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Safe, clean waterways

MIDDLE FORK BEARGRASS CREEK WATERSHED-BASED PLAN

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EXECUTIVE SUMMARY

As our communities continue to grow and change, it is valuable to recognize that a constant remains—humans continue to have a strong connection to water. Whether you live, work or play in a watershed, the water connects us all and plays an important part in our health and well-being. With the 50th anniversary of the 1972 amendments to the Clean Water Act (CWA), it is a good time to reflect on the efforts put toward clean water and the value that water brings to our everyday lives. Included in the CWA are national water quality goals for waterways to be fishable, swimmable and safe for use as drinking water supplies, as well as strict standards to measure and protect water quality.

Middle Fork Beargrass Creek (Middle Fork) is a unique urban watershed located in the east part of Jefferson County, Kentucky, and is home to residences, businesses, schools, parks, nature trails, malls and even a historic farm. Along with active citizen groups, there are many residents, business owners and other stakeholders working together to improve water quality and address nonpoint source pollution within Middle Fork. Currently, Middle Fork falls short of meeting all standards for healthy waterways and therefore will benefit from a watershed-based plan. As defined by the Kentucky Division of Water (DOW), "A watershed plan is a strategy that provides assessment and management information for a geographically defined watershed, including the analyses, actions, participants and resources for developing and implementing the plan." This watershed plan was funded utilizing Section 319(h) funding, in partnership with the Louisville/Jefferson County Metropolitan Sewer District (MSD).

An understanding of Middle Fork's past is critical for stakeholders who propose changes affecting its future. Middle Fork was historically a strategic resource and economic catalyst for early growth in the watershed, but it became polluted due to early industrial practices and was affected by several catastrophic floods. For many years, areas of the Three Forks of Beargrass Creek, including Middle Fork, were modified to fit the community's wants and needs. Portions of Beargrass Creek were relocated and channelized due to development, and the impacts of the increased impervious area caused increased runoff during rain events. The history of this watershed has helped form what the landscape looks like today and drives the needs for improvement in the future.

Two key components distinguish this plan from other watershed plans developed in Kentucky. First, this plan is for a fully urbanized watershed with a diverse land use and population. Second, the types of partnerships that were fostered and leveraged to better characterize the watershed were unique. As the first watershed plan for Jefferson County, Middle Fork Beargrass Creek Watershed was chosen for this study because of the extensive existing network of invested project partners, watershed stakeholders and interested public. In an urban watershed like Middle Fork, the actions stakeholders take to care for the land affect water quality and the health of our streams. Input from all parties informed the decision to pursue this monitoring and assessment project with the goal of watershed ecology and in-stream water quality improvements.

This watershed-based plan provides a road map that project partners, watershed stakeholders and the public can utilize to improve water quality in Middle Fork. Watershed planning assists communities with managing nonpoint source pollutants that can impact water quality in streams and rivers. Stream conditions, land use practices and other data collected within the entire watershed help biologists, engineers, planners, government officials and community members better understand the watershed's needs. In addition, this data helped identify potential projects and best management practices (BMPs) that assist in improving water quality conditions of the watershed.

The Kentucky Watershed Planning Guidebook lays out the necessary information for an effective watershed-based plan. It introduces the watershed approach, which consists of iterative steps to characterize existing conditions, identify and prioritize problems, define objectives, develop protection or remediation strategies, and implement and adapt selected actions as needed. The Middle Fork Beargrass Creek Watershed-Based Plan describes some of the water quality issues facing the watershed, presents the results of a water quality monitoring effort aimed at identifying the sources and levels of point and nonpoint source pollution, and outlines potential efforts to address these issues.

Specific interest was given to in-stream suspended sediments and bacteria when developing the monitoring plan for this project, as these parameters, along with identified Total Maximum Daily Loads (TMDLs), were considered areas of specific concern for the watershed. With the parallel efforts of the U.S. Army Corps of Engineers (USACE) Three Forks of Beargrass Creek study, this watershed plan benefited from additional stream walks to better characterize stream conditions both in-stream and along the stream corridor. While the USACE Three Forks study was larger in scope and assessed the Muddy, Middle and South Forks of Beargrass Creek, both projects evaluated existing in-stream and riparian habitat, as well as recreational opportunities, resulting in a more robust data set for characterization of nonpoint source pollution challenges.

A major component of understanding the watershed's health is characterizing the watershed based on water quality parameters collected through monitoring. In the lead-up to the beginning of monitoring and through initial investigation of the watershed, several relevant observations were made by the team that shaped the logistical approach and setup of the project. The need for a targeted watershed-based sampling plan was identified for the collection of accurate and precise data on water quality and stream conditions. Collection efforts for Middle Fork performed by Kentucky DOW and MSD were combined to characterize the stream health and water quality of the watershed and to identify further improvement opportunities.

Nonpoint source pollution parameters identified for monitoring of the Middle Fork Beargrass Creek watershed included *E. coli*, pH, temperature, specific conductance, total suspended solids, turbidity, dissolved oxygen and nutrients. For the purposes of this watershed plan, Kentucky ecoregional medians developed from DOW reference reaches were used to develop benchmarks for each parameter that did not have a regulatory limit. DOW provided the Outer Bluegrass ecoregion data for reference reaches and stations that had good and excellent biological data. These water quality data were used to establish the benchmarks for nonregulatory criteria (total phosphorus, total nitrogen, ammonia, specific conductance, total suspended solids and turbidity). These monitoring data, along with stakeholder knowledge, informed a working group that was able to draft a Best Management Practices Plan that included both structural and nonstructural projects. In addition, the working group reinforced the need for programmatic efforts, such as utilizing public art and art education programs and activities to increase public awareness and activism to improve water quality and promote the existing stormwater credit program.

BMPs in this plan also support continued public education and outreach, as well as expanded engagement through new approaches. The COVID-19 pandemic has taught us that volunteering and advocacy are changing; therefore, the use of modern technology and communication methods is critical for engagement of volunteers. The goal of the education and outreach efforts remains the same for both traditional and new outreach methods: to create greater opportunity for community members to become involved in watershed improvement efforts and solutions. In the presence of COVID-19, the activities may look different, but are intended to work toward creating educational opportunities while keeping everyone safe.

Regardless of the challenges, the development team recognized that continuing nonstructural efforts such as engagement of community members and students and active participation of partners and stakeholders, along with implementation of structural BMPs that address sediment and nutrients are possible, and these efforts are the best path to addressing nonpoint source pollution issues within the watershed. After the identification of BMPs suitable for the watershed, action items were developed for each BMP to provide additional details supporting implementation. The watershed team solicited the input of community members and subject matter experts to develop the BMP table, which provides the initial roadmap for implementing the Middle Fork Beargrass Creek Watershed-Based Plan.

The efforts put into developing this watershed plan are all a part of Phase I, and following the approval of this plan, it is anticipated that Phase II will begin. Phase II will involve hiring a watershed coordinator to oversee and track all of the projects and communications for Middle Fork Beargrass Creek. Engagement will continue with coordinated working groups, including a Steering Committee, Watershed Work Group, Education and Outreach Focus Group, and BMP Development Group. Phase II will also focus on better characterization of the system during degradation of the stream corridor and how it impacts the overall stability and health of the watershed.

It is important to note that watershed planning is an iterative process. The data collected during this watershed planning effort are a new baseline for project development; however, the need for continued data collection, monitoring and public engagement is anticipated to be ongoing to address nonpoint source pollution control and to identify any emerging concerns within the watershed. The watershed plan will be reviewed, updated and submitted to the state for review every five years, as described in the BMP plan. Additionally, an annual assessment will be performed to evaluate BMP implementation and effectiveness, funding opportunities, Phase II monitoring data and messaging to target audiences.

The goals of this watershed plan are to both improve water quality in Middle Fork Beargrass Creek and to create greater opportunities for community members to become involved in improvement efforts and solutions. Just as it has taken 50 years to reflect on and see improvements from the Clean Water Act, improvements in this watershed will take time. As efforts in the watershed continue, additional goals and objectives will be developed to address new or growing areas of concern.

By continuing work in this watershed, including implementation of structural and nonstructural BMPs and monitoring of nonpoint source pollutants, Middle Fork Beargrass Creek will one day meet water quality standards, indicating a healthy waterway. Improving water quality will allow for more uses of our waterways, such as wading, fishing and swimming in the Middle Fork, strengthening the connection of those who live, work and play in the watershed. The connection between the environment, water and humans is more important than ever before amidst a global pandemic and growing concern for the environment. Now is the time to accelerate work toward addressing impairments and ensuring that generations to come will benefit from these sustainable solutions.

CHAPTER 1. INTRODUCTION TO MIDDLE FORK BEARGRASS CREEK

1.0 INTRODUCTION TO MIDDLE FORK BEARGRASS CREEK

1.1 INTRODUCTION

The Clean Water Act (CWA) includes national water quality goals for waterways to be fishable, swimmable and safe for use as drinking water supplies. The Act includes strict standards to measure and protect water quality. Currently, Middle Fork Beargrass Creek falls short of meeting all standards for healthy waterways. This watershed-based plan provides a road map that project partners, watershed stakeholders and the public can utilize to improve water quality in Middle Fork Beargrass Creek (Middle Fork). Ultimately, in an urban watershed, the actions stakeholders take to care for the land affects water quality and the health of our streams.

Watershed planning assists communities with managing nonpoint source pollutants like bacteria, sediment, pesticides, fertilizers, metals and nutrients that can run off to streams, lakes and rivers, causing pollution. Stream conditions, land use practices and other data collected within the entire watershed help biologists, engineers, planners, government officials and community members better understand the watershed's needs. In addition, these data can help identify potential projects and best management practices (BMPs) that can be developed to improve water quality conditions within the watershed. The Middle Fork Beargrass Creek Watershed-Based Plan describes some of the larger water quality issues facing the Watershed, presents the results of a water quality monitoring effort aimed at identifying the sources and levels of point and nonpoint source pollution, and outlines potential efforts to address these issues. Chapter 1 briefly introduces the watershed, as well as the project partners and watershed stakeholders who have committed to supporting the development of this watershed plan.

The concepts of watershed planning, monitoring and assessment described in this document are discussed in more detail in the Watershed Planning Guidebook for Kentucky Communities, 1st Edition (KWA and DOW, 2010) and Kentucky's Water Health Guide (DOW, Undated). The reader is encouraged to refer to these documents as excellent resources for watershed planning.

1.2 ABOUT MIDDLE FORK BEARGRASS CREEK

Middle Fork Beargrass Creek includes approximately 61 linear miles of stream within the 14-digit Hydrologic Unit Code 05140101250010 (HUC-14), in Jefferson County, Kentucky. The Hydrologic Unit Code (HUC) is a cataloging system developed to identify watersheds in the United States and for geographic description and data storage purposes. Middle Fork Beargrass Creek is one of three streams (Muddy Fork, Middle Fork and South Fork) that join to form the larger Beargrass Creek watershed as depicted in Figure 1.1. The Middle Fork Beargrass Creek watershed drains 25.2 square miles, which is more than Muddy Fork Beargrass Creek, which drains about nine square miles, but less than South Fork Beargrass Creek, which drains 26.7 square miles.

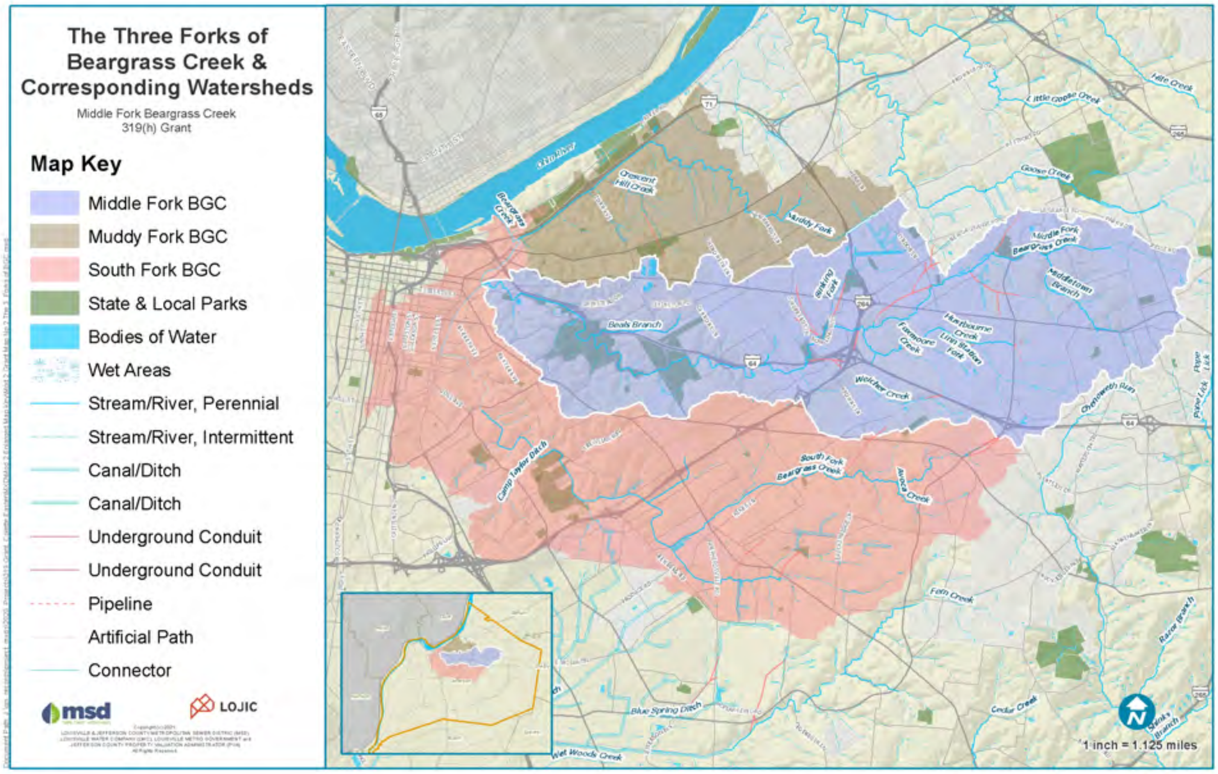

Figure 1.1 Three Forks of Beargrass Creek and Corresponding Watersheds

Due to the nature of development within this watershed, these streams are true urban streams, including channelization and increased runoff from impervious surfaces. A very high percentage of this watershed is covered by impervious surfaces (asphalt, cement, rooftop, etc.). In addition, there are combined sewer overflows (CSOs) and sanitary sewer overflows (SSOs) in the watershed that are actively being addressed through Louisville and Jefferson County Metropolitan Sewer District (MSD) Consent Decree programs and projects. Concentrations of bacteria such as fecal coliform and *Escherichia coli* (*E. coli)* frequently exceed water quality standards. Large stream flow fluctuations during storm events result in impacts on the biological communities and their habitat in the streams. Fast-moving stormwater scours the stream banks, causing erosion, sedimentation and siltation, resulting in the decline of water quality and habitat quality.

Land use in the Middle Fork Beargrass Creek watershed is mostly residential and commercial, with many of the commercial properties located along Shelbyville Road and Hurstbourne Lane. An area of agricultural land is also located in this watershed behind the Oxmoor Mall. Agricultural areas comprise approximately 2.65% of the land use in the watershed. Based on an MSD analysis of land use data from the Louisville/Jefferson County Information Consortium (LOJIC), impervious surfaces such as roads, rooftops and driveways cover about 37% of this watershed. Better water quality and quantity management requires the reduction of CSOs and elimination of SSOs, as well as addressing nonpoint source pollution issues. Revegetation of stream banks, including addressing invasive species and emphasizing native species, as well as modification of stream channels to produce reaeration zones are examples of strategies that will be considered during the watershed planning process as potential ways to improve both stream habitat and water quality.

1.2.1 Watershed History in Louisville

The settlement of Louisville was established during the Revolutionary War in 1778. A growing population in the early 1800s led to a growing pollution problem, especially for the waterways that ran through the city. The creeks became the dumping ground for human and agricultural wastes as early settlement occurred along their banks. Historians specifically note that the earliest major sources of pollution to the stream included swine livestock accessing the stream, as well as discharge from slaughterhouses. In 1805, the Hog and Pond Law was enacted to ban free-roaming pigs and to have all stagnant ponds drained. However, due to a lack of funding, the draining portion could not be completed, and stagnant water became the suspected cause of the Yellow Fever epidemic in 1822. For years, waterways were the source of disease, eventually leading to Louisville's nickname, the "graveyard of the west" (MSD, Undated).

Middle Fork Beargrass Creek is central to the development of Louisville Metro. It was a strategic resource and economic catalyst for early growth but became polluted due to early industrial practices and was affected by catastrophic floods. This watershed has a history of water quality impairments which has left areas of Middle Fork Beargrass Creek in need of restoration.

At the time of Louisville's establishment, Beargrass Creek below the confluence of the Middle and South Forks, ran through what is now downtown with its outlet originally being somewhere between what is now Third and Fourth Streets (Figure 1.2).

Figure 1.2 Historical Location of Beargrass Creek (1831)

Photo Credit: Louisville and Its Environs

In the 1850s, the Beargrass Creek was rerouted away from downtown Louisville and channelized for more efficient waste disposal to the Ohio River, resulting in the current alignment of the stream, known as the Beargrass Creek Cutoff, shown on Figure 1.3

Figure 1.3 Current Location of Beargrass Creek

The remainder of the 19th century saw increasing population in Louisville and a subsequent expansion in sewer construction. Approximately 100 miles of sewers were built, though they still were routed directly to either Beargrass Creek or the Ohio River. Between 1906 and 1913, an additional 54 miles of sewers were developed, including the first "interceptor" sewers which rerouted sewage from Beargrass Creek and delivered it directly to the Ohio River (DOW, 2011a). Figure 1.4 shows the construction of a sewer in the 1930s in Louisville.

Figure 1.4 Sewer Construction at Beargrass Creek

Photo Credit: University of Louisville Photo Archives, MSD Collection

Upon completion of the Locks and Dam 41 in the 1920s, later named the McAlpine Locks and Dam in 1960, elevated water levels occurred in the river. The first pump stations were constructed to alleviate some flooded sewer lines. The first wastewater treatment plant began operating in Louisville in 1958, originally called Fort Southworth Plant, now named Morris Forman Water Quality Treatment Center (WQTC). This WQTC is located along the Ohio River in southwest Louisville, downstream of the city. Urban expansion in the middle of the 20th century outpaced the construction of sewer lines to service the new neighborhoods. Therefore, many suburban areas, such as those in the Middle Fork Beargrass Creek watershed, were initially built operating on individual septic systems. Other areas were serviced by small and independent "package" sewage treatment plants. A 1959 ban on individual septic systems due to pollution led to the increase in package treatment plants and the slow expansion of sewer lines (MSD, Undated).

During the 1970s and 1980s, MSD worked with local governments in Jefferson County to reduce the number of septic systems. By the mid-1980s, efforts were being made to establish a county-wide sanitary sewer system and eliminate the existing package treatment plants and remaining septic systems. By 1994, more than 175 small wastewater plants and thousands of septic systems were eliminated through the sanitary sewer expansion. The last package treatment plant in the Middle Fork Beargrass Creek watershed was closed in 1994 at Foxboro Manor (MSD, Undated.) Although Louisville Metro is now on a sanitary sewer system, with some areas in and near downtown served by a combined sewer system, there are still water quality issues in both the Middle Fork Beargrass Creek Watershed and surrounding watersheds.

For many years, areas of the three forks of Beargrass Creek were modified to fit the community's wants and needs. Portions of Beargrass Creek were relocated and channelized due to development, and the impacts of the increased impervious area caused increased runoff during rain events. Middle Fork Beargrass Creek was impacted by increased development east of downtown Louisville, including St. Matthews, Hurstbourne, Douglass Hills, Jeffersontown, Anchorage and others. While sewer lines have improved in more recent years, and future projects are being planned, combined and sanitary sewer overflows are still an issue within the Middle Fork Beargrass Creek watershed. The history of this watershed has helped form what the landscape looks like today and drives the needs for improvement in the future.

1.2.2 Watershed and Waterways Description

The Middle Fork Beargrass Creek watershed is located in Jefferson County, in the western part of the Salt River as shown on Figure 1.5. The Salt River Basin is one of seven river basins recognized by the Kentucky Division of Water (DOW). The Salt River Basin and the minor Ohio River tributaries flow through portions of 19 Kentucky counties and drain approximately 5,200 square miles of land, representing 13% of the state (DOW, 2015). The watersheds that make up the Salt River Basin include the Salt River, Rolling Fork, Sinking Fork and Ohio River Tributaries. As a tributary to the Ohio River, the Beargrass Creek watershed, including Middle Fork Beargrass Creek, is one of the minor Ohio River tributaries.

Jefferson County is in the Outer Bluegrass region of Kentucky. The elevation in the county ranges from 383 to 902 feet above sea level. Jefferson County was formed in 1780 and was later divided to form four additional counties: Nelson (1785), Shelby (1792), Bullitt (1797) and Oldham (1824). The county seat, where Middle Fork Beargrass Creek is located, is Louisville. The United States Census Bureau in 2019 estimates the county population to be 766,757 in a land area of 380.42 square miles, with an average of 1,948.1 people per square mile. It is the most populous county and the most densely populated county in the state. Jefferson County is in the Kentuckiana Regional Planning and Development Agency (KIPDA) Area Development District. The Louisville and Jefferson County governments were merged into the Louisville/Jefferson County Metro Government (Louisville Metro) in 2003. (Kentucky Atlas and Gazeteer, 2020)

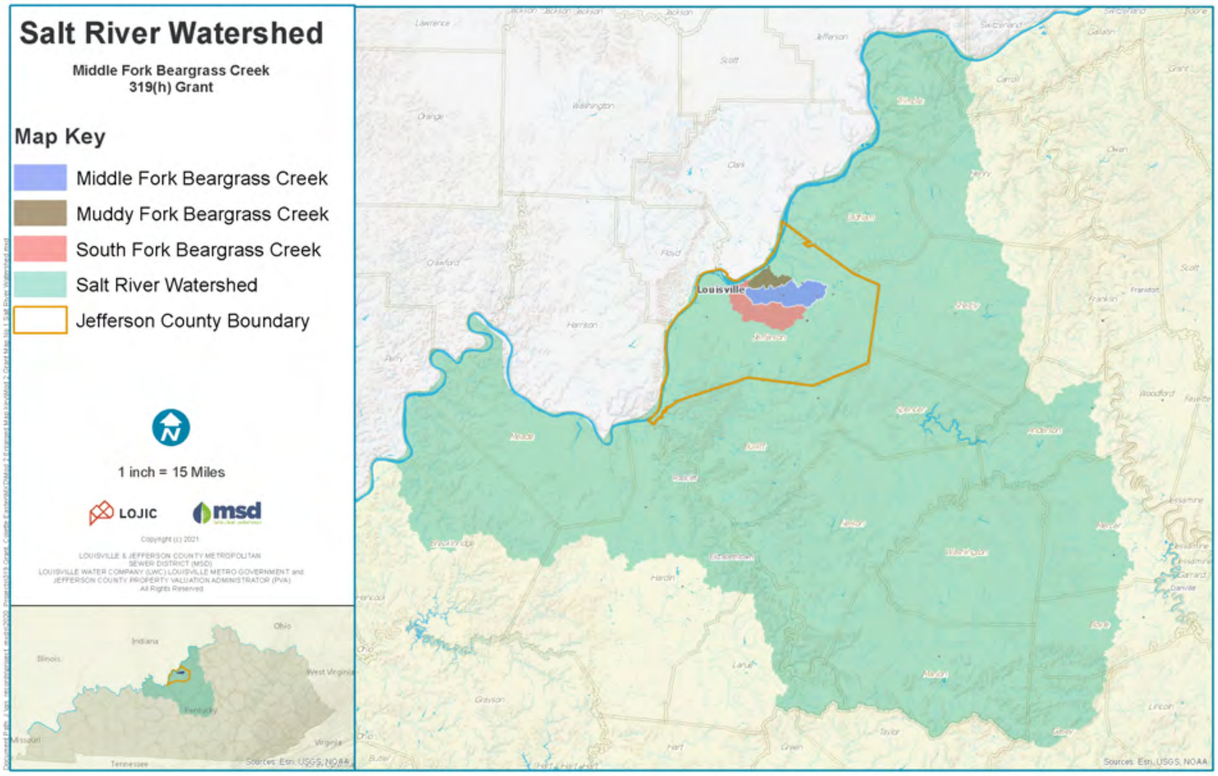

Figure 1.5 Salt River Basin, Jefferson County and Beargrass Creek

The Middle Fork Beargrass Creek is one of three streams that join to form the larger Beargrass Creek watershed. The small streams that eventually form the Middle Fork Beargrass Creek originate in the cities of Anchorage, Middletown and Douglass Hills, flowing west across St. Matthews, then joining the South Fork Beargrass Creek near Irish Hill. The South Fork then joins with the Muddy Fork to become Beargrass Creek near the intersection of Interstates 71 and 64.

The watershed boundary, waterbodies, monitoring sites and rain gauges that will form the basis of the data sources used to assess the health of the Middle Fork Beargrass Creek are shown on Figure 1.6. Monitoring sites include three Long Term Monitoring Network (LTMN) sites operated by MSD, seven DOW 319(h) monitoring sites where DOW collected water quality data in the watershed, nine MSD 319(h) monitoring sites where MSD collected water quality data in the watershed, some of which are co-located with DOW sites, and four MSD rain gauges. Additional information regarding the watershed and condition of streams in the Middle Fork Beargrass Creek is provided in Chapter 2. Exploring Middle Fork Beargrass Creek. Figure 1.6 provides details regarding the monitoring locations.

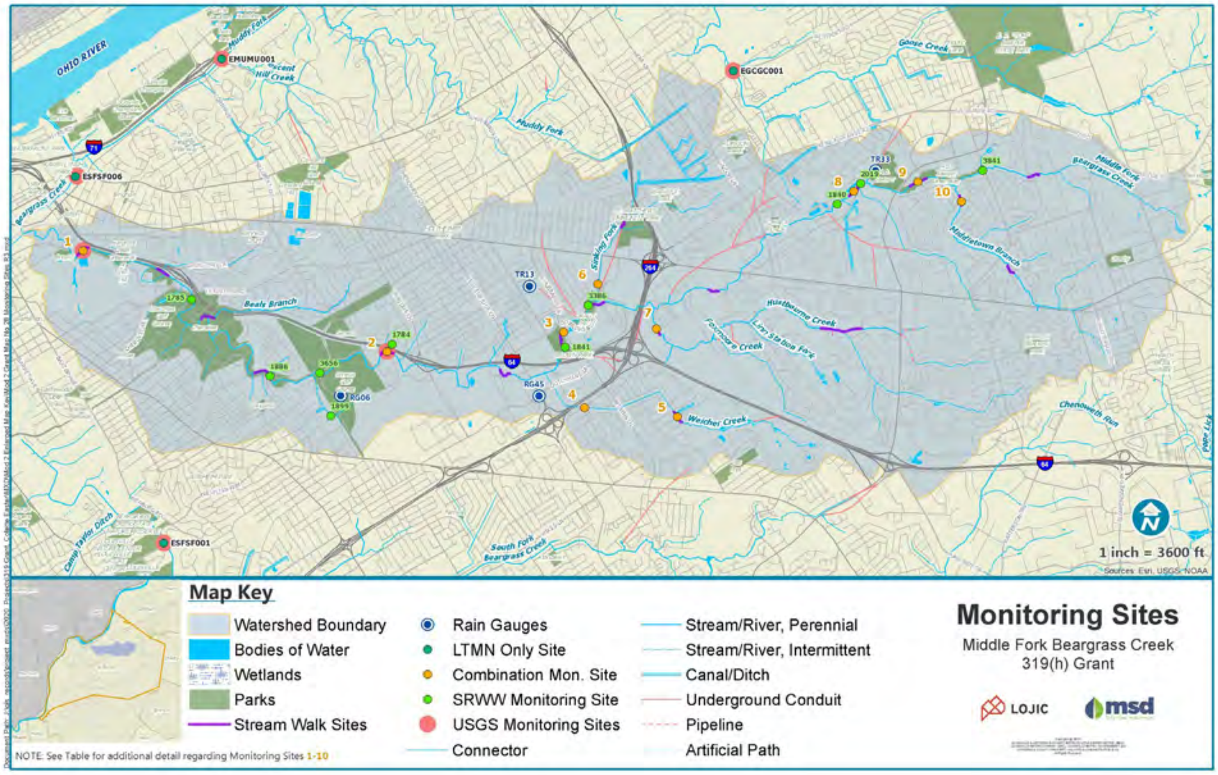

Figure 1.6 Waterbodies, Monitoring Sites, Rain Gauges and Stream Walks

1.2.3 Why Middle Fork Beargrass Creek?

Development of a watershed plan for the Middle Fork Beargrass Creek is one of many programs and projects that MSD has undertaken or completed to achieve its vision, mission and core values.

- **MSD Vision:** The innovative regional utility for safe, clean waterways.
- **MSD Mission:** Provide quality wastewater, stormwater and flood protection services to protect public health and safety through sustainable solutions, fiscal stewardship and strategic partnerships.
- **Core Values:**
  - **Employees**: Work in a safe and respectful manner that promotes collaboration, trust, diversity, quality of work and continuous learning.
  - **Customer Service**: Achieve a premium level of customer satisfaction by serving our customer promptly in a responsive and respectful manner.
  - **Public Education**: Enhance public knowledge of our Mission and responsibilities through open, honest communication with our customers and community stakeholders.
  - **Accountability**: Maintain the highest levels of integrity to ensure the public trust through transparency, financial responsibility and stewardship.

- **Environment**: Continually improve the environmental quality of our waterways through collaboration with the community and by maintaining our infrastructure.
- **Community**: Advocate on behalf of our community for public health, safety and protection in accordance with our Mission.

MSD's Vision and Mission focus on clean, safe waterways and the agency's role in protecting public health. As introduced in this chapter and described in detail in Chapter 2, MSD has invested significant effort in improving the cleanliness and safety of the Middle Fork Beargrass Creek, but much remains to be done to achieve this goal.

Development of the Middle Fork Beargrass Creek Watershed-Based Plan supports MSD's Core Values through the extensive public education efforts associated with plan development, and by working in collaboration with the community to improve the environmental quality of this waterway.

This project is being conducted in a watershed that was deemed a priority for development of Total Maximum Daily Loads (TMDLs) at the statewide level. TMDLs are studies that determine how much of a pollutant a waterbody can receive and still meet the Kentucky Surface Water Standards. DOW developed a Fecal Coliform TMDL for the Beargrass Creek watershed, including Middle Fork Beargrass Creek (DOW, 2011a). This TMDL included target reductions of fecal coliform bacteria needed to achieve the water quality standards. The guidance from DOW for 319(h) funding prioritizes watersheds with TMDLs for grant funding (DOW, 2019), and the Beargrass Creek TMDL included development of a Beargrass Creek Watershed Plan as an important strategy to enable more effective targeting of restoration funds and resources, thus improving environmental benefit, protection and recovery.

Another consideration for selecting the Middle Fork Beargrass Creek is the energy provided by dedicated, enthusiastic partners. A wide variety of partners, including government agencies, nonprofit groups and consulting firms, readily agreed to commit their time and energy to working together for positive change in the Middle Fork Beargrass Creek watershed.

Despite water quality issues, there is a strong community presence and active use of this watershed for recreation. There are several paved trails along Middle Fork Beargrass Creek used for recreational activities and by commuters, making it highly traveled by the community and individuals who love the outdoors. Accessibility to the stream in some areas provides high visibility for potential outreach and education opportunities. A local volunteer organization, Beargrass Creek Alliance, continues to actively work to engage the community to improve the waterway. Past programs and projects have provided educational information on the state of the watershed and projects such as rain barrel installations and storm drain stenciling. Salt River Watershed Watch (SRWW), a local volunteer water monitoring group has trained volunteers and collected stream samples throughout the Salt River basin, including in the Middle Fork Beargrass Creek, since 1999. Section 1.3 of this document outlines the partner commitments, and Section 1.4 describes the partner entities.

Projects that have been completed or are underway in this watershed provide a catalyst for continued improvements. MSD continues to implement many programs and projects within the watershed to reduce the frequency and volume of CSOs, to eliminate SSOs, and to minimize impacts of stormwater to the maximum extent practicable. These programs and projects have resulted in several notable improvements in water quality over the years. Some of these improvements have been summarized and published in the 2016 Water Quality Synthesis Report (MSD, 2016). MSD will prepare the next Water Quality Synthesis Report during this permit term and will update this section with those findings prior to the submittal of the final draft of Middle Fork Beargrass Creek Watershed-Based Plan. The findings from the 2016 Water Quality Synthesis Report include the following for Middle Fork Beargrass Creek:

- A 34% reduction in fecal coliform bacteria at Lexington Road between 2004 and 2015
- A 24% and 12% improvement in fish community scores at Browns Lane and Lexington Road, respectively
- An 11% improvement in aquatic insect (e.g., benthic macroinvertebrate) scores at Old Cannons Lane
- Aquatic habitat was rated as good and stable at Old Cannons Lane
- Nitrogen, phosphorus and total suspended solids were generally low at Browns Lane and Old Cannons Lane
- Dissolved oxygen met water quality criteria 98% of the time between 2013 and 2015 and improved by 15% since 2005 at Old Cannons Lane and was deemed fair and improving at Browns Lane
- Although dissolved oxygen met water quality criteria only 76% of the time at Lexington Road, between 2013 and 2015, it had improved by 10% since 2005

These findings highlight the combined positive effects of ongoing programs and projects on water quality. However, work remains to be done.

1. Fish communities were rated as fair or poor at the three monitoring sites in 2015
2. Aquatic insect communities were rated as fair at the three monitoring sites in 2015
3. Aquatic habitat was rated as fair and declining at Lexington Road
4. Fecal coliform levels were elevated above water quality standards at all three monitoring sites, were increasing at Browns Lane and were unchanged at Old Cannons Lane
5. Nitrate levels were elevated at Browns Lane and Old Cannons Lane
6. Total phosphorus and total suspended solids were elevated at Lexington Road

1.2.4 Summary of Local Concerns about the Watershed

During the grant application process in 2017, project partners were asked to complete a survey about their concerns and goals for the Middle Fork Beargrass Creek watershed. When asked why the Middle Fork Beargrass Creek is important to them, many partners said that they enjoy the recreational opportunities and parks in and around Middle Fork Beargrass Creek. There are many areas where people and pets can interact with the stream, emphasizing the importance to have a clean and healthy waterway. Some partners actively work in the watershed by participating in studies and mitigation efforts because they live in the watershed and are invested in improving it.

Parks in the watershed such as Seneca Park, Cherokee Park and Beargrass Creek Greenway are used year round and were identified as specific areas of concern due to the higher chance for contact with the water. The other locations of concern mentioned were the shopping malls located along Shelbyville Road where there is a lot of impervious surface. Additional concerns included the high amount of impervious surface, streambank erosion and CSO discharges. These issues can be addressed with improved infrastructure and mitigation projects, but education and outreach play a vital role in community engagement and investment for sustained water quality improvements.

The final question of the survey asked partners to define their goals for the watershed. The consistent goal of the partners was improved water quality for Middle Fork Beargrass Creek. Other common goals included habitat and ecosystem improvement, to improve water quality so the stream can support recreational activities like swimming and fishing, and to promote consistent community involvement and awareness.

1.3 PROJECT GOALS AND EXPECTED OUTCOMES

The purpose of this watershed plan is to develop a framework and potential projects that can be implemented to improve the water quality in the Middle Fork Beargrass Creek watershed. Two important components of this watershed plan include sustained community engagement and structural and nonstructural BMPs that benefit the watershed. This section outlines the specific goals for this watershed plan and multiple objectives under each goal. The approved grant application is included as Appendix 1.1.

1.3.1 List of Project Goals and Expected Outcomes

Goal 1: Improve water quality in the Middle Fork Beargrass Creek by developing a DOW- and Environmental Protection Agency (EPA)-approved watershed plan that meets EPA A-I criteria.

- Objective 1: Compile available background information about the Middle Fork Beargrass Creek watershed
- Objective 2: Determine current conditions of the Middle Fork Beargrass Creek watershed through interpretation of collected water quality data and visual assessment
- Objective 3: Develop a BMP Implementation Plan for the Middle Fork Beargrass Creek watershed
- Objective 4: Develop measurable milestones and evaluation criteria for determining the long-term success of the watershed planning and implementation efforts

Goal 2: Create greater opportunity for community members to become involved in watershed improvement efforts and solutions.

- Objective 1: Continue to work with the Steering Committee and the Watershed Work Group
- Objective 2: Support a watershed group for the Middle Fork Beargrass Creek
- Objective 3: Provide outreach to the local community on nonpoint source pollution and related environmental issues in their watershed

1.4 PROJECT PARTNERS AND WATERSHED STAKEHOLDERS

Project partners are an integral part of watershed planning. Developing partnerships with businesses, organizations and/or agencies that have similar interests and want to achieve the same goal allows for a variety of resources to be available. Each partner comes from a different background and area of expertise, and as such, will have a unique role in the planning effort. This section introduces each project partner and watershed stakeholder. A description of each partner or stakeholder is provided as well as their role in the watershed plan development and how their expertise can be utilized in the planning effort.

1.4.1 List of Project Partners and Watershed Stakeholders

***Company Partner*: AECOM**

Description: AECOM, located in downtown Louisville at 500 West Jefferson Street, has over 60 technical staff members, including water resources, transportation, power and environmental compliance/air quality engineering groups. Globally, AECOM has several offices that operate independently, thereby offering clients a “small firm” relationship with the benefits (resources, expertise and manpower) of a large, international firm. The AECOM Louisville office water resources group of professionals consists of water resource engineers, hydraulic and hydrology engineers, biologists, GIS specialists, database specialists, computer programmers, design engineers, professional trainers and floodplain specialists.

Role: AECOM assists MSD's Municipal Separate Storm Sewer System (MS4) program with technical water quality assistance and is supportive of the watershed plan to improve the water quality in Middle Fork of Beargrass Creek. They will assist with technical knowledge and results from sampling efforts, volunteering, public outreach and education, and creek cleanups.

https://aecom.com/

***Not for Profit Partner*: Beargrass Creek Alliance**

Description: Volunteer watershed group specific to the Beargrass Creek Watershed and supported by Kentucky Waterways Alliance. The Beargrass Creek Alliance seeks to preserve Louisville's Beargrass Creek through community involvement. The mission of the Beargrass Creek Alliance is to raise awareness about Beargrass Creek and make it clean, safe, and accessible for all. This group dedicated to protecting Kentucky waterways through the Clean Water Policy, restoration, watershed planning and clean water networking.

Role: The Beargrass Creek Alliance will provide a direct and essential connection to watershed residents who are committed to taking an active role in water quality initiatives. Wherever possible, the Beargrass Creek Alliance will be relied upon to engage, promote, and participate in activities and programs identified in the watershed plan.

https://www.kwalliance.org/beargrass-creek-alliance.html

***Company Partner*: Jacobs**

Description: Technical professional services firm that provides technical, professional and construction services, as well as scientific and specialty consulting.

Role: They will assist by providing technical knowledge and results from sampling efforts, volunteering, public outreach and education, and creek cleanups.

https://www.jacobs.com/

***Not for Profit Partner*: Kentucky Waterways Alliance**

Description: Volunteer group dedicated to protecting Kentucky waterways through the Clean Water Policy, restoration, watershed planning and clean water networking.

Role: Kentucky Waterways Alliance's mission is to protect, restore and celebrate Kentucky's waterways, which is directly supported by the watershed plan. From their years of experience, they will assist with public outreach and engagement, publicity, participation in watershed planning review and in-kind contributions such as creek cleanups, Every Drop events, storm drain marking and celebration bicycle tours.

https://kwalliance.org/

***Agency Partner*: Louisville Department of Metro Parks and Recreation**

Description: Agency responsible for maintenance and conservation of the parks, with a vision for Louisville to be a clean, green, safe and inclusive city where people love to live, work and play.

Role: The Louisville Department of Metro Parks and Recreation will help lead public education, volunteer events, maintenance activities associated with the Louisville Loop from Beargrass Creek Greenway to River Road, and the recently completed Beargrass Creek Trail Conceptual Shared Use Path and Ecological Restoration Plan, which evaluated potential trail paths and ecosystem restoration opportunities.

https://louisvilleky.gov/government/parks

***Non-Profit Partner*: River City Paddle Sports**

Description: River City Paddle Sports' mission is to expand community access to all paddle sports in the Greater Louisville area through education, outreach and competition. Using 30-foot Voyageur Canoes, they will explore the lower reaches and the backwaters of Beargrass Creek. Paddling one mile of the Creek, they are able to witness the ecological and aesthetic impact of the community on the environment.

Role: River City Paddle Sports has a rich history of working with students for watershed sampling and paddling. They will lead environmental field trips through the watershed and promote the documentary, *Beargrass: The Creek in Our Backyard*.

https://rivercitypaddlesports.wordpress.com/

***Non-Profit Partner*: Salt River Watershed Watch**

Description: Volunteer organization dedicated to improving the health of waterways through monitoring, water improvement projects and environmental education.

Role: Salt River Watershed Watch (SRWW) will provide SRWW sampling data for screening purposes, screening level water quality sampling and interpretation, and environmental education.

www.srww.org

***Company Partner*: Stantec**

Description: Stantec is a professional services company in the design and consulting industry that provides consulting services in planning, engineering, architecture, landscape architecture, surveying, environmental sciences, project management and project economics. Locally, Stantec employs nearly 100 staff supporting water, environmental, transportation, geotechnical, geographic information systems, programming and financial services.

Role: Stantec currently supports MSD's monitoring program for wet weather sampling and will provide technical assistance with developing the watershed plan, including knowledge from previous sampling efforts, coordination to identify mitigation opportunities and historic knowledge of projects within the Middle Fork Beargrass Creek watershed.

http://stantec.com

***Company Partner*: Third Rock**

Description: Third Rock Consultants, LLC (Third Rock) embraces a watershed-scale approach to restoring Kentucky waters to swimmable, fishable resources. Third Rock engineers, aquatic ecologists, wetland scientists and GIS analysts have years of collective experience in the areas of watershed planning, water quality monitoring, hydrologic modeling, stream and wetland restoration, and the design of best management practices. They believe there is no substitute for on-the-ground watershed evaluation to supplement mapping and other data, and they understand that each watershed requires a customized approach that addresses a range of goals. They identify and prioritize unique management strategies, while considering the many project parameters (budget, site constraints, etc.) involved with watershed planning and monitoring.

