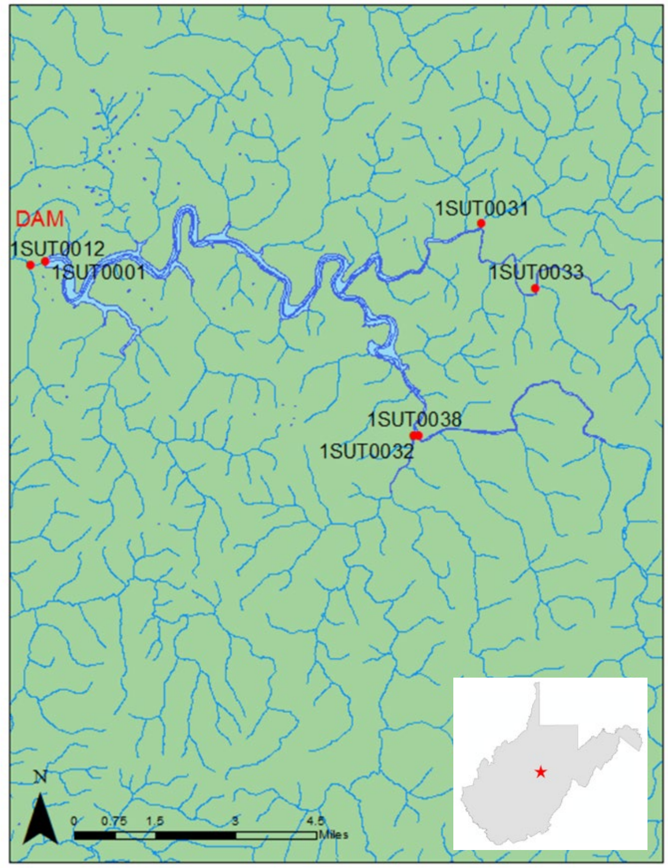

Figure 46. Water quality sampling locations for Sutton Lake in 2017.

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.

Table 35. 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	NO CRITERIA
			Total Kjeldahl Nitrogen	1	NO CRITERIA
			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	NO CRITERIA
			Strontium	4	NO CRITERIA
			Sulfate	3	NO CRITERIA

Tappan Lake (TAL) Water Quality Summary

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.

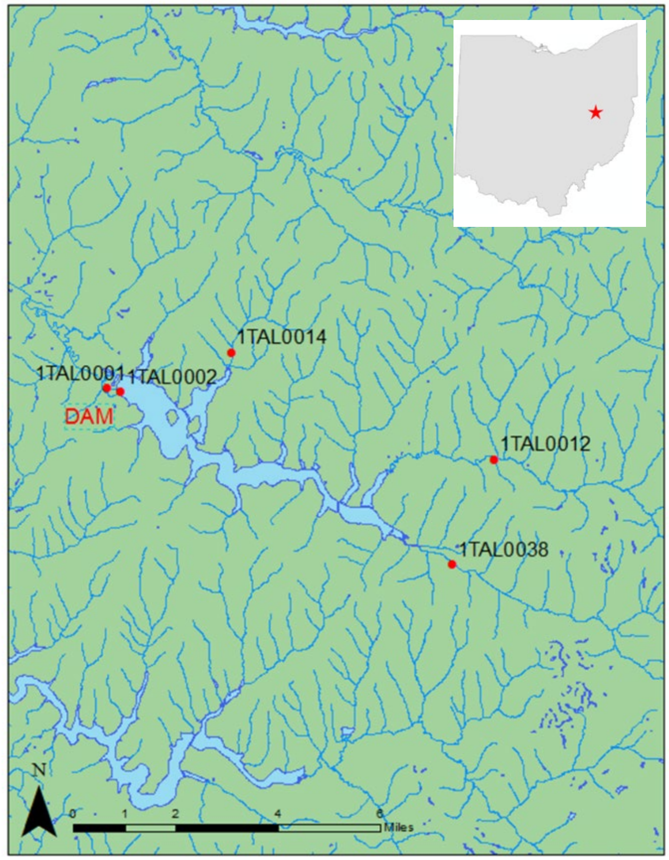

Figure 47. Water quality sampling locations for Tappan Lake in 2018.

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.

Table 36. 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	NO CRITERIA
			Specific Conductance	4	NO CRITERIA
			Strontium	5	NO CRITERIA
			Sulfate	2	NO CRITERIA
			Kjeldahl Nitrogen, Total	5	NO CRITERIA
			Phosphorus, Total	6	NO CRITERIA
1TAL0002	Lake	Little Stillwater Creek	Kjeldahl Nitrogen, Total	2	NO CRITERIA
			Specific Conductance	3	NO CRITERIA
			Strontium	3	NO CRITERIA
			Sulfate	2	NO CRITERIA
1TAL0027	Inflow	Clear Fork	Aluminum	2	NO CRITERIA
			Iron	3	NO CRITERIA
			Kjeldahl Nitrogen, Total	1	NO CRITERIA
			Phosphorus, Total	4	NO CRITERIA
			Specific Conductance	6	NO CRITERIA
			Strontium	5	NO CRITERIA
			Sulfate	5	NO CRITERIA
1TAL0014	Inflow	Lower Beaverdam Run	Aluminum	1	NO CRITERIA
			Iron	3	NO CRITERIA
			Phosphorus, Total	4	NO CRITERIA
			Specific Conductance	2	NO CRITERIA
1TAL0045	Inflow	Standingstone Fork	Iron	1	NO CRITERIA
			Phosphorus, Total	1	NO CRITERIA
			Specific Conductance	7	NO CRITERIA
			Strontium	7	NO CRITERIA
			Sulfate	8	NO CRITERIA

Tom Jenkins Dam (TJE) Water Quality Summary

Last updated: April 2016

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 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.