Role: Third Rock has previously provided MSD with aquatic macroinvertebrate surveys, water quality sampling and habitat assessment services. They support this project and will contribute technical assistance with assessment and integration of biological and habitat assessments, technical assistance with visual surveys and geomorphic assessments, and identification of priority areas and BMPs to address hydromodification BMPs.

https://www.thirdrockconsultants.com/

1.5 PUBLIC INVOLVEMENT PLAN

This section describes efforts to support Goal 2 of the project: Create greater opportunity for community members to become involved in watershed improvement efforts and solutions. The collaboration with project partners helps to create events and opportunities to educate the community. The education aspect of the project is crucial to developing a watershed plan because it informs the public and stakeholders of the waterway that is a part of their everyday lives. Teaching the community of the waterway's history and current state not only helps to make them aware of the issues present, but also can encourage them to get involved. This section also includes a schedule of education and outreach opportunities available to the community.

1.5.1 Education and Outreach Activities, Schedule and Report

- Creek Cleanups (KWA, 2 @ 3 hours each)
- Every Drop Events (KWA, 2 events)
- Storm Drain Marking Events (KWA, 2 @ 2 hours each)
- Bicycle or Walking Tours for Watershed Residents (KWA, 2 @ 2 hours each)
- Film Showings for "Beargrass: The Creek in Our Backyard" (KWA, 4 @ 1.5 hours each)
- Monthly Updates to Beargrass Creek Alliance (KWA, 24 updates)
- Monthly Social Media Updates (KWA, 24 during project)
- Canoe Trips (River City Paddle Sports, 3 @ 3 hours each)
- Invasive Species Removal Events (Metro Parks, 2 events)
- Annual Volunteer Events (Metro Parks, 2 events)
- Public Interpretive Programs (Metro Parks, 2 events)
- Beargrass Creek Greenway Maintenance (Metro Parks, 15 @ 8 hours each)

1.6 CHALLENGES DURING THE STUDY

In March 2020, the governor of the Commonwealth of Kentucky issued a stay-at-home order for all non-essential employees due to the health risks associated with the spread of COVID-19. As a utility, the work that MSD provides to the community is considered an essential business, but new precautions were put in place to help prevent the spread of the virus. The stay-at-home order not only affected MSD's internal operations but put a hindrance on MSD's ability to reach out to other organizations and consultants to continue to facilitate the community education and outreach activities.

It was estimated that 752 hours of volunteer work would be contributed to the outreach efforts. However, due to efforts to prevent the spread of COVID-19, the original scope for public outreach was modified. Many hours had been allotted for Earth Day activities in April 2020, but all of those events were cancelled. As a result, MSD has worked with partners to plan new, unique opportunities to involve the community while maintaining social distancing requirements. Possible activities include virtual clean-ups, outdoor showings of *Beargrass: The Creek in Our Backyard*, creating an informational video about native species as stream buffers, and others.

The goal of the education and outreach efforts remains the same: to "create greater opportunity for community members to become involved in watershed improvement efforts and solutions." In the presence of COVID-19, the activities look different but are intended to work toward creating educational opportunities while keeping everyone safe.

1.6.1 Revised Education and Outreach Activities, Schedule and Report

The revised education and outreach activities, schedule and report are located in Chapter 1, Appendix 1.2.

CHAPTER 2. EXPLORING THE MIDDLE FORK BEARGRASS CREEK WATERSHED

2.0 EXPLORING THE MIDDLE FORK BEARGRASS CREEK WATERSHED

2.1 INTRODUCTION

This chapter provides an overview of the Middle Fork Beargrass Creek watershed. Major topics addressed in this chapter include water resources, natural features, human influences and impacts, demographics and social considerations, team observations and interim conclusions. Major sources of information for this chapter were compiled by documents and databases available from MSD and the references compiled for the Watershed Planning Guidebook for Kentucky Communities, 1st Edition (KWA and DOW, 2010). This chapter summarizes publicly available historical data, literature and other resources available at the onset of the project. Collaboration with project partners and watershed stakeholders was also essential to the development of this section.

2.2 WATER RESOURCES

2.2.1 Watershed and Political Boundaries

The Middle Fork Beargrass Creek is located in central Jefferson County, Kentucky. The headwaters of Middle Fork Beargrass Creek originate in the cities of Anchorage, Middletown and Douglass Hills, flowing west across the City of St. Matthews, then joining the South Fork Beargrass Creek near Irish Hill. The South Fork then joins with the Middle Fork to become the mainstem of Beargrass Creek. Muddy Fork joins Beargass Creek downstream near the intersection of I-64 and I-71 and then flows into the Ohio River.

Prominent features of this watershed include Cherokee Park, Seneca Park, Cave Hill Cemetery, the Southern Baptist Seminary, Bowman Field, Big Spring Country Club, Mall St. Matthews, Oxmoor Center shopping mall and the Hurstbourne Country Club (MSD, 2017b, *Watershed Master Plan*, Section 2.1.1).

Like many American cities, Louisville Metro consists of Louisville, as well as numerous small cities and neighborhoods. There are 26 cities that lie entirely or partly within the Middle Fork Beargrass Creek watershed, listed below and shown on Figure 2.1.

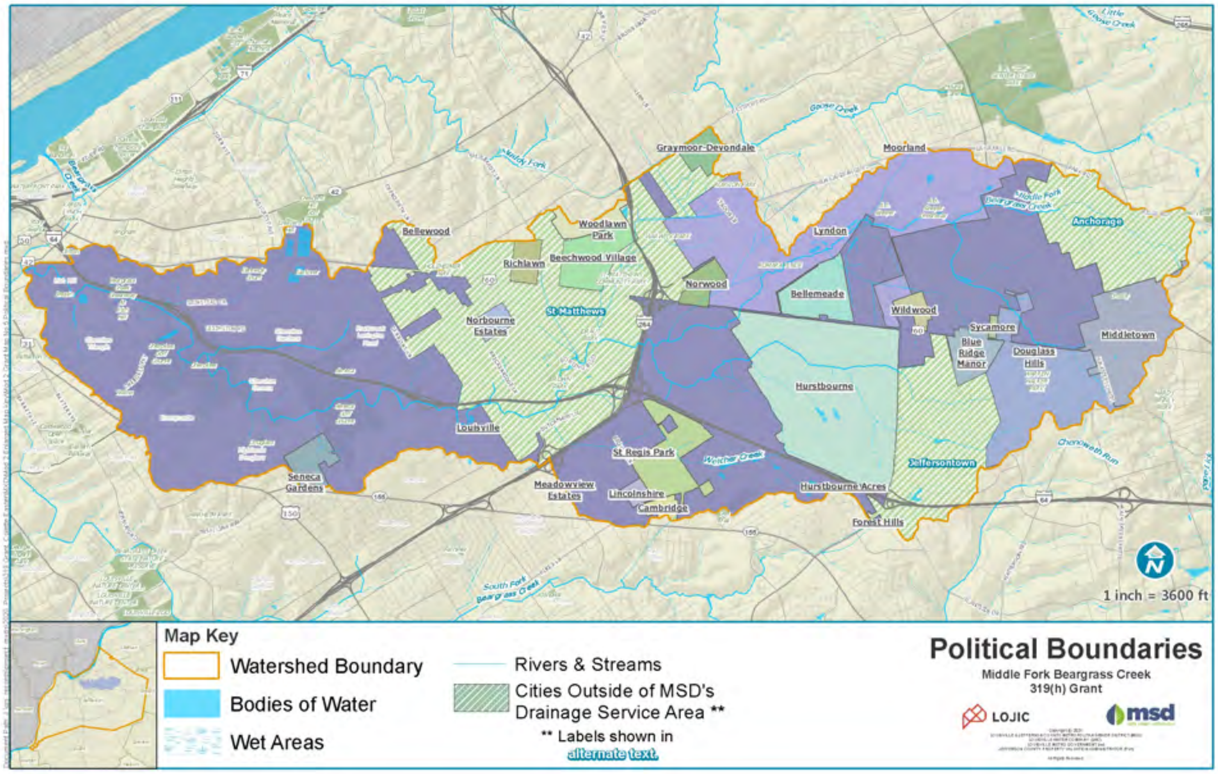

Figure 2.1 Political Boundaries in the Middle Fork Beargrass Creek Watershed

2.2.2 Hydrology

This section addresses major facets of hydrology including stream locations, rainfall, stream discharge and wetlands.

Stream Locations: Middle Fork Beargrass Creek flows for approximately 14.3 miles from its headwaters to its confluence with South Fork Beargrass Creek. Including the Middle Fork mainstem, there are approximately 61 miles of perennial and intermittent streams and tributaries within the Middle Fork Beargrass Creek watershed. The following are the named tributaries feeding Middle Fork Beargrass Creek: Beals Branch, Sinking Fork, Weicher Creek, Foxmoore Creek, Hurstbourne Creek, Linn Station Fork and Middletown Branch.

Sinking Fork is an intermittent stream that flows from St. Matthews near I-264 to its confluence with the Middle Fork Beargrass Creek near Bowling Boulevard near Arthur K. Draut Park. Weicher Creek flows approximately 3.1 miles from its headwaters near Havers Place, adjacent to I-64, through the Oxmoor Country Club and St. Regis Park, under I-264 to its confluence with Middle Fork Beargrass Creek near Dutchmans Lane, just south of Browns Park. Hurstbourne Creek flows approximately 3.2 miles from its headwaters to the confluence with Middle Fork Beargrass Creek near Steeplecrest Circle.

Foxmoore Creek, Country Club Branch and Linn Station Fork are tributaries that flow into Hurstbourne Creek. Other tributaries that flow into the Middle Fork Beargrass Creek include Middletown Branch, Sinking Fork and Beals Branch. The confluence of Middle Fork Beargrass Creek and Beals Branch is in the northern part of Cherokee Park. See Figure 2.2.

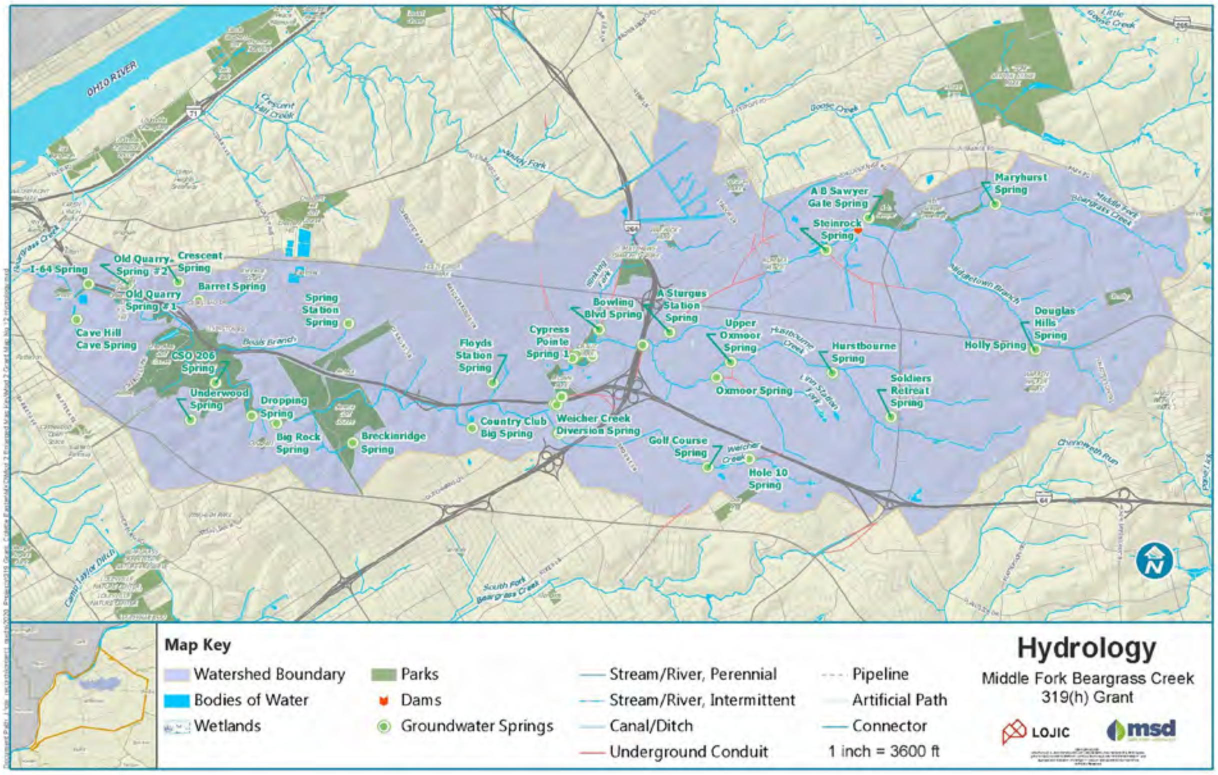

Figure 2.2 Middle Fork Beargrass Creek Hydrology

Figure 2.3 depicts the 17 sub-basins that were delineated in MSD's Watershed Master Plan (MSD, 2017b).

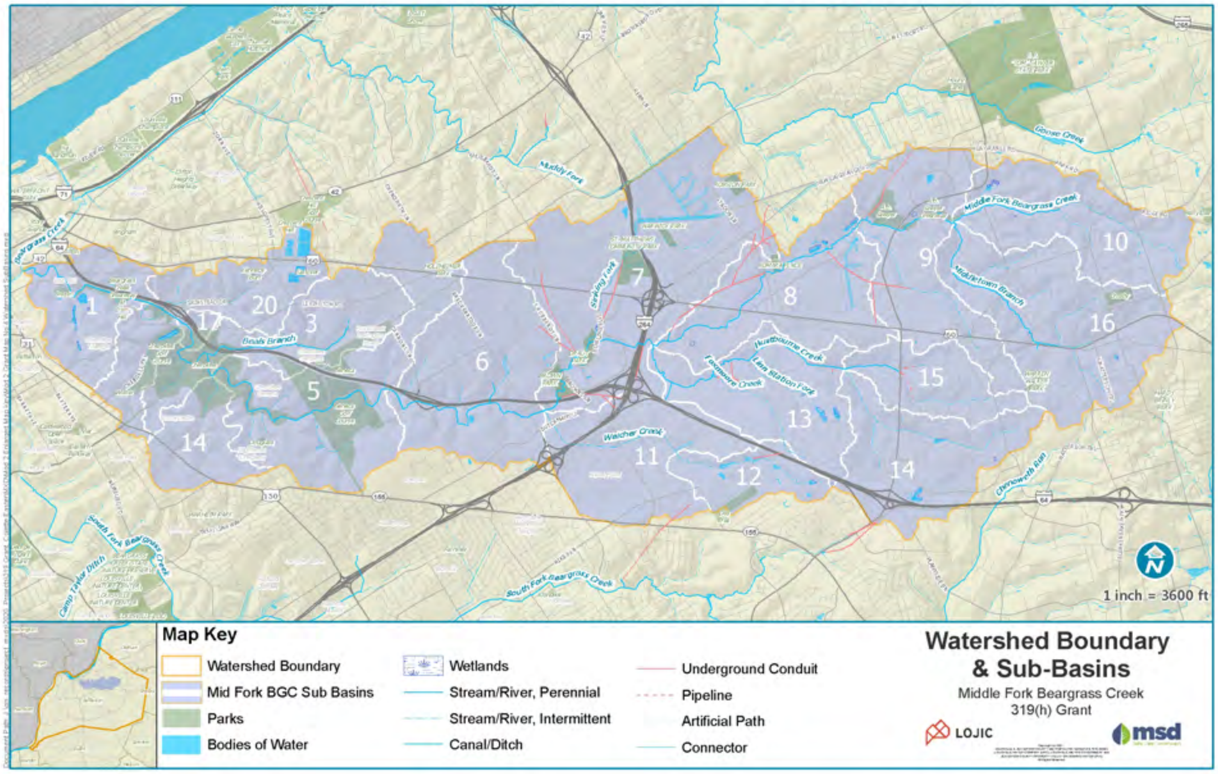

Figure 2.3 Watershed Boundary and Sub-Basins

Rainfall: Rainfall and other precipitation events are major factors influencing hydrology. The Commonwealth of Kentucky is within the Ohio Valley Climatological Region, one of nine distinct regions recognized in the United States by the National Oceanic and Atmospheric Administration (NOAA). This region is characterized by mostly moderate weather with the potential for occasional severe weather conditions. Temperatures in this region fluctuate seasonally, with the lowest yearly average temperatures occurring in January and highest average temperatures occurring in July. Minimum temperatures in January can reach 20°F, while maximum temperatures in July can reach up to 90°F, although extremes can occur on both ends. Kentucky averages between 38 and 48 inches of precipitation per year, or between three and five inches per month. On average, approximately 11 inches of Kentucky's yearly precipitation falls as snow. Table 2.1 shows monthly climatological data for Louisville Metro.

Table 2.1 Climatological Data for Louisville, Kentucky, 1981-2010

Month	Max. Temp (ºF)	Min. Temp (ºF)	Avg. Temp (ºF)	Precipitation (in.)	Snow (in.)	Total
January	43.0	26.8	34.9	3.24	3.7	6.94
February	47.8	29.9	38.8	3.18	4.5	7.68
March	57.9	37.8	47.8	4.17	1.4	5.57

Month	Max. Temp (ºF)	Min. Temp (ºF)	Avg. Temp (ºF)	Precipitation (in.)	Snow (in.)	Total
April	68.8	47.3	58.0	4.01	0.1	4.11
May	77.1	57.0	67.1	5.27	0.0	5.27
June	85.3	66.0	75.6	3.79	0.0	3.79
July	88.7	69.9	79.3	4.23	0.0	4.23
August	88.3	68.5	78.4	3.33	0.0	3.33
September	81.5	60.5	71.0	3.05	0.0	3.05
October	70.1	48.9	59.5	3.22	0.1	3.32
November	57.9	39.5	48.7	3.59	0.1	3.69
December	45.8	30.0	37.9	3.83	2.6	6.43

According to NOAA, the average rainfall for Louisville between 1948 and 2020 ranged between 3.0 inches and 5.0 inches (NOAA, 2021). There are two MSD rain gauges in the Middle Fork Beargrass Creek watershed: TR-13 at St. Matthews Elementary School and TR-33 at A.B. Sawyer Park. The rain recorded at these gauges in 2019 was often much higher or much lower than the historic monthly averages from NOAA. No data were recorded on TR-13 from February 24, 2019, to April 18, 2019. See Figure 2.4.

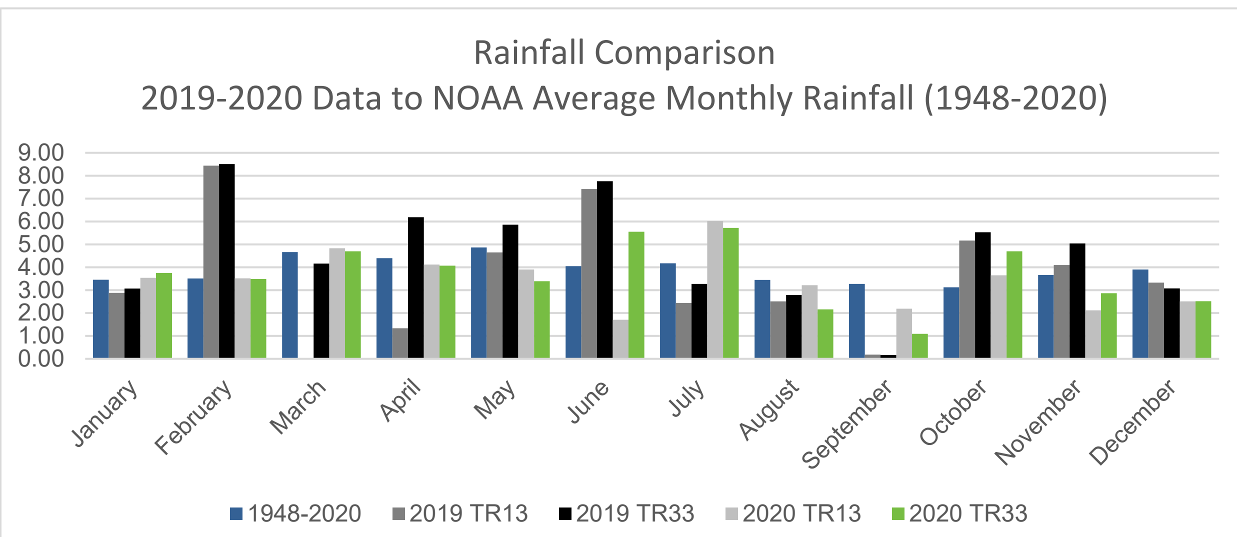

Figure 2.4 Average Rainfall (1948-2020), MSD Rainfall Gauge 2019 and 2020 Data

Stream Discharge: Stream flow is another important aspect of watershed hydrology. There are two stream gauges on Middle Fork Beargrass Creek that measure stream discharge every 15 minutes. One gauge is located at Lexington Road (USGS 03293500), and the other is located at Old Cannons Lane (USGS 03293000). USGS monitors stream flow at these locations. Sondes are operated cooperatively by MSD and USGS, which measure water temperature, pH, dissolved oxygen and conductivity every 15 minutes.

The current and historical data are available from the USGS National Water Information System (NWIS) https://waterdata.usgs.gov/ky/nwis/rt.

The monitoring station at Lexington Road is located near the outlet of the Middle Fork Beargrass Creek and drains 98% of the total watershed. This site has collected discharge data continuously at 15-minute intervals since 2003. Average stream discharge recorded at this location is 38.1 cubic feet per second (ft^3/s). The maximum recorded instantaneous flow observed over the recording history is 4,400 ft^3/s, while the minimum recorded flow is 0.8 ft^3/s. At this location, flows under 2.7 ft^3/s make up 10% of total recorded flows, while flows under 72 ft^3/s make up 90% of total recorded flows, and flows over 500 ft^3/s represent less than 1% of all recorded flows. The median recorded flow at this location is 13 ft^3/s (USGS, 2020). This indicates that elevated flows occur briefly during hydrologic events, and subside shortly after, with extended periods of significantly lower flows in the dry periods in between storm events. In addition to discharge, water quality parameters, including temperature, dissolved oxygen, conductivity and pH, are monitored and recorded for this site. The monitoring station at Old Cannons Lane is located near the middle of the Middle Fork Beargrass Creek mainstem and drains 74% of the total watershed. This site also collects data for stream discharge, temperature, dissolved oxygen, conductivity and pH.

Wetlands: According to the National Wetland Inventory (NWI), there are four classifications of wetlands identified in the Middle Fork Beargrass Creek watershed: freshwater emergent, freshwater forested/shrub, freshwater ponds and riverine. Table 2.2 contains information on the distribution of wetlands. Riverine wetland is the most apparent wetland classification in the watershed, consisting of 127 acres.

Table 2.2 Distribution of Wetlands

Wetland Type	Total Area (Acres)	Percent of Wetland Total	Percent of Watershed
Freshwater Forested/Shrub Wetland	0.9	0.5%	0.01%
Freshwater Pond	47.6	26.9%	0.29%
Riverine	127.5	72.1%	0.79%
Freshwater Emergent Wetland	0.9	0.5%	0.01%
Total	**176.9**	**100.00%**	**1.10%**

As shown on Table 2.2, there are a total of 176.9 acres of wetlands representing 1.1% of the land area of Middle Fork Beargrass Creek watershed. The locations of wetlands are shown on Figure 2.5.

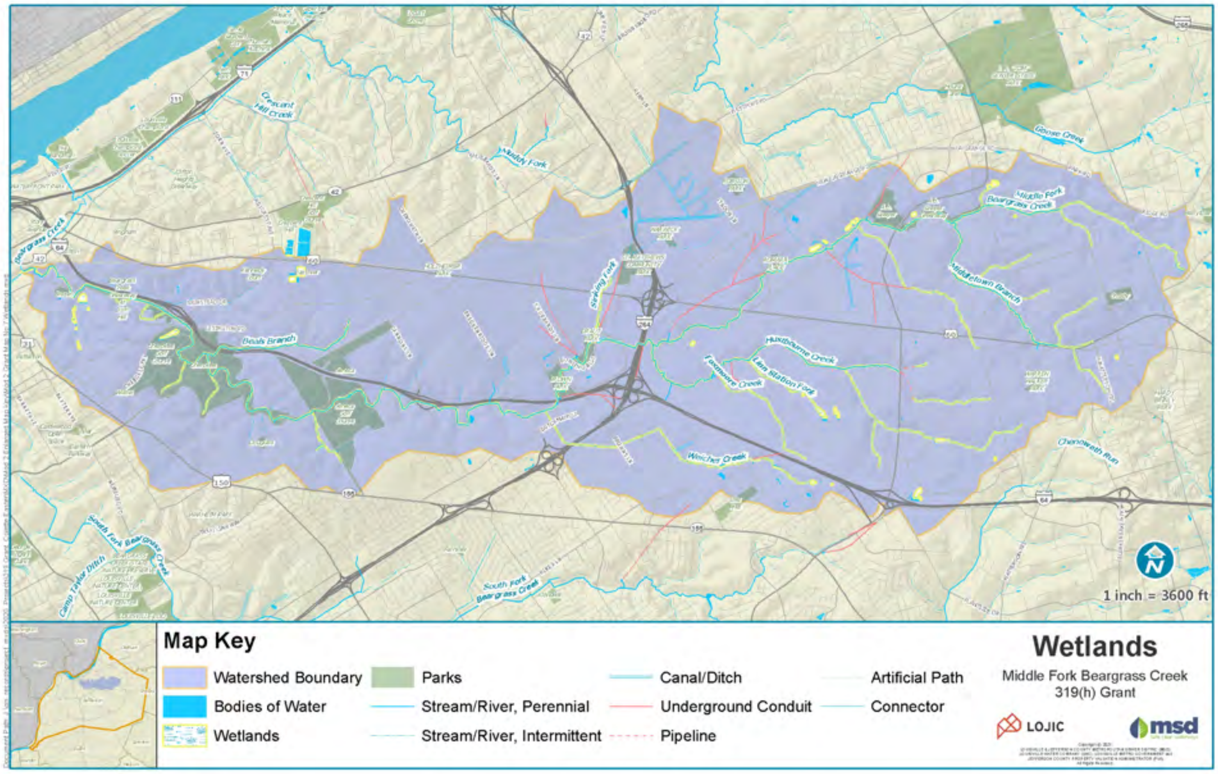

Figure 2.5 Wetlands in Middle Fork Beargrass Creek

2.2.3 Groundwater-Surface Water Interaction

A karst landscape most commonly develops on limestone but can develop on several other types of rocks, such as dolostone, gypsum and salt. Precipitation infiltrates into the soil and flows into the subsurface from higher elevations and generally toward a stream at a lower elevation. Weak acids found naturally in rain and soil water slowly dissolve the tiny fractures in the soluble bedrock, enlarging the joints and bedding planes (Kentucky Geological Survey, Karst). Figure 2.6 shows a typical karst landscape in Kentucky.

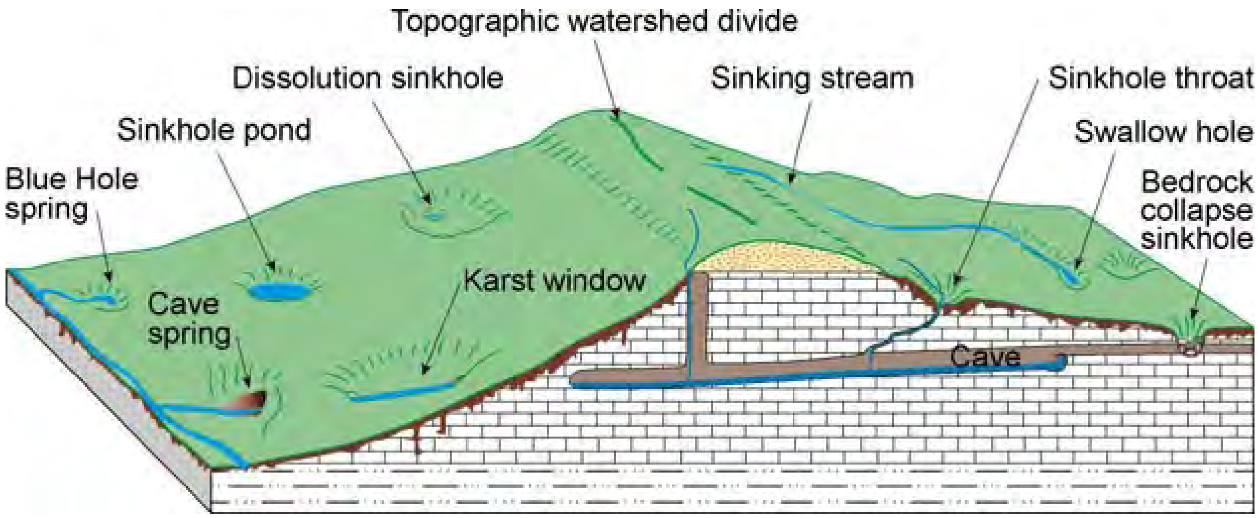

Figure 2.6 Karst Landscape

Groundwater hydraulics and water yield within a watershed are largely influenced by the underlying geologic formations and the prevalence and development of karst features. In Kentucky, physiographic regions are defined by their respective geologic, topographic and hydrologic features. Five physiographic regions have been defined in Kentucky, each with its own distinct groundwater-surface water interaction mechanisms: the Eastern Coal Field, Western Coal Field, Gulf Coastal Plain, Mississippian Plateau and the Bluegrass Region, which is divided into an Inner and Outer sub-region. The Ohio River Alluvium is a unique hydrogeologic region that follows the course of the Ohio River along the northern border of the state but is generally not considered an official state physiographic region (Ray et al., 1994).

The Middle Fork Beargrass Creek watershed is within the Outer Bluegrass physiographic region, which is underlain with Ordovician Age limestones with interbedded shale layers. Ohio River Alluvium, characterized by Pleistocene glacial outwash sediments, occurs in the watershed at the downstream reaches near the watershed outlet at the confluence with the South Fork Beargrass Creek, with additional deposits occurring near the main channel, extending upstream some distance.

Numerous springs and several karst groundwater basins are located largely within Jefferson County. The Middle Fork Beargrass Creek watershed has karst features throughout the watershed area. Figure 2.7 depicts the karst area, sinkholes, streams and underground conduits in the Middle Fork Beargrass Creek.

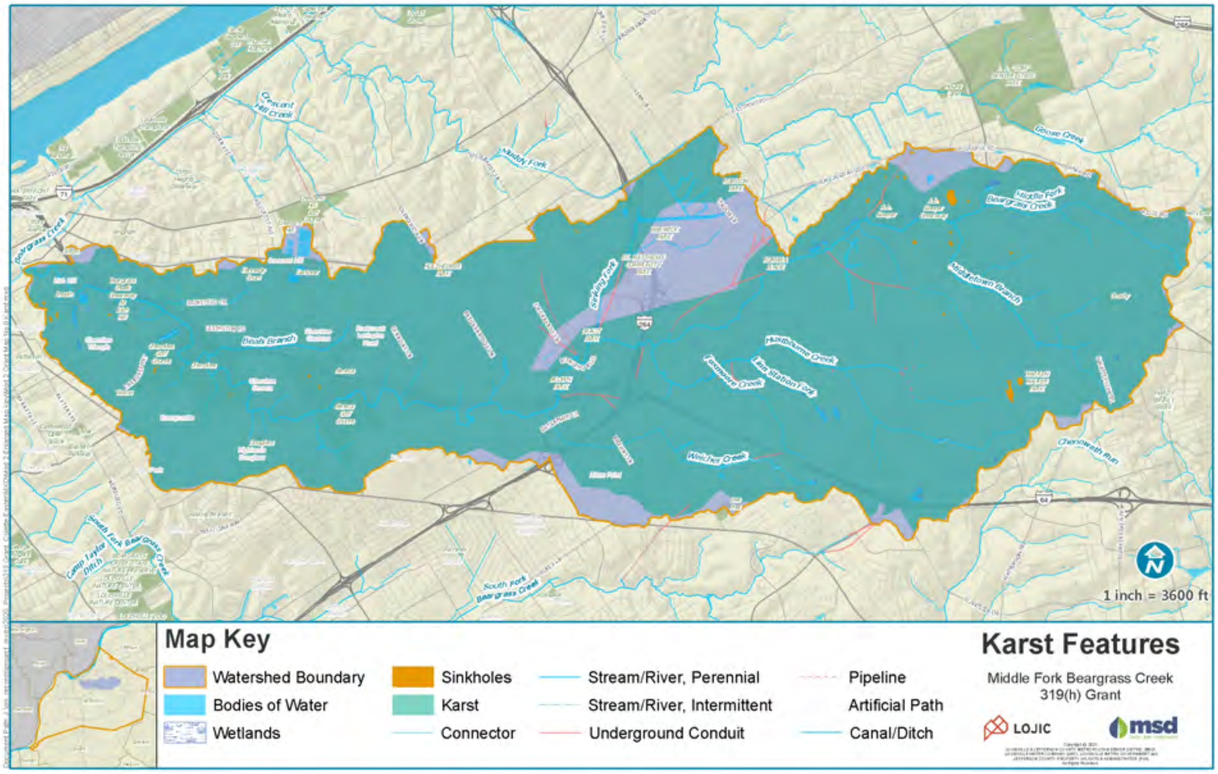

Figure 2.7 Karst Features

DOW developed groundwater sensitivity data that are depicted on Figure 2.8**.** The data can be used as a resource for preventing groundwater contamination. Groundwater is susceptible to contamination from activities on the land surface and once contaminated can be difficult and expensive to remediate. The map presents a generalized assessment of the relative hydrogeologic sensitivity to pollution. Sensitivity was defined as the ease and speed at which a contaminant could move into and within groundwater systems. (Ray et.al., 1994). Based on groundwater recharge, flow and dispersion rates, the index ranges from one (low) to five (high). A five indicates the area is highly susceptible to groundwater pollution. The hydrologic sensitivity index ranges from three near the confluence to five over the majority of the watershed. The map also depicts the estimated locations and general direction of underground movement of water through the karst system using data from the National Hydrography Dataset (NHD). See Figure 2.8.

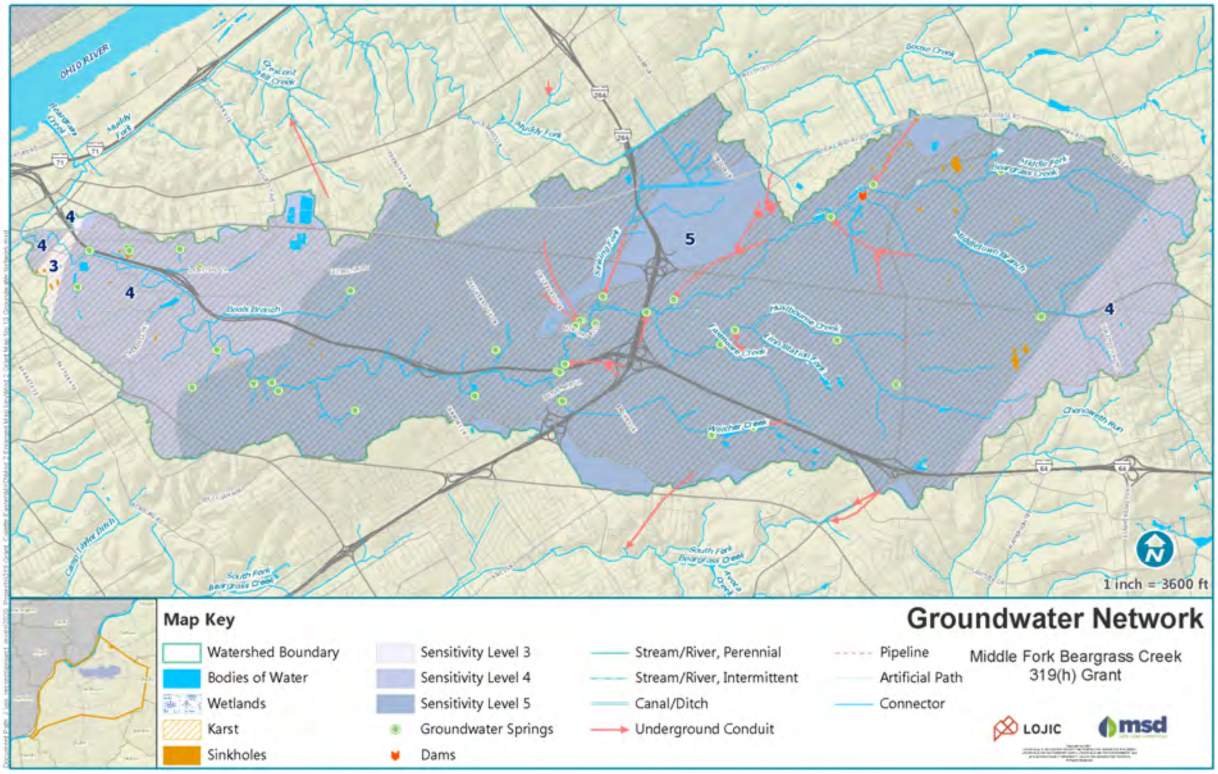

Figure 2.8 Groundwater Network of the Middle Fork Beargrass Creek Watershed

Groundwater Quality: The Kentucky Groundwater Data Repository was queried to obtain nutrient data for wells and springs in Jefferson County, Kentucky. GIS was used to clip the data to the Middle Fork Beargrass Creek watershed boundary. There were 25 sampling sites identified, including 22 springs and three for which the site type was not identified. The following data summary focuses on nutrient data collected from the 22 springs. The springs were sampled between June 20, 2000, and May 4, 2016, and each site was sampled between one and 12 times. Results are summarized on Table 2.3.

Table 2.3 Water Quality Data for Springs in the Middle Fork Beargrass Creek Watershed

Parameter	Sample Count	Minimum Concentration (mg/L)	Average Concentration (mg/L)	Maximum Concentration (mg/L)
Ammonia-N	22	0.02	0.082	0.775
Ammonia-N (Colorimetric)	4	0.02	0.040	0.1
Nitrate	4	8.7	19.550	30.3
Nitrate-N	22	0.01	3.199	6.85
Nitrite	4	0.002	0.013	0.027
Nitrite-N	22	0.002	0.028	0.102

Parameter	Sample Count	Minimum Concentration (mg/L)	Average Concentration (mg/L)	Maximum Concentration (mg/L)
Orthophosphate	4	0.156	0.533	0.921
Orthophosphate-P	22	0.025	0.073	0.3
Phosphorus	20	0.018	0.086	0.467
Phosphorus, Total Recoverable	4	0.05	0.163	0.27
Total Kjeldahl Nitrogen	5	0.08	0.270	1.03

Most of the nutrient concentrations were low, with the exception of nitrate concentrations above 10 mg/L in three springs that were sampled on June 20, 2000. A spring near Trinity Road and Beals Branch Road had a nitrate value of 14.6 mg/L (90002175). A spring near Spring Drive and Cowling Avenue had a nitrate value of 24.6 mg/L (90002232). A spring near Bickel Road and South Ewing Avenue had a nitrate value of 30.3 mg/L (90002241). The Trinity Road and Bickel Road springs are located north of I-64. The Spring Drive spring is located outside of Cherokee Park. Given the distance, it is not likely that the water quality of the Middle Fork Beargrass Creek would be significantly affected.

DOW performed dye tracing and analysis for *E. coli* bacteria, nutrients, metals and other water quality parameters in 30 springs in Beargrass Creek in Jefferson County and 16 springs in Sinking Creek in Breckinridge County between April 2004 and March 2009 (Blair, R. J. and J. A. Ray, 2009).

The springs studied by DOW in the Middle Fork Beargrass Creek watershed were along the mainstem or tributaries, with the exception of Breckinridge Spring, which is located at the Bowman Field airport. Discharge from the springs ranged from 0.01 to 1.1 cfs, with an average of 0.3 cfs. The total discharge from the studied springs was estimated to be 5.46 cfs. Discharge from the springs is locally important to maintaining base flow during dry periods but is relatively small compared to stream discharges.

Springs in the Middle Fork Beargrass Creek had low or non-detected levels of metals and pesticides, but concentrations of nutrients, including nitrate and total phosphorus, were elevated above index values used in the report. Concentrations of *E. coli* bacteria were elevated in all but one spring, Breckinridge Spring.

Dye tracing studies identified exfiltration from the sewage collection system into springs, and infiltration of spring water into the collection system was common in this watershed. Several factors contributed to this finding, including location of sewer lines along the creek, shallow placement of the lines and the age of the collection system. MSD is aware of these collection system issues and has developed a priority ranking for addressing them. Addressing the issues associated with the aging infrastructure in the Middle Fork Beargrass Creek is a priority for MSD.

The National Water Quality Monitoring Council Water Quality Portal was queried to identify monitoring locations in Jefferson County, Kentucky. GIS was used to clip the data to the Middle Fork Beargrass Creek watershed boundary. The available site information for these sites was queried from the USGS National Water Information System (NWIS) database. The NWIS database included 10 stream sites, one spring, five wells and two atmosphere sites. The data was collected between 1946 and 1998 and was considered to be outdated for the purpose of this watershed plan.

2.2.4 Flooding

Flooding is an issue in the Middle Fork Beargrass Creek watershed. There are scientific and regulatory definitions for floodplains and floodways. A stream floodplain is defined as the land adjacent to a stream that is subject to flooding when rainfall causes the stream to exceed its banks. The Federal Emergency Management Agency (FEMA) provides a regulatory context for floodplains in regard to flood insurance through the National Flood Insurance Program (NFIP) and associated regulatory products, including the Flood Insurance Rate Maps (FIRMS). The 1% chance floodplain is a regulatory designation by FEMA that includes the requirement that a structure maintain flood insurance. Due to this regulatory requirement, FEMA includes the 1% chance floodplains on the FIRMs. Floodways are areas that can experience potentially dangerous flowing water during floods. A regulatory floodway, pursuant to FEMA, is the channel of a river, stream or waterbody and the adjacent land that must be reserved in order to discharge the base flood without cumulatively increasing the water surface elevation more than a specific height.

In addition to the FEMA floodplain and floodway requirements, MSD has also developed a Local Regulatory Floodplain. The Local Regulatory Floodplain is an area having a 1% likelihood of being equaled or exceeded in any given year based on a fully developed watershed. Because of the significance of flooding in Louisville due to Ohio River flooding, stream flooding and local drainage issues, MSD has placed additional requirements on land disturbances that affect the local regulatory floodplain and as such, MSD requires permits to build, develop or repair a structure in a floodplain. This permit is required in addition to those from DOW. The Local Regulatory Floodplain and the NFIP floodplains are depicted on Figure 2.9.