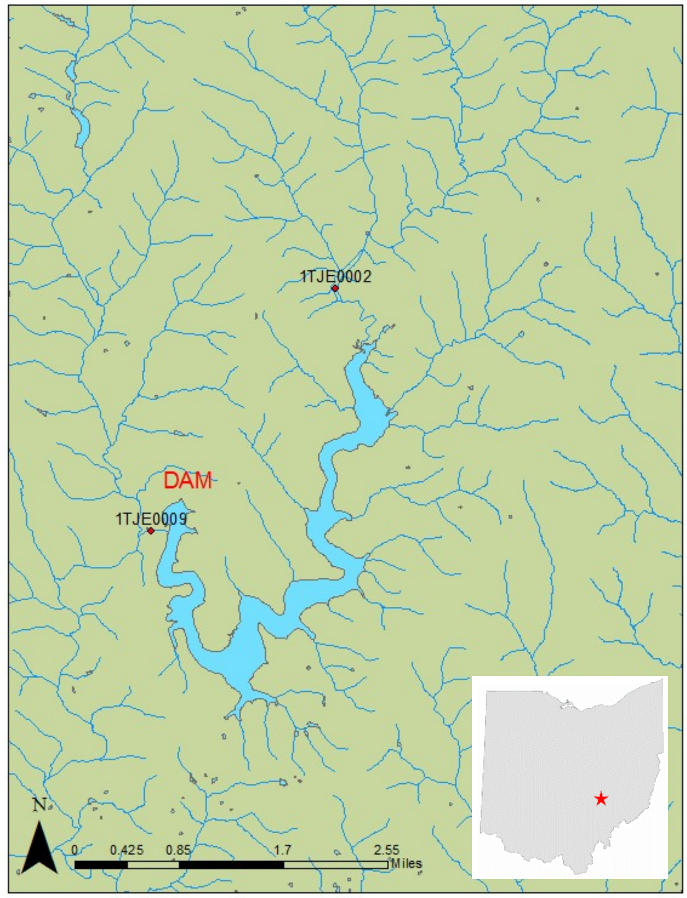

Figure 48. Water quality sampling locations for Tom Jenkins Dam in 2015.

WATERSHED SUMMARY: Tom Jenkins Dam (Burr Oak Lake) is located 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

2015 ACTIVITIES: Four sampling events occurred at two sites in FY2015. Only two of the sampling events included all water chemistry parameters. Additional physical chemistry readings were taken the last two sampling events in 2015. These events include routine water quality sampling of inflows and outflow. *NEXT SAMPLING YEAR: 2020*

ADDITIONAL INFORMATION: None

Table 37. Tom Jenkins Dam samples exceeding state criteria and/or District levels of concern in 2015.

STATION	STATION TYPE	STREAM NAME	ANALYTES W/ELEVATED CONCENTRATIONS	NUMBER OF SAMPLES EXCEEDING SCREENING VALUE	EXCEEDED APPLICABLE NATIVE STATE CRITERIA
1TJE0002	Inflow	East Branch	None	-	-
1TJE0009	Outflow	East Branch	TKN	2	NO CRITERIA

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 phosphorus, specific conductivity, strontium, iron, aluminum, manganese, sulfate, pH, 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.

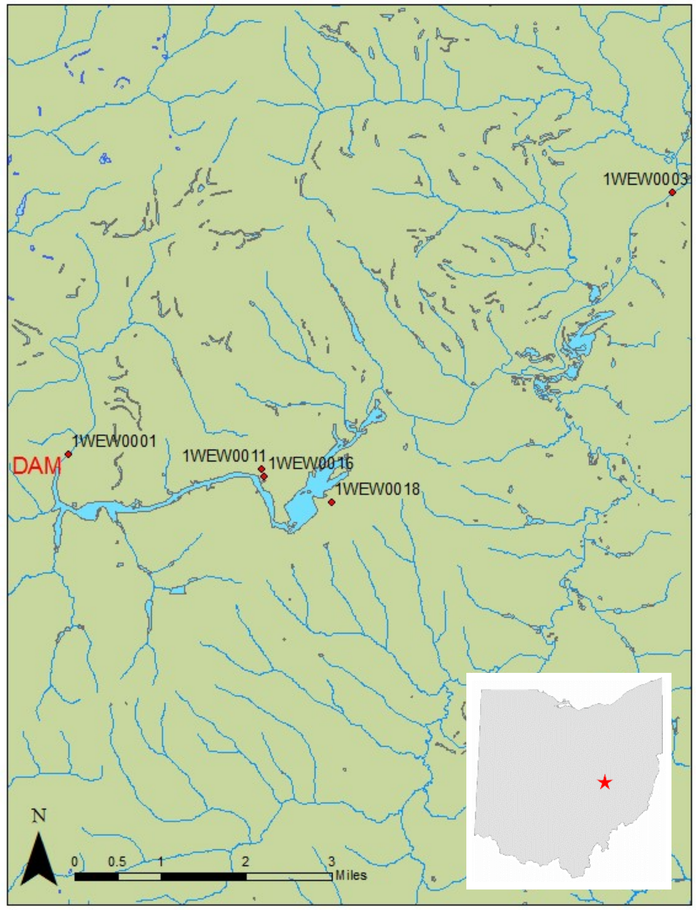

Figure 49. Water quality sampling locations for Wills Creek Lake in 2015.

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 dam 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

2015 ACTIVITIES: Three sampling events occurred at five sites in FY 2015. Only one sampling event included all water chemistry parameters. Additional physical chemistry readings were taken the last two sampling events in 2015. These events include routine water quality sampling of inflows and outflow. *NEXT SAMPLING YEAR: 2020*

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.

Table 38. Wills Creek Lake samples exceeding state criteria and/or District levels of concern in 2015.

STATION	STATION TYPE	STREAM NAME	ANALYTES W/ELEVATED CONCENTRATIONS	NUMBER OF SAMPLES EXCEEDING SCREENING VALUE	EXCEEDED APPLICABLE NATIVE STATE CRITERIA
1WEW0001	Outflow	Wills Creek	TKN	1	NO CRITERIA
			Phosphorus, Total	1	NO CRITERIA

STATION	STATION TYPE	STREAM NAME	ANALYTES W/ELEVATED CONCENTRATIONS	NUMBER OF SAMPLES EXCEEDING SCREENING VALUE	EXCEEDED APPLICABLE NATIVE STATE CRITERIA
			Strontium, Total	1	NO CRITERIA
1WEW0003	Inflow	Wills Creek	Phosphorus, Total	1	NO CRITERIA
			Strontium, Total	1	NO CRITERIA
1WEW0011	Inflow	Mine Discharge into treatment pond	Iron, Total	1	NO CRITERIA
			pH	3	3
			Sp. Conductivity	3	NO CRITERIA
			Strontium, Total	1	NO CRITERIA
			Sulfate, Total	1	NO CRITERIA
1WEW0016	Inflow	Discharge from treatment pond	Iron, Total	1	NO CRITERIA
			Manganese, Total	1	NO CRITERIA
			pH	3	3
			Sp. Conductivity	3	NO CRITERIA
			Strontium, Total	1	NO CRITERIA
			Sulfate, Total	1	NO CRITERIA
1WEW0018	Inflow	Mine Discharge	Aluminum, Total	1	NO CRITERIA
			Iron, Total	1	NO CRITERIA
			Manganese, Total	1	NO CRITERIA
			pH	3	3
			Sp. Conductance	3	NO CRITERIA
			Strontium, Total	1	NO CRITERIA
			Sulfate, Total	1	NO CRITERIA

Yatesville Lake (YBC) Water Quality Summary

Last updated: April 2019

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.

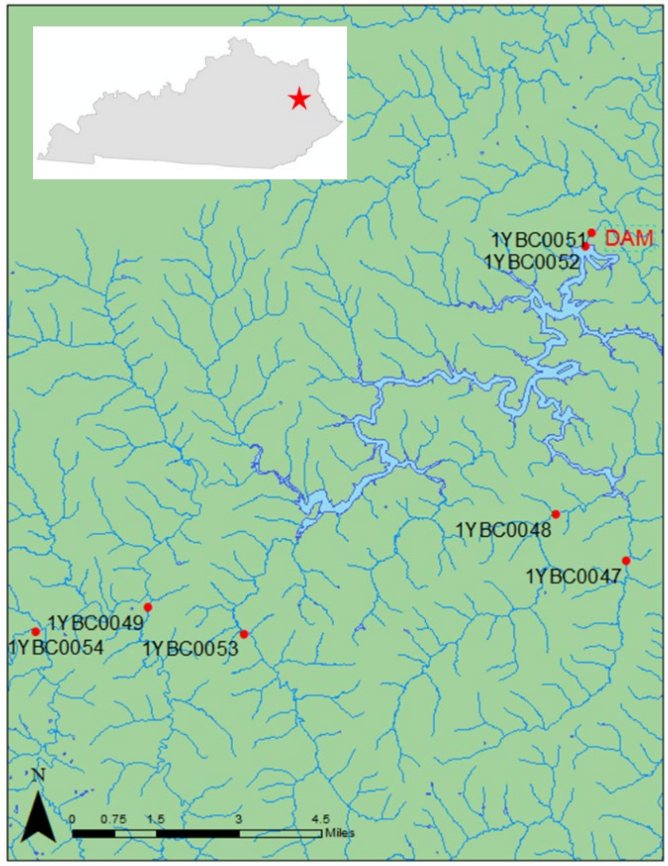

Figure 50. Water quality sampling locations for Yatesville Lake in 2013.

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.

Table 39. 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	NO CRITERIA
			Iron	1	Yes
			Specific Conductivity	3	NO CRITERIA
			Strontium	3	NO CRITERIA
			Sulfate	2	NO CRITERIA
			Kjeldahl Nitrogen, Total	1	NO CRITERIA
			Phosphorus, Total	1	NO CRITERIA
1YBC0048	Inflow	Right Fork Little Blaine Creek	Aluminum	1	NO CRITERIA
			Iron	1	Yes
			Kjeldahl Nitrogen, Total	1	NO CRITERIA
			Manganese	2	NO CRITERIA
			Phosphorus, Total	1	NO CRITERIA
			Specific Conductivity	3	NO CRITERIA
			Strontium	4	NO CRITERIA
			Sulfate	3	NO CRITERIA
1YBC0049	Inflow	Hood Creek	Aluminum	1	NO CRITERIA
			Dissolved Oxygen	1	Yes
			Iron	4	No
			Kjeldahl Nitrogen, Total	1	NO CRITERIA
			Phosphorus, Total	1	NO CRITERIA
1YBC0050	Lake	Blaine Creek	None	-	-
1YBC0051	Outflow	Blaine Creek	None	-	-
1YBC0053	Inflow	Brushy Creek	Aluminum	1	NO CRITERIA
			Dissolved Oxygen	1	Yes
			Iron	2	Yes
			Kjeldahl Nitrogen	3	NO CRITERIA
			Phosphorus, Total	1	NO CRITERIA
1YBC0054	Inflow	Blaine Creek	Iron	1	No
			Phosphorus, Total	1	NO CRITERIA
			Specific Conductance	3	NO CRITERIA
			Strontium	5	NO CRITERIA

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.

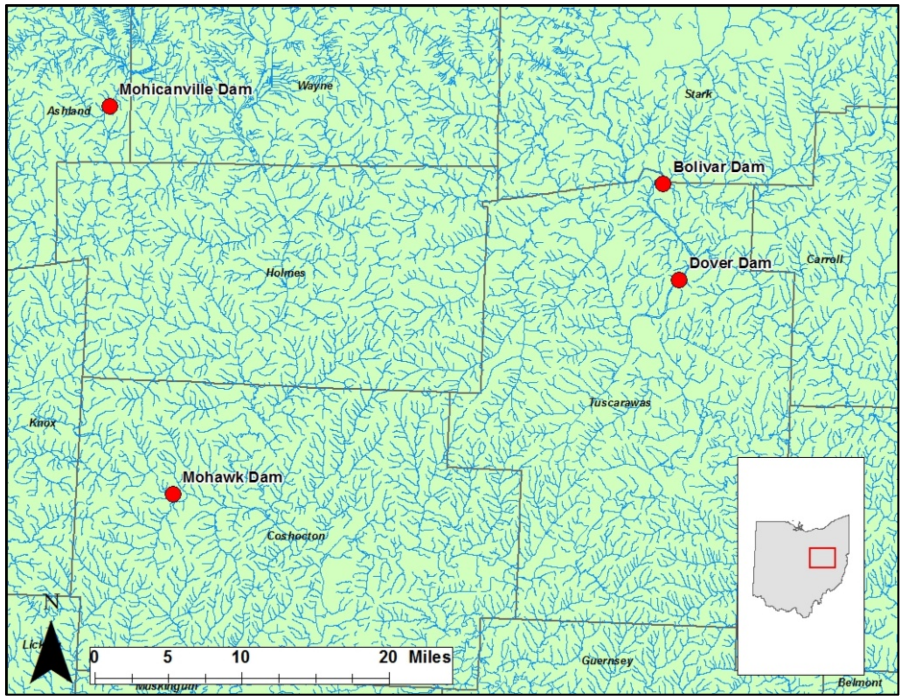

Figure 51. The locations of the four dry dams managed by the Huntington District USACE.

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.

Appendix D – Muskingum Modification Study

Atwood Lake

Description

Monthly maximum peaks range from approximately 20 to 60 ppm. The majority of monthly maximums are under 10 ppm. Yearly maximums most commonly fall in July and August. H_2S daily averages were below 1 ppm for 49% of the monitoring season for the period of May 20, 2008 to September 9, 2018. Daily averages during the monitoring season below 1 ppm are most frequent in May and June.