Floodplain maps are available on MSD's website: https://louisvillemsd.org/programs/floodplain-management/maps. The Commonwealth of Kentucky developed the Kentucky Flood Hazard Portal https://watermaps.ky.gov/RiskPortal/, which is an interactive tool to view the FIRM data in Kentucky, including the Middle Fork Beargrass Creek.

Louisville Metro also participates in the NFIP's Community Rating System (CRS), which is administered by MSD. The CRS is a voluntary incentive program that recognizes and encourages community floodplain management practices exceeding the minimum requirements of the NFIP. Based on the amount of reduced flood risk resulting from the community's efforts, CRS Communities are classified on a scale of 1-10 and receive discounts on flood insurance premiums ranging from 5% up to 45% depending upon the rating. Since 2015, MSD has achieved a Class 3 rating and Jefferson County residents receive up to a 35% discount on flood insurance premiums.

There are several parks located along the Middle Fork Beargrass Creek. These parks provide open space where flooding can occur without property damages and allow recreational use during drier periods. Cherokee Park and Seneca Park, which are owned by Louisville Metro, are located along Middle Fork Beargrass Creek in the Highlands neighborhood. There are also two parks located in the City of St. Matthews—Brown Park and Arthur K. Draut Park—which are located in the floodplain along the Middle Fork Beargrass Creek near Bowling Boulevard (MSD, 2017b).

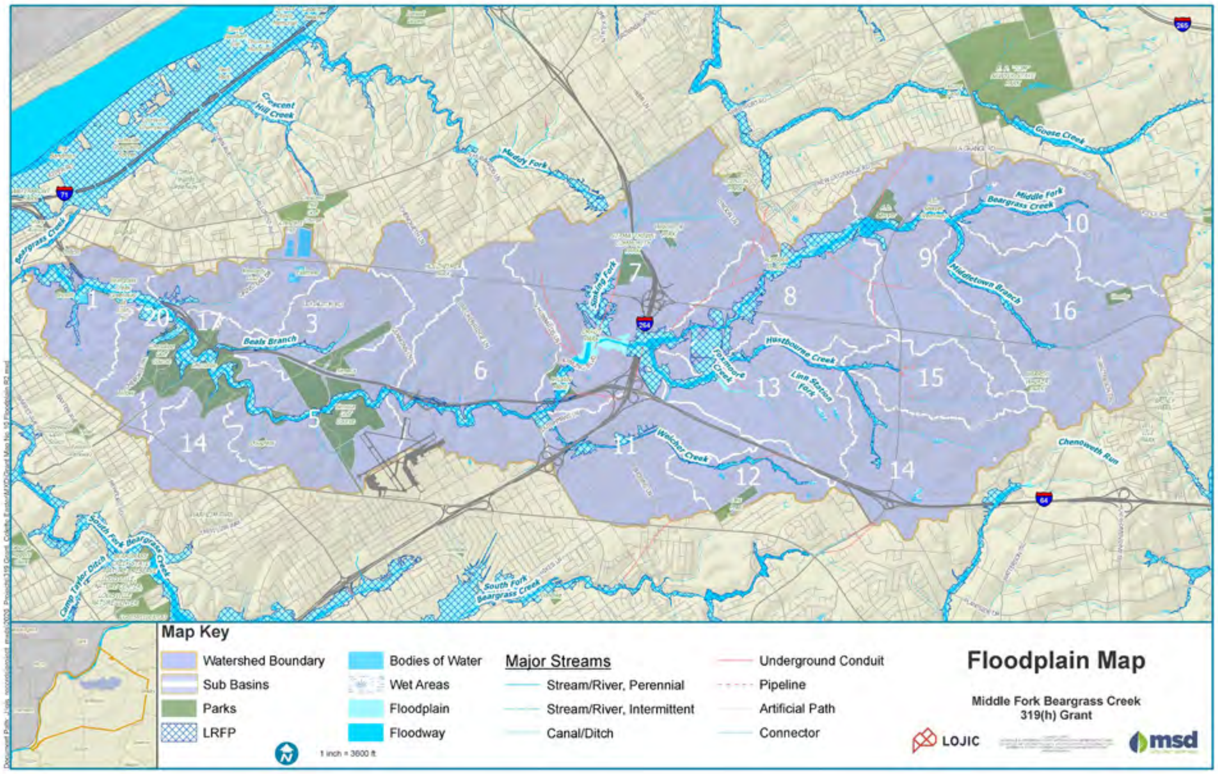

Figure 2.9 Floodplain Map

Improvements have been made in the Middle Fork Beargrass Creek watershed to reduce flooding. The Whipps Mill Basin is a regional flood storage basin owned by MSD that is situated in the upper portion of the Middle Fork Watershed. It is a 21-foot high municipal dry dam, built in 2000, which covers a 40-acre site, providing flood protection for hundreds of residents. The Whipps Mill dam is the only dam regulated by DOW within the watershed. This dam is considered a Class C dam, indicating a high hazard risk. Figure 2.10 displays the location of the Whipps Mill dam within the watershed.

MSD inspects Class C dams under its responsibility, including the Whipps Mill dam, on a quarterly basis. The quarterly inspections address aspects of the dam facility including: access roads, riprap and erosion protection, berm condition including potential sources of piping failure, concrete spillways, inlets and outlets, and control valves. Inspections are visual, and any deficiencies identified by MSD inspectors are addressed by MSD maintenance crews. MSD's practices meet or exceed current industry standards for the four major categories (MSD, 2017a). MSD submits quarterly inspection reports to DOW and DOW performs dam safety inspections annually. More information regarding MSD's Flood Preparedness program can be found at: https://louisvillemsd.org/programs/floodplain-management/flood-preparedness and information about Division of Water's dam safety program can be found at https://eec.ky.gov/Environmental-Protection/Water/FloodDrought/Pages/DamSafety.aspx.

The Woodlawn Park Basin is a regional basin located on an approximately five-acre site in the central portion of the Middle Fork Beargrass Creek watershed.

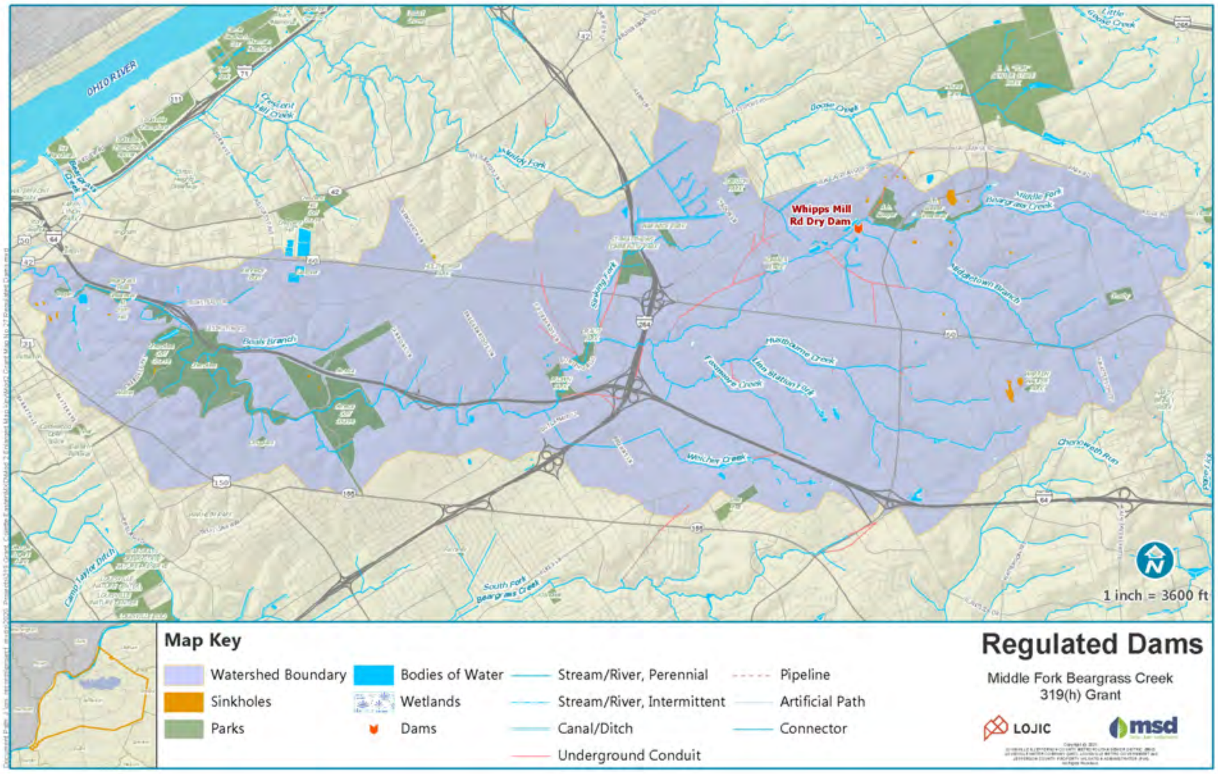

Figure 2.10 Location of Regulated Dam

There are currently 64 local detention basins located in the Middle Fork Beargrass Creek watershed, which are depicted in Figure 2.11. These basins detain stormwater after storms and play a role in reducing the frequency and severity of flooding. They also serve to improve stormwater quality by allowing suspended solids to settle during the holding period. Some detention basins are owned, maintained and operated by MSD, and others are the responsibility of private entities.

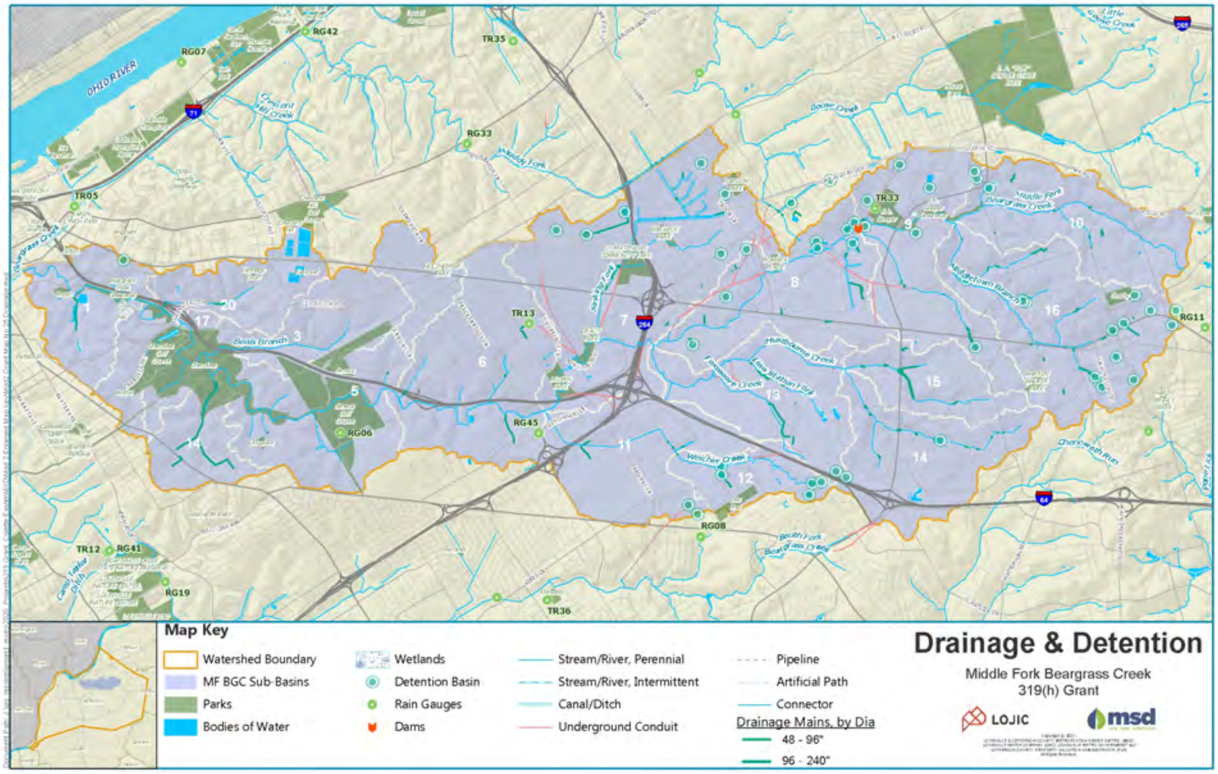

Figure 2.11 Detention Basins

2.2.5 Regulatory Status of Waterways

The United States Environmental Protection Agency (EPA) is responsible for overseeing the requirements of the Clean Water Act (CWA). The CWA regulates discharges of point source and nonpoint source pollutants into waters of the United States and establishes the mechanism to enforce water quality standards. In general, it requires that the waters of the nation be drinkable, swimmable and fishable. (DOW, Undated).

To support the drinkable, swimmable, fishable goals, the CWA requires states to establish and enforce legal limits of pollution for surface waters in water quality standards. In Kentucky, the legal limits of pollution are set for a variety of parameters such as bacteria (*E. coli*), dissolved oxygen, metals, temperature and pH in Surface Water Standards established in 401 KAR 10.

As a part of the legal limits of pollution, Kentucky designates uses for each body of water. The designated uses of the Middle Fork Beargrass Creek are: Primary Contact Recreation (PCR), Secondary Contact Recreation (SCR) and Warm Water Aquatic Habitat (WAH). Fish Consumption (FC) is an implied designated use. These designated uses are defined briefly below, with additional information available in the Watershed Planning Guidebook for Kentucky Communities, 1st Edition (KWA and DOW, 2010) and Kentucky's Water Health Guide (DOW, Undated) as well as in the regulations in 401 KAR 10.

- **Primary Contact Recreation (PCR):** refers to swimming or other activities where submersion may occur and water could be swallowed. The PCR season is May 1 through October 31.

- **Secondary Contact Recreation (SCR):** refers to fishing, boating, wading or other activities where parts of skin come in contact with the water, but submersion does not occur. The SCR requirements are in effect year-round.
- **Warm Water Aquatic Habitat:** refers to a healthy variety of animals that live in water.
- **Fish Consumption:** refers to the safety of eating the fish.

DOW waterbody assessment protocols are described in Consolidated Assessment and Listing Methodology: Surface Water Quality Assessment in Kentucky, the Integrated Report, DOWSOP03036 (DOW, 2015). DOW compiles water quality data from their monitoring programs as well as data submitted by other entities. Data are reviewed for quality and completeness, and final data are used to assess the status of waterbodies for the Integrated Report. Designated uses are assessed independently, i.e., a waterbody may fully support one or more designated use(s) but be impaired for one or more other designated use(s). DOW assessment categories as shown in the Consolidated Assessment and Listing Methodology are shown on Table 2.4.

Table 2.4 DOW Assessment Categories

Category	Definition
1	All designated uses for waterbody Fully Supporting
2	Assessed designated uses is/are Fully Supporting, but not all designated uses assessed
2B	Segment currently supporting uses, but 303(d) listed and proposed to EPA for delisting
2C	Segment with an EPA approved or established TMDL for the following uses now attaining Full Support
3	Designated uses have not been assessed (insufficient data)
4A	Segment with an EPA approved or established TMDL for listed uses not attaining Full Support
4B	Nonsupport segment with an approved alternative pollution control plan (e.g., BMP) stringent enough to meet full support level of all uses within a specified time
4C	Segment does not support designated uses, but this is not attributable to a pollutant or combination of pollutants
5	TMDL is required
5B	Segment does not support designated uses based on evaluated data, but based on KY listing methodology, insufficient data are available to make a listing determination; no TMDL needed

The EPA reviews the Integrated Report, including any proposals from DOW to remove waterbodies from Category 5, TMDL required, (i.e., delist). EPA has approval authority over Category 5. In addition to the assessment category, DOW also identifies pollutants and suspected sources in the Integrated Report. Suspected sources that are considered to be nonpoint sources are listed in the 319(h) grant guidance document (DOW, 2019). The most recent Integrated Report to Congress on the Condition of Water Resources in Kentucky, with data from 2016, was published in 2018 (DOW, 2018). The current regulatory status for waterbodies in Middle Fork Beargrass Creek watershed is shown on Table 2.5 and Figure 2.12.

Table 2.5 Regulatory Status of Middle Fork Beargrass Creek Waterbodies

Waterbody	WAH	Primary Contact	Assessment Category (1)	Causes	Sources (3)
Middle Fork Beargrass Creek 0.0 to 2.0	5-NS	4A-NS	5	Habitat assessment, Fecal coliform, Nutrient/ Eutrophication Biological Indicators, Organic Enrichment (Sewage) Biological Indicators	Channelization, sanitary sewer overflows (collection system failure), urban runoff/ storm sewers
Middle Fork Beargrass Creek 2.0 to 2.9	2-FS	4A-NS	4A **(2)**	Fecal coliform	Sanitary sewer overflows (collection system failure), urban runoff/storm sewers
Middle Fork Beargrass Creek 2.9 to 15.3	2-FS	4A-NS	4A **(2)**	Fecal coliform	Illegal dumps or other inappropriate waste disposal, sanitary sewer overflows (collection system failure), urban runoff/storm sewers

Notes:

1. Assessments were not performed for secondary contact and fish consumption
2. Stream segment in Assessment Category 4A because Total Maximum Daily Load for Fecal Coliform: Six Stream Segments within the Beargrass Creek Watershed, Jefferson County, Kentucky, was approved in 2011.
   Channelization, urban runoff/storm sewers and illegal dumps or other inappropriate waste disposal are classified as nonpoint sources of pollution per KDOW, 2019.

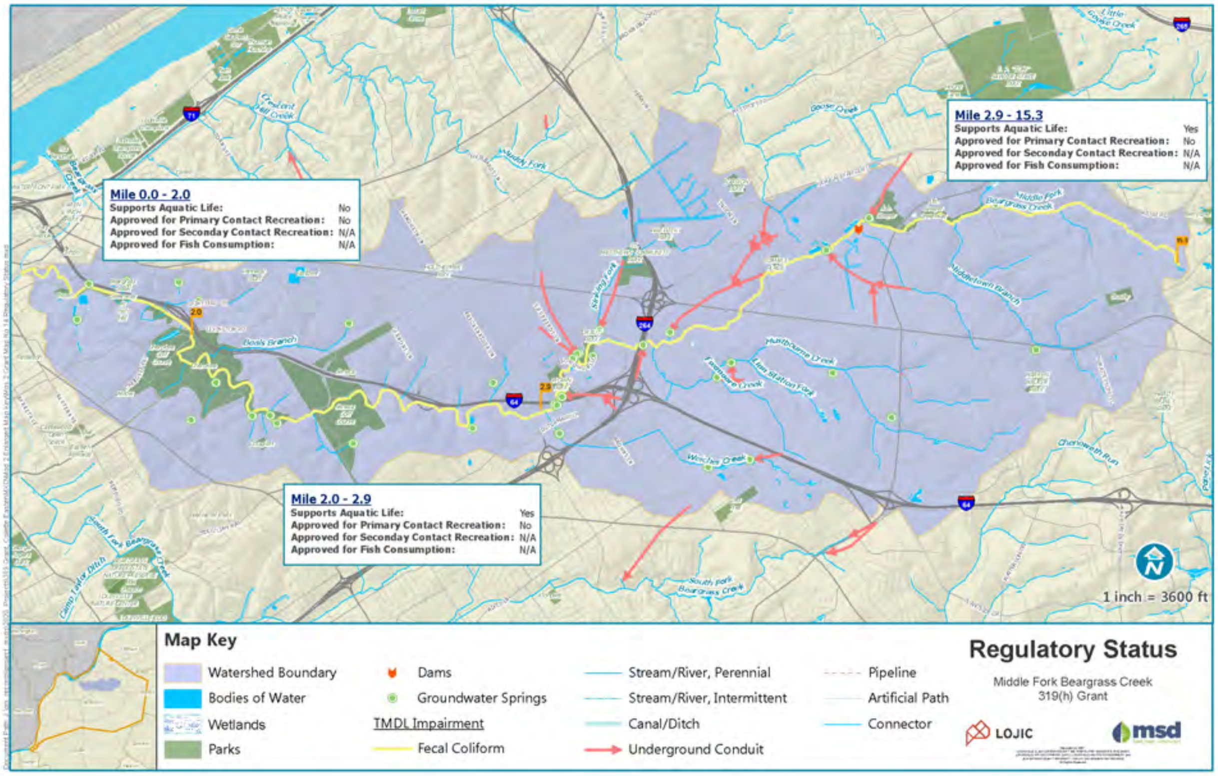

Figure 2.12 Regulatory Status of Middle Fork Beargrass Creek Waterbodies

2.2.6 Water Chemistry and Biology

MSD conducts monitoring county-wide throughout the MS4 service area as required by the MS4 Permit. The Long-Term Monitoring Network (LTMN) was established in 1999 and includes three monitoring locations in the Middle Fork Beargrass Creek watershed: Browns Lane (EMIMI009), which drains 15.2 square miles, Old Cannons Lane (EMIMI002), which drains 18.9 square miles, and Lexington Road (EMIMI010), which drains 24.8 square miles (Louisville and Jefferson County MSD, 2017). These sampling locations are depicted in Chapter 1 on Figure 1.6 and further supported by Table 2.6.

Table 2.6 Middle Fork Beargrass Creek Monitoring Locations

Map ID	Station ID (DOW, MSD, USGS)	Waterbody	Location	River Mile	Drainage Area (mi^2)	Latitude	Longitude
1	DOW - DOW08047007 MSD - EMIMI010 USGS - 03293500	Middle Fork Beargrass Creek **(1,2)**	Lexington Road	0.9	24.8	38.250276	-85.716868
2	DOW - DOW08047008 MSD - EMIMI002 USGS - 03293000	Middle Fork Beargrass Creek **(1,2)**	Old Cannons Lane	5.4	18.7	38.23729	-85.66468

Map ID	Station ID (DOW, MSD, USGS)	Waterbody	Location	River Mile	Drainage Area (mi^2)	Latitude	Longitude
3	MSD - EMIMI009	Middle Fork Beargrass Creek **(2,3)**	Browns Lane	7.97	15.2	38.2403	-85.6345
4	DOW - DOW08047010	Weicher Creek **(4)**	Above Blossom-wood Drive	0.55	1.3	38.23016	-85.63071
5	MSD - EMIMI033	Weicher Creek	Lincoln Road	1.56	0.57	38.22902	-85.61491
6	DOW - DOW08047009 MSD - EMIMI038	Middle Fork Beargrass Creek UT 8.45 (Sinking Fork)	Below Bowling Boulevard	0.3	2.6	38.24683	-85.62881
7	DOW - DOW08047011 MSD - EMIMI039	Middle Fork Beargrass Creek UT 9.1	Off Steeplecrest Circle	0.2	3.9	38.24093	-85.61867
8	DOW - DOW08047012 MSD - EMIMI040	Middle Fork Beargrass Creek	Off Old Whipps Mill Road	11.7	5	38.25984	-85.58529
9	MSD - EMIMI041	Middle Fork Beargrass Creek **(3)**	Forest Bridge Road	12.38	4.07	38.26126	-85.57434
10	DOW - DOW08047013 MSD - EMIMI042	Middle Fork Beargrass Creek UT 12.8	Above Foxboro Road	0.2	2.2	38.25867	-85.5668

Notes:

1. USGS Gages record stream discharge; MSD/USGS sondes record pH, DO, temperature, conductivity on 15-minute intervals: 03293500, 03293000
2. MSD LTMN sites: EMIMI010, EMIMI002, EMIMI009
3. MSD 319(h) monitoring site, not sampled by DOW 319(h) monitoring
4. MSD not monitoring this site for 319(h) monitoring; DOW monitored this site, but it is an intermittent tributary, so MSD discontinued this site

Per MS4 Permit requirements, monitoring includes:

- MS4 Quarterly and Recreation Season
- Wet Weather Water Quality Monitoring
- Biological and Habitat
- Continuous Monitoring (sonde)
- Stream Flow Discharge

MS4 Quarterly and Recreation Season: Trained MSD staff collect quarterly water quality samples, typically in January, April, July and October of each year. During the May 1 to October 31 recreation season, five bacteria samples are collected each month at each LTMN site. Samples are analyzed at MSD's laboratory located at the Morris Forman WQTC using analytical methods approved by the EPA. As required by the MS4 permit, the sample results are compared to available water quality criteria found in 401 KAR 10:031.

As reported in the 2019 MS4 Annual Report, average TSS concentrations at the Middle Fork of Beargrass Creek were 9.13 mg/L at Browns Lane, 7.38 mg/L at Old Cannons Lane and 5.38 mg/L at Lexington Road. Average total nitrogen was 2.70 mg/L at Browns Lane, 2.15 mg/L at Old Cannons Lane and 2.08 mg/L at Lexington Road. The average oil and grease concentrations were 1.50 mg/L at Browns Lane, 1.50 mg/L at Old Cannons Lane and 2.63 mg/L at Lexington Road. All quarterly samples were less than the hardness dependent chronic aquatic life criteria for copper. Average (geometric mean) concentrations of *E. coli* bacteria ranged from 373 MPN/100 mL to 3,382 MPN/100 mL in samples collected at the three monitoring locations in the Middle Fork of Beargrass Creek watershed. The water quality criteria for *E. coli* bacteria were not met in any of the six months during the recreational season at the monitoring sites at Browns Lane, Old Cannons Lane and Lexington Road.

As reported in the 2016 State of the Streams Report, which describes status and trends between 1999-2015, total nitrogen, phosphorus, ammonia, suspended solids and trace metal concentrations were low; however, nitrate concentrations were elevated at Browns Lane. Fecal coliform bacteria concentrations at Browns Lane were some of the highest in the Louisville Metro — and were getting worse. At Old Cannons Lane, total nitrogen, ammonia, phosphorus and suspended solids concentrations were low; however, nitrate concentrations were elevated. Trace metal concentrations exceeded aquatic life criteria more often than most other monitoring sites. Fecal coliform bacteria concentrations were consistently elevated. At Lexington Road, nitrate, ammonia and total nitrogen concentrations were low; however, phosphorus and suspended solids concentrations were elevated. Metals concentrations exceeded aquatic life criteria more often than other monitoring sites. Fecal coliform bacteria concentrations were elevated but improving.

Wet Weather Monitoring: Pursuant to the MS4 permit, MSD collects three wet weather samples during each five-year permit term. MSD has focused wet weather sampling on the May 1 to October 31 recreation season. Between 2013 and 2020, MSD has collected samples during four storms. The dates of these storms are September 20, 2013; July 26, 2014; June 23, 2017; and June 21, 2019. In 2021, MSD revised the sampling protocol for wet weather events. From 2013-2020, the wet weather sampling protocol for conducting a wet weather event included a prediction of at least 0.50 inches of precipitation in a six hour period across the sampling area with less than 0.1 inches of rain in the preceding 48 hours. MSD implemented a pilot project in 2021 to modify the protocol for a wet weather event to require a minimum of 0.10 inches of rainfall, following at least 48-hour period of little to no rain. MSD rain gauges located within Jefferson County continue to be used to monitor antecedent conditions for wet and dry sampling events via this website: http://raingauge.louisvillemsd.org/. It is anticipated that MSD will continue to summarize and analyze the data collected during the wet weather events.

Biological Communities and Aquatic Habitat Assessments: MSD contracted with trained professional biologists to collect biological community and aquatic habitat data using protocols developed by EPA and DOW approximately every two years. Biological data collection includes fish, benthic macroinvertebrate and algal communities. Benthic macroinvertebrates are animals that live on, in or around the bottom of streams, do not have backbones and can be seen without a microscope. They are often the immature forms, or larvae, of insects that live on land as adults. Using DOW protocols, visual assessments of aquatic habitat conditions were collected concurrently with fish and benthic macroinvertebrate sampling.

Using DOW protocols, the species data for each biological community are used to calculate a numerical score (i.e., index) and narrative rating. DOW biologists developed indices for Fish (KIBI – Kentucky IBI), Macroinvertebrates (MIBI or sometimes MBI) and Algae (Diatom Biotic Index – DBI). Watershed drainage area is used to scale assessment scores. The three LTMN sites are classified as wadeable streams by DOW protocols for benthic macroinvertebrate assessments. (DOW, 2015)

The indices are based upon community structure including level of tolerance to pollution and stream disturbance as well as function (i.e., the role that the organism has in the ecosystem). The number of individuals, community structure and function are used to calculate a numerical index from the sample, which is then converted to a narrative rating.

As reported in the 2019 MS4 Annual Report, benthic communities were rated as poor at Browns Lane and at Old Cannons Lane and were rated as fair at Lexington Road, based on data collected in spring 2017. Fish communities were rated as fair at Browns Lane and at Old Cannons Lane and poor at Lexington Road, based on data collected in the fall of 2017. Habitat quality was rated as fair at Browns Lane, good at Old Cannons Lane and fair at Lexington Road, based on data collected in 2017. Algal communities were rated as fair at Browns Lane, good at Old Cannons Lane and excellent at Lexington Road in 2017.

As reported in the 2016 State of the Streams Report, at Browns Lane, the health of fish communities was fair and improving, aquatic insect communities were consistently fair and algal communities were good but declining. Aquatic habitat was fair and improving. At Old Cannons Lane, health of fish communities was fair and declining, aquatic insect communities were fair and improving and algal communities were good but declining. Aquatic habitat was consistently good. At Lexington Road, health of fish communities was poor and improving, aquatic insect communities were consistently fair and algal communities were consistently excellent. Aquatic habitat was fair and declining.

Macroinvertebrate sampling was performed at 27 designated LTMN sites in and around Jefferson County in May 2019. Three of the sites are located within the Middle Fork Beargrass Creek watershed at Browns Lane, Old Cannons Lane and Lexington Road. The Browns Lane and Old Cannons Lane monitoring sites were sampled on May 9, 2019. The Lexington Road monitoring site was sampled on May 17, 2019. MSD has historically conducted macroinvertebrate community assessments in May and June, and this timeframe falls within the end of the sampling index period for headwater streams (March through May) and the beginning of the index period for wadable streams (May through September) as designated by DOW. The monitoring sites within Middle Fork Beargrass Creek were classified as wadable streams with watersheds greater than five square miles. (Redwing, 2019)

DOW has developed a multi-metric approach to evaluate the biotic integrity of macroinvertebrate communities called the Macroinvertebrate Bioassessment Index (MBI). Metric criteria are based on regional reference data and stream size. The MBI can be used to rank the quality of stream reaches affected by urban development, agricultural activities, residential/commercial development, or road and bridge construction. The monitoring locations within the Middle Fork watershed are within the Bluegrass (BG) Bioregion. The MBI scoring criteria for the narrative ratings range from excellent to very poor as shown in Table 2.7. The MBI narrative ratings for the Middle Fork Beargrass Creek monitoring sites are rated as "poor" as shown in Table 2.8 (Redwing, 2019).

Table 2.7 MBI Scoring Criteria for Narrative Ratings in the Bluegrass Bioregion

Wadable (5 mi^2 to 200 mi^2) Ratings	
Narrative Rating	**Score**
Excellent	≥ 70
Good	61-69
Fair	41-60
Poor	21-40
Very Poor	0-20

Table 2.8 MBI Results in Middle Fork for the 2019 Macroinvertebrate Community Assessment

Station Name	MBI Score	Description	Watershed Area (mi^2)
Middle Fork at Browns Lane	32.4	Poor	15.2
Middle Fork at Old Cannons Lane	27.8	Poor	18.9
Middle Fork at Lexington Road	38.5	Poor	24.8

Habitat assessment results can be used to supplement biological and physicochemical data for determining the overall health of a sampling reach. Habitat criteria were developed relative to stream size and bioregion based on the DOW's *Methods for Assessing Habitat in Wadable Waters.* The Rapid Bioassessment Protocol (RBP) scoring criteria for narrative ratings range from Good to Poor as shown in Table 2.9. The RBP narrative ratings for the Middle Fork Beargrass Creek monitoring sites are rated as Fair to Good as shown in Table 2.10 (Redwing, 2019).

Table 2.9 RBP Scoring Criteria for Narrative Ratings in the Bluegrass Bioregion

Wadable (5 mi^2 to 200 mi^2) Ratings	
Narrative Rating	**Score**
Good (fully supporting)	≥ 130
Fair (partially supporting)	114-129
Poor (non-supporting)	0-113

Table 2.10 RBP Results in Middle Fork for the 2019 Macroinvertebrate Community Assessment

Station Name	RBP Score	Description	Watershed Area (mi^2)
Middle Fork at Browns Lane	114	Fair	15.2
Middle Fork at Old Cannons Lane	137	Good	18.9
Middle Fork at Lexington Road	127	Fair	24.8

Continuous Monitoring (Sonde): Louisville MSD and the USGS operate a cooperative continuous monitoring (sonde) program as part of the MS4 permit monitoring. MSD purchases, calibrates and maintains sonde equipment, and USGS reviews and houses the data in their National Water Information System (NWIS) database. In the Middle Fork Beargrass Creek watershed, sonde data are available from Old Cannons Lane and Lexington Road. The sonde at Browns Lane does not have telemetry capabilities, so the data are manually downloaded and stored at MSD. Since these data are considered provisional, they have not been analyzed and reported.

As reported in the 2019 MS4 Annual Report, final continuous monitoring data were available between April 1, 2018, and June 30, 2019, in the Middle Fork Beargrass Creek at Old Cannons Lane and Lexington Road. During this period, the temperature data set was 95.0% complete at Middle Fork Beargrass Creek at Old Cannons Lane and 93.6% complete at Middle Fork Beargrass Creek at Lexington Road with 100% of available values meeting the temperature criterion. At Old Cannons Lane, the dissolved oxygen record was 94.7% complete, average dissolved oxygen was 8.8 mg/L and the dissolved oxygen criteria were met 98.1% of the days with a complete record. At Lexington Road, the dissolved oxygen record was 78.9% complete, average dissolved oxygen was 6.9 mg/L and the dissolved oxygen criteria were met 67.8% of the days with a complete record. During this time period, the pH data set was 94.1% complete at Middle Fork Beargrass Creek at Old Cannons Lane and 90.8% complete at Middle Fork Beargrass Creek at Lexington Road, and 100% of available values met the pH criterion. The specific conductance record was 71.9% complete at Middle Fork Beargrass Creek at Old Cannons Lane and 80.0% complete at Middle Fork Beargrass Creek at Lexington Road. Specific conductance ranged from 65 uS/cm to 1,640 uS/cm at these two sites.

Status and trends in dissolved oxygen were reported in the 2016 Synthesis Report using data collected 2005 to 2015. The average daily dissolved oxygen concentration was calculated from readings collected at 15-minute intervals. Days with more than half of the data available were included in the analysis.

At Old Cannons Lane, the dissolved oxygen criteria were met 98% of the time and improved 15% between 2005 and 2015. At Lexington Road, the dissolved oxygen criteria were met 76% of the time and improved 10% between 2005 and 2015.

Fecal Coliform TMDL for Beargrass Creek: Fecal coliform data collected by MSD between 2000 and 2004 were used to develop the Final TMDL for Fecal Coliform Six Stream Segments within the Beargrass Creek Watershed (DOW, 2011). In addition to the three LTMN sites, MSD also monitored a site along Lexington Road (EMIMI004). The results excerpted from the TMDL Appendix A, shown on Figure 2.13 highlight significantly elevated levels of fecal coliform bacteria, especially prior to March 2002.

Final
Beargrass Creek Fecal coliform TMDL December, 2011

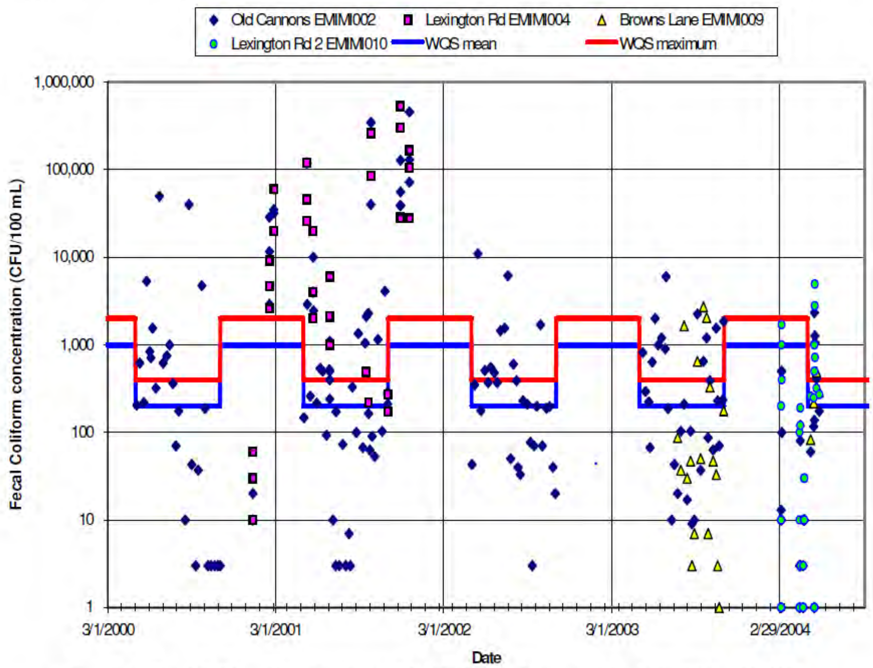

Figure A.2 Fecal Coliform Observations in Middle Fork of Beargrass Creek (3/1/2000 – 9/1/2004)

Figure 2.13 Fecal Coliform Bacteria Data Used in Beargrass Creek TMDL

Stream Gaging: Stream discharge measurements were described in Section 2.2.2 Hydrology.

2.2.7 Salt River Watershed Watch

Salt River Watershed Watch (SRWW) is a non-profit group of almost 100 volunteers who give their time to improve streams in the Salt River Basin through a coordinated campaign of water quality monitoring, skills development, water improvement projects, and environmental education.

Watershed Watch in Kentucky (WWKY) is the statewide organization that coordinates volunteer monitoring across Kentucky. WWKY is one of seven watershed groups that monitor streams, rivers and lakes across our state. Additional information regarding WWKY can be found on their website: https://www.kywater.org/.

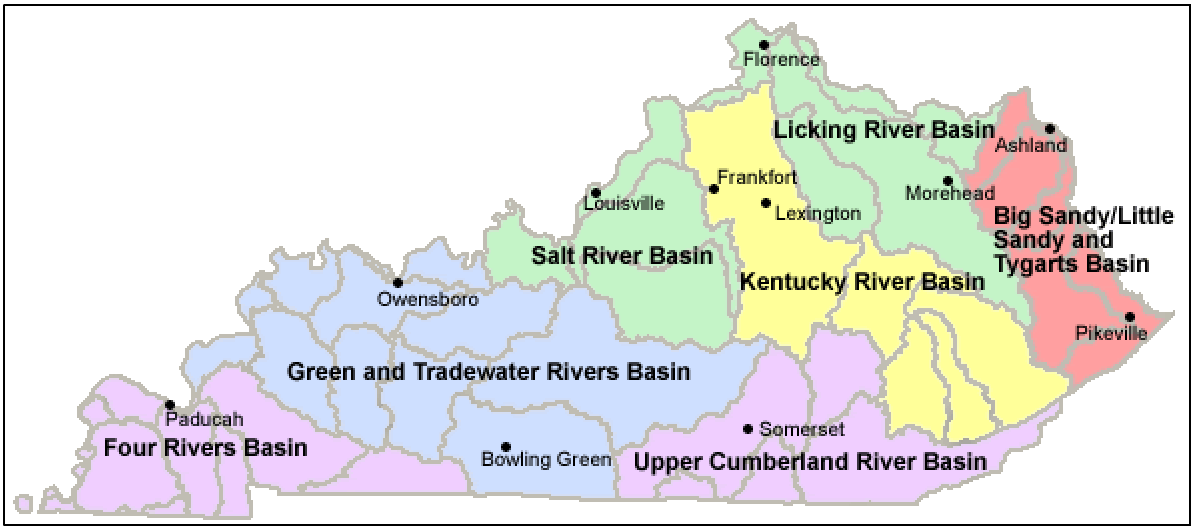

Figure 2.14 Watershed Watch in Kentucky Basins

SRWW holds free training workshops each spring to train new volunteers and recertify existing volunteers. Recertification training is required every three years. The training program was standardized by WWKY. Hach and LaMotte water test kits are loaned to trained volunteers so they can test water quality (i.e., pH, dissolved oxygen, conductivity, temperature). SRWW volunteers choose a stream to monitor, or program leaders to assist new volunteers with establishing a monitoring site. Volunteers calibrate their conductivity meter using standard solution, then use test kits and collect bacteria samples three times each year on the second Saturdays in May, July and September. Volunteers also record 48-hour rainfall, observations of stream flow and turbidity. Stream biology and habitat are studied each June. Bacteria samples are analyzed at a professional laboratory. Water quality and bacteria results are reviewed by data managers in each basin, including SRWW. Final, approved data are publicly available through the Watershed Watch Data Portal managed by the Kentucky Geological Survey and University of Kentucky: http://kgs.uky.edu/wwky/main.htm. Figure 2.15 provides an example of data available through the Watershed Watch Data Portal.

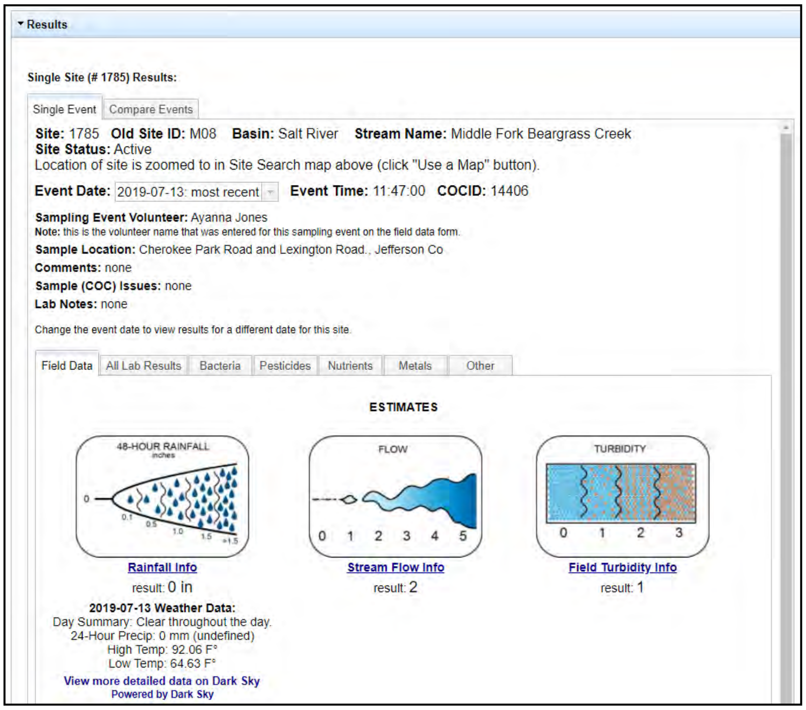

Figure 2.15 Watershed Watch Data Portal Example Data

In addition to the monitoring program, SRWW works with other organizations and agencies to plant native trees, shrubs, and plants along streams. SRWW environmental education efforts include working with middle and high schools to support water quality science fair projects, class projects and field trips to local streams. Numerous canoe trips are offered in partnership with River City Paddle Sports.