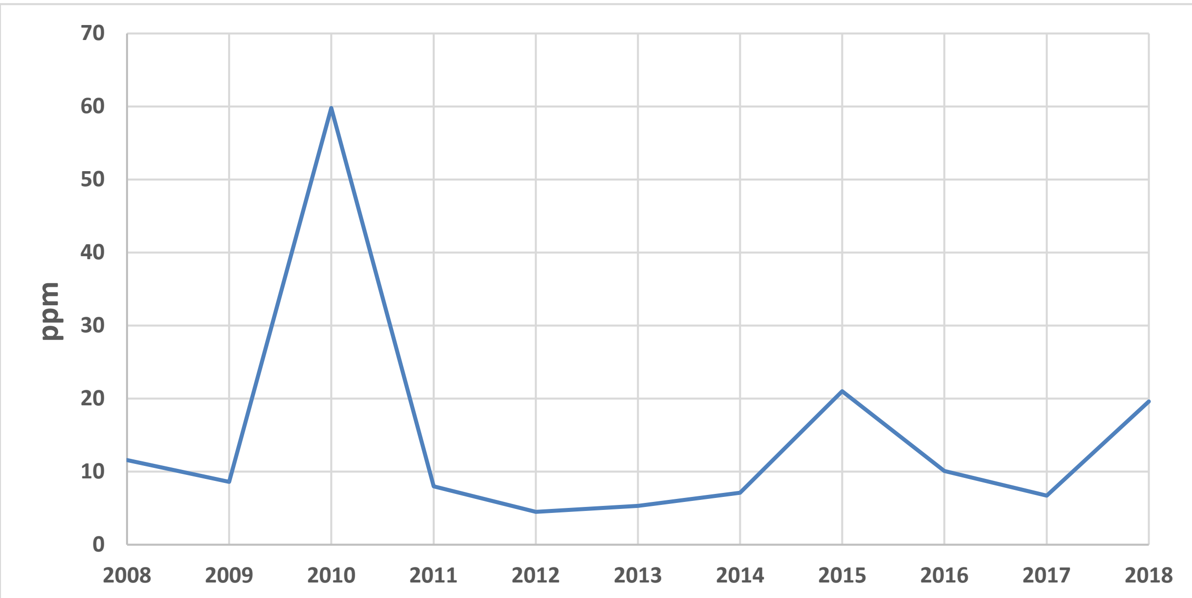

Figure 1. Atwood Yearly Maximums

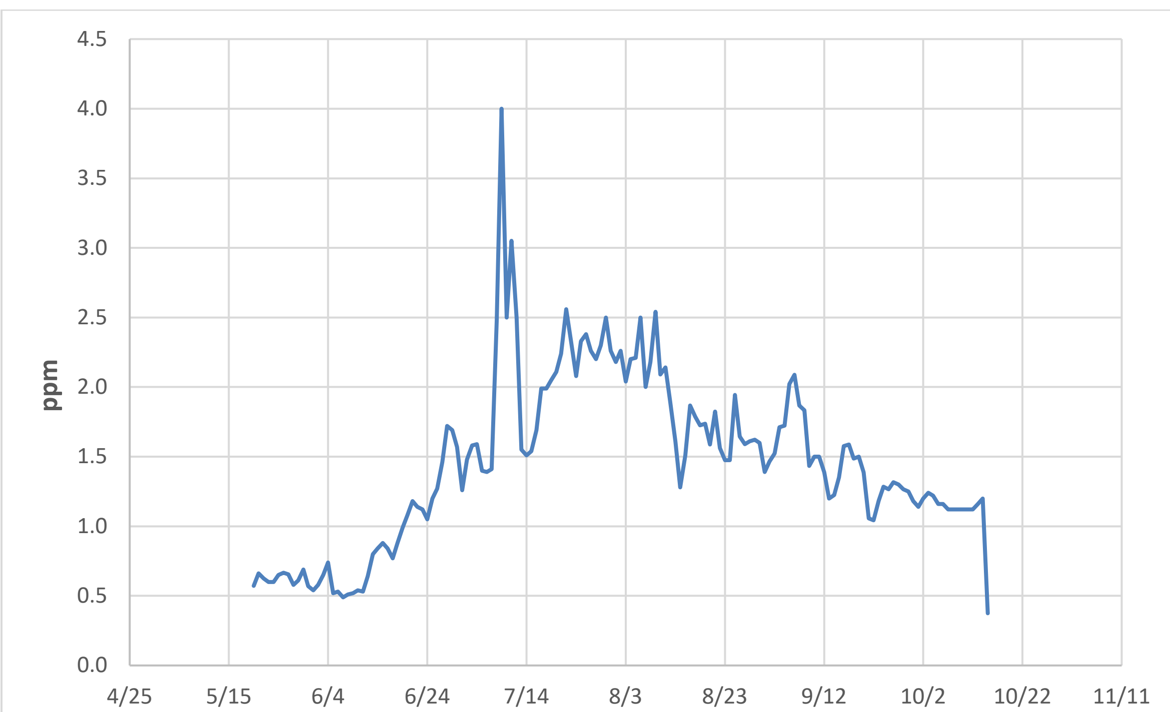

Figure 2. Atwood Daily Averages 2008-2018 *excludes 2017 data due to abnormal flow data

Clendening Lake

Description

Monthly maximum peaks range from approximately 200 to 370 ppm and generally exhibit a sharp increase throughout the monitoring season, peaking in September in most years. H_2S daily averages were below 1 ppm for 11% of the monitoring season for the period of May 20, 2008 to September 9, 2018. Daily averages during the monitoring season below 1 ppm occur mostly in May and to a lesser extent in June.