A free conference is hosted each year, typically in February to present and discuss monitoring results and projects. This event is open to volunteers and anyone who is interested in SRWW. Additional information regarding SRWW can be found on their website: www.srww.org.

2.2.7.1 SRWW Monitoring Sites in Middle Fork Beargrass Creek

The Kentucky Geological Survey (KGS) database was queried to obtain data from Jefferson County on March 17, 2021. The data are included in Appendix 2.1. The data were mapped using location data from the KGS database and Google Map to concretely identify sites in the Middle Fork Beargrass Creek watershed. While SRWW has been monitoring streams since 1999, the earliest data available in the Middle Fork Sites, from upstream to downstream are shown on Table 2.11 and Figure 2.16.

Table 2.11 SRWW Monitoring Sites in Middle Fork Beargrass Creek Watershed

Site ID	Stream Name	Site Location	Latitude	Longitude	Initial Result	Last Result
3841	Middle Fork Beargrass Creek	Middle Fork Beargrass Creek along Forest Green Trail, Louisville, Jefferson Co.	38.26297	-85.56329	5/11/2019	9/26/2020
3386	Middle Fork Beargrass Creek	Arthur Draut Park	38.24378	-85.63026	5/16/2015	5/12/2018
1841	Middle Fork Beargrass Creek	J. Graham Brown Park, downstream from Browns Ln bridge.	38.238	-85.634	7/12/2014	9/25/2020
1784	Middle Fork Beargrass Creek	Old Cannons Lane.	38.2383	-85.6638	6/7/2014	9/15/2018
1899	Bowman Field Spring	Intersection of Seneca Valley Rd and PeeWee Reese Ln	38.228	-85.674	5/16/2015	5/14/2016
3656	Middle Fork Beargrass Creek	Seneca Park, about two tenths of a mile from Pee Wee Reese Way. The golf course abuts it on one side.	38.23427	-85.67595	6/20/2017	9/14/2019
2030	Beargrass Creek	Big Rock **(1)**	38.21694	-85.68333	5/19/2012	7/13/2018
1886	Middle Fork Beargrass Creek	Big Rock pavilion in Cherokee Park. **(1)**	38.23375	-85.6846	6/7/2014	5/11/2019
1785	Middle Fork Beargrass Creek	Cherokee Park Road and Lexington Road.	38.24395	-85.69812	7/13/2013	7/13/2019
3361	Middle Fork Beargrass Creek	On Beargrass Creek Road about a half mile before it meets with Lexington Road.	38.24669	-85.70149	5/16/2015	7/8/2017
2068	Middle Fork Beargrass Creek	Bridge at Payne Street	38.25126	-85.71973	9/13/2014	5/13/2017
Note 1. Sites 2030 and 1886 are located on Middle Fork Beargrass Creek at Big Rock.						

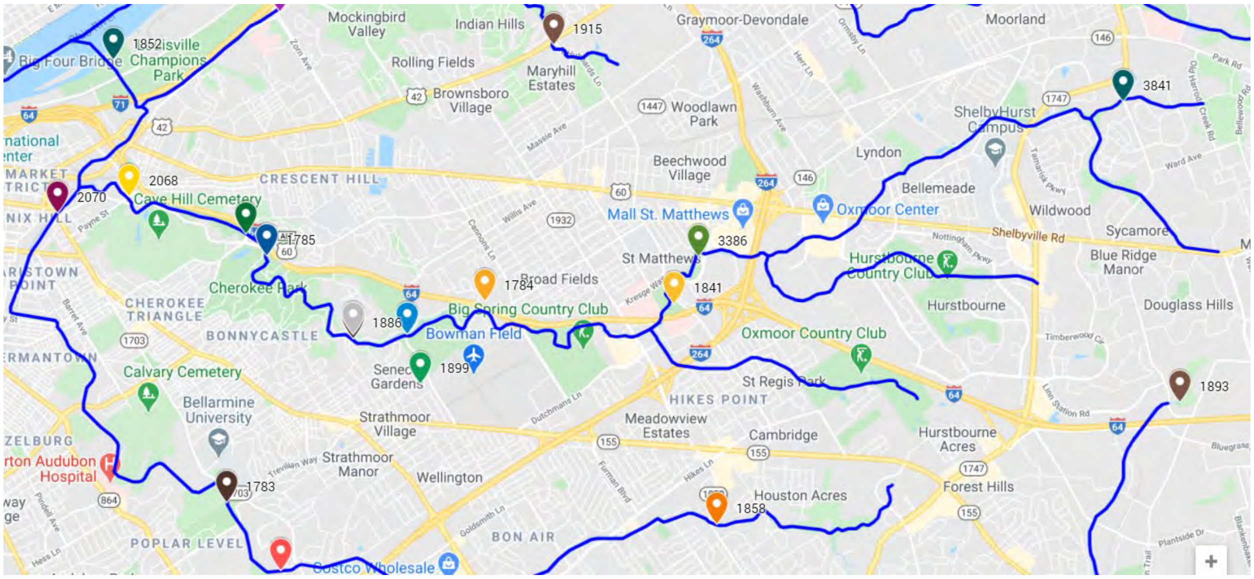

Figure 2.16 SRWW Monitoring Sites in Middle Fork Beargrass Creek Watershed

2.2.7.2 SRWW Monitoring Results for Middle Fork Beargrass Creek Watershed

Dissolved Oxygen: There were 73 dissolved oxygen tests completed and results ranged from 2.0 milligrams per liter (mg/L) to 10 mg/L. Seven results (10%) were less than 4 mg/L, which is the dissolved oxygen criterion for streams in the Middle Fork Beargrass Creek watershed. Sporadic low dissolved oxygen readings were observed in Middle Fork Beargrass Creek at J. Graham Brown Park (Site #1841, 2 results), at Big Rock (Site 2030, 2 results) and near Lexington Road (Site 3361, 2 results). Dissolved oxygen was less than 4 mg/ L at Bowman Field Spring at the Intersection of Seneca Valley Road (Site 1899) in one sample.

pH: The pH of water samples ranged from 5.3 to 8.7 Standard Units. One result collected in September 2016 at J. Graham Park (Site #1841) was below 6.0 Standard Units, which is the minimum criteria for pH.

Temperature: Water temperature ranged from 7.0 to 26 degrees Celsius. All temperature readings met the water quality criteria for temperature.

Conductivity: Specific conductivity ranged from 53 to 780 microsiemens per centimeter (uS/cm). The Kentucky Surface Water Standards regulates conductivity using a narrative criterion.

Bacteria: There were 58 samples collected for *E. coli* bacteria at SRWW sites in the Middle Fork Beargrass Creek. Results ranged from 79 to 7,701 colonies per 100 milliliters (mL). The Kentucky Surface Water Standards criteria for *E. coli* requires concentrations of less than 130 colonies per 100 mL collection of at least five samples in 30 days. Since up to three SRWW samples are collected per year, it is not possible to directly compare SRWW results to the criteria. However, six of nine locations had maximum concentrations of *E. coli* bacteria that exceeded 1,000 MPN/100 mL. The downstream two sites had average concentrations that exceeded 1,000 MPN/100 mL. These results indicate that bacteria concentrations are elevated in the Middle Fork Beargrass Creek. *E. coli* bacteria results are summarized by site on Table 2.12.

Table 2.12 SRWW *E. coli* Bacteria Results for Middle Fork Beargrass Creek

Site ID	Site Location (1)	# Results	*E. coli* Concentration (MPN/100 mL) Minimum	Average	Maximum
3841	Middle Fork Beargrass Creek along Forest Green Trail, Louisville, Jefferson Co.	3	340	399	457
3386	Arthur Draut Park	6	275	467	880
1841	J. Graham Brown Park, downstream from Browns Ln bridge.	11	210	741	1,396
1784	Old Cannons Lane.	4	194	452	1,050
1899	Bowman Field Spring at the intersection of Seneca Valley Rd and Pee Wee Reese Ln	2	196	206	216
3656	Seneca Park, about two tenths of a mile from Pee Wee Reese Way. The golf course abuts it on one side.	8	75	460	1,529
2030	Big Rock	12	185	799	2,020
1886	Big Rock pavilion in Cherokee Park.	2	259	290	320
1785	Cherokee Park Road and Lexington Road.	5	192	1,836	7,701
3361	On Beargrass Creek Road about a half mile before it meets with Lexington Road.	5	124	1,125	2,380
2068	Bridge at Payne Street	0	NA	NA	NA
Note: 1. All sites located on Middle Fork Beargrass Creek, except 1899, which is located at Bowman Field Spring.					

Through a special project conducted by SRWW between 2000 and 2008, fecal coliform bacteria concentrations were intensely monitored in the Middle Fork Beargrass Creek at Big Rock. Big Rock is a streamside recreational area in Cherokee Park. Cherokee Park was designed by noted American landscape architect Frederick Law Olmsted. The “big rock” fell from a cliff above and scouring from floods has created a pool enjoyed by summertime swimmers. Upstream from Big Rock, the level limestone shelves of the stream bottom attract waders of all ages. However, due to known sewer overflow issues, the area is posted with signs warning against contact with the water after storms. Big Rock Bacteria Monitoring Project 1999-2008 Final Report is included as Appendix 2.2.

Volunteers monitored at Big Rock five times per month during the May 1 to October 31 recreation season between May 1, 2000 and May 31, 2008, for a total of 49 months. Results were compared to the Kentucky Surface Water Standard for primary and secondary contact recreation for fecal coliform bacteria.

Primary contact refers to direct contact with water through swimming and secondary contact refers to indirect contact with water through wading or fishing. The primary contact (i.e., swimming) criteria required that fecal coliform content not exceed 200 colonies per 100 mL as a geometric mean of at least five samples collected within 30 days and concentrations shall not exceed 400 colonies per 100 mL in twenty percent or more of those samples. The primary contact criteria were effective during the May 1 to October 31 recreation season.

The secondary contact (i.e., wading or fishing) criteria required that fecal coliform content not exceed 1,000 colonies per 100 mL as a geometric mean of at least five samples collected within 30 days and concentrations shall not exceed 400 colonies per 100 mL in twenty percent or more of those samples. The secondary contact criteria were effective all year. Note that the fecal coliform criteria have been replaced by the *E. coli* criteria.

Per the SRWW report, the primary contact recreation criteria were met in one of 49 sampled months between May 1, 2000 and May 31, 2008. The secondary contact recreation criteria were met in 21 of 49 months. These results highlight the long-term nature of elevated bacteria concentrations in the middle reaches of Middle Fork Beargrass Creek.

Other Data: Between one and five results for nutrients and other parameters are available in the KGS database for SRWW sites in Middle Fork Beargrass Creek. Due to the low number of samples at each site, results were summarized by parameter rather than by site on Table 2.13.

Table 2.13 SRWW Data for Nutrients and Other Parameters

Parameter (1)	# of Results	Minimum	Average	Maximum
Ammonia (as N)	13	0.022	0.089538462	0.269
Chloride	8	13.58	70.54625	106.57
Conductivity	5	184	576	727
Nitrate & Nitrite	8	1	1	1
Nitrate & Nitrite (as N)	5	0.344	1.2498	1.727
Nitrogen, Total	5	0.874	2.013	2.597
Phosphorus, Total	13	0.089	0.129	0.21
Solids, Total Suspended	8	2	9.475	41.8
Sulfate	8	5.3	36.7275	55.9
Total Hardness	8	138	228.5	278
Total Kjeldhal Nitrogen	8	1	1.125	2
Turbidity	5	0	0.4	1
Note 1. All results reported in mg/L except conductivity, which was reported as uS/cm.				

2.2.8 Geomorphological Data

Fluvial geomorphology describes the interaction of moving water on the Earth's surface with the underlying geologic formation, and specifically how the formation of the land surface influences the physical shape of the surface water channels. Factors that influence the geomorphology of a given riverine system include watershed geology, topography, soils composition and climatological factors influencing flow regimes of streams.

Streams are constantly changing because erosion, transport and deposition are continuous processes. The study of these processes and the way they shape the surface of the earth is called geomorphology. These processes affect stream habitat for the animals and plants that live in the stream as well as water quality. Streams and rivers change naturally over time and in response to climate. For example, geomorphic forces occurring over eons formed the Grand Canyon. Streams and rivers are also affected by changes in the landscape caused by human alterations such as agriculture and urbanization. Fluvial geomorphology is an emerging science that explores these relationships.

The Watershed Planning Guidebook for Kentucky Communities, 1st Edition (KWA and DOW, 2010) (the Guidebook) recommends the use of available Rapid Bioassessment Protocol (RBP) data as a qualitative assessment of geomorphic conditions of streams in the watershed. MSD has collected these data concurrently with benthic and fish community assessments approximately every other year since 2005 for a total of nine assessments. Generally, the same team of professional biologists completed the visual assessments to score LTMN sites. Scores are grouped into four narrative categories: optimal (16-20), suboptimal (11-15), marginal (6-10) and poor (1-5). Per the Guidebook, the following six of 10 components of the RBP were used in this assessment. The description of the assessment components was adapted from the Guidebook, Watershed Basics chapter.

- **Embeddedness:** The amount of fine sediment surrounding the rocks on the bottom of the stream provides an indication of upstream erosion and deposition of those eroded materials at the stream site. Large amounts of erosion in a stream can contribute to high total suspended solids, and high embeddedness can cover habitats available for benthic macroinvertebrates, many of which are food for fish and other aquatic life.
- **Velocity/Depth Regime:** This measurement evaluates the variety of stream habitats available for fish and other aquatic life. Ideally, fast shallow riffles, fast deep runs, slow deep pools and slow shallow glides should be present to provide a diverse habitat for a diverse aquatic community. Streams that have been straightened or altered by dam construction may lack one or more of these habitats.
- **Sediment Deposition:** This measurement evaluates the presence of islands or point bars formed by deposition of sediment, gravel and other materials in a stream. This is a natural process, but excessive sediment deposition can indicate an unstable habitat, as islands and point bars form and move with storms. A healthy aquatic community requires a relatively stable habitat.
- **Channel Alteration:** Streams should naturally meander, but may be altered by dams, straightening or channelization with concrete or gabion baskets. Generally, streams with altered channels change the natural flow of water and sediment in a detrimental way.
- **Frequency of Riffles:** Riffles are the shallow gravel areas where stream water bubbles over rocks, adding dissolved oxygen and providing habitat for benthic macroinvertebrates and other aquatic life. Streams that lack riffles tend to have lower dissolved oxygen and less diverse aquatic communities.
- **Bank Stability:** Eroding stream banks increase the amount of sediment in a stream, which can cover habitat (measured as embeddedness), reduce water quality (measured as total suspended solids) and reduce the ability of fish to find food. The left bank and right bank are assessed independently, then summed to give an overall bank stability score in the RBP assessment.

The scoring for these six characteristics is shown on Table 2.14.

Table 2.14 Scoring for Six Components of RBP Considered in Middle Fork Beargrass Creek

Characteristic	Optimal Score 16-20	Suboptimal Score 11-15	Marginal Score 6-10	Poor Score 1-5
2. Embeddedness	Gravel, cobble and boulder particles are 0-25% surrounded by fine sediment. Layering of cobble provides diversity of niche space.	Gravel, cobble and boulder particles are 25-50% surrounded by fine sediment.	Gravel, cobble and boulder particles are 50-75% surrounded by fine sediment.	Gravel, cobble and boulder particles are more than 75% surrounded by fine sediment.
3. Velocity/ Depth Regime	All four velocity/depth regimes present (slow-deep, slow-shallow, fast-deep, fast-shallow). (Slow is < 0.3 m/s, deep is > 0.5 m.)	Only 3 of the 4 regimes present (if fast-shallow is missing, score lower than if missing other regimes).	Only 2 of the 4 habitat regimes present (if fast-shallow or slow-shallow are missing, score low).	Dominated by 1 velocity/depth regime (usually slow-deep).
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than 5% (<20% for low-gradient streams) of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% (20-50% for low-gradient) of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 30-50% (50-80% for low-gradient) of the bottom affected; sediment deposits at obstructions, constrictions and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 50% (80% for low-gradient) of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yrs.) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.

Characteristic	Optimal Score 16-20	Suboptimal Score 11-15	Marginal Score 6-10	Poor Score 1-5
7. Frequency of Riffles	Occurrence of riffles relatively frequent; ratio of distance between riffles divided by width of the stream <7:1 (generally 5 to 7); variety of habitat is key.	Occurrence of riffles infrequent; distance between riffles divided by the width of the stream is between 7 to 15.	Occasional riffle or bend; bottom contours provide some habitat; distance between riffles divided by the width of the stream is between 15 to 25.	Generally all flat water or shallow riffles; poor habitat; distance between riffles divided by the width of the stream is a ratio of >25.
8 Bank Stability	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.

The result categories for the RBP scores are shown on Table 2.15, with the most recent result highlighted. Most of the results are in the suboptimal category, indicating that there is the potential for improvement.

Table 2.15 Initial Geomorphic Characterization Based on RBP Scores

Site ID	Location	Poor (1-5)	Marginal (6-10)	Suboptimal (11-15)	Optimal (16-20)
Embeddedness					
EMIMI009	Browns Lane		**2**	5	2
EMIMI002	Old Cannons Lane			**5**	4
EMIMI010	Lexington Road			**7**	2
Velocity Depth Regime					
EMIMI009	Browns Lane		2	**6**	1
EMIMI002	Old Cannons Lane		1	**8**	
EMIMI010	Lexington Road		2	**5**	2
Sediment Deposition					
EMIMI009	Browns Lane		1	**5**	3
EMIMI002	Old Cannons Lane			1	**8**
EMIMI010	Lexington Road		1	**6**	2

Site ID	Location	Poor (1-5)	Marginal (6-10)	Suboptimal (11-15)	Optimal (16-20)
Channel Alteration					
EMIMI009	Browns Lane			**3**	6
EMIMI002	Old Cannons Lane			**3**	6
EMIMI010	Lexington Road		1	**8**	
Frequency of Riffles or Bends					
EMIMI009	Browns Lane	1	**6**	2	
EMIMI002	Old Cannons Lane		**7**	2	
EMIMI010	Lexington Road			**6**	3
Bank Stability					
EMIMI009	Browns Lane		**7**	2	
EMIMI002	Old Cannons Lane		1	**8**	
EMIMI010	Lexington Road		**6**	2	1
Total		**1**	**37**	**84**	**40**

The scores for the six geomorphic categories included in this assessment were summed for each habitat assessment date for the three LTMN sites to provide a preliminary evaluation of trends over time. Results for Middle Fork Beargrass Creek at Browns Lane (EMIMI009) indicate relatively stable geomorphic conditions over time. However, Middle Fork Beargrass Creek at Old Cannons Lane (EMIMI002) and Lexington Road (EMIMI010) showed declining geomorphic conditions over time. See Figure 2.17.

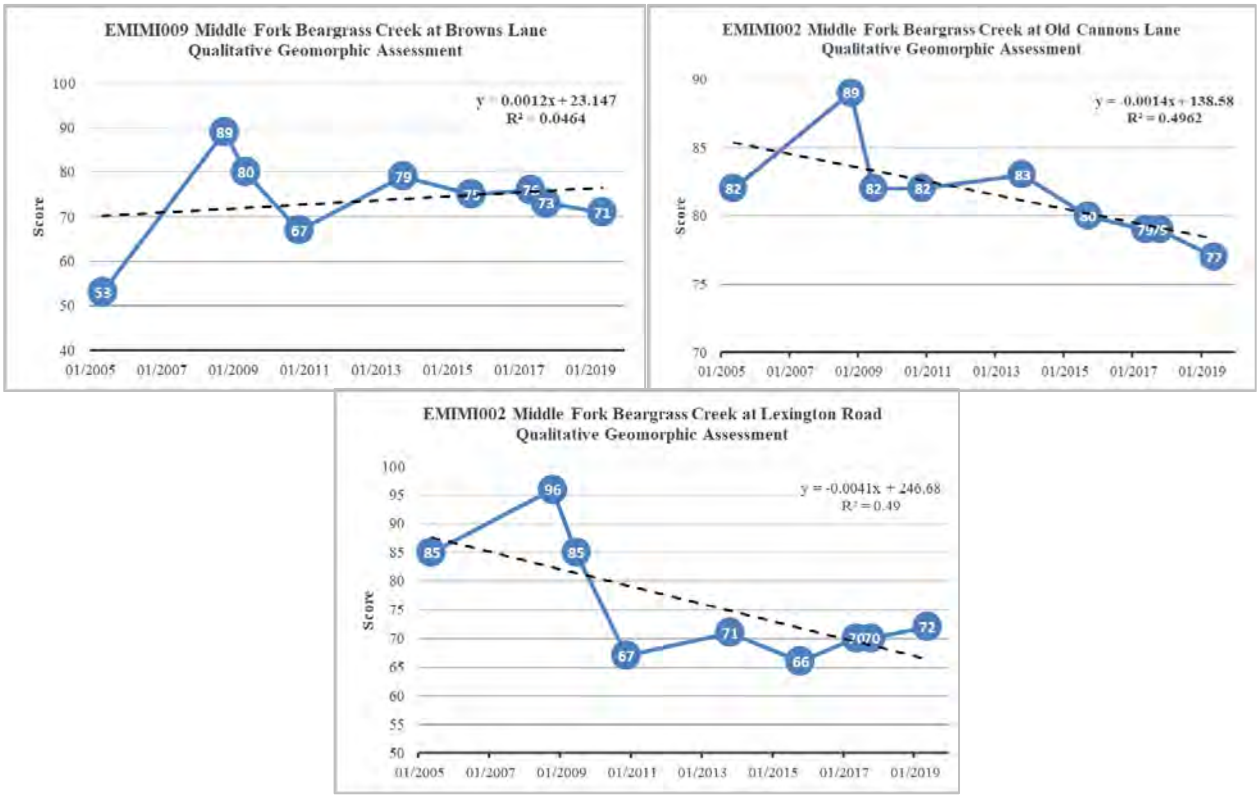

Figure 2.17 Initial Geomorphic Trends Based on RBP Scores

The riparian assessments conducted as part of this watershed planning project are anticipated to provide more detailed assessments at more locations so that the overall geomorphic conditions of this watershed are better understood. With this improved understanding, potential projects designed to improve geomorphic conditions can be identified as part of this watershed planning project.

There are several projects, ranging from 2006 to the present, that provide characterization data for the Middle Fork Beargrass Creek watershed. These include: Stream Assessment Report for Beargrass Creek, Beargrass Creek Ecological Reach Characterization Report, Supplemental Environmental Project (SEP) with Metro Parks, Beargrass Creek Trail Conceptual Shared Use Path and Ecological Restoration, and the most recent Three Forks Beargrass Creek Ecosystem Restoration Feasibility Study.

The Stream Assessment Report for Beargrass Creek was completed in 2006 and includes the following data: calibration of USGS gauge stations to bankfull conditions at two locations; collection of geomorphic data from stable stream reaches within the same hydro-physiographic region; collection and analysis of suspended sediment data for the South and Middle Forks of Beargrass Creek (one location at Old Cannons Lane in Middle Fork); characterization of streambank stability and erosion potential of several stream reaches including Middle Fork Beargrass Creek and Weicher Creek; and the establishment of 24 monitoring locations along four stream segments.

The Beargrass Creek Ecological Reach Characterization Report was completed in May 2008 as part of the CSO Long Term Control Plan (LTCP) project. The report provides the methods and results prioritizing the stream reaches in all three forks of Beargrass Creek. The reaches were rated on observed and potential ecological conditions and potential benefits from water quality improvements. Out of 37 reaches assessed, eight stream reaches were in the Middle Fork Beargrass Creek. Stream bank erosion potential was measured using the Bank Erosion Hazard Index (BEHI). The BEHI data were obtained from the Stream Assessment Report for Beargrass Creek. Index of Biotic Integrity (IBI) data were also provided by MSD, which were collected as part of the LTMN in 2005.

A Supplemental Environmental Project (SEP) (2006-2009) was implemented by Louisville Metro Parks, which included signage, invasive species removal, water quality and soil analysis, and an initial biological inventory that included a partnership with Louisville Male High School. Additionally, Metro Parks worked with MSD on reconstruction of a wetland/stormwater retention basin within the project area.

A major planning effort was completed in 2017 as a partnership between Louisville Metro Parks, the United States Army Corps of Engineers (USACE) Louisville District and TetraTech's consultant team to evaluate the Beargrass Creek Trail Conceptual Shared Use Path and Ecological Restoration opportunities. This report outlines several restoration opportunities within the Beargrass Creek watershed, specifically along Middle Fork Beargrass Creek. These opportunities can be found on Louisville Metro Parks' website (USACE and Louisville Metro Government, Undated). Restoration opportunities include stream relocation and restoration, bank stabilization and other storm water management projects involving green practices. These opportunities could potentially improve water quality and watershed health by reducing erosion and thereby total suspended solids; reducing summer water temperatures and increasing dissolved oxygen by improving riparian vegetation and the tree canopy; and improving stormwater quality through green infrastructure practices. MSD and the USACE recently partnered on a larger planning project that encompasses the entire Beargrass Creek watershed. The ongoing "Three Forks" project is anticipated to identify ecosystem restoration opportunities in the Muddy, Middle and South Forks of Beargrass Creek.

2.3 NATURAL FEATURES

This section describes the following natural features of the Middle Fork Beargrass Creek watershed: geology and topography, soils, and the ecoregion.

2.3.1 Geology and Topography

The entire Middle Fork Beargrass Creek watershed is situated in the Eastern Uplands Topographic Region. Broad steep-sided valleys and flat to gently rolling plateaus dominate the terrain. Middle Fork Beargrass Creek has cut deeply into this terrain and flows through a well-entrenched channel, where near vertical cliffs are common (MSD, 2016). Major geologic formations are summarized on Table 2.16 and shown on Figure 2.18**.**

Table 2.16 Geologic Formations in the Beargrass Creek Watershed

Geologic Formation	Karst Development	Hydrogeologic Sensitivity to Pollution
New Albany Shale (MDnb)	Minor	High – this shale underlain by significant karst development
Sellersburg and Jeffersonville Limestone (Dsj)	Well-developed	Extremely High – swallet and shaft drain with conduit flow
Louisville Limestone (Slw)	Well-developed	Extremely High – swallet and shaft drain with conduit flow

Source: KDOW, 2011a, Table 1.2. and Kentucky Geologic Map Service

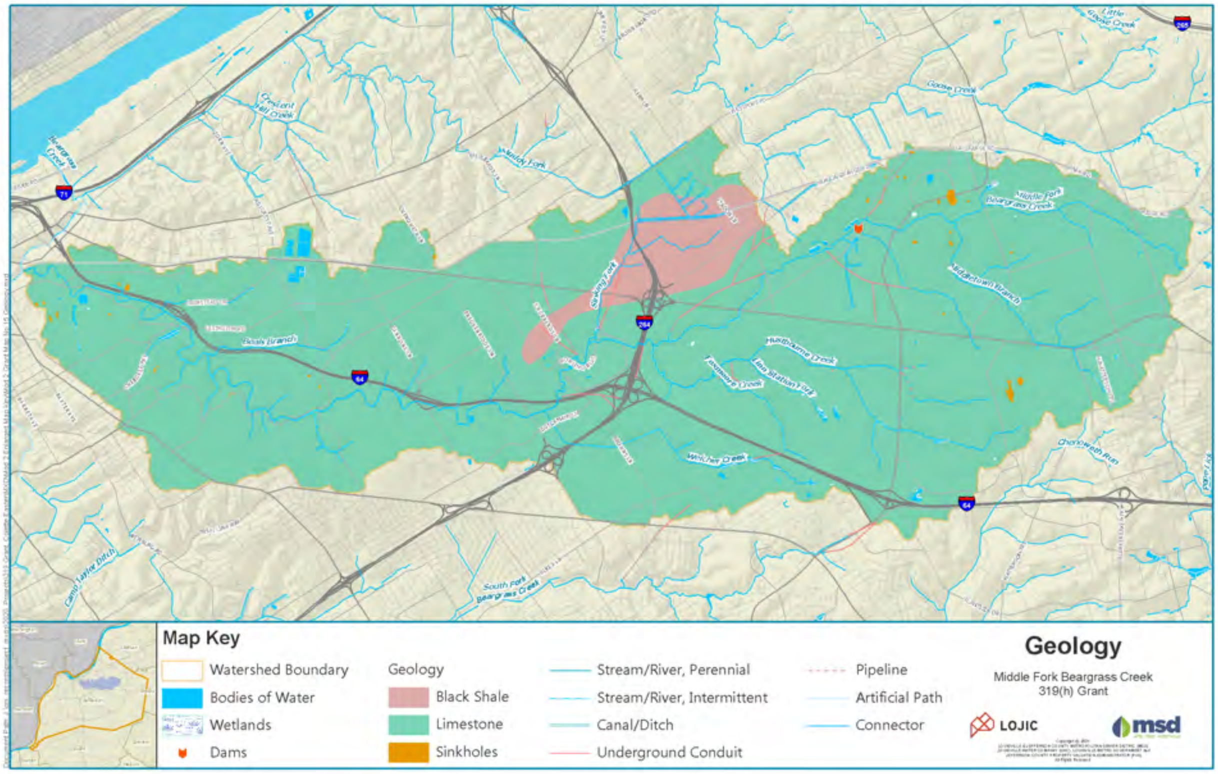

Figure 2.18 Geology

The major portion of this watershed is underlain by limestones of the lower Devonian and middle Silurian ages. A notable exception is the Lyndon and St. Matthews area, which is underlain by middle Devonian age shale. Middle Fork Beargrass Creek has eroded deep into these rocks, and in some instances, shales of middle Silurian age are exposed. The general dip of these rock beds, or strata, is toward the west at a little less than one foot in one-hundred feet. A northeast trending synclinal axis is observed, however, in the Lyndon/St. Matthews area. A northeast trending anticlinal axis is also observed in the Seneca Gardens/Seneca Park area. Karst activity is represented by some small sinkholes and springs, particularly in the Lyndon/Oxmoor area and in the area of the Sinking Fork. Karst features in the immediate area have been known to connect the Middle Fork Beargrass Creek surface-subsurface hydraulic system to adjacent basins, with portions of the Muddy Fork Beargrass Creek surface water catchment being drained to the Middle Fork through karst sinkholes and subsurface conduits (DOW, 2011a).

Well-developed karst features are common for Ordovician limestone formations, and this is the case for the Middle Fork Beargrass Creek watershed. Karst features in the watershed include sinkholes and underground drainage systems developing in the Sellersburg and Jeffersonville Limestones, with Louisville Limestones developing some sinkholes and underground drainage, but being largely characterized by water yielded to springs and wells. Shale deposits are generally considered to be an inhibitor of karst development and subsurface hydraulics, but because the New Albany shale layer in Jefferson County is thin, impediment to karst development is minimal in the area (Ray et al., 2008).

Based on a 10-meter digital elevation model (DEM), the elevation of the Middle Fork Beargrass Creek watershed ranges from 405 feet to 749 feet above mean sea level with lowest elevations near the confluence with South Fork Beargrass Creek and along the Middle Fork mainstem, and higher elevations in the headwaters near the cities of Anchorage, Middletown and Douglass Hills. See Figure 2.19**.**

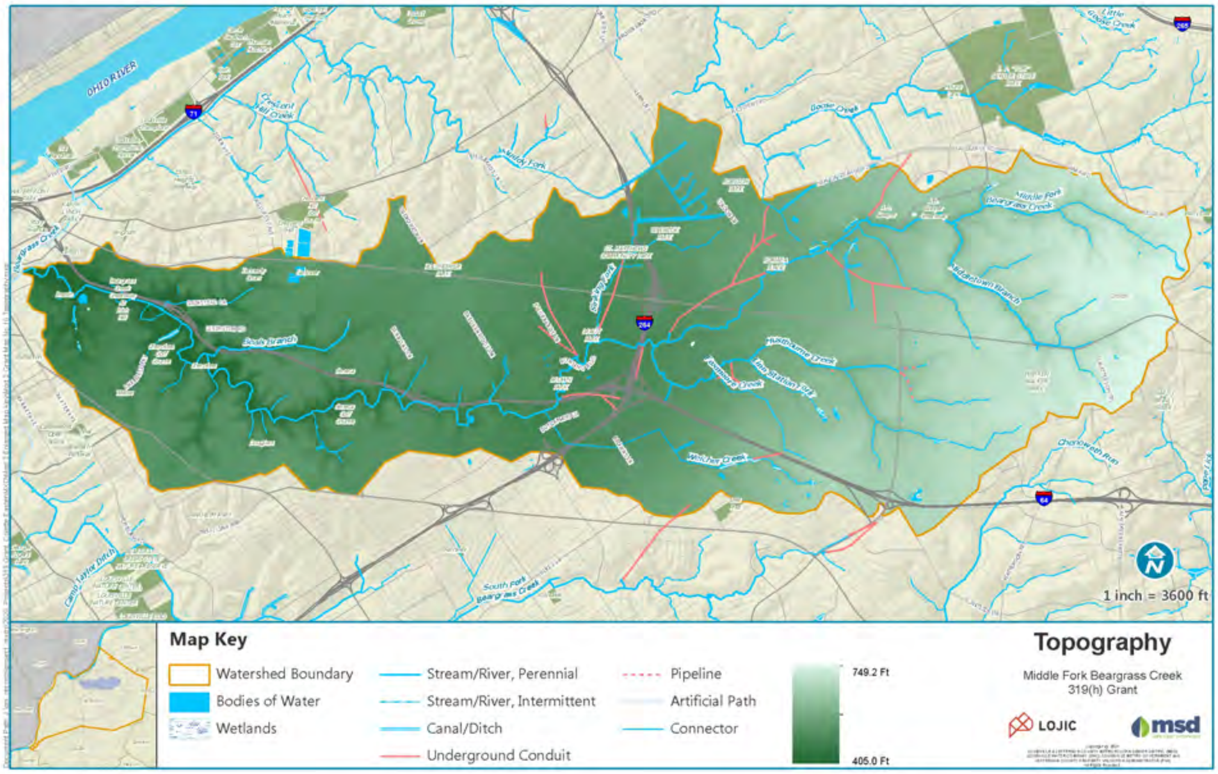

Figure 2.19 Topography

2.3.2 Soils

The Middle Fork Beargrass Creek watershed is largely made up of silt-loam soils, with the majority of soil slopes in the watershed falling between 0% to 2% and 2% to 6%. The downstream reaches of the stream network, located in the western portion of the watershed, are comprised of soils with relatively low infiltration rates and moderate runoff potentials. Soil series that occur in this portion of the watershed include Dickson, Lawrence, Linside, Newark and Russellville series. Much of the upstream (eastern) portions of the watershed are comprised of Ashton, Crider, Huntington and Russellville soil series, which are characterized by lower runoff potentials and moderate to high infiltration rates (Blandford et al., 2005). Much smaller portions of the watershed, specifically areas near the stream channel in the headwaters of the watershed, are comprised of rocky silt-loams and silty clay-loams. These areas belong to the Corydon soil series. They contain relatively higher concentrations of rocky and clay soil types, and they are characterized by high runoff potentials and low infiltration rates (Blandford et al., 2005).

The hydrologic characteristics of soils have a major influence on how water moves from surface precipitation through soils and to streams. Soil hydrologic groups B, C and D are present in the Middle Fork Beargrass Creek watershed; soil hydrologic group is not defined for the developed parts of the watershed. Soil hydrologic groups are described below (Natural Resource Conservation Service, 2007) and are shown on Figure 2.20**.**

- **Group B:** moderately low runoff potential when thoroughly wet. Water transmission through the soil is unimpeded. Group B soils typically have between 10% and 20% clay and 50% to 90% sand and have loamy sand or sandy loam textures.
- **Group C:** have moderately high runoff potential when thoroughly wet. Water transmission through the soil is somewhat restricted. Group C soils typically have between 20% and 40% clay and less than 50% sand and have loam, silt loam, sandy clay loam, clay loam and silty clay loam textures.
- **Group D:** high runoff potential when thoroughly wet. Water movement through the soil is restricted or very restricted. Group D soils typically have greater than 40% clay, less than 50% sand and have clayey textures.

Hydrologic soil groups C and D are likely to produce more runoff which can generate stream flow, since the movement through the soil is restricted.

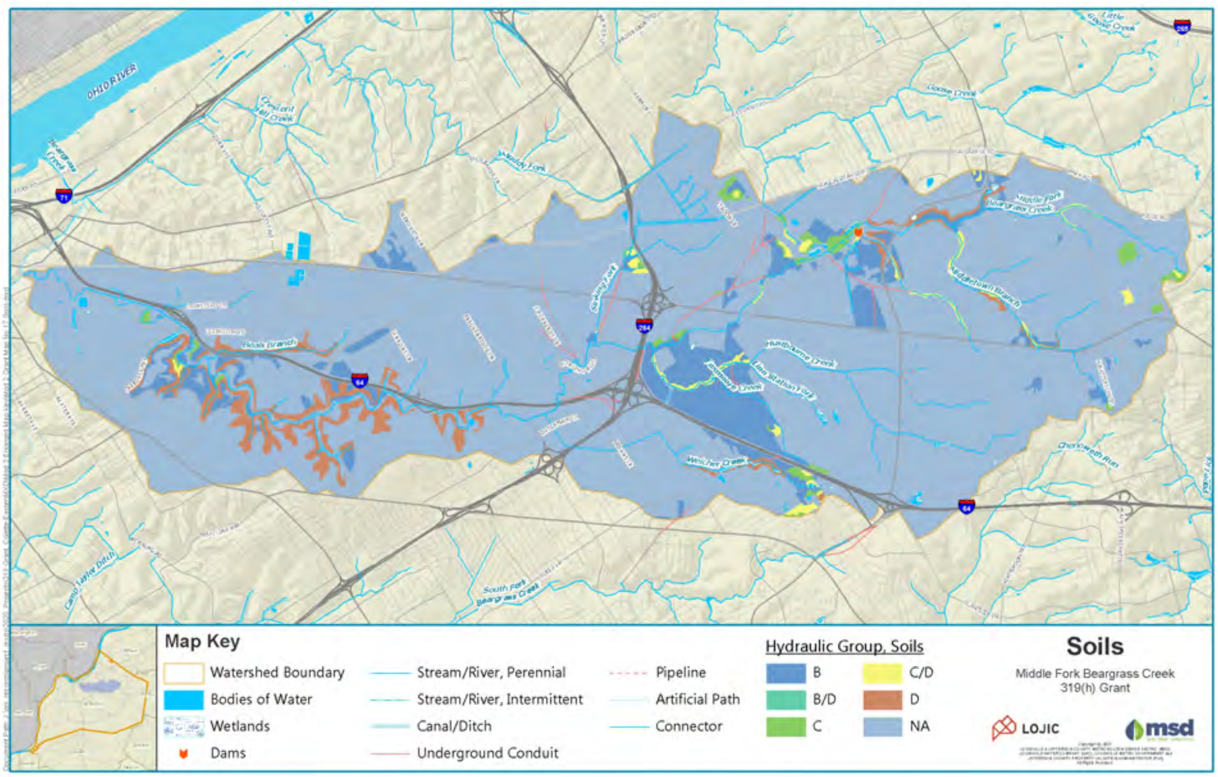

Figure 2.20 Hydrologic Characteristics of Watershed Soils

2.3.3 Ecoregion

The Middle Fork Beargrass Creek is located in the Outer Bluegrass Region (Region 71d) of the Interior Plateau (Region 71) Outer Bluegrass Ecoregion (Woods et al., 2002). The Kentucky Department of Fish and Wildlife Resources (KDFWR, 2013) summarizes the Outer Bluegrass Ecoregion as follows: The Outer Bluegrass (71d) contains sinkholes, springs, entrenched rivers, and intermittent and perennial streams with a rolling to hilly topography. The local relief varies but is usually less than in the geomorphically distinct Knobs–Norman Upland (71c). Discontinuous glacial outwash and leached, pre-Wisconsinan till deposits occur in the north from Louisville to Covington. These deposits do not occur south of this area in Kentucky.

The pastureland and cropland are widespread, and dissected areas are wooded. Upland streams have moderate to high gradients and cobble, boulder or bedrock substrates. Mean stream density is greater than in Ecoregion 71l but less than in Ecoregion 71k. Concentrations of suspended sediment and nutrients can be high. (KDFWR, 2013)

2.4 RIPARIAN/STREAMSIDE VEGETATION

Prior to the settlement and subsequent urban development within the Middle Fork Beargrass Creek watershed, the streamside vegetation in the region was characterized by open savannah woodlands in the upland areas of the watershed, with mixed hardwood forests common along river drainages and in gorges. Common species native to the region included white oak, northern red oak, black oak, hickory, yellow buckeye, white ash, blue ash, eastern red cedar, scarlet oak, black walnut, black maple, beech, yellow-poplar, basswood, black cherry, sugar maple, chinquapin oak, bur oak and black locust. Cane was prominent in stream corridors, both along the streamside and in the stream bottoms (Küchler, 1964).

Development has reduced the natural vegetative buffers surrounding streams in the Louisville area, including the Middle Fork of Beargrass Creek.

2.5 RARE AND EXOTIC/INVASIVE PLANTS AND ANIMALS

According to the KDFWR, there are over 630 species of wildlife observable in Jefferson County, Kentucky. This number includes approximately 118 species of fish, over 310 species of birds, 38 species of mammal, 36 species of reptiles and 31 species of amphibians. Of these species, NatureServe lists 12 species of significant concern (NatureServe, 2019). The Kentucky Nature Preserves partnered with NatureServe, which provides a database of rare species by county. Table 2.17 displays the list of these species, including the scientific name, common species name, major group, and various regulatory statuses associated with each species. Aquatic species of concern in Jefferson County include one species of crayfish, one species of fish, and three species of aquatic mussels, all of which are directly influenced by the quality of surface waters in this area, including the Middle Fork Beargrass Creek. Additional species include two types of bat, one species of snake, one species of beetle and three types of flowering plant. While these species are not directly tied to stream water quality, overall watershed health is tied to ecological health and success.