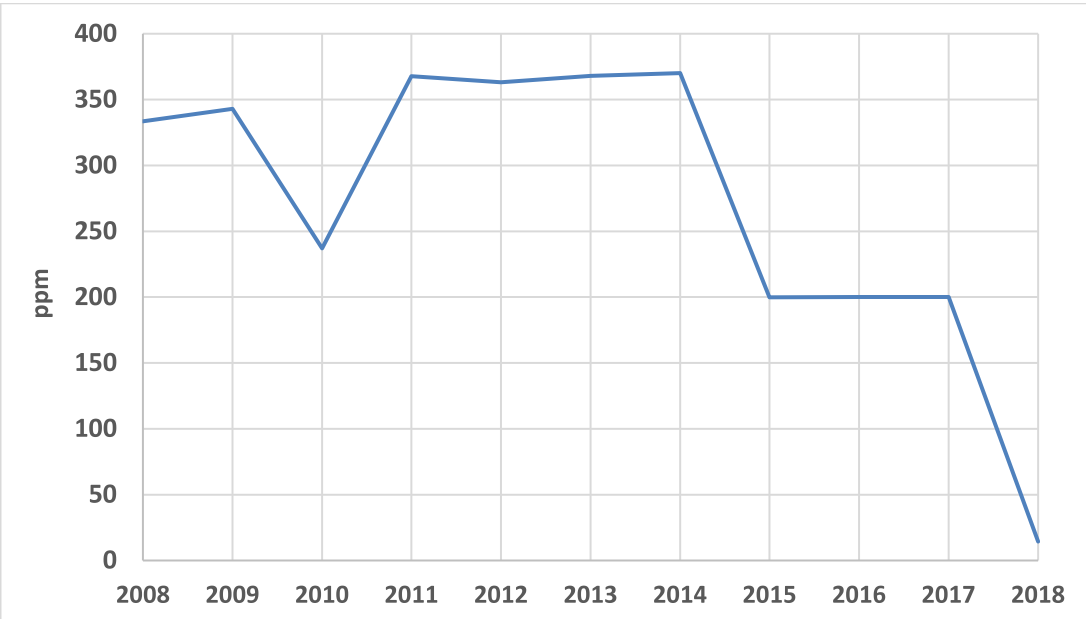

Figure 3. Clendening Yearly Maximums

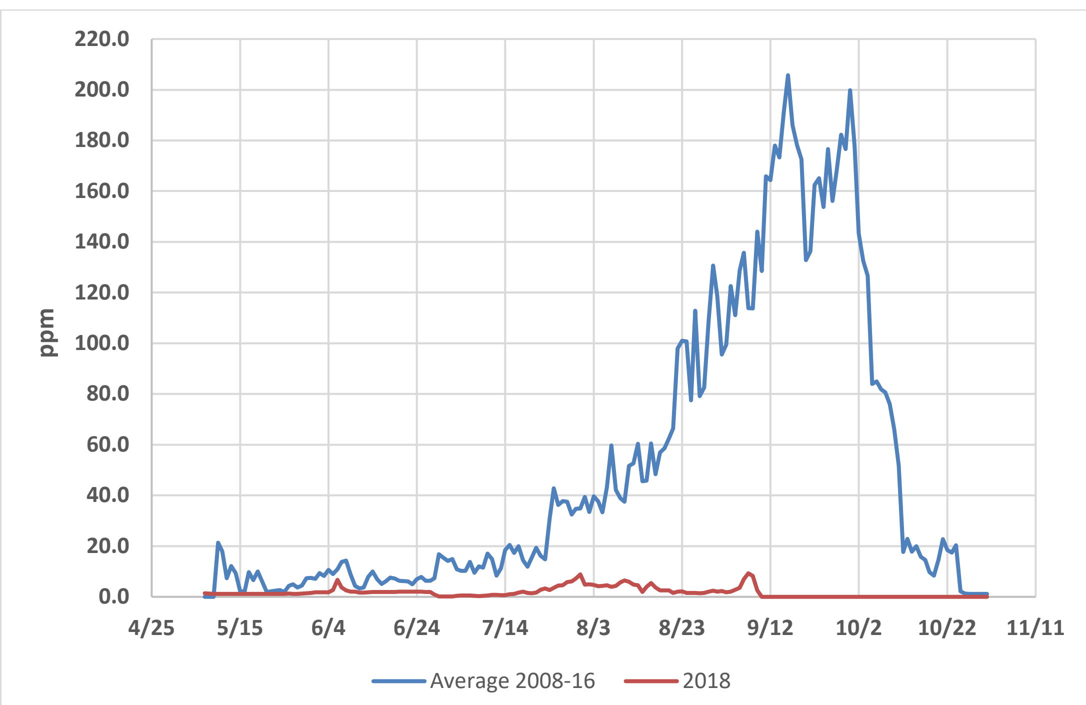

Figure 4. Clendening Daily Averages 2008-2018 *excludes 2017 due to modification

Leesville Lake

Description

Monthly maximums range from approximately 10 to 45 ppm and exhibit a steady increase until July and August when they fall back to early season levels in September and October. H_2S daily averages were below 1 ppm for 56% of the monitoring season for the period of May 20, 2008 to September 5, 2017. Daily averages during the monitoring season below 1 ppm are most common from mid-May to late June.