Table 2.17 Species of Concern for Jefferson County, Kentucky

County Name	Jefferson
State	Kentucky
Numbers of Species of Concern	11

[1]U.S. ESA Listed, Proposed, Candidate and Nature Serve Imperiled (G1-G2) Species

Scientific Name[2]	Common Name	Major Group	NatureServe Global Status	U.S. Federal Status[3]	State Status
Alosa alabamae	Alabama Shad	Freshwater and Anadromous Fishes	G2: Imperiled		S1
Clonophis kirtlandii	Kirtland's Snake	Reptiles	G2: Imperiled		S2

Scientific Name[2]	Common Name	Major Group	NatureServe Global Status	U.S. Federal Status[3]	State Status
Faxonius jeffersoni	Louisville Crayfish	Crayfishes	G1: Critically Imperiled		S1
Leavenworthia exigua	Tennessee Gladecress	Flowering Plants	G4: Apparently Secure	PS	SNR
Leavenworthia exigua var. laciniata	Kentucky Gladecress	Flowering Plants	T1	LT	S1S2
Myotis grisescens	Gray Myotis	Mammals	G4: Apparently Secure	LE	S2
Myotis sodalis	Indiana Myotis	Mammals	G2: Imperiled	LE	S1S2
Plethobasus cyphyus	Sheepnose	Freshwater Mussels	G3: Vulnerable	LE	S1
Pleurobema clava	Clubshell	Freshwater Mussels	G1: Critically Imperiled	LE, XN	S1
Potamilus capax	Fat Pocketbook	Freshwater Mussels	G2: Imperiled	LE	S1
Pseudanophthalmus troglodytes	Louisville Cave Beetle	Ground Beetles	G1: Critically Imperiled		S1
Trifolium stoloniferum	Running Buffalo Clover	Flowering Plants	G3: Vulnerable	LE	S2S3

[2]Links to NatureServe Explorer Comprehensive Species Report
[3]Links to U.S. Fish & Wildlife Service's Environmental Conservation Online System (ECOS)

Abbreviations: LE – Listed Endangered; PS – Partial Status; E – Endangered; T – Threatened; S – Special Concern; LE, XN – Listed Endangered, Nonessential Experimental Population

A second records search was conducted through the U.S. Fish and Wildlife Services' Information for Planning and Consultation (IPAC) planning tool. The search focused on the general area of the Middle Fork Beargrass Creek watershed. The IPAC report included 14 threatened, endangered or candidate species on the species list in the general project area of Middle Fork Beargrass Creek watershed. The summary is provided in Table 2.18.

Table 2.18 IPAC Endangered and Threatened Species in the Middle Fork Beargrass Creek

Common Name	Scientific Name	Type
Mammals		
Gray Bat	*Myotis grisescens*	Endangered
Indiana Bat	*Myotis sodalis*	Endangered
Northern Long-eared Bat	*Myotis septentrionalis*	Threatened
Clams		
Clubshell	*Pleurobema clava*	Endangered
Fanshell	*Cyprogenia stegaria*	Endangered
Northern Riffleshell	*Epioblasma torulosa rangiana*	Endangered
Orangefoot Pimpleback	*Plethobasus cooperianus*	Endangered
Purple Cat's Paw	*Epioblasma obliquata*	Endangered
Rabbitsfoot	*Quadrula cylindrica*	Threatened
Ring Pink	*Obovaria retusa*	Endangered
Rough Pigtoe	*Pleurobema plenum*	Endangered
Sheepnose Mussel	*Plethobasus cyphyus*	Endangered
Spectaclecase	*Cumberlandia monodonta*	Endangered
Flowering Plants		
Running Buffalo Clover	*Trifolium stoloniferum*	Endangered

Several invasive or nuisance species are prevalent within the watershed. Invasive plant species are especially prevalent along the stream channel and along sections of channelized or otherwise disturbed riparian zones. Invasive plant species include amur honeysuckle, porcelain-berry, Japanese hop and bur cucumber.

Louisville Metro Department of Parks and Recreation and Olmstead Parks are engaged in invasive species removal. Invasive species removal by the Louisville Metro Department of Parks and Recreation is included as an activity in the development of this watershed plan. Olmstead Parks prioritizes invasive species removal by maintaining a Park Steward Program which trains volunteers in the removal of invasive species throughout the 17 Olmstead Parks, including Cherokee Park, and six parkways in Louisville.

2.6 HUMAN INFLUENCES AND IMPACTS

This section describes the history of human influences and impacts within the Middle Fork Beargrass Creek watershed, including water use, land use and impervious surfaces, other disturbances, land disturbances that can impact waterways and hazardous materials.

2.6.1 Water Use

Water use encompasses drinking water supplies, as well as storm water and wastewater discharges from municipal and industrial sources, CSOs and SSOs.

Drinking Water Supplies: The Louisville Water Company (LWC) is the public water supplier to Louisville Metro and parts of Bullitt and Oldham Counties, including Middle Fork Beargrass Creek. The Ohio River is the source for the city's drinking water. LWC operates a surface water treatment plant and a ground water treatment plant, both with intakes on the Ohio River. The Louisville Water Company also draws water through the aquifer with five riverbank filtration wells at the B.E. Payne Water Treatment Plant. The Crescent Hill Reservoir Pump Station and Filter Plant is located in the northwestern portion of the watershed. The Louisville Water Company maintains a coverage of pressurized water lines in LOJIC. There are 358 miles of mapped pressurized water lines within the watershed, as shown on Figure 2.18. Areas that do not have mapped water lines include the Bowman Field airport and Oxmoor Farm. To depict the areas without water lines, Figure 2.21 includes aerial imagery.

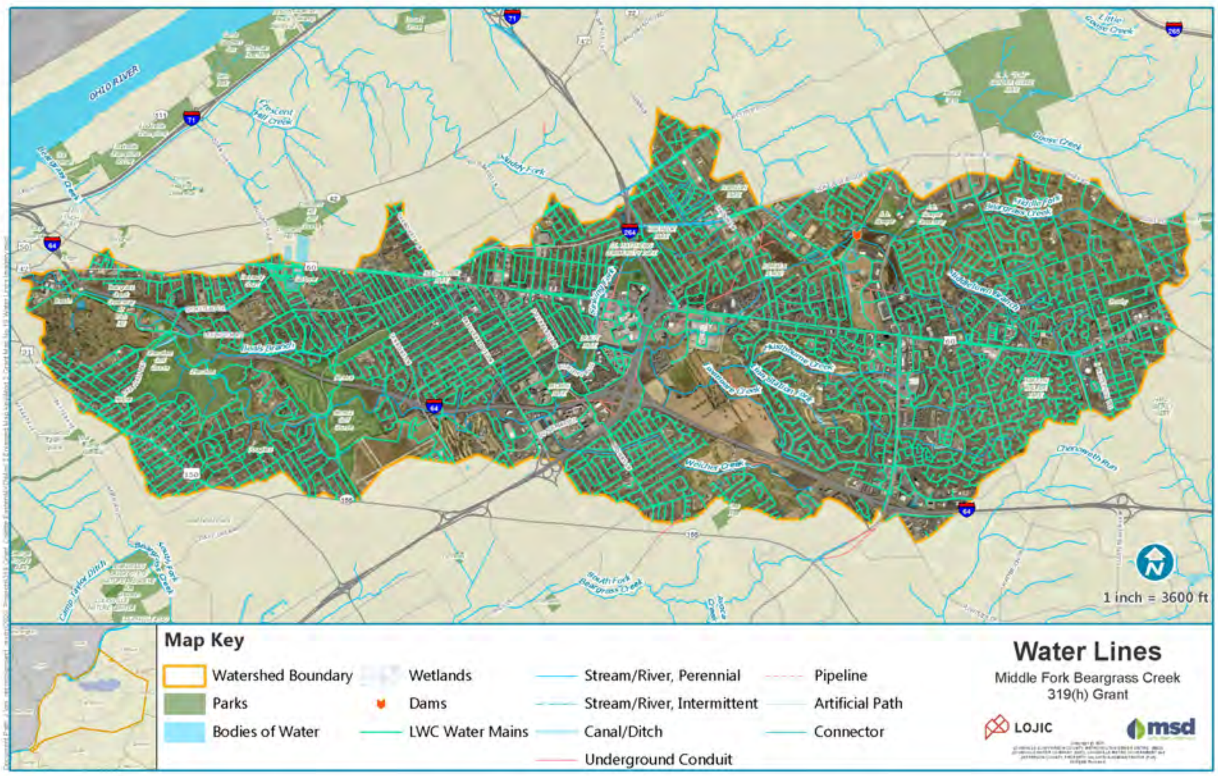

Figure 2.21 Water Lines

DOW approved LWC's Wellhead Protection Plan (WHPP) in 2014. The goal is to safeguard groundwater from contamination feeding into the wells within the Wellhead Protection Area (WHPA) near Prospect (Louisville Water Company, 2014). The wellhead protection areas are located north of the Middle Fork Beargrass Creek**.**

There are three domestic wells, one agricultural well and 11 remediation wells located in the watershed, as shown on Figure 2.22**.** The remediation wells have been plugged, indicating that the remediation was completed. The domestic wells are located in the City of Anchorage, and the agricultural well is located in the City of Wildwood.

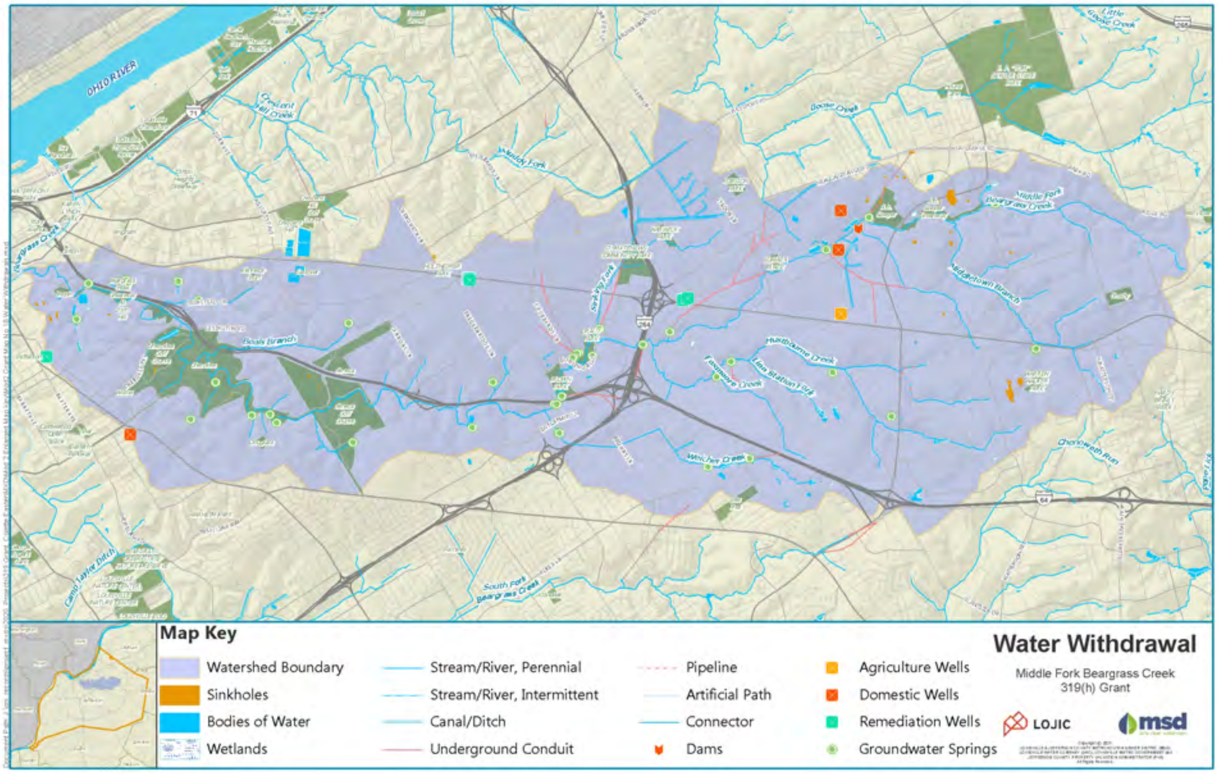

Figure 2.22 Permitted Water Withdrawals

Wastewater Discharges: This section describes permitted discharges, wastewater collection and unsewered areas, as well as CSOs and SSOs.

All discharges within the watershed are identified and permitted through the Kentucky Pollutant Discharge Elimination System (KPDES). As of 2019, there were 40 facilities that were permitted to discharge in the Middle Fork Beargrass Creek watershed through the KPDES permit program. These facilities were considered to be minor discharges. Notable locations include an individual permit to discharge industrial stormwater from Bowman Field Regional Airport (KY0), a general permit to discharge from a potable water treatment facility (Louisville Water Company Zorn Station located at the Crescent Hill Water Plant) and three general permits to discharge from an individual homeowner wastewater treatment unit (KYG4). The remaining 35 general permits were issued for stormwater discharges from construction projects (KYR10). Figure 2.23 displays the locations of these discharges, and Table 2.19 catalogs relevant information for each.

More information regarding the permits can be found on DOW's Permits and Certifications page: https://eec.ky.gov/Environmental-Protection/Water/PermitCert/Pages/default.aspx.

Tempo Agency Interest (AI) numbers can be used to download permit documents from DOW's e-Search page: https://eec.ky.gov/Environmental-Protection/Pages/services.aspx

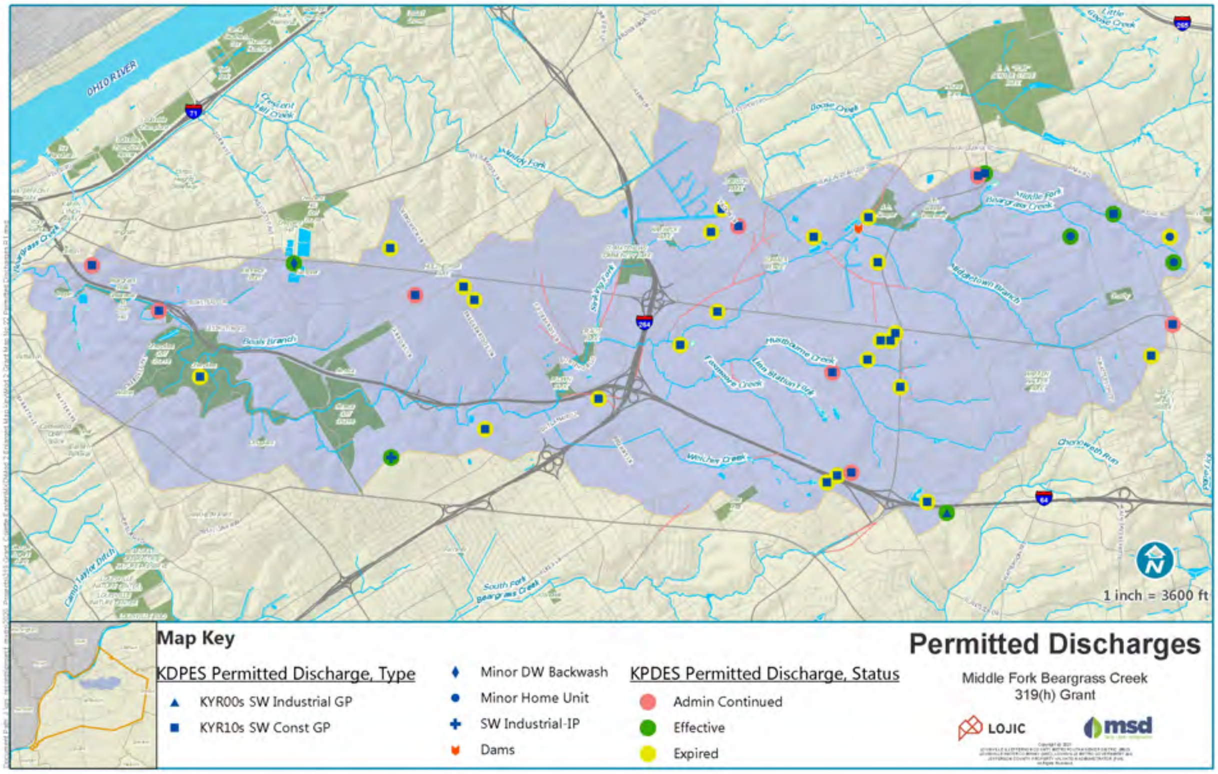

Figure 2.23 Permitted Wastewater Discharges

Table 2.19 Permitted Wastewater Discharges

KPDES Permit #	TEMPO	Permit Name
Permit Type: Individual Permit for Industrial Stormwater Discharge		
KY0092177	1972	Bowman Field Regional Airport
Permit Type: General Permit for Residential Wastewater Treatment Discharge		
KYG402424	127124	Private Residence
KYG402573	136034	Private Residence
KYG402802	166251	Private Residence
Permit Type: General Permit for Minor Drinking Water Backwash		
KYG640140	2129	Louisville Water Co – Zorn Station
Permit Type: General Permit for Construction		
KYR003573	2174	United Parcel Service – Freight
KYR10K916	48066	Grove Pointe at Masonic Homes of Kentucky
KYR10L125	132604	Citadel Self Storage
KYR10L400	120038	Stonecrest Senior Living Facility

KPDES Permit #	TEMPO	Permit Name
KYR10L454	133397	Warwick Storage
KYR10L479	66980	A.B. Sawyer Park Master Plan Implementation Phase 1
KYR10L677	101933	I-64 & Grinstead CSO Basin
KYR10L847	50198	Hurstbourne Country Club Streambank Stabilization Project – Phase 1
KYR10L861	109805	NTS 805 Shelbyhurst Office Building
KYR10L911	48059	Advanced Business Solutions
KYR10L938	135194	KYTC PCN ##-#### (KYTC Item No. 5-344.01)
KYR10L941	78527	St. Matthews Library and City Hall Addition and Renovation
KYR10M066	135482	Ormsby Lane Senior Apartments
KYR10M217	135882	Bonnycastle Hill Site Improvements
KYR10M316	136113	Transcend Credit Union
KYR10M517	136641	Bennett and Bloom Medical Office Building
KYR10M542	5333	Blairwood Club Expansion Phase 2
KYR10M547	109639	Sproutlings Pediatric Daycare Expansion
KYR10M622	136836	Dayton Building
KYR10M653	136962	Hurstbourne Town Center Apartments
KYR10M789	137428	Stewart Condos – 703 Lyndon Lane
KYR10M977	137697	202 Oxmoor Lane Apartments
KYR10N284	160489	Middletown Eastwood Trail
KYR10N536	161818	Carvana
KYR10N645	48159	Oxmoor Center Redevelopment
KYR10N651	136962	Hurstbourne Town Center – Hyatt House Louisville East
KYR10N679	162467	Hurstbourne Town Center Tracts 4, 5 & 6
KYR10N747	1967	Big Spring Country Club Phase 2 Clubhouse
KYR10N760	60727	Kentucky Farm Bureau Amenity Area
KYR10N863	109805	Shelbyhurst 435 Office Building
KYR10N916	163757	Golden Retriever Rescue and Adoption
KYR10N957	106527	Sound Barrier Wall, I-64 Westbound, Section 2
KYR10O107	164391	N. Hurstbourne Climate Controlled Storage
KYR10O272	106527	I-Move Ky
KYR10O567	166044	St. Luke's Episcopal Church Expansion

Wastewater Collection and Unsewered Areas: MSD is responsible for collecting untreated wastewater from residences as well as commercial and industrial facilities in the Middle Fork Beargrass Creek watershed. The City of Anchorage is partly served by sewers and partly served by septic systems. MSD maintains a coverage of the sewer collection system in LOJIC. There are approximately 44 miles of combined sewer lines and approximately 300 miles of sanitary sewer lines in the Middle Fork Beargrass Creek watershed, as shown on Figure 2.24**.** Wastewater collected from sewer lines in the Middle Fork Beargrass Creek is treated at the Morris Forman WQTC. This is Kentucky's largest and oldest water quality treatment center. On a normal day, it treats 100 million gallons of wastewater, and during storms, the plant treats up to 350 million gallons per day. Here, wastewater is treated, then chlorinated and dechlorinated before being released into the Ohio River in west Louisville, south of Chickasaw Park. Chlorination is used to disinfect the treated wastewater, and dechlorination removes the excess chlorine to reduce toxicity of the final effluent.

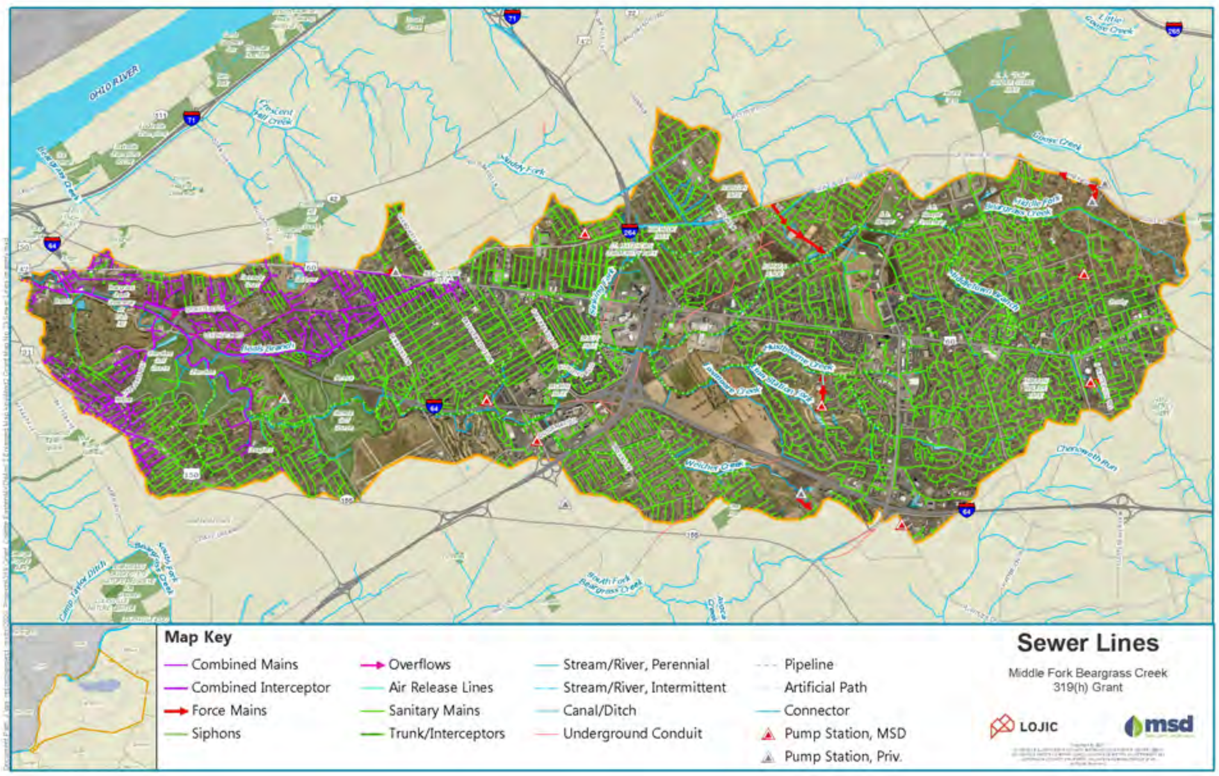

Figure 2.24 Sewer Lines

Combined and Sanitary Sewer Overflows: The earliest sewers in Louisville were built in the 1800s to drain stormwater to a river or stream after a rain event. When indoor plumbing became common in Louisville homes, sanitary sewers became necessary to drain wastewater. The most convenient way to accomplish this was to combine the sanitary waste with the stormwater in the same pipe. These "combined sewers" still exist and can be found in the area inside I-264, as shown on Figure 2.25 Combined and Sanitary Sewer Overflows. Combined sewers were designed to overflow to streams, including the Middle Fork Beargrass Creek, and the Ohio River during heavy rain events. The combined sewer overflows (CSOs) reduce the likelihood of sewage backing up into buildings, but they pose a water quality issue due to the presence of untreated sewage mixed with stormwater.

The area between I-264 and the Middle Fork Beargrass Creek headwaters is served by separate sanitary sewers, which are designed to carry only wastewater; stormwater is conveyed through a separate drainage system. These separate sanitary sewers were not built to overflow. However, stormwater finds ways to enter these pipes. When the sewage collection system pipes fill up, or if pump stations are undersized or malfunction, overflows may occur at manholes and pump stations. The overflow is a discharge of raw sewage to streams, ground or into a building. These overflows are called sanitary sewer overflows (SSOs).

As of 2020, there were 248 active sanitary sewer overflows (SSOs) within the Middle Fork Beargrass Creek watershed area. The SSOs are mitigated, monitored and prioritized as part of the ongoing IOAP efforts. Of these, 157 were classified as documented capacity related recurring overflow locations, 54 were classified as Force Majeure (i.e, overflows with this status have only occurred during storms or events where written request and authorization have been approved by regulatory authorities), 28 were classified as beyond approved design storm (i.e., occurred with storms beyond the current level of protection identified in the IOAP that have not been requested/approved Force Majeure events), and nine were classified as suspected (i.e., can be maintenance or capacity-related and MSD personnel did not actually witness the overflow, but only see evidence that it occurred).

As of September 2020, there were 12 combined sewer overflows (CSO) remaining in the Middle Fork Beargrass Creek watershed (CSO080, CSO082, CSO086, CSO123, CSO125, CSO126, CSO127, CSO140, CSO144, CSO162, CSO166, and CSO209). A sewer separation project was completed to eliminate CSO 206, which was located in Cherokee Park.

Locations of CSOs and SSOs, based on data available from LOJIC, are shown on Figure 2.25.

Through the Consent Decree and Amended Consent Decree, MSD has undertaken many projects and programs to eliminate SSOs by 2024 and reduce the frequency and volume of CSOs to required levels by 2021. Information about these efforts can be found on MSD's Consent Decree website: https://louisvillemsd.org/consent-decree

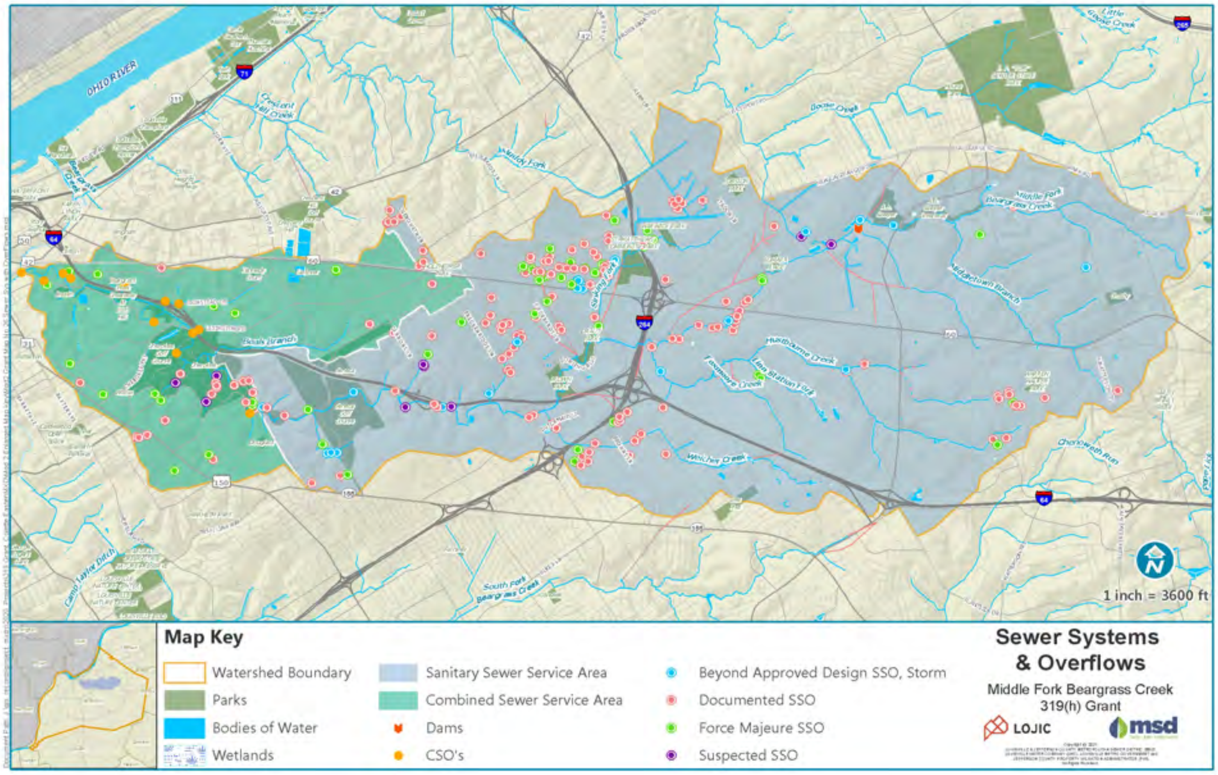

Figure 2.25 Combined and Sanitary Sewer Overflows

Stormwater: Stormwater in the area outside the Combined Sewer Area shown on Figure 2.25 is managed under MSD's MS4 Permit (KYS000001). The stormwater system consists of drainage swales; channels; storm drains; pipes; drainage ponds, which carry rainfall and snow melt that occurs within the Middle Fork Beargrass Creek watershed boundary away from residences; and businesses. Stormwater is released through stormwater outfalls to Middle Fork Beargrass Creek and its tributaries, and eventually to the Ohio River. Along its journey, stormwater accumulates soil and pollutants—such as lawn chemicals, pet waste and oil—which can harm our waterways (MSD, 2020).

MSD monitors the effects of stormwater on streams within the MS4 service area, including three locations within the Middle Fork Beargrass Creek watershed. Recent monitoring results and long-term trends were described in Section 2.2.6 Water Chemistry and Biology.

MSD has many efforts underway to reduce the impacts of stormwater on local streams, including ordinances that describe stormwater requirements and penalties for noncompliance, permits for new development and redevelopment projects that disturb the soil, encouraging use of green infrastructure BMPs to manage stormwater and maintenance of a 25-foot buffer for projects adjacent to perennial streams. More information regarding MSD's stormwater program can be found on the Stormwater and Drainage website: https://www.louisvillemsd.org/what-we-do/stormwaterdrainage Through interlocal agreements, MSD partners with the cities of Anchorage, Jeffersontown and St. Matthews, as well as Louisville Metro Government to implement these programs.

2.6.2 Land Use and Impervious Surfaces

Land Use: Land uses and surface cover have significant influence on the hydrology of a watershed. This includes implications for surface water infiltration potential and runoff volume and timing during rain and snow melt events, as well as pollutant build-up and subsequent wash-off dynamics that affect in-stream water quality. Because the Middle Fork Beargrass Creek watershed is entirely within the Louisville Metro area, the land use is largely urban or urban-residential, and approximately 37% of the watershed is covered by impervious surfaces such as roads, parking lots and roofs.

Land use data compiled from two sources were analyzed to characterize the Middle Fork Beargrass Creek watershed. Land use data from the National Land Cover Database (NLCD) show that the largest land use areas in the watershed include Developed Open Space and Low Intensity Developed areas, with 29% and 27% of the watershed covered by the two land uses, respectively. These areas are made up of residential areas, neighborhoods and generally developed open areas. Medium and High Intensity Developed areas make up approximately 19% of the watershed, comprised of commercial or industrial areas, as well as large roadways such as interstates and large arterial roads. Altogether, developed land use designations make up roughly 75% of the watershed, according to the NLCD. The remaining 25% undeveloped portion of the watershed is made up of mostly forest (21%), agricultural land (3%) and open water or wetlands (1%). Results are summarized Table 2.20**.**

Table 2.20 Land Use in Middle Fork Beargrass Creek Watershed (NLCD)

Land Use	Percent Area
Developed Open Space	29.16
Developed Low Intensity	27.27
Developed Medium Intensity	13.43
Developed High Intensity	5.62
Barren Land	0.03
Deciduous Forest	18.32
Evergreen Forest	2.32
Mixed Forest	0.04
Herbaceous	0.13
Hay Pasture	1.72
Cultivated Crops	0.93
Woody Wetlands	0.06
Emergent Herbaceous Wetlands	0.04
Open Water	0.95
Total Developed	**75.47**
Total Undeveloped	**24.53**

An additional analysis of land use was performed using data available from the Louisville and Jefferson County Information Consortium (LOJIC). Land use data from LOJIC show that the largest land use area in the watershed is residential land use, with Single-Family Residential comprising 52% of the land use in the watershed and Multi-Family Residential comprising 8% of the land use. Commercial and business, industrial, and transportation land uses comprise approximately 21% of the land use in the watershed. Vacant undeveloped land, parks, cemeteries, etc., and public or semi-public land uses cover 10%, 6% and 3% respectively. Overall, the LOJIC database yields 81% developed land area in the watershed, and 19% undeveloped land area in the watershed. Table 2.21 and Figure 2.26 display the results of the LOJIC land use analysis.

Table 2.21 Land Use in Middle Fork Beargrass Creek Watershed (LOJIC)

Land Use Category	Percent Area
Single Family Residential	51.99
Vacant/Undeveloped	10.37
Parks, Cemeteries, etc.	6.30
Public, Semi-Public	2.71
Commercial and Office	2.00
Industrial	11.28
Multi-Family Residential	7.66
Transportation	7.77
Total Developed	**80.61**
Total Undeveloped	**19.39**

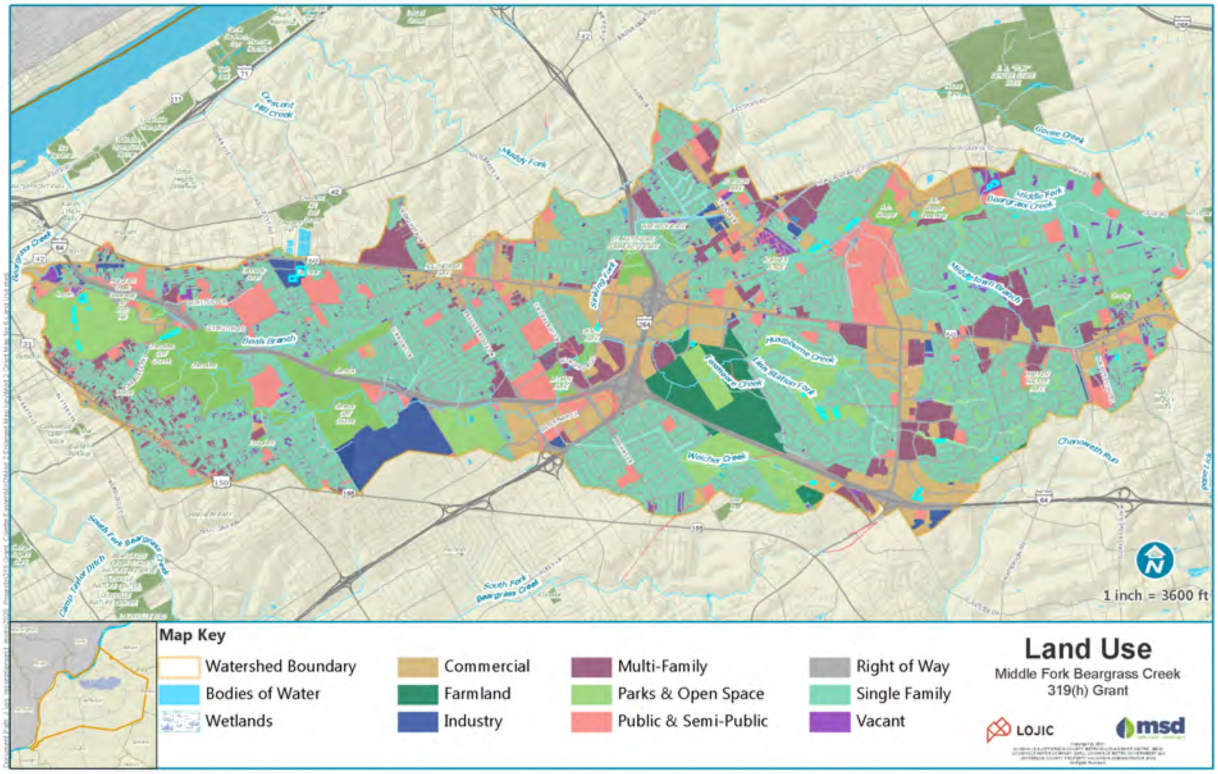

Figure 2.26 Land Use in Middle Fork Beargrass Creek Watershed (LOJIC)

Land use planning along Beargrass Creek and its subwatersheds have been a topic of interest for many years. Past and current activities that complement this project include the Beargrass Creek Trail Conceptual Shared Use Path and Ecological Restoration Plan (https://louisvilleky.gov/government/parks/beargrass-creek-trail-conceptual-shared-use-path-ecological-restoration-plan) and the US. Army Corps of Engineers' Three Forks of Beargrass Ecosystem Restoration Feasibility Study (USACE Three Forks Study). The Beargrass Creek trail and ecological restoration plan focused on a specific corridor of the watershed from Grinstead Drive to the mouth of Beargrass Creek at the Ohio River. While the USACE Three Forks Study was larger in scope and assessed the Muddy, Middle, and South Forks of Beargrass Creek, both projects evaluated existing in-stream and riparian habitat as well as recreational opportunities. Proposed modifications to current land uses include projects that will improve ecological habitat, provide education and outreach opportunities, as well as enhance and improve recreational use.

The Middle Fork Beargrass Creek watershed is comprised of portions of Louisville Metro, as well as portions of 26 other municipalities. These include portions of the Highlands, Seneca Gardens, St. Regis Park, St. Matthews, Lyndon, Hurstbourne and Middletown. The land uses in these municipalities are largely made up of low intensity developed, single-family residential neighborhoods. Medium to high intensity developed areas include commercial and industrial areas, which are properties located mostly in St. Matthews along Shelbyville Road and along Hurstbourne Lane. These areas include large areas of impervious roadways, building rooftops and parking lots. Some agricultural land behind the Oxmoor Mall in the central portion of the watershed consists of several agricultural fields, including some open hay/pasture fields and cultivated crop fields. Several undeveloped and forested areas exist in the St. Matthews area and in the western portion of the watershed. Parks, cemeteries and golf courses in the area provide open spaces with minimal impervious area and forested near-stream riparian areas that allow for stormwater to run off and infiltrate naturally into soils.

Impervious Surfaces: Streamflow varies naturally in response to rain and snow melt, and seasonally tends to be higher in the winter and spring, lower in summer and fall. Streams may flow very little or not at all during times of drought. Periodic low flows can stress aquatic organisms by reducing the amount of stream habitat available to them, and if concurrent with hot air temperatures, can lead to excessive stream temperature and low dissolved oxygen conditions. Very high flow can reduce habitat quality critical to organisms by eroding stream banks and beds, by moving or covering stream bed habitat like rocks and woody debris, and by physical scouring or displacement of organisms. Higher stream flow can increase significantly both in frequency and volume in areas where impervious surfaces such as roofs and roads prevent water from filtering into the soil. As the extent of impervious surfaces increases, the amount of runoff increases during storm events (MSD, 2014). An analysis was performed using LOJIC data to estimate the extent and location of impervious surfaces in the watershed. Using this analysis, approximately 37% of the watershed is covered by impervious surfaces. Figure 2.27 shows the location and extent of the impervious surfaces.

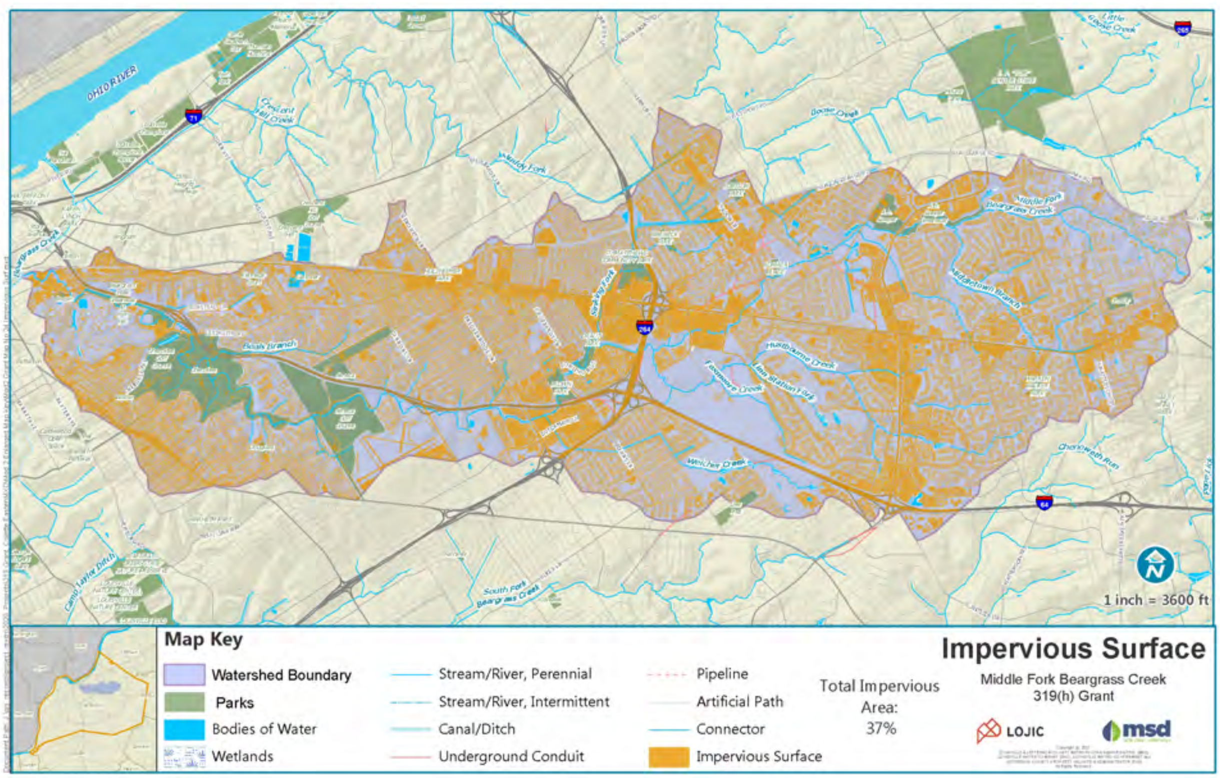

Figure 2.27 Impervious Surfaces

2.6.3 Other Water Disturbances

Water disturbances refer to any artificial stream alterations such as channelization, artificial armoring or dredge/fill activities in the stream channel. Due to the highly urban nature of the watershed, these features are prevalent within the Middle Fork Beargrass Creek watershed. Areas of specific note include areas of channel modification, including channelization and armoring in the middle sections of the watershed, where the main channel flows near the Oxmoor shopping mall and Mall St. Matthews. The channel has also been significantly artificially channelized near the downstream extent of the watershed where the stream runs parallel to Interstate 64 and Lexington Road, between Lexington Road at the upstream extent of the reach and the Irish Hill neighborhood at the downstream extent. A review of the U.S. Army Corps of Engineers' Louisville District list of Issued Standard Permits through June 2019 showed that no permits have been issued within the Middle Fork Beargrass Creek in the last five years, indicating that recent projects have not contributed to instream channelization or hydrologic modification. The current Louisville Metro Floodplain Management Ordinance prohibits the channelization of any intermittent or perennial streams within Louisville Metro.

2.6.4 Land Disturbances that Can Impact Waterways

For purposes of watershed planning, land disturbances generally are used to indicate major land disturbance operations such as mining and large-scale land clearances. While these activities are not relevant to the Middle Fork Beargrass Creek watershed, land disturbances due to general land development and urbanization are certainly and especially relevant to the watershed. Urban development in the near-stream and riparian areas can cause significant disturbances that impact in-stream condition, including loss of a riparian filter for pollutants and increased sediment delivery to the stream when land is cleared for construction with inadequate sediment filters installed.

Per the Louisville Metro Floodplain Management Ordinance, a 25 foot buffer from the top of bank on each side of any intermittent or perennial streams must be maintained to preserve existing natural vegetation. Erosion prevention and sediment control is regulated through the Erosion Prevention and Sediment Control (ESPC) Ordinance. Land disturbing activity that disturbs more than 2,000 square feet or is located within 50 feet of an intermittent or perennial stream requires a Site Disturbance Permit and best management practices to be installed that are designed to accomplish an 80% design removal efficiency goal for total suspended solids.

2.6.5 Hazardous Materials

The EPA website "Cleanups in My Community" (https://www.epa.gov/cleanups/cleanups-my-community#map) provides maps or lists of a comprehensive variety of contaminated sites including:

- Brownfields
- Revolving Loan Fund
- National Priority List (NPL)
- Oil Pollution Act
- Resource Conservation and Recovery Act (RCRA)
- Base Realignment and Closure (BRAC)
- Comprehensive Environmental Response, Compensation and Liability Act (CERCLA)
- Clean Water Act

This website was used to query contaminated sites in Louisville, and the results were mapped using the site addresses and clipped to the Middle Fork Beargrass Creek watershed. No contaminated sites were identified in the Middle Fork Beargrass Creek through this search.

In order to reduce the potential for releases of hazardous materials, Louisville Metro adopted an Ordinance requiring the submittal of a Hazardous Materials Use and Spill Prevention Control (HMPC) Plan by any business that manufactures, uses or stores hazardous materials in excess of designated quantities. The HMPC plan must state how a business will respond to spills or discharges of these materials. The Ordinance also directs MSD to administer and enforce the program. The current Louisville Metro Hazardous Materials Ordinance was approved on July 2, 2007, as Ordinance No. 121, Series 2007 which amended and re-enacted Chapter 95 of the Louisville Metro Code of Ordinances.

The 2016 Louisville Metro Hazard Mitigation Plan defines hazardous materials as any materials, solids, liquids or gasses that can harm people, other living organisms, property or the environment, and they are often subject to chemical regulations. This plan identifies the potential contamination by hazardous materials as the number five prioritized hazard risk in Jefferson County (Louisville Metro Emergency Services, 2016). Sources of hazardous materials include chemical manufacturers, gas/service stations, hospitals and hazardous materials waste sites.

Release of hazardous materials is a concern for this watershed. The Interstate 64 corridor, which runs through the Middle Fork Beargrass Creek watershed, has been identified as a major transport route for hazardous materials in the Louisville/Jefferson County Hazardous Material Commodity Flow Analysis, which was prepared by Western Kentucky University and the Louisville/Jefferson County Emergency Management Agency. Hazardous materials such as gasoline, explosives, and corrosive and flammable materials were noted as traveling on this roadway. In addition, hazardous materials can be released during floods.

2.7 DEMOGRAPHICS AND SOCIAL CONSIDERATIONS

Population: The Middle Fork Beargrass Creek watershed makes up an important commercial and residential area of Louisville Metro. Louisville Metro is the most populous city in Kentucky, with the current population estimated by the U.S. Census Bureau to be 766,757 as of July 1, 2019. (US Census Bureau, Undated)

The area was settled in the late 18th century by European explorers. By 1800, the population was approximately 4,000 people. By 1900, the population had grown to 232,550, and by 2000, there were about 694,213 people in Jefferson County. See Figure 2.28.

In recent years, population in the larger Louisville metropolitan statistical area has continued to grow due to employment opportunities, a relatively low cost of living and affordable housing prices. As a result, Louisville and surrounding counties have contributed approximately 30% of all population growth in the Commonwealth of Kentucky in 2010. Figure 2.28 displays the historic population trends in Louisville. Future projections estimate that the population of Louisville could increase to 872,231, a 17.7% increase, by the year 2040 (Kelly et al., 2015).

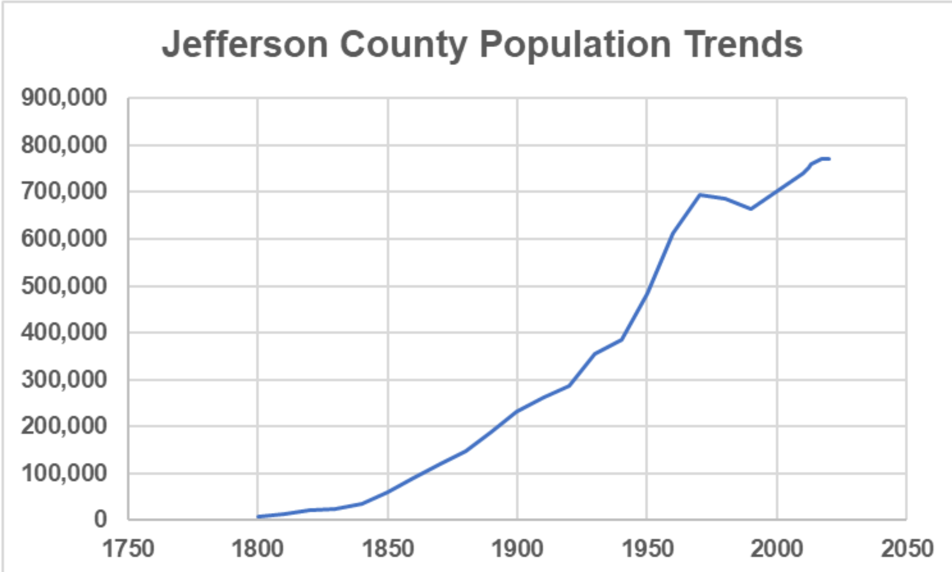

Figure 2.28 Louisville/Jefferson County Population Trends

Based on World Population Review data

Average Household Income: According to the U.S. Census Bureau, the median household income in Jefferson County in 2018 was $54,357, approximately $7,600 lower than the national average of $61,937. The employment rate in Jefferson County was 66%, which is higher than the national average of 59.8%. However, the poverty rate in Jefferson County, at 15% in 2018, was higher than the national average of 13.1%.

Average Age: The age demographics in Jefferson County consist of approximately 61.3% of the population falling between the ages of 18 and 65, while 16.7% of the population is older than 65, and the remaining 22% of the population in the city is under 18 years old. In Jefferson County, approximately 90% of the population has completed at least a high school or equivalent degree, while only 33% of the population has completed some level of college or earned a degree. The nation as a whole has a slightly lower percentage of high school or equivalent graduates, at 88.3% of the population, but has a larger percentage of collegiate graduates, at 41.2% of the population.

Demographic and social statistics for Jefferson County were summarized from the U.S. Census Bureau Quick Facts website: https://www.census.gov/quickfacts/jeffersoncountykentucky shown on Table 2.22.

Table 2.22 Demographic and Social Considerations

Characteristic	Data
People	
Population estimates, July 1, 2019, (V2019)	766,757
Population estimates base, April 1, 2010, (V2019)	741,075
Housing	
Housing units, July 1, 2019, (V2019)	349,321
Owner-occupied housing unit rate, 2014-2018	62%

Characteristic	Data
Median value of owner-occupied housing units, 2014-2018	164,400
Building permits, 2019	3,435
Families & Living Arrangements	
Households, 2014-2018	310,318
Persons per household, 2014-2018	2.42
Language other than English spoken at home, percent of persons age 5 years+, 2014-2018	9%
Computer and Internet Use	
Households with a computer, percent, 2014-2018	87%
Households with a broadband Internet subscription, percent, 2014-2018	81%
Education	
High school graduate or higher, percent of persons age 25 years+, 2014-2018	90%
Bachelor's degree or higher, percent of persons age 25 years+, 2014-2018	33%
Health	
With a disability, under age 65 years, percent, 2014-2018	10%
Economy	
In civilian labor force, total, percent of population age 16 years+, 2014-2018	66%
Income & Poverty	
Median household income (in 2018 dollars), 2014-2018	$ 54,357
Per capita income in past 12 months (in 2018 dollars), 2014-2018	$ 31,980
Percent in poverty	15%
Businesses	
Total employer establishments, 2018	19,818
Total employment, 2018	447,035
Geography	
Population per square mile, 2010	1,948
Land area in square miles, 2010	380
FIPS Code	21111

2.8 TEAM OBSERVATIONS

The Middle Fork Beargrass Creek watershed was chosen for this study because of the extensive existing network of invested project partners, watershed stakeholders and interested public. Input from all parties informed the decision to pursue this monitoring and assessment project with the goal of watershed ecology and in-stream water quality improvements.

In the lead-up to the beginning of monitoring and through initial investigation of the watershed, several relevant observations were made by the team, which shaped the logistical approach to and setup of the project. First, the need for continued collection of accurate and precise data on water quality and stream conditions was identified. Past data collection efforts by entities such as the DOW and MSD, among others, could be added and supplemented to assess changes in stream health and water quality, as well as areas for further improvement. Specific interest was given to in-stream suspended sediments and bacteria when developing the monitoring regimen for this project, as these parameters, along with identified TMDLs, were identified as areas of specific concern for the watershed.

Additionally, project partners and watershed stakeholders identified further assessment of urban encroachment into floodplains and the loss or lack of streamside riparian buffers as potential areas of need. Further, in preliminary reconnaissance of the watershed, nonpoint source pollution sources such as pet waste and litter were noted as being especially prevalent in the stream and near selected monitoring locations.

2.9 EXPLORING THE MIDDLE FORK BEARGRASS CREEK WATERSHED

The GIS data summarized in Chapter 2 demonstrate that these streams are true urban streams, with increased runoff from impervious surfaces leading to channelization in streams. A high percentage of this watershed is covered by impervious surfaces (asphalt, cement, rooftops, etc.). In addition, there are combined sewer overflows (CSOs) and sanitary sewer overflows (SSOs) in the watershed that are actively being addressed through the MSD Consent Decree programs and projects. Land use in the Middle Fork Beargrass Creek watershed is mostly residential and commercial, with many of the commercial properties located along Shelbyville Road and Hurstbourne Lane. An area of agricultural land is also located in this watershed behind the Oxmoor Mall. Data presented in Chapter 2 support the premise that there are sources in the watershed that contribute to elevated bacteria and TSS. Large stream flow fluctuations have also been identified in the watershed through the LTMN data collected by MSD.

CHAPTER 3. MONITORING IN MIDDLE FORK BEARGRASS CREEK WATERSHED

3.0 MONITORING

3.1 INTRODUCTION

Streams are constantly changing in response to season, weather, runoff during storms, geology, groundwater inputs, water withdrawals and other factors. Because many factors affect streams, understanding their water quality requires several different tools. These tools include stream samples, water quality and flow meters, biological samples, and stream habitat assessments. Taken together, the results of these types of water monitoring data paint a picture of stream and watershed health.

This chapter provides an overview of the approach taken by the Kentucky Division of Water (DOW) and the Louisville and Jefferson County Metropolitan Sewer District (MSD) for the monitoring conducted in support of this watershed plan. A summary of the data collected by DOW and MSD, and the quality assurance review of these data are also presented. The monitoring results, including comparisons to applicable water quality criteria and characterization of water quality under wet and dry conditions, along with a more detailed data analysis, are presented in Chapter 4.

3.2 OVERVIEW OF EXISTING MONITORING

Existing monitoring data discussed in this section include the LTMN data collected through MSD's MS4 permit; the United States Geological Survey (USGS) cooperative program to collect continuous water quality and stream discharge data; and volunteer monitoring data collected by Salt River Watershed Watch (SRWW), as described below. The monitoring data collected through these programs were summarized in Chapter 2 of this watershed plan.

- **Louisville MSD:** MSD conducts monitoring at three locations on the mainstem of Middle Fork Beargrass Creek per requirements of the current MS4 Permit (KYS000001) and reports the results in MS4 Annual Reports and periodic State of the Streams Reports https://louisvillemsd.org/WaterQuality. (Louisville and Jefferson County MSD, Undated)
- **USGS**: National Water Information System (NWIS) database https://waterdata.usgs.gov/ky/nwis/qw (USGS, Undated)
- **National Water Quality Monitoring Council**: Water Quality Portal, which is a cooperative service sponsored by the USGS, the Environmental Protection Agency (EPA), and the National Water Quality Monitoring Council (NWQMC). It serves data collected by over 400 state, federal, tribal and local agencies, including DOW. https://www.waterqualitydata.us/ (NWQMC, Undated)
- **SRWW:** Watershed Watch in Kentucky Data Portal: https://kgs.uky.edu/wwky/main.htm (KGS, Undated)

Past monitoring in Middle Fork Beargrass Creek by DOW was not considered as a part of this watershed plan.

The SRWW volunteer monitoring program was formed in 1999 under the umbrella of Watershed Watch in Kentucky, the statewide volunteer monitoring program. Through this program, trained volunteers collected *Escherichia coli* (*E. coli)* bacteria samples and tested pH, temperature, conductivity and dissolved oxygen using field kits. Bacteria samples, and some nutrient samples, have been analyzed by the University of Louisville's water quality lab in the past. Currently, *E. coli* samples are analyzed by a laboratory certified by DOW to perform analyses. Sampling is scheduled three times per year—in the spring, summer and fall. When a volunteer retires from the program, an effort is made to encourage new volunteers to sample site(s) where there are existing data to improve data continuity in this volunteer stream monitoring program.

The existing monitoring data are summarized on Table 3.1. Monitoring sites are shown in Chapter 1 on Figure 1.6. The Salt River Watershed Watch volunteer monitoring sites are listed on Table 3.2 Salt River Watershed Watch Monitoring Sites.

Table 3.1 Overview of Existing Monitoring Data

Sampling Organization	Monitoring Type	# of Sites Sampled	# of Sampling Events	Years Sampled	General WQ	Bacteria	Nutrients	TSS (1)	Metals	Biological / Habitat	Sonde	Stream Discharge
MSD	MS4 Quarterly & Recreation Season	3	2,140 (approximate)	1999-present	x	x	x	x	x	x		
MSD & USGS	Sonde **(2)**	3	continuous	1999-present							x	
USGS	Stream Gaging	2	continuous	1944-present								x
SRWW **(3)**	Volunteer	10	~30	1999-present	x	x	x					

Notes:

1. TSS: Total Suspended Solids
2. Sonde parameters include pH, water, temperature, dissolved oxygen and conductivity.

   Some historical SRWW data are in paper form and may not readily be available for this analysis.

Table 3.2 Salt River Watershed Watch Monitoring Sites

Site ID	Location	Sample Period	Site Status
1785	Cherokee Park Road and Lexington Road	1999-2009, 2013-2015, 2018-present	Active
1886	Middle Fork at Big Rock pavilion, Cherokee Park	1999-2011, 2014-2016, 2017-present	Active
3656	Middle Fork at Seneca Park, near Pee Wee Reese Road	2017-present	Active
1784	Middle Fork at Old Cannons Lane	1999-2009, 2014 - present	Active
1841	Middle Fork at Brown Park	1999-2009, 2014-present	Active
3386	Middle Fork at Arthur K. Draut Park	2015 - present	Active
1840	Middle Fork at Old Whipps Mill Road	2003-2009	Inactive
2019	Middle Fork at Holly Springs subdivision, below ponds	1999-2012	Inactive
3841	Middle Fork at Forest Green Trail	2019-present	Active
1899	Bowman Field Spring at Seneca Valley Road and Pee Wee Reese Road	1999-2009, 2015-present	Active

3.3 SUMMARY OF MONITORING NEEDS

Monitoring needs for this watershed plan were identified by comparing the existing monitoring to the Watershed Planning Guidebook for Kentucky Communities, 1st Edition (KWA and DOW, 2010), hereinafter referred to as Guidebook. Chapter 3 of the Guidebook provides a detailed description of the monitoring required for watershed plans and a phased approach to monitoring:

- **Phase I Monitoring:** Monthly sampling for a specific list of water quality, field parameters (e.g., pH, dissolved oxygen, temperature, conductivity) and stream discharge for one year. For either May or June, 319(h) grant recipients are required to sample five times for *E. coli* bacteria, field parameters and stream discharge. Up to 10 sampling sites are required to be distributed across the study watershed.
- **Phase II Monitoring:** At the end of Phase I monitoring, grant recipients are expected to identify up to three subwatersheds to focus subsequent pollutant source identification monitoring. The process described above for Phase I monitoring is repeated in up to three subwatersheds. In addition, biological monitoring for benthic macroinvertebrate communities and aquatic habitat assessments are required for Phase II monitoring.

The concepts of Phase I and II monitoring are shown on Figure 3.1**,** which was excerpted from the Guidebook.

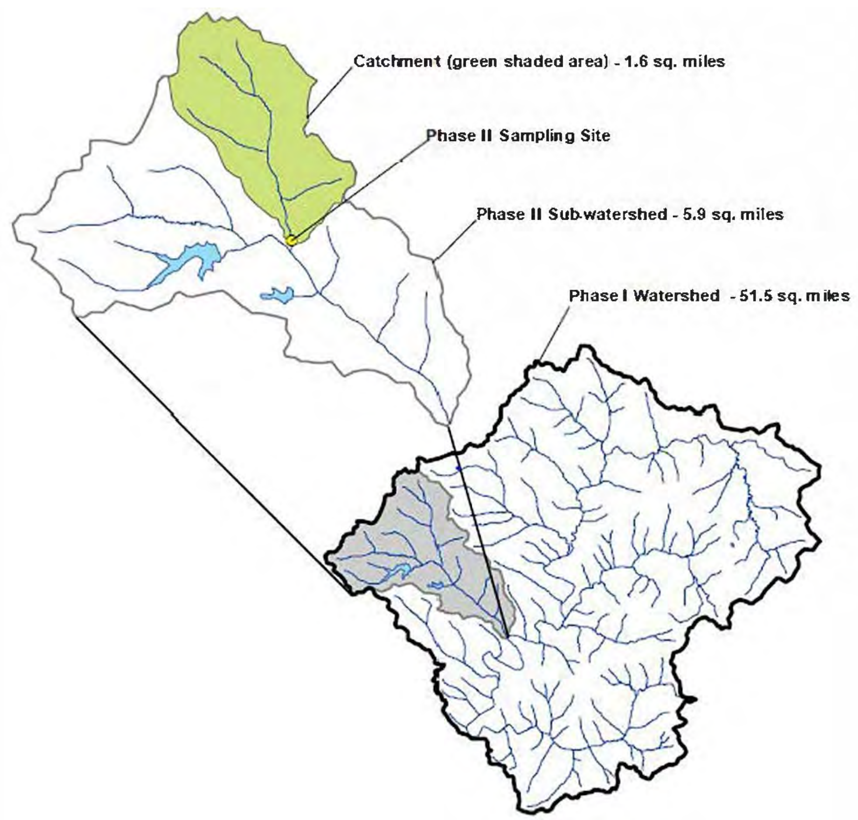

Figure 3.1 Phase I and Phase II Monitoring

When developing the proposal for the watershed planning effort, it was recognized that MSD, USGS and community stakeholders had already collected a significant amount of data, which is required for a 319(h) watershed plan. However, as described below, there were gaps in the available data because the monitoring was originally performed for other purposes.

Spatial Extent: As shown on in Chapter 1 on Figure 1.6 Waterbodies, Monitoring Sites, Rain Gauges and Stream Walks, the existing MSD and USGS monitoring in this watershed has focused on the stream reach extending from the confluence with South Fork Beargrass Creek upstream to Browns Lane, at River Mile 7.97. The three monitoring sites are located on the mainstem of Middle Fork Beargrass Creek. The SRWW monitoring extends the length of the mainstem and includes the Bowman Field spring. However, as a volunteer monitoring effort, the data set is limited and focused on *E. coli* bacteria and field parameters. In order to develop the watershed plan, additional monitoring sites in the headwaters and tributaries were needed.

Parameters: Monitoring conducted by MSD and USGS has focused on parameters required in the MS4 Permit, which are listed on Table 3.3**,** along with parameters required by the Guidebook. This table highlights that some, but not all, of the parameters required by the Guidebook are included in MSDs MS4 monitoring. Therefore, current data for additional parameters were needed to develop the watershed plan.

Table 3.3 Watershed Planning Guidebook and MS4 Monitoring Parameters

Group	Parameter	Guidebook (1)	MS4 Permit 2/1/2017 to 1/31/2022
Bacteria **(2)**	*E.coli (Escherichia coli)*	X	X
Water Quality	NO3/NO2 (Nitrate/Nitrite)	X	
	NH3-N (Ammonia – Nitrogen)	X	
	TKN (Total Kjeldahl Nitrogen)	X	
	Total Nitrogen **(3)**		X
	TP (Total Phosphorous)	X	
	OP (Orthophosphate)	X	
	BOD5 (Biochemical Oxygen Demand)	X	
	Oil and Grease		X
	Copper, Total Recoverable		X
Sediment	TSS (Total Suspended Solids)	X	X
Flow **(4)**	Stream Discharge	X	X
Field Parameters **(4)**	Turbidity (actual or estimated)	X	
	pH	X	X
	DO (Dissolved Oxygen)	X	X
	Conductivity	X	X
	% Saturation (Percentage of DO)	X	
	Temperature	X	X

Group	Parameter	Guidebook (1)	MS4 Permit 2/1/2017 to 1/31/2022
Habitat **(5)**	Habitat Assessment (Barbour method)	X	X
Biology **(5)**	Benthic Macroinvertebrate Assessment	X	X
	Fish Community Assessment		X
	Algal Community Assessment		X

Notes:

1. See Guidebook, Table 3.1. Watershed Plan Monitoring Table
2. Per the Guidebook, *E. coli* bacteria are required to be collected monthly for 11 months, plus five times per month in either May or June.
3. Total Nitrogen is calculated as the sum of Nitrate plus Nitrite Nitrogen and Total Kjeldahl Nitrogen, so MSD monitors these parameters separately and reports Total Nitrogen.
4. Per the Guidebook, stream discharge and field parameters are required to be collected during every sampling event.
5. This watershed planning effort for the Middle Fork Beargrass Creek is considered to be a hybrid of Phase I and Phase II monitoring.

Sampling Frequency: The Guidebook requires monthly monitoring for one year for all parameters listed on Table 3.3 In addition, five *E. coli* samples in 30 days are required during May or June, per the Guidebook. The MS4 permit requires quarterly monitoring for water quality, and five *E. coli* bacteria samples in 30 days for the six-month recreation season of May 1 to October 31. Therefore, monthly monitoring was needed to better characterize water quality for the entire year.

Biological Communities and Aquatic Habitat Assessments: As required by the MS4 permit, MSD collects data on the health of biological communities (e.g., fish, benthic macroinvertebrates and algae) along with aquatic habitat assessments every two years. Per the Guidebook, aquatic habitat and benthic macroinvertebrate monitoring is required for Phase II watershed plans. DOW collected aquatic habitat and benthic macroinvertebrate communities during the first year of the watershed planning project. Therefore, monitoring for this watershed plan is considered to be a hybrid of Phase I and Phase II monitoring requirements.

Riparian Assessment: DOW attributed biological impairment in part to poor quality habitat in the lower reaches of Middle Fork Beargrass Creek (River Mile 0.0 to 2.0) in the most recent Integrated Report. In addition, impairments to biological communities and fair and poor habitat conditions have been documented in MSD's 2016 Synthesis Report and MS4 annual reports. (MSD, 2016 and 2019) Riparian assessments are recommended in the Guidebook (KWA and DOW, 2010). Therefore, a systematic riparian assessment was included in the 319(h) grant application and performed during this project in partnership with the USACE.

3.4 OBTAINING ADDITIONAL DATA THROUGH MONITORING

This section describes the efforts undertaken by DOW and MSD to ensure that a robust data set was available to characterize the Middle Fork Beargrass Creek for this watershed plan. Water quality monitoring conducted in support of this watershed plan included:

DOW Middle Fork Beargrass Creek Watershed Monitoring: During the grant application development, DOW offered to contribute to the development of the watershed-based plan for the Middle Fork Beargrass Creek. DOW determined that due to the unique conditions of this urban watershed, a detailed sampling plan that included additional water quality parameters as well as data for biological communities and aquatic habitat were needed to better understand the current water quality conditions and to help support future water quality improvement projects and prioritization efforts. DOW monitoring included water quality, field parameters (e.g., dissolved oxygen, pH, water temperature, conductivity), stream discharge, benthic macroinvertebrate communities and aquatic habitat. DOW monitoring was conducted between March 21, 2019, and February 18, 2020.

Louisville MSD Middle Fork Beargrass Creek Watershed Monitoring: Louisville MSD's sampling efforts included monthly monitoring at nine sites, including five on the mainstem and four on tributaries to Middle Fork Beargrass Creek. MSD sampling focused on *E. coli* bacteria, field parameters and stream discharge. MSD conducted monitoring between March 11, 2020, and February 24, 2021.

DOW and MSD monitoring sites are shown on Table 3.4 and Figure 2 of the approved MSD Quality Assurance Project Plan (QAPP), which is included in Appendix 3.1 (MSD, 2020). Table 3.4 provides additional details for each monitoring location depicted on Figure 1.6 Waterbodies, Monitoring Sites, Rain Gauges and Stream Walks.

Table 3.4 Middle Fork Beargrass Creek Monitoring Site Locations

Site ID	Station ID (DOW, MSD, USGS)	Waterbody	Location	River Mile	Drainage Area (mi^2)	Latitude	Longitude
1	DOW - DOW08047007 MSD - EMIMI010 USGS - 03293500	Middle Fork Beargrass Creek **(1,2)**	Lexington Road	0.9	24.8	38.250276	-85.716868
2	DOW - DOW08047008 MSD - EMIMI002 USGS - 03293000	Middle Fork Beargrass Creek **(1,2)**	Old Cannons Lane	5.4	18.7	38.23729	-85.66468
3	MSD - EMIMI009	Middle Fork Beargrass Creek **(2,3)**	Browns Lane	7.97	15.2	38.2403	-85.6345
4	DOW - DOW08047010	Weicher Creek **(4)**	Above Blossom-wood Drive	0.55	1.3	38.23016	-85.63071
5	MSD - EMIMI033	Weicher Creek	Lincoln Road	1.56	0.57	38.22902	-85.61491
6	DOW - DOW08047009 MSD - EMIMI038	Middle Fork Beargrass Creek UT 8.45 (Sinking Fork)	Below Bowling Boulevard	0.3	2.6	38.24683	-85.62881

Site ID	Station ID (DOW, MSD, USGS)	Waterbody	Location	River Mile	Drainage Area (mi^2)	Latitude	Longitude
7	DOW - DOW08047011 MSD - EMIMI039	Middle Fork Beargrass Creek UT 9.1	Off Steeplecrest Circle	0.2	3.9	38.24093	-85.61867
8	DOW - DOW08047012 MSD - EMIMI040	Middle Fork Beargrass Creek	Off Old Whipps Mill Road	11.7	5	38.25984	-85.58529
9	MSD - EMIMI041	Middle Fork Beargrass Creek **(3)**	Forest Bridge Road	12.38	4.07	38.26126	-85.57434
10	DOW - DOW08047013 MSD - EMIMI042	Middle Fork Beargrass Creek UT 12.8	Above Foxboro Road	0.2	2.2	38.25867	-85.5668

Notes:

1. USGS Gages record stream discharge; MSD/USGS sondes record pH, DO, temperature, conductivity on 15-minute intervals: 03293500, 03293000
2. MSD LTMN sites: EMIMI010, EMIMI002, EMIMI009
3. MSD 319(h) monitoring site, not sampled by DOW 319(h) monitoring
4. MSD not monitoring this site for 319(h) monitoring; DOW monitored this site, but it is an intermittent tributary, so MSD discontinued this site

Parameters: In addition to the 17 parameters required in the Guidebook (KWA and DOW, 2010) shown on Table 3.3, DOW collected and analyzed samples for 37 additional parameters, including additional forms of nutrients, metals and water chemistry. The additional parameters were included by DOW due to the urban environment in this watershed. Louisville MSD's sampling efforts focused on evaluating bacteria pollution more broadly in this watershed through sampling for *E. coli* bacteria, field parameters and stream discharge.

Riparian Assessment: MSD had planned to conduct riparian assessments at approximately 10 locations with available grant funding and match contribution. However, MSD was able to leverage a simultaneous project in the Beargrass Creek Watershed, the Three Forks Beargrass Creek Ecosystem Restoration Feasibility Study, with which the Louisville and Jefferson County Metropolitan Sewer District (MSD) is partnering with the US Army Corps of Engineers (USACE) to enhance the stream walks for riparian conditions monitoring that were originally scoped as part of the Middle Fork Beargrass Creek 319(h) project (USACE, 2019). By partnering with the USACE, riparian assessments were completed at 25 sites in the Middle Fork Beargrass Creek watershed. Figure 1.6 Waterbodies, Monitoring Sites, Rain Gauges and Stream Walks, depicts riparian assessment locations for the Middle Fork Beargrass Creek. Additional assessments were performed in the South Fork and Muddy Fork Beargrass Creek through the Three Forks project.

After the 319(h) grant was awarded, Louisville MSD agreed to be a local project sponsor with the USACE for the Three Forks of Beargrass Creek Ecosystem Restoration Feasibility Study (i.e., Three Forks project). The purpose of this comprehensive study is to identify measures to restore the ecological integrity of the Beargrass Creek watershed, including Middle Fork, South Fork and Muddy Fork. The Three Forks project is intended to identify innovative restoration techniques and engineering solutions that are compatible with floodplain management to improve ecosystem structure, function and processes that have been lost over time. After the feasibility study is completed, anticipated in 2022, the USACE is eligible to request implementation funding for priority projects identified during this phase.

The following sections describe water quality and stream flow monitoring conducted by DOW and MSD, and Section 3.5 describes riparian assessments that were conducted by USACE and MSD. The summaries presented in this document are supplemented by appendices containing monitoring reports for each phase of monitoring.

3.4.1 DOW Monitoring

DOW prepared the Water Quality Monitoring Quality Assurance Project Plan, Revision 2.0., Effective March 1, 2019 (DOW, 2019) and the 2019 Success Monitoring Program Study, Phase I Watershed Plan Monitoring in Middle Fork Beargrass Creek (DOW, 2019a). These documents describe the specific monitoring DOW conducted, including site locations, sampling considerations, quality control requirements and project completeness. These documents are supported by numerous division-wide quality assurance documents and Standard Operating Procedures (SOPs). SOP documents are available on the DOW website, including project-specific and programmatic documents that were used to evaluate data quality (https://eec.ky.gov/Environmental-Protection/Water/QA/Pages/default.aspx) (DOW, Undated).

DOW monitored the seven locations shown on Table 3.4 between March 21, 2019, and February 18, 2020. For MSD monitoring, some locations were either added or moved from DOW's original seven locations. See Section 3.4.2 Louisville MSD Monitoring for details. DOW conducted sampling at least once per month during the one-year monitoring period. *E. coli* bacteria data were collected five times in the 30-day period between May 9, 2019, and June 6, 2019, then monthly between July and October 2019 (i.e., for the remainder of the 2019 recreation season). During each site visit, field parameters and stream discharge were measured. Water quality samples were analyzed at the State Laboratory in Frankfort, Kentucky. This laboratory is certified by the Kentucky Department for Environmental Protection (DEP) to perform the analysis included in this project.

The DOW monitoring included parameters that are required by the current Guidebook (KWA and DOW, 2010), plus 34 additional parameters. The DOW monitoring parameters are shown on Table 3.5, with parameters required by the Guidebook shown in bold.

Table 3.5 DOW Monitoring Parameters

Parameter Type	Parameter(s) (1)
Bacteria	***E. coli* bacteria**
Bulk	**biochemical oxygen demand**, bromide, chloride, fluoride, nitrate, nitrite, sulfate, turbidity, total dissolved solids, total suspended solids
Nutrients	**ammonia (as N), nitrate-nitrite**, **total Kjeldahl nitrogen**, total organic carbon, **total phosphorus, ortho-phosphorus (field filtered)**
Sediment	**total suspended solids**
Alkalinity	acidity, alkalinity, alkalinity-carbonate, alkalinity-bicarbonate

Parameter Type	Parameter(s) (1)
Metals and Hardness	aluminum, antimony, arsenic, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, molybdenum, nickel, potassium, selenium, silver, sodium, thallium, vanadium, zinc, total hardness
Field Parameters	**turbidity, pH, dissolved oxygen, dissolved oxygen % saturation (calculated) conductivity, temperature**
Stream Flow	**stream discharge**
Biology & Habitat	**benthic macroinvertebrates, habitat assessment**
Notes: 1. Parameters required by the Guidebook are shown in bold.	

Benthic macroinvertebrates and aquatic habitat assessments were completed between March and July 2019. DOW biologists identified benthic macroinvertebrates to the species level, and these data were used to calculate the Macroinvertebrate Index of Biological Integrity (MIBI). MIBI scores were used to assign the narrative rating of Good, Fair or Poor for headwater and wadeable sites in the Bluegrass Physiographic Province based on DOW protocols. USEPA's Rapid Bioassessment Protocol (RBP) was used to assess the quality of aquatic habitat using DOW protocols. RBP scores were used to assign a narrative rating of Good, Fair or Poor for headwater and wadeable sites in the Bluegrass Physiographic Province based on DOW protocols. The benthic macroinvertebrates assessment data will be analyzed during Phase II monitoring.

DOW monitoring results for water quality and field parameters are presented in Appendix 3.2 DOW Water Quality Monitoring Results. Note that DOW collected and reviewed the data set and then provided it to MSD in PDF and Excel formats. MSD performed a quality assurance review and prepared Appendix 3.2 DOW Water Quality Monitoring Results to support development of this watershed-based plan.

3.4.2 Louisville MSD Monitoring

MSD invested significant effort to develop the QAPP (MSD, 2020) and SOP (MSD, 2020a) using templates provided by DOW. These documents were approved by DOW on May 8, 2020. Development of these documents included two field visits with DOW to observe their water quality sample collections, training for MSD field technicians and extensive review by DOW. The QAPP and SOP outline MSD's quality assurance and quality control procedures that addressed safety, staff training, instrument calibration, maintenance and operation, sample collection procedures and collection of quality control instrument measurements and quality control samples. These documents were used to review the quality of MSD's data. MSD's QAPP and SOP are included in Appendix 3.1

The purpose of the MSD 319(h) monitoring was to support the development of the Middle Fork Beargrass Creek Watershed-Based Plan, characterize water quality and stream flow at the selected sites, and to supplement the water quality monitoring performed by DOW.

Water quality monitoring sites were selected to address monitoring needs described in Section 3.3 and to build upon the data collected by DOW. MSD accompanied DOW to their monitoring sites and performed several site reconnaissance efforts to identify the final sampling locations. The rationale for MSD's monitoring locations is presented on Table 3.6 and is also included as Table 6. MSD 319(h) Monitoring Site

Rationale in MSD's Approved QAPP for 319(h) Monitoring for the Middle Fork Beargrass Creek Watershed Plan (MSD, 2020).

Table 3.6 MSD 319(h) Monitoring Site Rationale

Station ID (DOW, MSD, USGS)	Waterbody	Location	Monitoring Rationale
DOW08047007 EMIMI010 03293500	Middle Fork Beargrass Creek	Lexington Road	Downstream end of watershed, add to LTMN and DOW 319(h) monitoring database
DOW08047008 EMIMI002 03293000	Middle Fork Beargrass Creek	Below Old Cannons Lane	Within CSO area, add to LTMN and DOW 319(h) monitoring database
EMIMI009	Middle Fork Beargrass Creek	At Browns Lane	Upstream of CSO area, add to LTMN monitoring database
DOW08047009 EMIMI038	Middle Fork Beargrass Creek UT 8.45 (Sinking Fork)	Below Bowling Boulevard	Commercial area
EMIMI033	Weicher Creek	Lincoln Road	Downstream of golf course
DOW08047011 EMIMI039	Middle Fork Beargrass Creek UT 9.1	Off Steeplecrest Circle	Suburban area
DOW08047012 EMIMI040	Middle Fork Beargrass Creek	Off Old Whipps Mill Road	Downstream of flood control dam and large wetland upstream of dam
EMIMI041	Middle Fork Beargrass Creek	Forest Bridge Road	Upstream of Old Whipps Mill Road dam
DOW08047013 EMIMI042	Middle Fork Beargrass Creek UT 12.8	Above Foxboro Road	Upstream end of watershed, characterized suburban area

Six sampling locations were sampled by both DOW and MSD. MSD added two new monitoring locations at Browns Lane and Forest Bridge Road. DOW sampled Weicher Creek at Blossomwood Drive; however, MSD sampled upstream at Lincoln Road (EMIMI033) because this location has more consistent flow. The Browns Lane location (EMIMI009) is one of MSD's LTMN sites and, by adding it to the 319(h) project, the MSD LTMN data from this site can be used to support development of this watershed plan. The Forest Bridge Road location (EMIMI041) is located on the mainstem above the Whipps Mill dam. The proposed MSD monitoring sites were mapped and provided to DOW for review and approval prior to establishing the locations as monitoring sites.

The MSD monitoring parameters are presented on Table 3.7. MSD monitoring was conducted between March 2020 and February 2021. Wet and dry sampling events are included in Appendix 3.3 MSD Water Quality Monitoring Results.

Table 3.7 MSD Monitoring Parameters

Parameter Type	Parameter(s) (1)
Bacteria	***E. coli* bacteria**
Field Parameters	**Turbidity, pH, Dissolved Oxygen, Dissolved Oxygen % Saturation (calculated) Conductivity, Temperature**
Stream Flow	**Stream discharge**
Notes: 1. Parameters required by the Guidebook are shown in bold.	

MSD water quality monitoring results are presented in Appendix 3.3 MSD Water Quality Monitoring Results.

3.5 RIPARIAN ASSESSMENT

In partnership with MSD, the USACE developed the Three Forks Beargrass Creek Ecosystem Restoration Feasibility Study. The project investigated the options to restore riparian and riverine habitat that has been lost over time in the Beargrass Creek watershed. Visual riparian assessments that were conducted as a part of this ecosystem corridor project were above and beyond the original 319(h) scope and were leveraged to benefit this watershed plan. Twelve project sites, in comparison to two or three original sites, were selected for the riparian assessments, with five being on Middle Fork Beargrass Creek.

The riparian assessment utilized the USACE-developed Simple Model for Urban Riparian Function (SMURF), which is a habitat restoration planning model. The SMURF assessed three major categories of outputs for riparian zones relating to instream processes, native faunal habitat and sources of resilience in highly disturbed areas (USACE, 2021). Volunteers conducted stream walks at the designated sites and used the SMURF scoresheet to score the left and right bank riparian zones. These sites are shown on Figure 1.6: Waterbodies, Monitoring Sites, Rain Gauges and Stream Walks.

It is anticipated that the data and SMURF scores found for the sites could be converted to rapid bioassessment protocol (RBP) scores during Phase II monitoring. The conversion to RBP scores will allow for the data to be readily compared and useful outside of the Three Forks study.

CHAPTER 4. ANALYZING MONITORING RESULTS

4.0 ANALYZING MONITORING RESULTS

4.1 GOALS OF THE ANALYSIS

Water quality data in the watershed were collected, consistent with the Watershed Planning Guidebook for Kentucky Communities, 1st Edition (KWA & DOW, 2010), hereinafter referred to as "Guidebook," with the purpose of determining the primary pollutants of concern and pollutant load reductions needed in the watershed, as well as determining types of best management practices (BMPs) and locations in which implementation of BMPs would be most effective in reducing pollutant sources. BMP workshops were held with a BMP committee to discuss the most feasible and efficient BMPs to reduce the pollutants of concern, which are discussed further in Chapter 5. Pursuant to the Guidebook, the purpose of the Phase I Analysis is to prioritize up to three smaller watersheds for additional assessment and implementation. The analysis presented in this chapter reviews the monitoring data collected in the watershed during the Phase I monitoring. The data collected over a two-year period reveal the likely pollutants of concern and the areas in which BMP implementation may provide improvements. Monitoring for watershed planning and implementation can be conducted in two phases. Phase I monitoring for this study focused on the characterization of the watershed for nonpoint source pollution concerns, water quality data and community prioritization. Phase II efforts will be designed to fill in data gaps identified during and after the Phase I analysis. It is anticipated that data gaps will be focused on specific pollutants of concern to lead to targeted structural and nonstructural BMPs for prioritization and defined in Phase I and II efforts.

4.2 PHASE I – ANALYSIS

Phase I monitoring was performed through an orchestrated effort between the Kentucky Division of Water (DOW) and the Louisville and Jefferson County Metropolitan Sewer District (MSD) water quality staff as part of this watershed plan over a two-year period, from March 21, 2019, through February 24, 2021. While both teams collected water quality data and field parameters, DOW also performed macroinvertebrate and habitat assessments at the DOW locations. MSD monitoring was conducted from March 11, 2020, through February 24, 2021, and included water quality data and field parameters. Details regarding sampling events and data quality analysis can be found in Appendices 3.2 and 3.3. The locations for monitoring locations are depicted on Figure 4.1 Middle Fork Beargrass Creek Monitoring Sites.