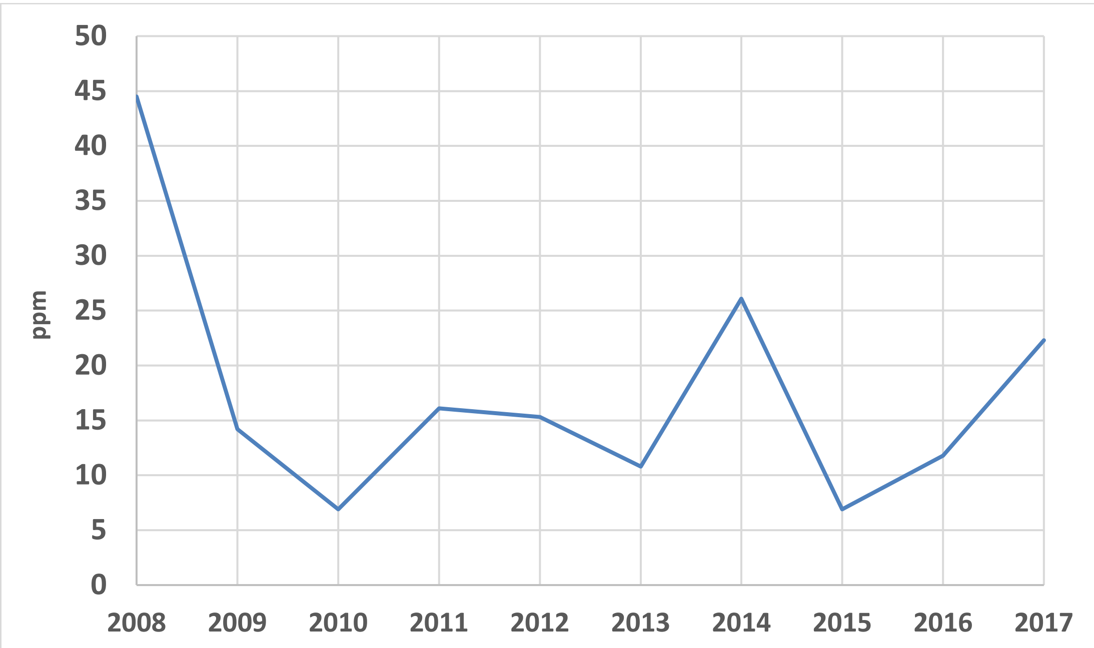

Figure 5. Leesville Yearly Maximum

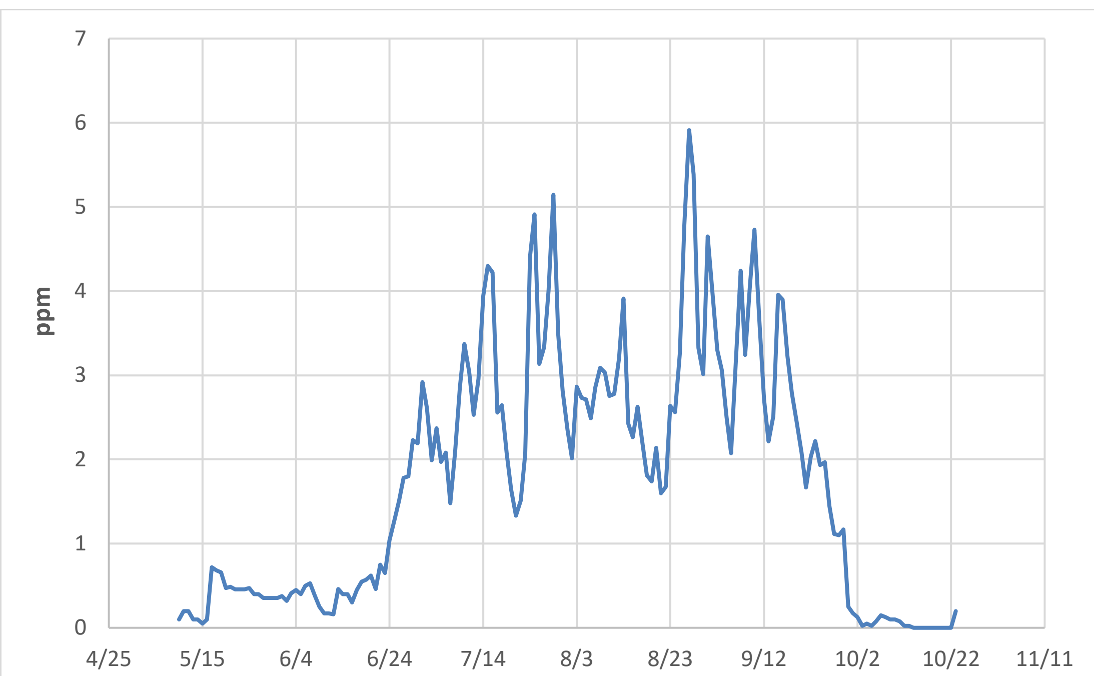

Figure 6. Leesville Daily Averages 2008-2018

Piedmont Lake

Description

Monthly maximum peaks range from approximately 100 to 350 ppm and typically increase sharply before peaking in August and September. After which, H_2S concentrations fall to early season levels. H_2S daily averages were below 1 ppm for 47% of the monitoring season for the period of May 20, 2008 to August 16, 2018. Daily averages during the monitoring season below 1 ppm are most common in May and June but are regularly observed throughout 2018 as a result of structural modification.

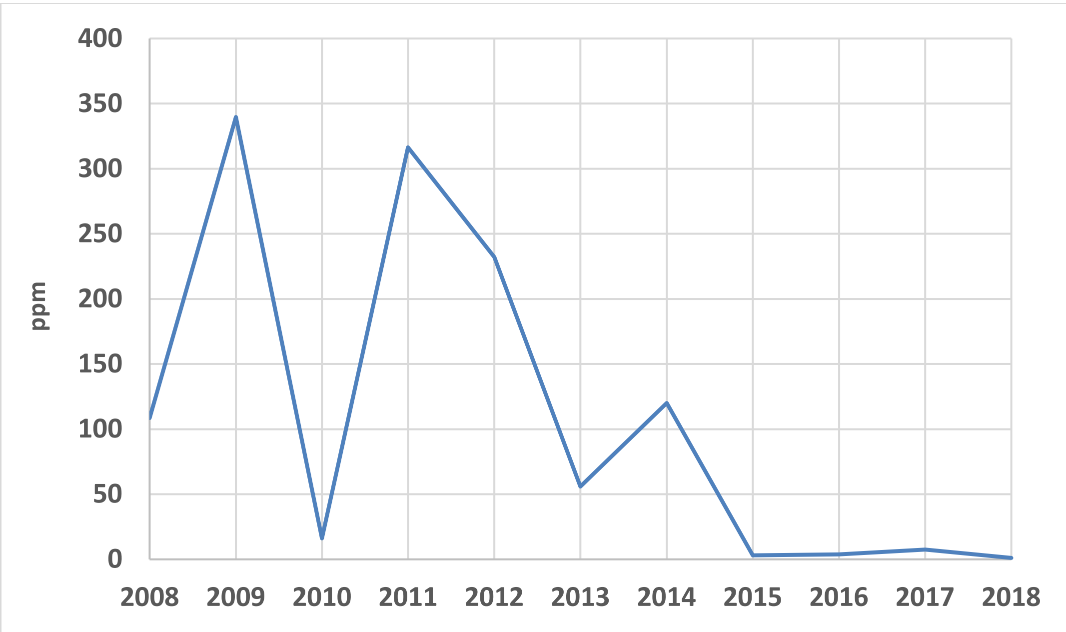

Figure 7. Piedmont Yearly Averages

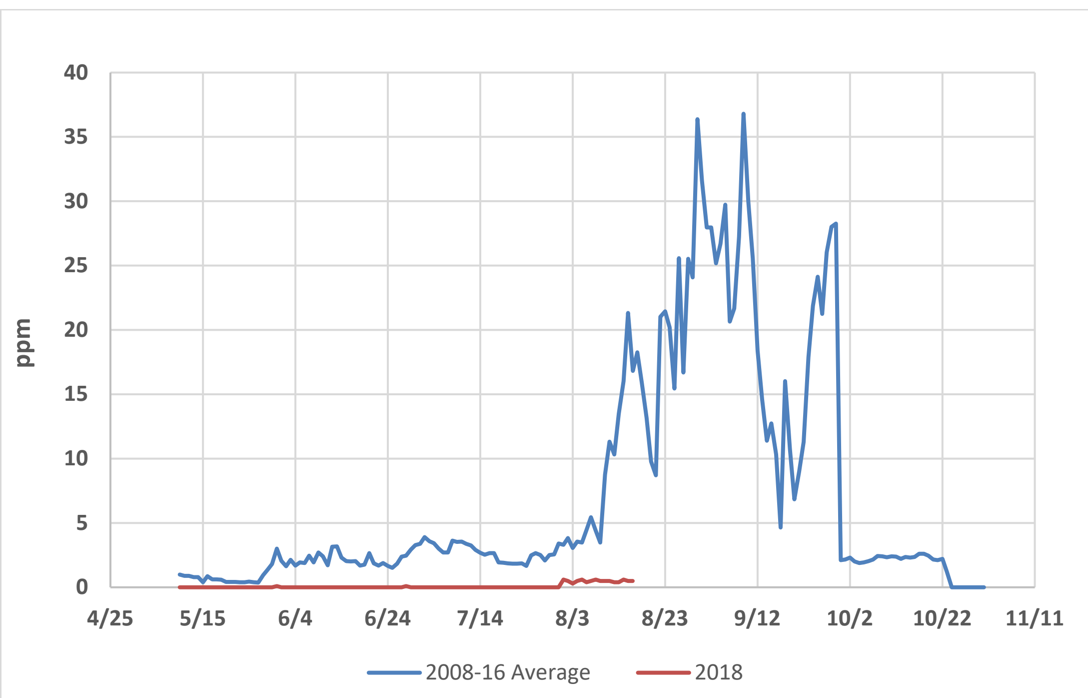

Figure 8. Piedmont Daily Averages 2008-2018 *excludes 2017

Tappan Lake

Description

Monthly maximum peaks range from approximately 80 to 350 ppm and typically increase sharply before peaking in August and September. H_2S was below 1 ppm for 51% of the monitoring season for the period of May 21, 2008 to September 9, 2018. Daily averages during monitoring season below 1 ppm generally occur in May and June but are regularly observed after structural modification.