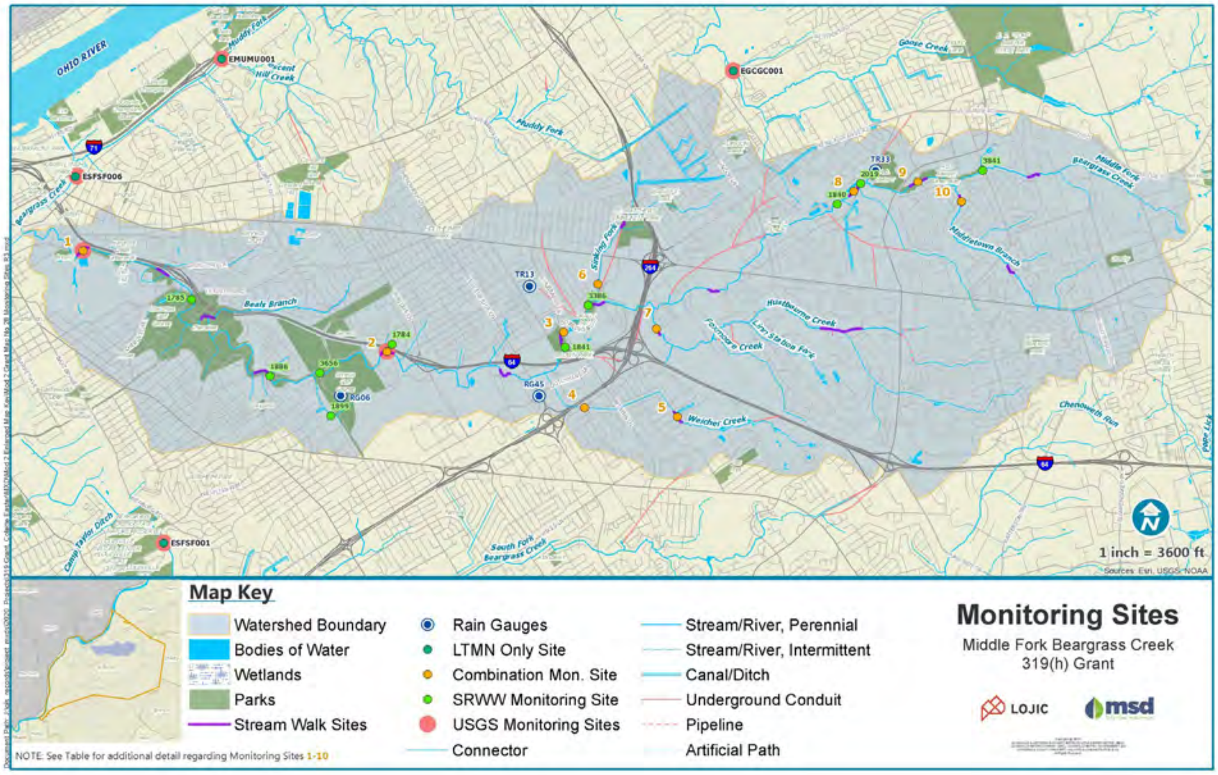

Figure 4.1 Middle Fork Beargrass Creek Monitoring Sites

For the purposes of Chapter 4, site identification numbers 1 through 10 are used to identify the 10 sampling locations shown in Table 4.1 Monitoring Locations. Due to the length of this monitoring program, at the mid-way point some adjustments to the sampling locations were made (as detailed in Appendix 3.3). Six of these sites (Sites 1, 2, 6, 7, 8 and 10) have both MSD location codes and DOW location codes. Site 4 was sampled exclusively by DOW, and Sites 3, 5 and 9 were sampled exclusively by MSD.

Table 4.1 Monitoring Locations provides a summary of the monitoring locations with information including the site identification number as seen on Figure 4.1, the name of the waterbody, street location, river mile, drainage area in square miles, latitude and longitude.

Table 4.1 Monitoring Locations

Site ID	Station ID (DOW, MSD, USGS)	Waterbody	Location	River Mile	Drainage Area (mi^2)	Latitude	Longitude
1	DOW - DOW08047007 MSD - EMIMI010 USGS - 03293500	Middle Fork Beargrass Creek (1,2)	Lexington Road	0.9	24.8	38.250276	-85.716868
2	DOW - DOW08047008 MSD - EMIMI002 USGS - 03293000	Middle Fork Beargrass Creek (1,2)	Old Cannons Lane	5.4	18.7	38.23729	-85.66468
3	MSD - EMIMI009	Middle Fork Beargrass Creek (2,3)	Browns Lane	7.97	15.2	38.2403	-85.6345
4	DOW - DOW08047010	Weicher Creek (4)	Above Blossom-wood Drive	0.55	1.3	38.23016	-85.63071
5	MSD - EMIMI033	Weicher Creek	Lincoln Road	1.56	0.57	38.22902	-85.61491
6	DOW - DOW08047009 MSD - EMIMI038	Middle Fork Beargrass Creek UT 8.45 (Sinking Fork)	Below Bowling Boulevard	0.3	2.6	38.24683	-85.62881
7	DOW - DOW08047011 MSD - EMIMI039	Middle Fork Beargrass Creek UT 9.1	Off Steeplecrest Circle	0.2	3.9	38.24093	-85.61867
8	DOW - DOW08047012 MSD - EMIMI040	Middle Fork Beargrass Creek	Off Old Whipps Mill Road	11.7	5	38.25984	-85.58529
9	MSD - EMIMI041	Middle Fork Beargrass Creek (3)	Forest Bridge Road	12.38	4.07	38.26126	-85.57434
10	DOW - DOW08047013 MSD - EMIMI042	Middle Fork Beargrass Creek UT 12.8	Above Foxboro Road	0.2	2.2	38.25867	-85.5668

Notes:

1. USGS Gages record stream discharge; MSD/USGS sondes record pH, DO, temperature, conductivity on 15-minute intervals: 03293500, 03293000
2. MSD LTMN sites: EMIMI010, EMIMI002, EMIMI009
3. MSD 319(h) monitoring site, not sampled by DOW 319(h) monitoring
4. MSD not monitoring this site for 319(h) monitoring; DOW monitored this site, but it is an intermittent tributary, so MSD discontinued this site

4.2.1 Habitat Assessment

Habitat assessments were performed throughout the watershed at specific sampling locations by DOW and through the partnership between the United States Army Corp of Engineers (USACE) and MSD for the Three Forks of Beargrass Ecosystem Restoration Feasibility Study (Three Forks). Assessments performed for the Three Forks project utilized two forms of assessment—one that focused on in-stream parameters and the other on riparian function. Assessment methodology included use of the Ohio EPA's Qualitative Habitat Evaluation Index (QHEI) (State of Ohio, 2006) and the Simple Model for Urban Riparian Function (SMURF) (McKay). The QHEI evaluates six parameters, including 1) substrate, 2) instream cover such as overhanging vegetation and rootmass, 3) meander pattern and stability, 4) erosion and riparian, 5) riffle/pool development and 6) stream gradient. The SMURF evaluates three main categories of riparian function: 1) within the stream buffer, 2) riparian and 3) from the perspective of the stream. These assessments are visually based and were performed at 12 locations throughout the watershed. While the QHEI and SMURF do not directly correlate with the habitat assessment performed by DOW, these assessments can be converted to the EPA's Rapid Bioassessment Protocol (RBP) during Phase II monitoring to inform BMP selections.

In 2019, DOW evaluated stream and riparian habitat using the EPA's RBP (2011), which is a visual-based assessment methodology that evaluates the condition of in-stream features as well as riparian condition along the banks and stream corridor. These assessments provide a snapshot of stream quality throughout various points in the watershed, even though they are only representative of the sampling point. The RBP can be used across the state and in any bioregion, although specific quality ranges are associated with each (see Figure 4.2).

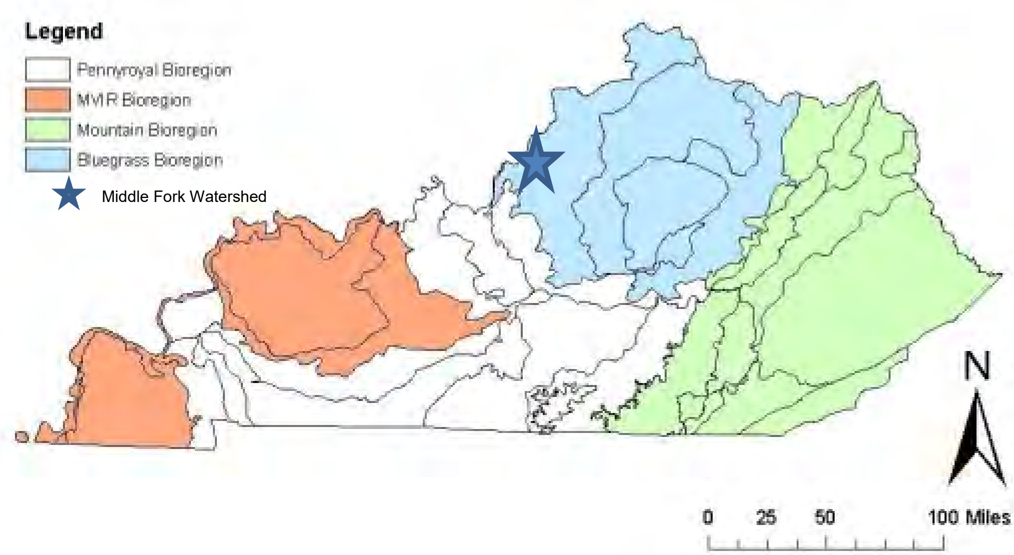

Figure 4.2 Designated Habitat Bioregions of Kentucky (Methods for Assessing Habitat in Wadeable Waters, 2011)

Middle Fork Beargrass Creek is located within the Bluegrass Habitat Bioregion with sampling locations among both wadeable and headwater systems. For the purpose of this study, high gradient assessment forms were used to evaluate 10 parameters reflecting the existing stream condition. Habitat quality for high gradient streams is considered excellent, average or poor based on the ranges shown in Table 4.2 Blugrass Bioregion Habitat Quality Range.

Table 4.2 Bluegrass Bioregion Habitat Quality Range

Stream Quality	Headwater Range		Wadeable Range	
Excellent	156	200	130	200
Average	142	155	114	129
Poor	0	141	0	113

At each station, a total of 10 individual parameters were assessed that focus on the condition of the stream bed, cross-sectional and profile features, historic alteration, bank stability and vegetation. Parameters such as bank stability (8a/8b), vegetative protection (9a/9b) and riparian vegetation (10a/b) can vary from one bank to another and are best characterized when evaluating the left bank (LB) independently from the right bank (RB). The maximum score of a left or right bank individually is 10, such that with both banks combined, a maximum score of 20 points may be achieved when the habitat quality for a metric is characterized as optimal. Overall stream quality of the watershed scored in the poor range, with a maximum score of 119 at Site 7: Middle Fork Beargrass Creek UT 9.1 off Steeplecrest Circle (DOW08047011). The lowest scores contributing to poor quality are those associated with bank stabilization, bank vegetation and riparian vegetation. Table 4.3 RBP Stream Quality Summary presents a summary of the RBP data collected at DOW sampling locations. Red coloring indicates poor habitat; orange, marginal; yellow, sub-optimal; and green, optimal. Photos of each location along with a brief description of the area are summarized in the following paragraphs.

Table 4.3 RBP Stream Quality Summary

Site ID	1) Epifaunal Substrate	2) Embeddedness	3) Velocity/Depth Regime	4) Sediment Deposition	5) Channel Flow Status	6) Channel Alteration	7) Frequency of Riffles	8a) Bank Stability (LB)	8b) Bank Stability (RB)	9a) Vegetative Protection (LB)	9b) Vegetative Protection (RB)	10a) Riparian Vegetative (LB)	10b) Riparian Vegetative (RB)	TOTAL Score	Overall Stream Quality
1	10	13	13	10	15	14	6	2	1	1	1	4	4	94	Poor
2	9	9	14	15	11	13	11	6	8	6	6	2	8	118	Average
3	RBP Not Collected														
4	5	3	8	7	14	4	13	7	9	4	2	1	1	78	Poor
5	RBP Not Collected														
6	8	7	8	5	12	14	5	4	4	5	5	5	6	88	Poor
7	12	13	14	10	12	15	12	6	6	6	6	5	2	119	Poor
8	8	7	13	13	15	12	9	6	4	6	2	4	1	100	Poor
9	RBP Not Collected														
10	11	9	17	6	15	12	14	3	2	3	2	6	2	102	Poor

Site 1: Middle Fork Beargrass Creek at Lexington Road was sampled by MSD between March 2019 and February 2021. This location is also monitored by MSD during the quarterly and recreational sampling required by the MS4 permit. This site is located on the main stem of the Middle Fork of Beargrass Creek (Middle Fork). It is approximately 0.9 river miles upstream of the confluence with South Fork and Muddy Fork, with a drainage area of 24.8 square miles. It is located in a predominantly urban area of the watershed and within the combined sewer system of the MSD service area.

The combined parameter score at this location was 94 (poor) and indicates low values attributed to bank instability and a lack of bank vegetation along both banks. Loss of trees, loss of root cover and lateral expansion of the banks (exposed manholes) can be seen in the photographs below. These issues translate to low epifaunal substrate, embeddedness, and sediment deposition and may affect velocity depth regime and frequency of riffles as pool/riffle sequences become sediment laden. Epifaunal substrate refers to the quantity and variety of the structures that provide refugia, feeding opportunities and spawning sites. Embeddedness is the degree to which the natural stream bed material is covered by silt, sand, mud or algae. Streams with low epifaunal and embeddedness scores exhibit decreased surface area available to macroinvertebrates and fish.

Site 1: Middle Fork Beargrass Creek at Lexington Road

Figure 4.3 Looking upstream: bank instability near Lexington Road

Figure 4.4 Looking downstream: stream bank and tree loss

Figure 4.5 Looking upstream: Inner berm erosion and undermining tree root mass

Figure 4.6 Left bank: Vertical stream banks and lateral stream bank erosion

Site 2: Middle Fork Beargrass Creek at Old Cannons Lane was sampled by MSD between March 2019 and February 2021. This location is also monitored by MSD during the quarterly and recreational sampling required by the MS4 permit. This site is located on the main stem of the Middle Fork Beargrass Creek. It is approximately 5.4 river miles upstream of the confluence with South Fork and Muddy Fork, with a drainage area of 18.7 square miles. Site 2 is located just upstream of Seneca Golf Course in a predominantly residential area near Seneca Park. Bowman Field Airport is approximately 1,300 feet south of the monitoring location, and Interstate 64 is 135 feet north.

A combined score of 118 (average) was observed at this location. This station has one of the highest scores among the sample stations; as a wadeable stream, it scored as a low average quality stream. All but one parameter scored in the marginal or suboptimal category. The interstate and open space below Old Cannons Lane contributed to lower riparian scores, while sedimentation, common to reaches low in the watershed, affected epifaunal substrate and embeddedness scores.

Site 2: Middle Fork Beargrass Creek at Old Cannons Lane

Figure 4.7 Looking upstream: embedded riffle substrate south of Old Cannons Lane

Figure 4.8 Left bank: open canopy along opposite bank

Site 3: Middle Fork Beargrass Creek at Browns Lane was monitored by MSD from March 2020 to February 2021. The location is also monitored by MSD during the quarterly and recreational sampling required by the MS4 permit. Site 3 is located at river mile 7.97, and the drainage area is 15.2 square miles. This site is located at the bridge at Browns Lane and Brown Park and is surrounded by commercial and residential land uses. The area near the pedestrian bridge is often frequented by the public and by wildlife. A section of Middle Fork Beargrass Creek in Brown Park was restored. No RBP habitat data were collected at this site.

Site 3: Middle Fork Beargrass Creek at Browns Lane

Figure 4.9 Looking upstream: embedded stream bed

Figure 4.10 Looking downstream: pedestrian access north of Brown Park

Site 4: Weicher Creek was sampled by DOW from March 2019 to February 2020. The area is located near river mile 0.55 of Weicher Creek, a tributary of Middle Fork Beargrass Creek, and drains approximately 1.3 square miles. It is approximately 500 feet upstream from where the creek travels under Interstate 264, Watterson Expressway. The monitoring location is located in a residential area that was developed primarily during the 1950s. Commercial areas border the neighborhood surrounding this site.

Visual observation of the RBP parameters indicates a total score of 78 (poor), one of the lowest scoring sites across the watershed. This site is highly affected by development and has been straightened in the past. Streams that have been straightened often exhibit bank instability due to vertical incision, loss of vegetation along stream banks, lack of riffle/pool sequences and sedimentation.

Site 4: Weicher Creek (DOW)

Figure 4.11 Looking upstream: embedded stream material

Figure 4.12 Looking downstream: stream substrate material

Site 5: Weicher Creek at Lincoln Road was sampled by MSD and visually assessed during the Three Forks stream walks. This site was selected to be relocated further upstream at the midpoint of the study due to the lack of baseflow at Site 4 throughout the year. (Site 4 and Site 5 should be considered together when evaluating tributary conditions and assessment.) Site 5 is located at river mile 1.56 of Weicher Creek, a tributary of Middle Fork Beargrass Creek, with a drainage area of 0.57 square miles. It is approximately one river mile upstream from Site 4. MSD relocated this monitoring site to focus on a location that is more representative of the Weicher Creek subwatershed. Site 5: Weicher Creek at Lincoln Road is located in a residential neighborhood with many of the homes constructed in the 1950s. It is just downstream of the Oxmoor Country Club, which includes a golf course and two detention ponds. No RBP habitat data were collected at this site.

Site 5: Weicher Creek at Lincoln Road (MSD)

Figure 4.13 Looking downstream: lack of riparian corridor and tree canopy cover

Figure 4.14 Looking upstream: residential land use constricting stream corridor

Site 6: Middle Fork Beargrass Creek UT 8.45 Sinking Fork was monitored by DOW and MSD between March 2019 and February 2021. It is located at river mile 0.3 of Sinking Fork, a tributary of Middle Fork Beargrass Creek, and has a drainage area of 2.6 square miles. Site 6 at Sinking Fork is located in the City of St. Matthews and is downstream of a heavily commercialized business area that includes two indoor shopping malls, automobile dealerships, restaurants, shopping and major thoroughfares.

The total RBP score at this location was 88 (poor). Instream and riparian parameters scored low with the exception of channel flow status and channel alternation, which on an individual parameter basis scored as suboptimal, indicating a level of functionality. Bank stability, vegetation and several parameters related to sedimentation scored low, indicating potential for habitat improvement activities.

Site 6: Middle Fork Beargrass Creek UT 8.45 Sinking Fork

Figure 4.15 Looking upstream: frequently disturbed habitat

Figure 4.16 Looking downstream: bank vegetation loss and instability

Site 7: Middle Fork Beargrass Creek UT 9.1 off Steeplecrest Circle was monitored by DOW and MSD between March 2019 and February 2021 and was visually assessed during the Three Forks stream walks. It is located at river mile 0.2 on an unnamed tributary and has a drainage area of 3.9 square miles. It is located near Oxmoor Mall, Oxmoor Farms and residential areas, including multifamily residential areas.

Habitat data collected at this station indicate a total score of 119 (poor), although it is the highest scoring site within the watershed sampling base. To date, this reach has been protected from development with a percentage of agricultural and open space land use. A thin riparian corridor shades the creek with a stable mix of bed material and habitat features.

Site 7: Middle Fork Beargrass Creek UT 9.1, Off Steeplecrest Circle

Figure 4.17 Looking upstream: cobble bed material and bank vegetation

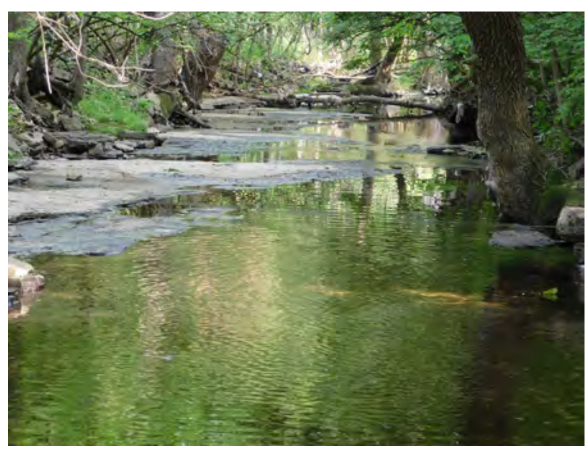

Figure 4.18 Looking downstream: in stream habitat

Site 8: Middle Fork Beargrass Creek off Old Whipps Mill Road was monitored between March 2019 and February 2021 as well as visually assessed during the Three Forks stream walks. It is located at river mile 11.7 and has a drainage area of five square miles. Site 8 is located downstream from the Whipps Mill Dry Dam and is near the University of Louisville Shelby Campus. There are two ponds near the monitoring location that store stormwater runoff. Electric transmission lines traverse this site, and the ground within the easement is maintained by methods such as bushhogging and/or tree clearing. Figure 4.19 shows where trees were removed that were near transmission lines along the bank of the creek near this site. Loss of stream bank vegetation contributes to stream bank lateral migration (exposure of the tower footer), increased water temperature, bank instability, loss of in-stream habitat and a reduction in riparian function.

Figure 4.19 Tree Removal near Old Whipps Mill

The total RBP score at this location was 100 (poor). Primary indicators of degradation are low vegetation, riparian and instream habitat scores. The stream has been historically straightened, resulting in the loss of riffle/pool sequences. Epifaunal substrate and embeddedness may be affected by bank instability, sediment loads and/or unstable habitat.

Site 8: Middle Fork Beargrass Creek Off Old Whipps Mill Road

Figure 4.20 Looking upstream: lack of instream habitat

Figure 4.21 Looking downstream: bedrock homogeneous stream bed

Site 9: Middle Fork Beargrass Creek at Forest Bridge Road was monitored by MSD from March 2020 to February 2021. Site 9 is located near river mile 12.38 and has a drainage area of 4.07 square miles. The site sits between a commercial area along Hurstbourne Lane and single family and multi-family homes. Forest Green Trail is located near Site 9. No RBP habitat data were collected at this site.

Site 9: Middle Fork Beargrass Creek at Forest Bridge Road

Figure 4.22 Looking upstream: riffle/pool sequences

Figure 4.23 Looking downstream: low bank height

Site 10: Middle Fork Beargrass Creek UT 12.8 Above Foxboro Road was sampled by DOW and visually assessed during the Three Forks stream walks. It is located at river mile 0.2 on an unnamed tributary of Middle Fork Beargrass Creek and has a drainage area of 2.2 square miles. The monitoring location is in a residential area and is the most upstream monitoring location for Phase I monitoring.

The overall stream quality score is 102 (poor). The culvert crossing at Foxboro Road historically catches a lot of debris flow and inhibits downstream throughflow. Vegetation loss along the stream bank contributes to bank instability, and the corridor is constrained, resulting in low scores. These issues affect other parameters such as sediment deposition, epifaunal substrate and embeddedness. Riffle/pool complexes are present upstream of Foxboro Road and exhibit a mix of gravel and cobble material.

Site 10: Middle Fork Beargrass Creek UT 12.8, Above Foxboro Road

Figure 4.24 Looking downstream: debris jam upstream of Foxboro Road

Figure 4.25 Looking upstream: high near vertical banks and undercut tree

4.2.2 Benchmarks

The Guidebook defines a benchmark as an acceptable water quality concentration for a healthy stream. To determine if the water quality parameters indicated good or poor water quality, a desirable concentration was needed as a comparison. The results of the monitoring were compared to regulatory water quality standards criteria and non-regulatory benchmarks to evaluate the condition of water quality in Middle Fork Beargrass Creek. Reference reach waters were used to develop the benchmarks. Reference reaches represent examples of undisturbed or the least unchanged streams within the ecoregion. The benchmarks provide a framework to improve habitat and water quality where results indicate low quality and to facilitate the planning of BMPs with the goal of protecting and restoring water quality in the watershed.

The Kentucky Watershed Planning Guidebook provides the following hierarchical-preferred sources for developing benchmarks:

1. Parameters that have water quality criteria identified in 401 KAR 10:031, Surface Water Standards, which are the numeric criteria in the regulation, will be used.
2. DOW reference reaches in a Phase I watershed can be used to develop the benchmarks. There are no DOW reference reaches in the Middle Fork Beargrass Creek watershed.
3. Kentucky ecoregional averages developed from DOW reference reaches can be used to develop benchmarks.

4. Criteria defined in the EPA Nutrient Criteria Database

Parameters that have water quality standards criteria identified in 401 KAR 10:031, Surface Water Standards, will be compared to the numeric criteria in the regulation. Parameters identified for monitoring of the Middle Fork Beargrass Creek watershed that fall into this category include *E. coli*, pH, temperature and dissolved oxygen. The numeric criteria for Warm-water Aquatic Habitat (WAH) are described in Table 4.4 Summary of Regulatory Criteria and Non-regulatory Benchmarks.

Based on the hierarchical-preferred sources above, the approaches for non-regulatory benchmarks have varied between watershed plans developed in Kentucky. The non-regulatory benchmarks that were developed for the Middle Fork Beargrass Creek are only intended for planning purposes. They have no impact on other watersheds; rather, they were developed as iterative goals for the Middle Fork Beargrass Creek to be revisited and adjusted.

For the purposes of this watershed plan, Kentucky ecoregional medians developed from DOW reference reaches were used to develop benchmarks. DOW provided the Outer Bluegrass ecoregion (71(d)) data for reference reaches and stations that had good and excellent biological data. This water quality data were used to establish the benchmarks with non-regulatory criteria (total phosphorus, total nitrogen, ammonia, specific conductance, total suspended solids and turbidity). The reference reach sites had different quantities of sampling events, ranging from one event to 22 events. To normalize the results and avoid over- or under-representing sites, the median value of results for each parameter at each site was calculated. The 75th and 90th percentiles were then calculated from the median values for each parameter. The 75th percentiles were used for all benchmarks, with the exception of total ammonia as N, which used the 90th percentile.

The benchmarks selected for this plan are shown in Table 4.4 Summary of Regulatory Criteria and Non-regulatory Benchmarks.

Table 4.4 Summary of Regulatory Criteria and Non-regulatory Benchmarks

Parameter	Benchmark	Type
pH	6.0 and 9.0 SU, and not to fluctuate more than 1.0 SU over 24 hours	Regulatory (WAH)
Temperature	<31.7°C(89°F)	Regulatory (WAH)
Dissolved Oxygen	>5.0 mg/L as a 24-hour average; or >4.0mg/L for instantaneous	Regulatory (WAH)
Un-ionized Ammonia	<0.05 mg/L	Regulatory (WAH)
E. coli	130 CFU/100mL as 30-day geometric mean, or 240 CFU/100mL as an instantaneous measurement	Regulatory (PCR)
Total Phosphorus	0.2 mg/L	Non-regulatory
Total Nitrogen	1.2 mg/L	Non-regulatory
Ammonia (as N)	0.1 mg/L	Non-regulatory
Specific Conductance	521.8 µS/cm	Non-regulatory
Total Suspended Solids	12.9 mg/L	Non-regulatory
Turbidity	11.6 NTU	Non-regulatory

4.2.3 Water Quality

As described in Chapter 1, the Middle Fork Beargrass Creek is a true urban watershed with channelization and increased runoff due to impervious surfaces. This presents unique challenges to water quality in these streams. The urban nature with land set aside for parks also leads to opportunities for increased community engagement and active use of this watershed for recreation. The following sections describe findings from the water quality data analysis from samples collected for this watershed-based plan. Pollutant concentrations were analyzed and compared to the benchmarks described in Section 4.0. The frequency parameters exceeded the benchmarks as reported; pollutant loads and yields are defined and outlined in Section 4.2.3.3. The analysis of potential pollutant sources is summarized and informs the selection of BMPs in this watershed.

DOW collected water quality data as described in Appendix 3.2 from March 21, 2019, through February 18, 2020. Appendix 3.3 provides an overview of the parameters MSD collected from March 11, 2020, through February 24, 2021.

Wet weather sampling demonstrates pollutants that have accumulated across the watershed and are being flushed into the waterways via stormwater runoff, while dry weather sampling events demonstrate the existing pollutants in the waterways and may indicate leaks or illicit discharges somewhere in the watershed. The sampling data from both MSD and DOW were classified as wet or dry sampling events based on the rainfall patterns prior to and during the sampling dates. Details of this classification can be found in Appendices 3.2 and 3.3.

Box and whisker plots are used to present the relative magnitude of pollutant concentrations between sites for each parameter. This plot divides the data into four groups, with the middle (interquartile range) of the data shown in the box, and the lower and higher extent of the data shown with the whiskers.

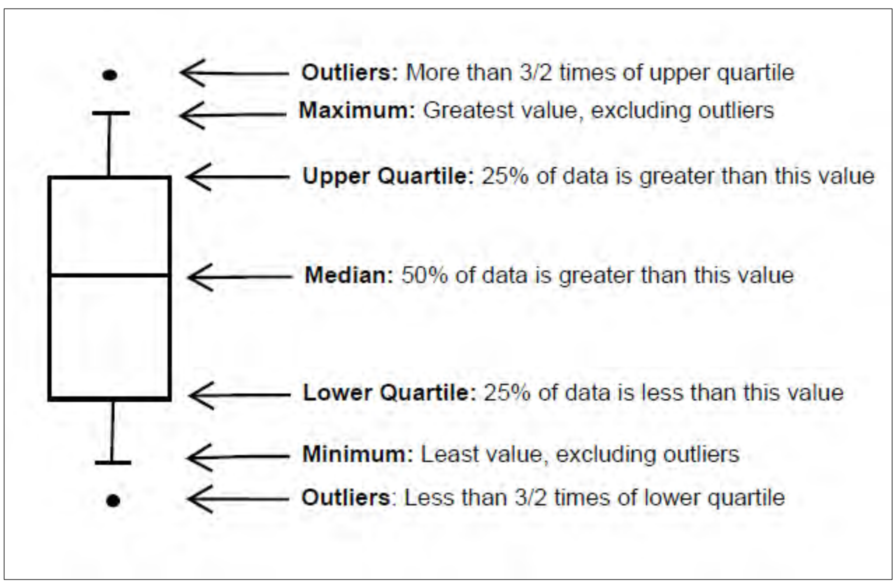

Figure 4.26 Box and Whisker Plot

4.2.3.1 *Pollutant Concentrations*

The results from the water quality monitoring were analyzed, and the resulting concentrations were compared to the water quality benchmarks, discussed in Section 4.0. By comparing the resulting monitoring concentrations to the benchmark concentrations, an indication of the water quality with respect to the specific parameter was inferred. The following sections summarize the purpose of tracking the pollutant, concentrations, comparison to the benchmark and graphical presentation. For parameters meeting the benchmark, no further analysis or development of pollutant loads was performed during Phase I.

4.2.3.1.1 Bacteria

E. coli is a bacterium that is commonly tracked to indicate potential pathogens in the system that can be harmful to humans. Samples were collected monthly from July to October 2019 and March 2020 to February 2021 as well as five times between May to June 2019 and 2020 to evaluate the geometric mean during the recreational period. The geometric mean requires not less than five samples collected during a 30-day period. Sites 4, 5, 6 and 7 had pooled or dry conditions during some sampling events; therefore, adequate samples could not be obtained to capture the required five samples to calculate the geometric mean at these sites. Sites 4 and 5 did not have the required five samples during both sampling years 2019 and 2020. The geometric mean was calculated for sites 6 and 7 during 2019, but not during 2020. Figure 4.27 displays the geometric mean calculated for Phase I analysis.

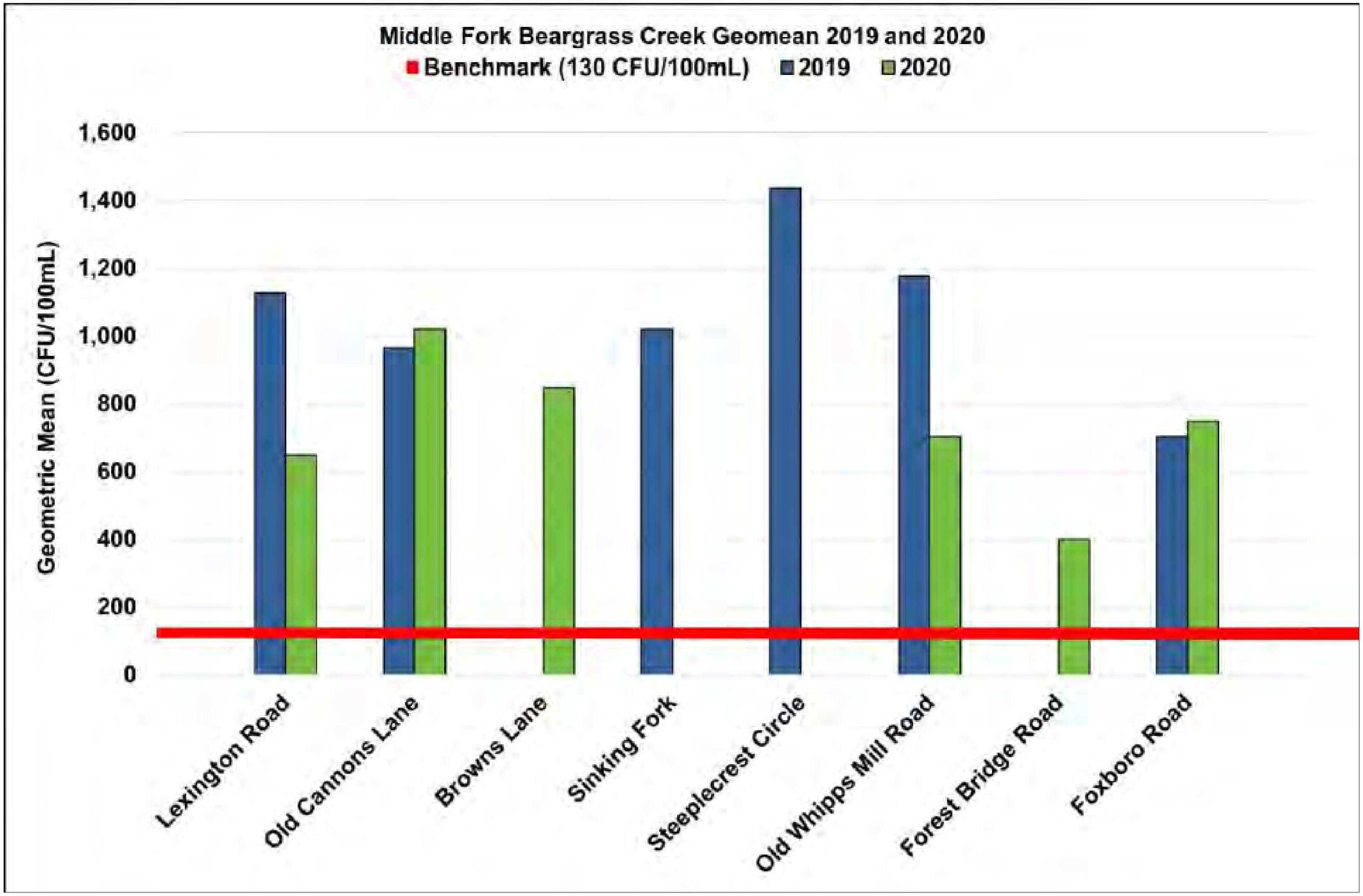

Figure 4.27 *E. coli* Geometric Mean Within the Watershed

The concentrations of *E. coli* exceeded the benchmark more often than the other water quality parameters, only meeting the instantaneous benchmark of 240 CFU/100mL 29% of the time and never meeting the benchmark of 130 CFU/100mL for the geometric mean. Table 4.5 *E. coli* Minimum, Average and Maximum Concentrations summarizes the minimum, average and maximum *E. coli* concentrations at each of the 10 sampling locations. Further analysis can be found in Appendix 4, Table 1. Overall, the *E. coli* concentrations during wet events were higher than the samples collected during dry events. Based on the results of the water quality monitoring effort conducted for this plan, *E. coli* is a primary pollutant of concern within the watershed.

Table 4.5 *E. coli* Minimum, Average and Maximum Concentrations

***E. coli* Results (CFU/100mL)**				
Site ID	**Location**	**Minimum**	**Average**	**Maximum**
1	Lexington Road	94	7644	141000
2	Old Cannons Lane	84	1933	17329
3	Browns Lane	144	1398	8070
4	Weicher Creek (DOW)	866	3508	7701
5	Weicher Creek (MSD)	4	1277	9210
6	Sinking Fork	76	9346	112000
7	Steeplecrest Circle	112	1711	10462
8	Old Whipps Mill Road	82	2051	24192
9	Forest Bridge Road	88	619	4090
10	Foxboro Road	112	1279	7400

Figure 4.28 Box and Whisker Plot – *E. coli* Instantaneous Concentrations Log Scale shows a box and whisker plot of the *E. coli* instantaneous concentrations data in natural log scale. The natural log of the values allows the data to be plotted on a smaller scale to better visualize how the grouping of data from each site compare to each other and compare to the benchmark. The benchmark for *E. coli* instantaneous results is 240 CFU/100mL. The natural log of this benchmark is 5.48 CFU/100mL.

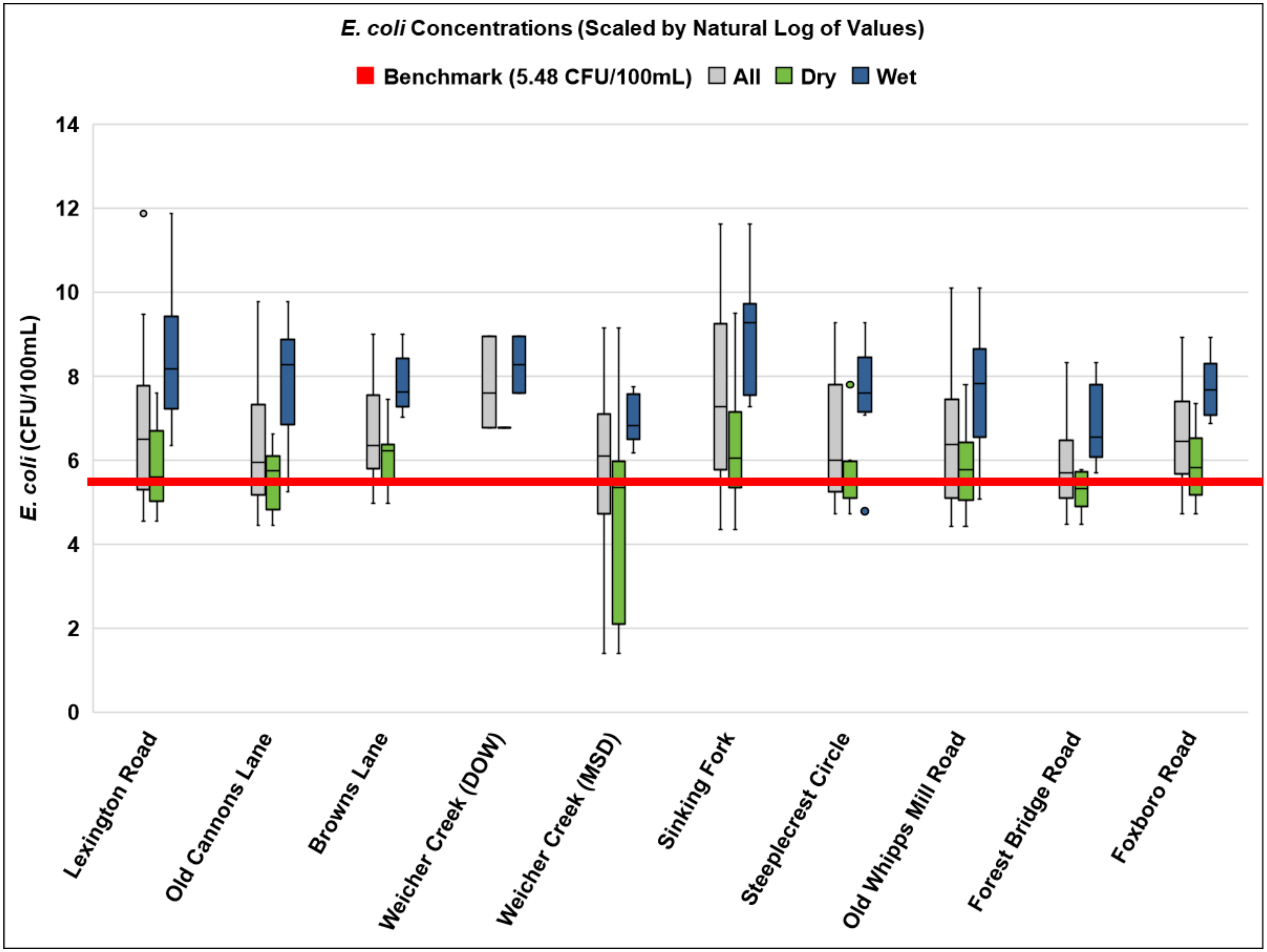

Figure 4.28 Box and Whisker Plot – *E. coli* Instantaneous Concentrations Log Scale

4.2.3.1.2 Nutrients

Aquatic organisms require nutrients in the water for survival. An excess level of nutrients such as nitrogen and phosphorus can result in undesirable effects such as eutrophication, which is the excessive growth of aquatic plants, resulting in an interference with desirable water uses (Meuller et al., 1987). Nutrients were collected at seven sites from March 2019 to February 2020 by DOW. This included total Kjeldahl nitrogen (TKN), nitrate, nitrite, total phosphorus (TP), orthophosphate (OP), ammonia and total suspended solids (TSS).

Phosphorus

Two forms of phosphorus were sampled, total phosphorus (TP) and orthophosphate (OP). Average concentrations for each form at the seven sites are shown in Table 4.6 Phosphorus Minimum, Average and Maximum Concentrations. The results for TP concentration ranged from less than the detection limit (0.02 mg/L) to 0.167 mg/L. The results for OP concentrations ranged from less than the detection limit (0.02 mg/L) to 0.075 mg/L. Samples were below the detection limit in 32% of the samples collected for TP and in 51% for OP. For sample concentrations below the detection limit, the results were reported as half the reporting limit, 0.02 mg/L for both TP and OP, resulting in a concentration of 0.01 mg/L. TP met the benchmark of 0.2 mg/L; therefore, pollutant loads and load reductions were not calculated, and further statistical analysis for Phase I data was not required, per the Guidebook.

Table 4.6 Phosphorus Minimum, Average and Maximum Concentrations

Phosphorus Results (mg/L)							
Site ID	Location	Orthophosphate (mg/L)			Total Phosphorus (mg/L)		
		Minimum	Average	Maximum	Minimum	Average	Maximum
1	Lexington Road	0.01	0.03	0.05	0.01	0.09	0.17
2	Old Cannons Lane	0.01	0.02	0.03	0.01	0.05	0.12
4	Weicher Creek (DOW)	0.01	0.02	0.04	0.01	0.04	0.12
6	Sinking Fork	0.01	0.02	0.04	0.03	0.07	0.11
7	Steeplecrest Circle	0.01	0.01	0.03	0.01	0.04	0.12
8	Old Whipps Mill Road	0.01	0.02	0.06	0.02	0.06	0.16
10	Foxboro Road	0.01	0.01	0.02	0.01	0.03	0.07

Nitrogen

Total Kjeldahl nitrogen (TKN), nitrate and nitrite were collected during Phase I monitoring. The sum of their concentrations for each sampling event gives the concentration of Total Nitrogen (TN). TN is an essential nutrient for plants and animals. However, an excess amount may lead to low levels of dissolved oxygen and negatively impact aquatic organisms.