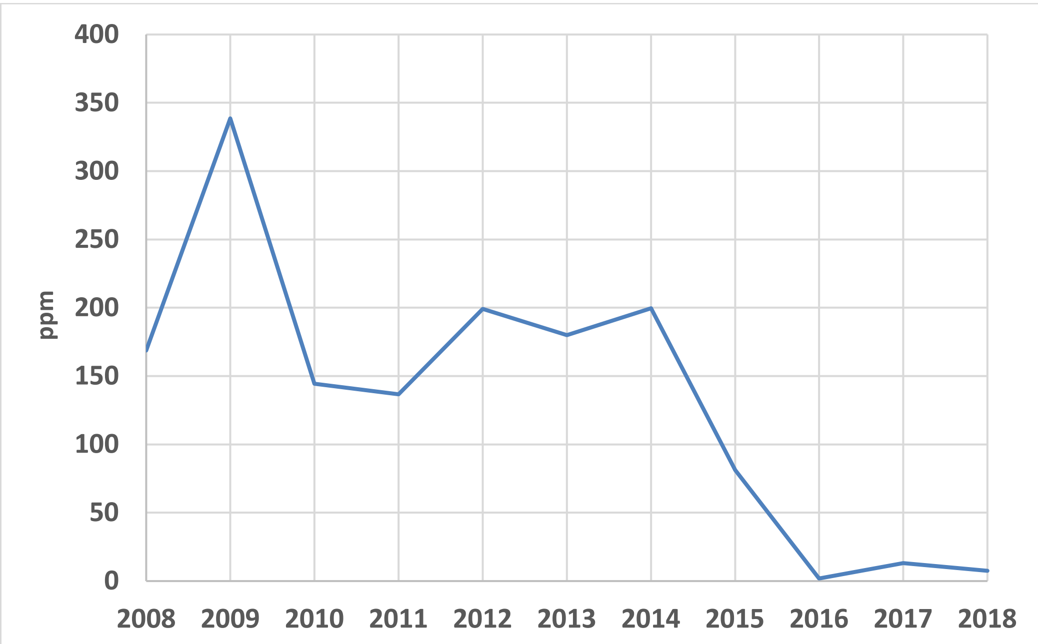

Figure 9. Tappan Yearly Maximums

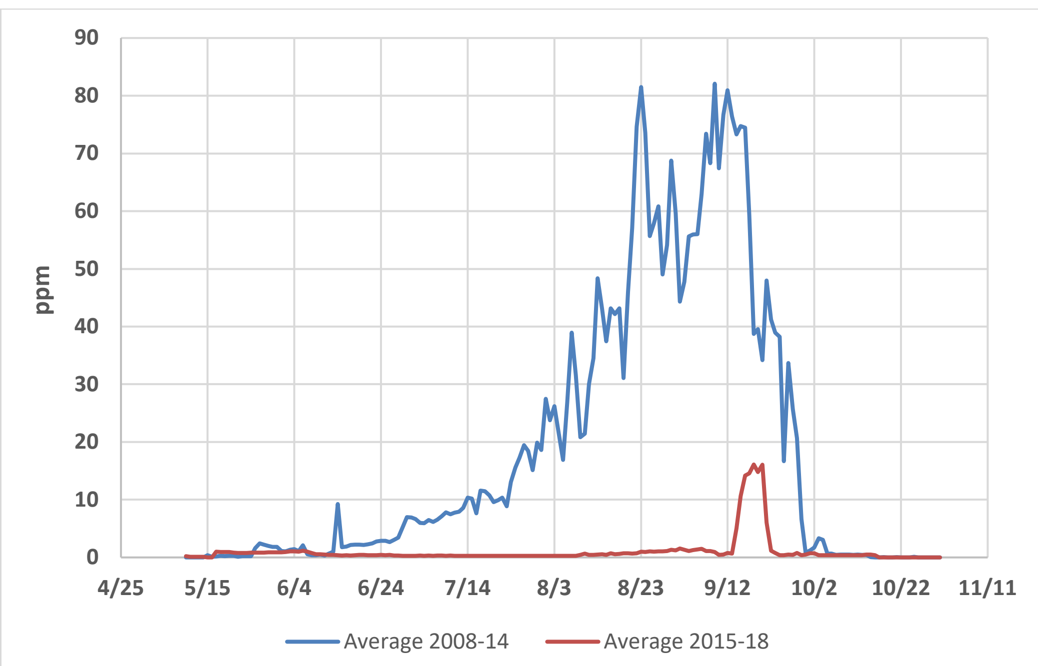

Figure 10. Daily Averages 2008-2018

Appendix E – Dillon Bathymetry and Storage Calculation

Figure 1. Bathymetry data collected using the EcoMapper and Acoustic Doppler Profiler.

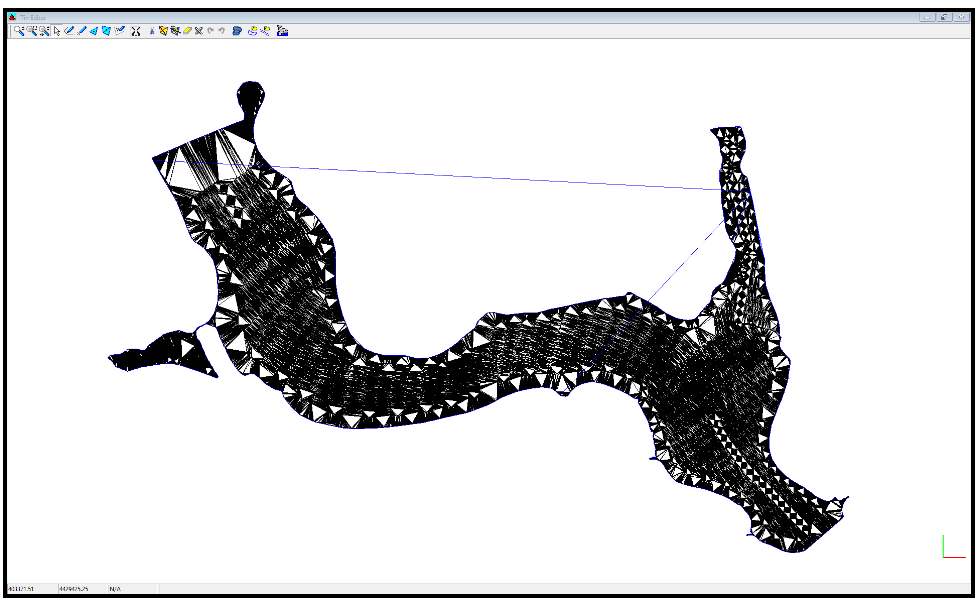

Figure 2. TIN model of bathymetry data.

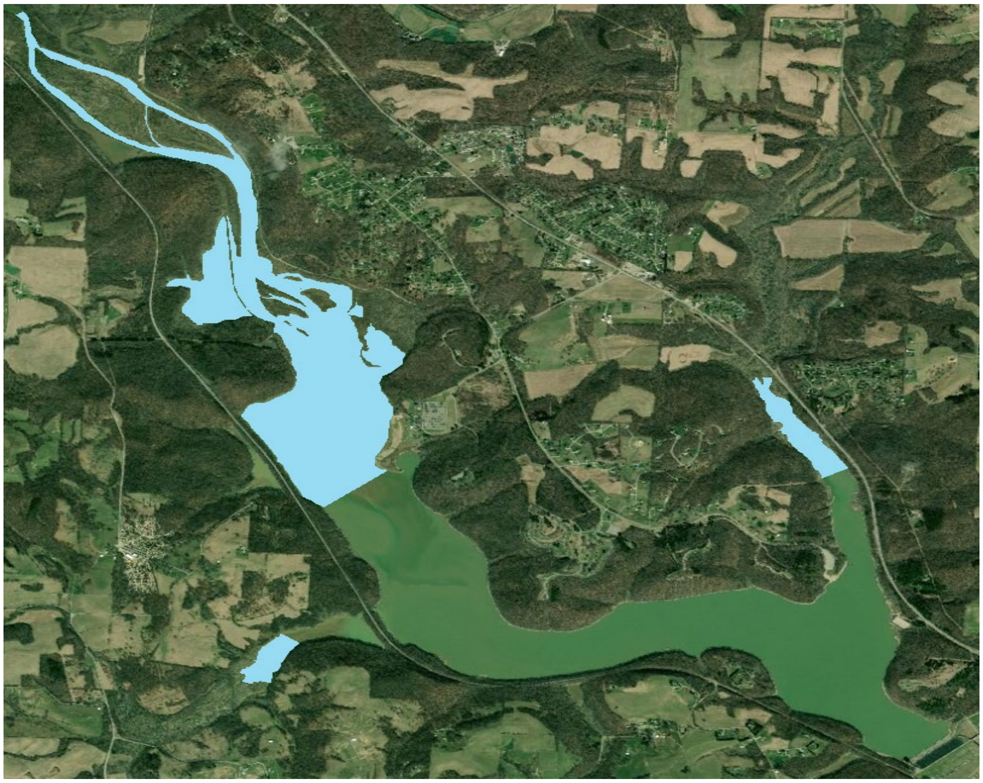

Figure 3. Shallow regions of the lake measured with a randomized approach.

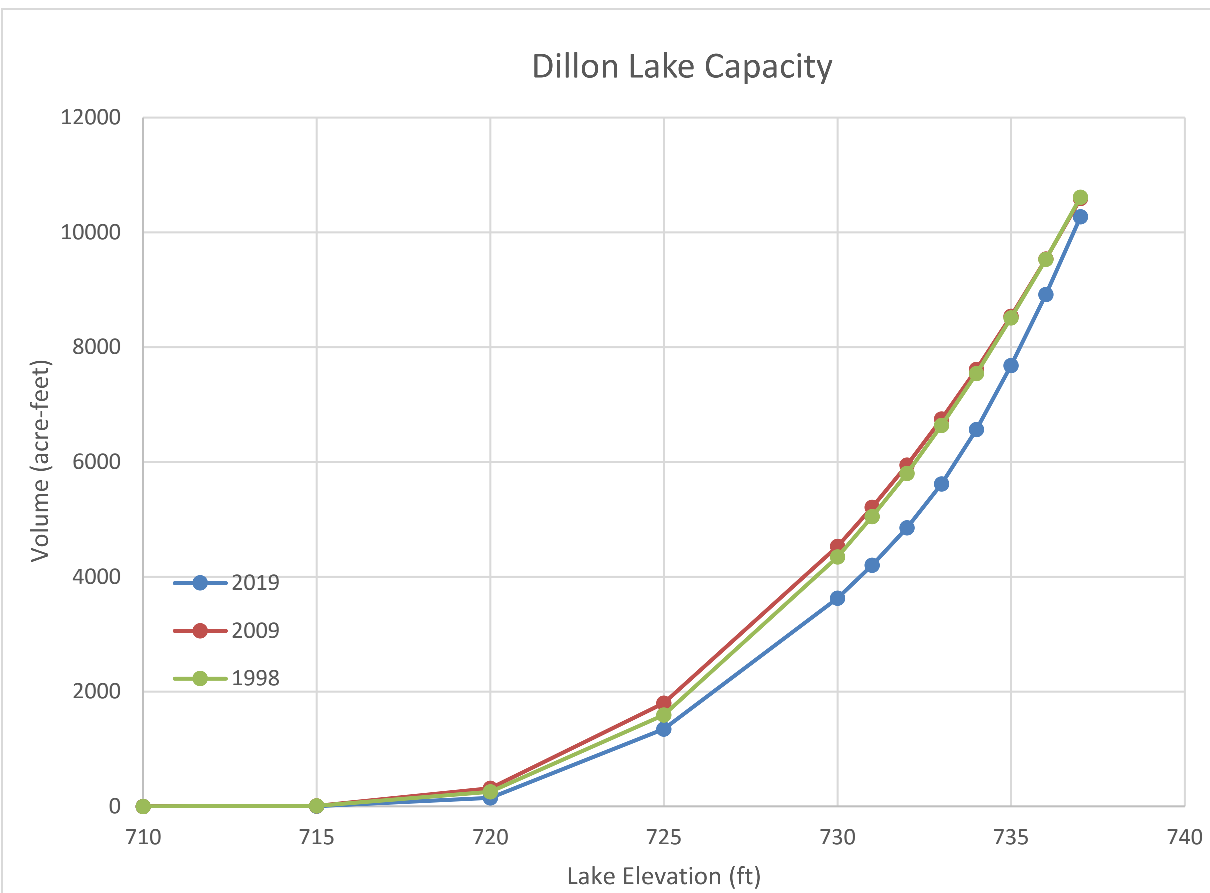

Figure 4. Updated storage capacity curves for Dillon Lake compared to previous surveys.