Table 4.7 Total Nitrogen Minimum, Average and Maximum Concentrations

Total Nitrogen Results (mg/L)				
Site ID	Location	Minimum	Average	Maximum
1	Lexington Road	0.78	1.68	2.61
2	Old Cannons Lane	0.84	1.80	2.67
4	Weicher Creek (DOW)	0.79	1.70	2.26
6	Sinking Fork	0.78	2.12	3.24
7	Steeplecrest Circle	1.55	2.23	3.29
8	Old Whipps Mill Road	0.81	1.66	2.29
10	Foxboro Road	1.02	1.71	2.34

TN concentrations ranged from 0.78 mg/L to 3.29 mg/L (Table 4.7 Total Nitrogen Minimum, Average and Maximum Concentrations). The minimum concentration of 0.78 mg/L occurred during a wet event on May 30, 2019, at Site 6, Sinking Fork, and during a dry event on September 17, 2019, at Site 1, Lexington Road. The TN results exceeded the benchmark of 1.2 mg/L in 85% of the samples collected. Figure 4.29 shows the sampling results for each site.

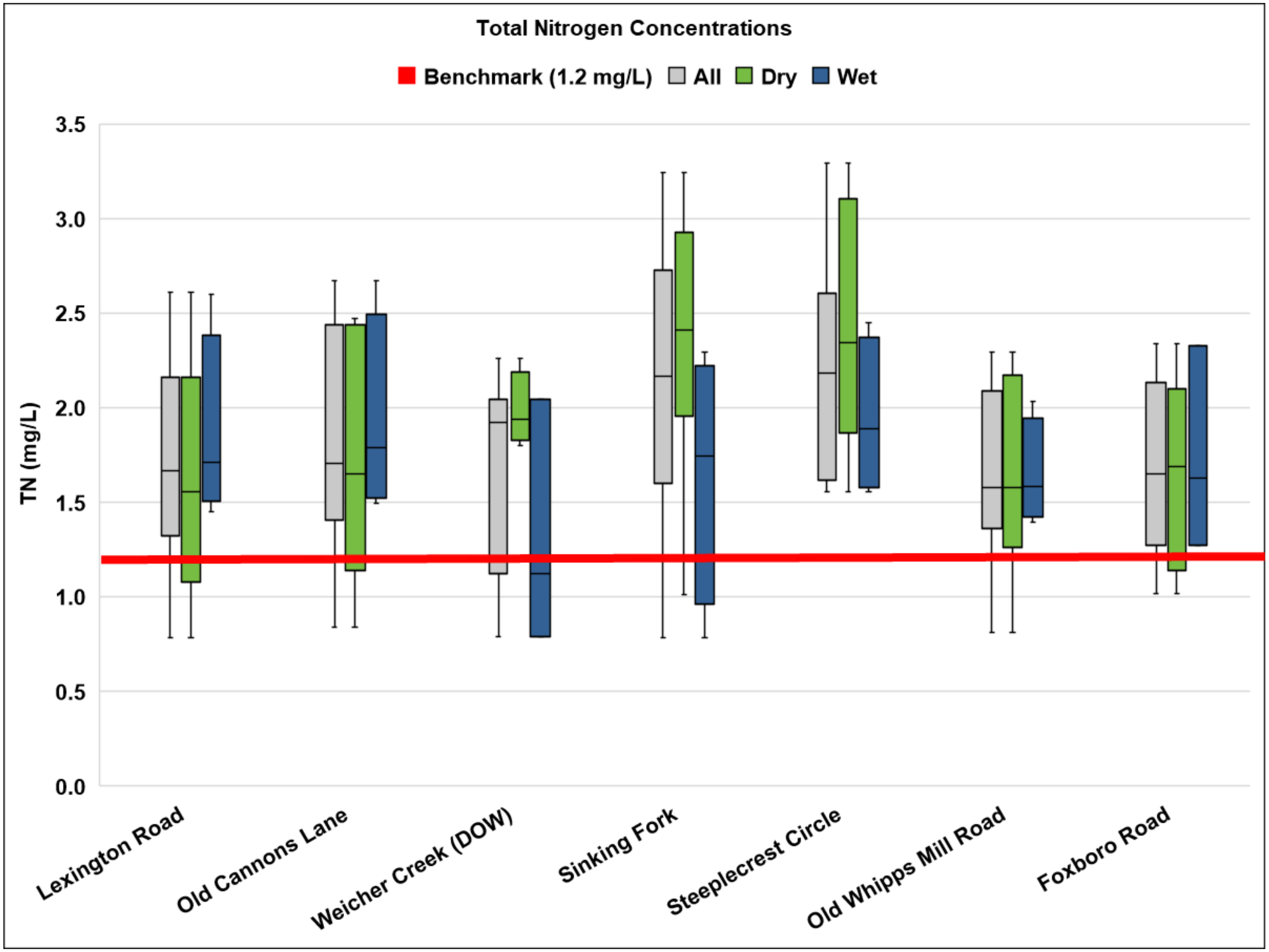

Figure 4.29 Box and Whisker Plot – Total Nitrogen Concentrations

Ammonia

Ammonia (as Nitrogen) samples were below the detection limit (0.05 mg/L) in 69% of the samples. The maximum concentration of 0.9 mg/L was an outlier that occurred at Site 8 off Old Whipps Mill Road during a dry event on September 17, 2019. Table 4.8 shows the minimum, maximum and average concentrations at each of the seven sites. Ammonia met the benchmark of 0.1 mg/L 86% of the time. Figure 4.30 shows a box and whisker plot of ammonia concentrations for all samples except the outlier previously discussed. Data collected at Old Cannons Lane, Weicher Creek (DOW), Steeplecrest and Foxboro monitoring sites were below the detection limit (0.05 mg/L) and reported as 0.025 mg/L. For the events that data were below the detection limit, the box and whisker plot display lines showing the statistical values were equal.

Table 4.8 Total Ammonia Minimum, Average and Maximum Concentrations

Total Ammonia Results (mg/L)				
Site ID	**Location**	**Minimum**	**Average**	**Maximum**
1	Lexington Road	0.025	0.100	0.24
2	Old Cannons Lane	0.025	0.037	0.095
4	Weicher Creek (DOW)	0.025	0.025	0.025
6	Sinking Fork	0.025	0.038	0.094
7	Steeplecrest Circle	0.025	0.029	0.065
8	Old Whipps Mill Road	0.025	0.120	0.900
10	Foxboro Road	0.025	0.028	0.070

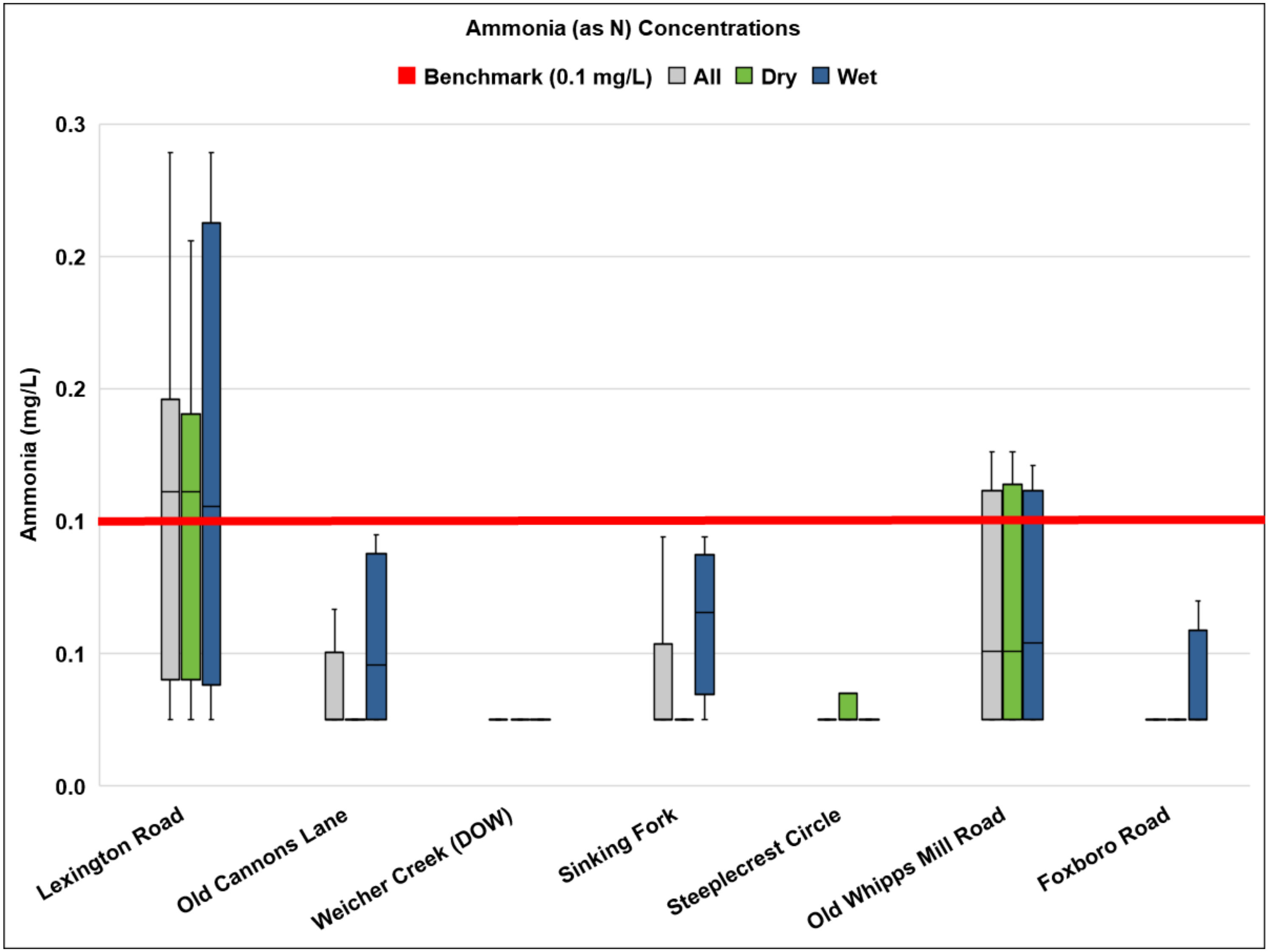

Figure 4.30 Box and Whisker Plot - Ammonia Concentrations

Ammonia concentrations, along with pH and water temperature recordings at each sampling time, were used to calculate unionized ammonia. Unionized ammonia is the form of ammonia toxic to fish. The warm water aquatic habitat criteria in the Commonwealth of Kentucky requires the unionized form of ammonia to be less than 0.05 mg/L at any time. All unionized ammonia samples collected for this plan were below this benchmark; therefore, pollutant loads and load reductions were not calculated, and further statistical analysis for Phase I data was not required, per the Guidebook.

Table 4.9. Unionized Ammonia Minimum, Average and Maximum Concentrations

Unionized Ammonia Concentrations				
Site ID	Location	Minimum	Average	Maximum
1	Lexington Road	0	0.0014	0.0040
2	Old Cannons Lane	0	0.0012	0.0045
4	Weicher Creek (DOW)	0.00042	0.00075	0.0010
6	Sinking Fork	0.00014	0.00035	0.00082
7	Steeplecrest Circle	0.00026	0.0011	0.0037
8	Old Whipps Mill Road	0	0.0012	0.0049
10	Foxboro Road	0	0.0011	0.0031

4.2.3.1.3 Sediment

Sediment pollution in water can cause numerous issues in ecosystems, such as reducing visibility for animals, clogging fish gills and filling in aquatic habitat. The urban nature of this watershed causes stormwater to move quickly over impervious surfaces and potentially scour stream banks, causing erosion and sedimentation, resulting in a decline in the water quality and habitat quality.

Total Suspended Solids

Total suspended solids (TSS) are a measure of clarity and an indicator of water quality. Material typically suspended in an urban environment may include clay, silt, and organic and inorganic materials such as grit and other impervious surface particles. Increased TSS levels correlate with several low habitat quality parameters such as sedimentation, which is an indicator that sediment is being transported through the system either through stream bank erosion or activities within the watershed. TSS data are shown in Figure 4.31 as a box and whisker plot. The highest maximum concentration observed, which is displayed as an outlier, was 60 mg/L at Site 1 at Lexington Road. This occurred on August 22, 2019. This sampling day was classified as a wet event and had the highest recorded rainfall on a sample date occurring during this project. The flow at Site 1 at Lexington Road on this date was measured at 89 cubic feet per second (cfs), the highest flow measured at this site during the TSS sampling period. This site is at the downstream point of Middle Fork Beargrass Creek where it flows to the South Fork Beargrass Creek. The lowest maximum concentration observed was 3.5 mg/L at Site 4 at Weicher Creek (DOW). This section of Weicher Creek is channelized. TSS met the benchmark of 12.9 mg/L during 85% of the sampling events. Further analysis can be found in Appendix 4, Table 1.

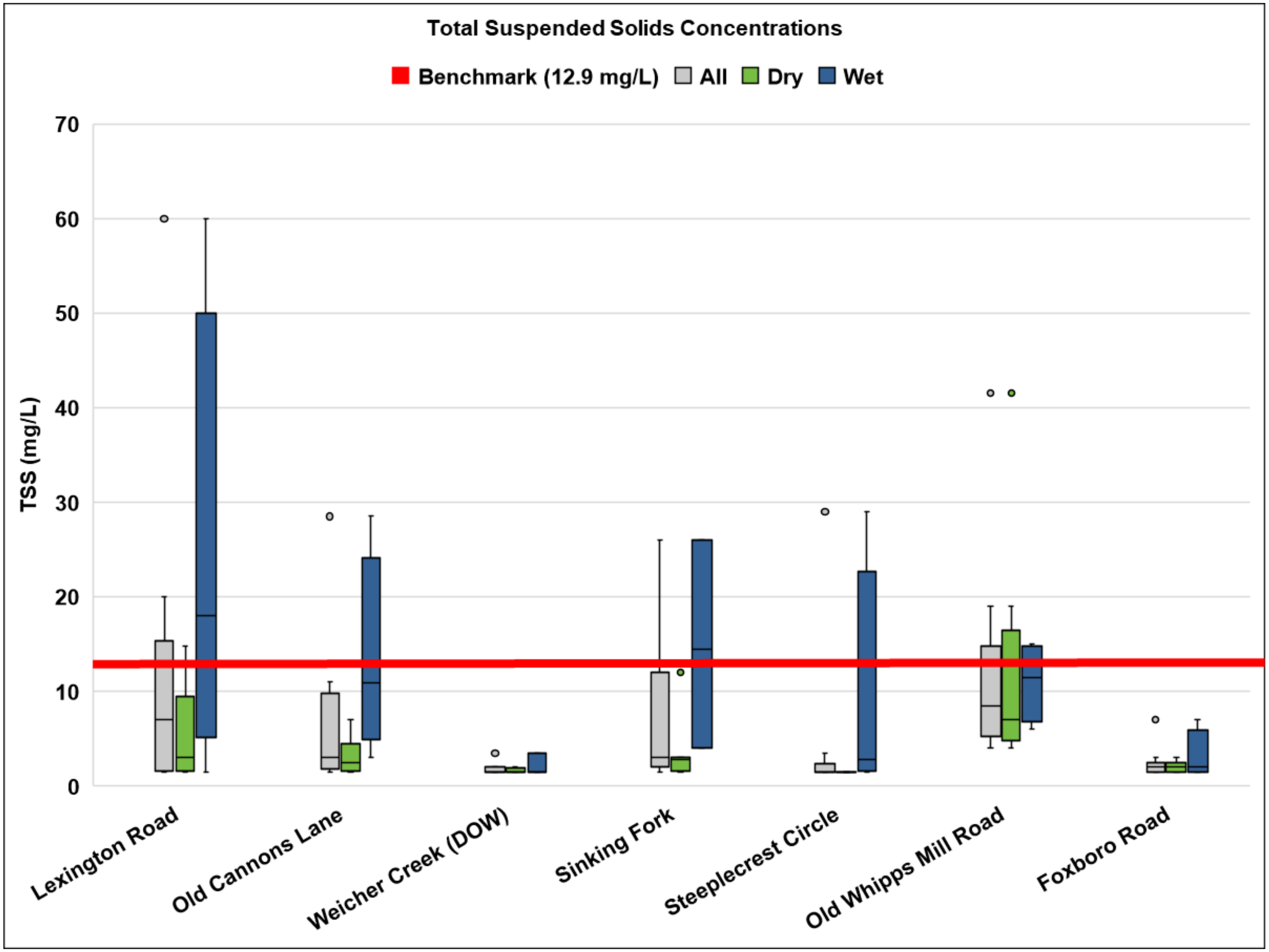

Figure 4.31 Box and Whisker Plot - Total Suspended Solids Concentrations

TSS concentrations were compared to the stream flow at the time of sampling. An increase in flow corresponded to an elevated concentration of TSS at most sites. The exceptions to this were three sampling events at Site 4 at Weicher Creek (DOW), Site 6 at Sinking Fork and Site 8 off Old Whipps Mill Road. For these three events, there was an increase in TSS concentration with no dramatic increase in stream flow.

4.2.3.1.4 Field Parameters

The field parameters used to evaluate water quality in the watershed were turbidity, dissolved oxygen, water temperature, pH and specific conductivity. The ideal range of these parameters provides a balanced environment for aquatic life. Stream flow is also an important field parameter used in the evaluation of the stream's reaction to weather and in evaluating the movement of the water within the channel.

Turbidity

Turbidity is a measure of clarity in the water, measured by the amount of light scattered by particulate material when light is shined through the water sample. High turbidity results affect light penetration, ecological productivity and habitat quality (Swanson et al., 1965). Turbidity results ranged from no turbidity measured to a maximum measurement of 32.7 NTU. Turbidity is a similar indicator to TSS, and the results showed a similar pattern when compared to stream flow, increasing during sampling events with elevated stream flow**.** Table 4.10 Turbidity Minimum, Average and Maximum Results summarizes the turbidity results from the monitoring data. Turbidity met the benchmark of 11.6 NTU during 94% of the sampling events. Further analysis can be found in Appendix 4, Table 1**.**

Table 4.10 Turbidity Minimum, Average and Maximum Results

Turbidity Results (NTU)				
Site ID	Location	Minimum	Average	Maximum
1	Lexington Road	0.60	8.0	33
2	Old Cannons Lane	0	3.3	23
3	Browns Lane	0	1.8	6.6
4	Weicher Creek (DOW)	1.5	2.4	3.6
5	Weicher Creek (MSD)	0	4.3	9.9
6	Sinking Fork	0	3.0	19
7	Steeplecrest Circle	0	1.9	9.8
8	Old Whipps Mill Road	0	5.3	31
9	Forest Bridge Road	0	1.5	14
10	Foxboro Road	0	1.7	8.7

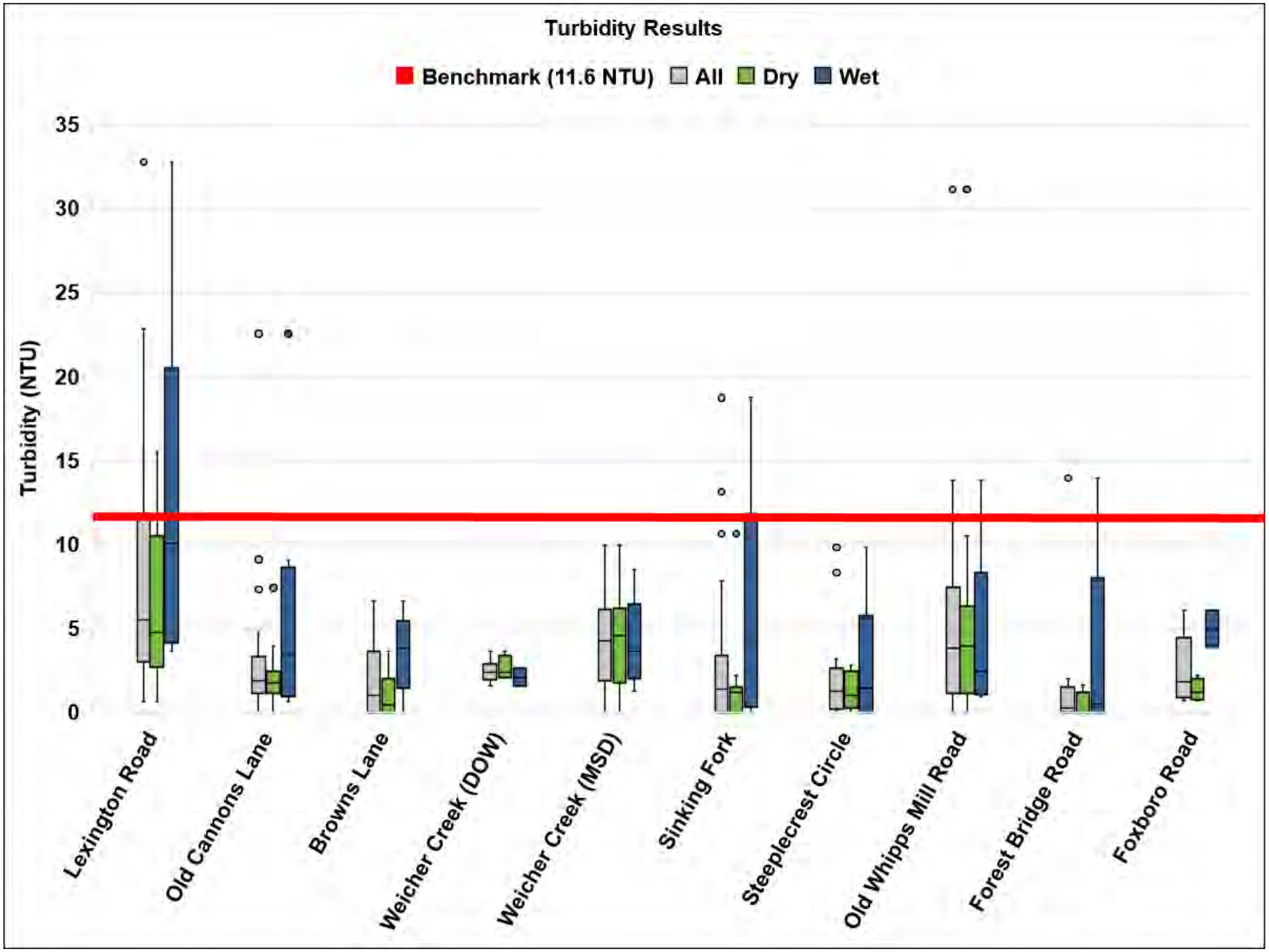

Figure 4.32 Box and Whisker Plot – Turbidity Results

Dissolved Oxygen

Dissolved oxygen (DO) is necessary for the survival of aquatic organisms. Fish require 5 to 6 mg/L of dissolved oxygen for normal activity. It is also needed for the decomposition of organic matter and is a measure of stream function. Riffle and pool sequences provide more oxygen than streams with homogonous or stagnant flow. Instantaneous readings of DO were compared to the WAH standard of 4.0 mg/L for instantaneous DO concentration. Levels lower than this are considered hazardous to organisms, and levels below 2 mg/L are lethal to fish. The WAH standard requires the daily average for DO to exceed 5.0 mg/L. This data set did not have readings to calculate a daily average at any of the sites. The DO concentrations ranged from 2.8 mg/L at Lexington Road to 15 mg/L at Foxboro Road. The instantaneous readings provide data for the point in time that the DO was collected. DO concentrations were less than 4.0 mg/L at Site 1 at Lexington Road 17% of the sampling times. The occurrences of low DO concentrations occurred during low flow, dry sampling events with the exception of July 22, 2020, being a wet event with elevated flow. The concentrations at the remaining nine sites were above 4.0 mg/L during all sampling times.

Table 4.11 Dissolved Oxygen Minimum, Average and Maximum Concentrations

Dissolved Oxygen Results (mg/L)				
Site ID	Location	Minimum	Average	Maximum
1	Lexington Road	2.8	6.9	10
2	Old Cannons Lane	5.3	8.6	13
3	Browns Lane	7.2	8.7	11
4	Weicher Creek (DOW)	7.0	9.8	12
5	Weicher Creek (MSD)	5.8	8.5	12
6	Sinking Fork	4.9	8.5	12
7	Steeplecrest Circle	5.1	9.8	16
8	Old Whipps Mill Road	4.9	8.8	11
9	Forest Bridge Road	7.6	9.5	12
10	Foxboro Road	6.9	10	15

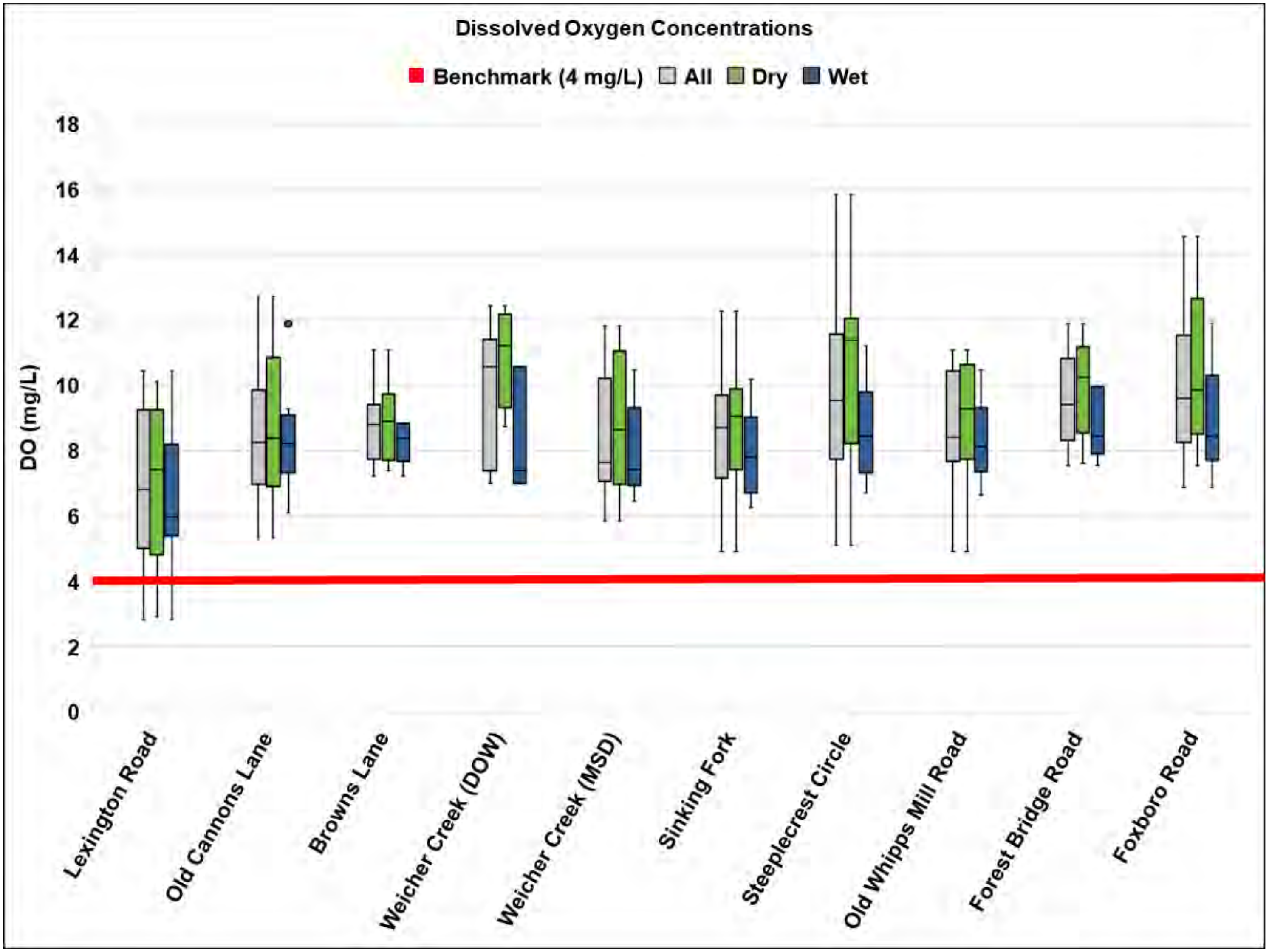

Figure 4.33 Box and Whisker Plot – Dissolved Oxygen Concentrations

Oxygen saturation is a measurement of the percentage of the mg/L of dissolved oxygen available to organisms and the aquatic environment. The percent saturation varies depending on water temperature and barometric pressure. DO percent saturation was recorded during each site visit. Results ranged from a minimum of 34% at Site 1 at Lexington Road to a maximum of 157% at Site 7 at Steeplecrest Circle. Site 1 at Lexington Road had the lowest DO and the lowest oxygen saturation overall. Based on research from Northern Kentucky University, the desired range of DO percent saturation is 80% to 120%. Levels below this range indicate a potential oxygen deficit, and levels above this range could indicate oversaturation. Oversaturation becomes a concern when there are excess nutrient concentrations leading to eutrophication. Additional analysis will be performed during Phase II to compare nutrients and habitat with dissolved oxygen saturation before determining BMP implementation for this parameter.

Table 4.12 Dissolved Oxygen Percent Saturation Results

Dissolved Oxygen Percent Saturation Results				
Site ID	Location	Minimum DO %	Average DO %	Maximum DO %
1	Lexington Road	34%	67%	93%
2	Old Cannons Lane	62%	86%	120%
3	Browns Lane	76%	86%	96%
4	Weicher Creek (DOW)	79%	96%	120%
5	Weicher Creek (MSD)	69%	83%	100%
6	Sinking Fork	52%	85%	130%
7	Steeplecrest Circle	60%	94%	160%
8	Old Whipps Mill Road	58%	88%	110%
9	Forest Bridge Road	83%	93%	110%
10	Foxboro Road	81%	100%	150%

Temperature

Water temperature is a particularly significant parameter in water quality analysis. Three principal reasons include: the aquatic ecosystem may be positively or negatively impacted by the discharge of excess heat from industrial or municipal effluents; all biological and chemical reactions are influenced by temperature; and the density of water, and in turn the transport of water, is affected by variations in temperature (Mueller et al., 1987). The temperature readings were compared to the month collected to verify consistency with the season. The WAH standard states that temperature should not exceed 31.7 degrees Celsius (89 degrees Fahrenheit). No readings in this watershed exceeded the threshold during the sampling period; therefore, further statistical analysis for Phase I data was not required. Table 4.13 Temperature Minimum, Average and Maximum Water Results summarizes the minimum, average and maximum water temperature readings for each site.

Table 4.13 Temperature Minimum, Average and Maximum Water Results

Water Temperature Results (°C)				
Site ID	Location	Minimum	Average	Maximum
1	Lexington Road	4.4	16	26
2	Old Cannons Lane	5.9	16	25
3	Browns Lane	7.3	15	22
4	Weicher Creek (DOW)	8.6	15	21
5	Weicher Creek (MSD)	3.1	16	25
6	Sinking Fork	7.7	16	23
7	Steeplecrest Circle	3.1	15	23
8	Old Whipps Mill Road	5.5	16	25
9	Forest Bridge Road	5.7	15	23
10	Foxboro Road	4.9	16	24

pH

pH is a measure of how acidic or basic water is. The pH of streams can affect organisms living in the water, and a change in pH can be an indicator of increasing pollution or other environmental factors. pH determines the solubility and biological availability of chemical constituents such as nutrients and heavy metals (USGS, undated). The WAH standards for pH require instantaneous readings between 6.0 and 9.0 SU, and these readings should not fluctuate more than 1.0 SU over 24 hours. This data set included instantaneous readings; therefore, fluctuation could not be determined. All values were within the WAH standard; therefore, further statistical analysis for Phase I data was not required. The values of pH ranged from a minimum of 6.94 SU measured during a wet event and a maximum of 8.62 SU measured during a dry event.

Table 4.14 pH Minimum, Average and Maximum Results

pH Results (SU)				
Site ID	Location	Minimum	Average	Maximum
1	Lexington Road	7.1	7.6	8.1
2	Old Cannons Lane	7.6	7.9	8.3
3	Browns Lane	7.3	7.6	7.8
4	Weicher Creek (DOW)	7.9	8.0	8.2
5	Weicher Creek (MSD)	7.3	7.7	8.0
6	Sinking Fork	6.9	7.3	7.6
7	Steeplecrest Circle	7.6	7.9	8.3
8	Old Whipps Mill Road	7.3	7.8	8.2
9	Forest Bridge Road	7.6	7.8	8.1
10	Foxboro Road	7.6	8.0	8.6

Specific Conductivity

Specific conductivity is an indicator of the presence of dissolved solids in water. High values are an indication that there may be chemical or sewage discharge. Additionally, limestone and clay soils may also be contributors that result in increased conductivity levels. Increased levels may also relate to higher temperature readings and levels of chlorides, phosphates and nitrates. Results varied from a minimum of 172.9 µS/cm measured at Site 6 at Sinking Fork to a maximum of 1551 µS/cm measured at Site 6 at Sinking Fork. The conductivity readings above 1,000 µS/cm occurred during the February 24, 2021, sampling event. This sampling event occurred a few days after a large snow and ice event that started to melt the day before the sampling. The values above 1,000 µS/cm are shown on Table 4.15 Specific Conductivity Minimum, Average and Maximum Results, but are not included on the box and whisker plot. Table 4.15 Specific Conductivity Minimum, Average and Maximum Results shows the minimum, average and maximum results at each of the ten sites. The average at most sites was above the benchmark of 521.8 µS/cm.

Table 4.15 Specific Conductivity Minimum, Average and Maximum Results

Specific Conductivity (µS/cm)				
Site ID	**Location**	**Minimum**	**Average**	**Maximum**
1	Lexington Road	285	565	1306
2	Old Cannons Lane	259	575	1237
3	Browns Lane	471	604	1218
4	Weicher Creek (DOW)	382	432	496
5	Weicher Creek (MSD)	367	485	595
6	Sinking Fork	173	610	1551
7	Steeplecrest Circle	254	568	1270
8	Old Whipps Mill Road	302	589	862
9	Forest Bridge Road	309	579	864
10	Foxboro Road	222	532	936

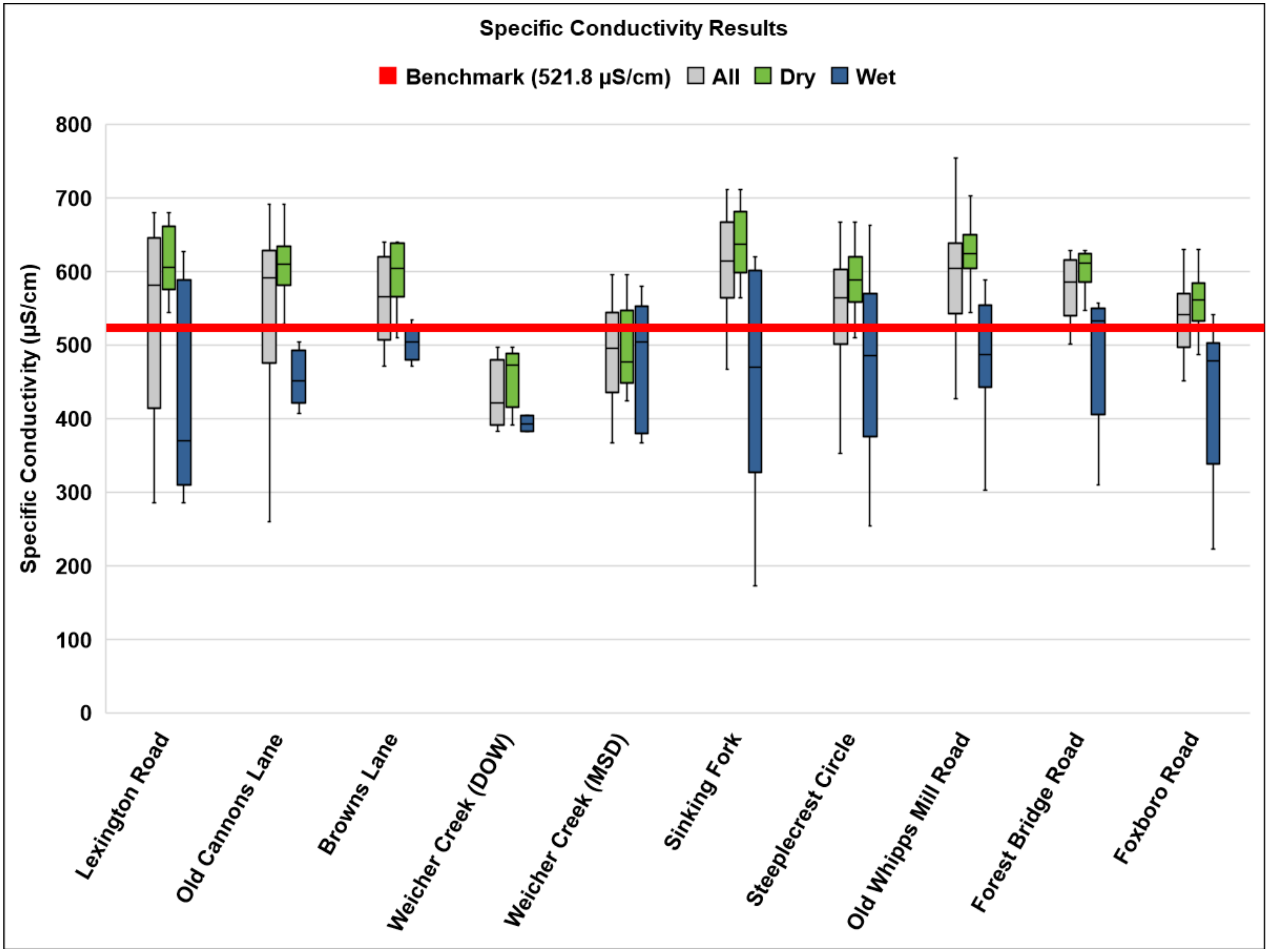

Figure 4.34 Box and Whisker Plot - Specific Conductivity Results

Stream Flow Discharge

The stream flow measured during sampling events was an instantaneous measurement and was used in the data analysis and load calculations. There are two USGS gages within the watershed (03293500 at Lexington Road and 03293000 at Old Cannons Lane) that measure stream flow every 15 minutes. Middle Fork Beargrass Creek exhibits flashy flows during storm events. Graphs included in Appendix 4 (Figures 1 and 2) show the measured flow at the two USGS gages during the August 22, 2019, sampling event. This event had the largest quantity of rainfall on the day of sampling with 0.9 inches falling the morning before sampling occurred. Rainfall was documented at TR 13, a rain gage at St. Matthews Elementary School, at 3:40 AM and continued until 5:20 AM. The graphs show a sharp increase in stream flow at both sites when the rain begins.

The latter half of 2019 experienced drier than average conditions, and streams recorded low flow frequently in July through November. Graphs included in Appendix 4 (Figures 3 and 4) depict stream flow at Lexington Road and Old Cannons Lane during the sampling period of March 2019 through February 2020. Additional graphs included in Appendix 4 (Figures 5 and 6) also show data for these sites beginning in 2016, showing how the period of low flow in 2019 compared to previous years.

Flow was not collected during some sampling events due to high flow conditions, dry or pooled conditions and two operating errors. The dry or pooled conditions occurred most often at the Weicher Creek, Sinking Fork and Steeplecrest sites. Table 2 in Appendix 4 details the sites and dates this occurred. For dry or pooled conditions, a water quality sample was not collected in accordance with the DOW and MSD quality assurance procedures. For events where a sample was collected but flow was not measured, the USGS gages were used to obtain the flow at the time of sampling to calculate loads. For the two sites with USGS gages, the flow was taken as measured by the gage. For sites upstream of the gages, a flow correction based on drainage area was used to obtain an estimated stream flow at that location (Table 4.16 Site List with Stream Flow Correction). This only affected DOW sampling sites. MSD did not have sampling events where samples were collected and flow was not measured. Stream flow results can be found in Table 3 of Appendix 4, and USGS stream gage graphs are also in Appendix 4. An explanation regarding how to use the USGS stream gage website is also provided in Appendix 4.

Table 4.16 Site List with Stream Flow Correction

Site ID	Location	Drainage Area	Gage/Proxy Gage	Flow Correction
1	Lexington Road	24.8	3293500	1
2	Old Cannons Lane	18.7	3293000	1
4	Weicher Creek (DOW)	1.3	3293000	0.07
6	Sinking Fork	2.6	3293000	0.14
7	Steeplecrest Circle	3.9	3293000	0.21
8	Old Whipps Mill Road	5	3293000	0.27
10	Foxboro Road	2.2	3293000	0.12

4.2.3.2 *Pollutant Exceedances*

Pollutant concentrations were compared to the benchmarks outlined in Table 4.4 Summary of Regulatory Criteria and Non-regulatory Benchmarks. *E. coli*, TSS, turbidity, TN, conductivity, ammonia (as N), and dissolved oxygen are the parameters that exceeded benchmarks. Table 1 is included in Appendix 4 with percent exceedances listed for each site. Unionized ammonia (as N), TP, pH and water temperature fell below their benchmarks during all sampling events at each location. *E. coli* concentrations were below the benchmark 29% of the time for instantaneous readings. The table shows *E. coli* exceeding 100% of the time at Site 4, Weicher Creek (DOW); however, this is only based on three sampling results, whereas other locations have more sampling results. Appendices 3.2 and 3.3 outline sample counts for each site. Sites 5, 7, 8 and 9 had the lowest percentage of exceedances for *E. coli;* the highest were recorded at Site 3 at Browns Lane and Site 6 at Sinking Fork. TN exceeded the benchmark 100% of the time at Site 7, Steeplecrest Circle, and over 70% of the time at the other six sites it was sampled. Pollutant loads, when compared to benchmarks, provide a means to target focused BMPs that will provide reductions. This is described further in Section 4.2.3.3.

When comparing wet and dry events, E. coli, TSS and turbidity revealed an increase in the frequency of samples exceeding their respective benchmarks during the wet events, as shown on the following graphs. The graphs include the locations where exceedances occurred. As described in Section 4.2.3, wet events demonstrate pollutants that have accumulated across the watershed and are being flushed into the waterways via stormwater runoff. This indicates a nonpoint source for these parameters, described in further detail in Section 4.2.3.4.

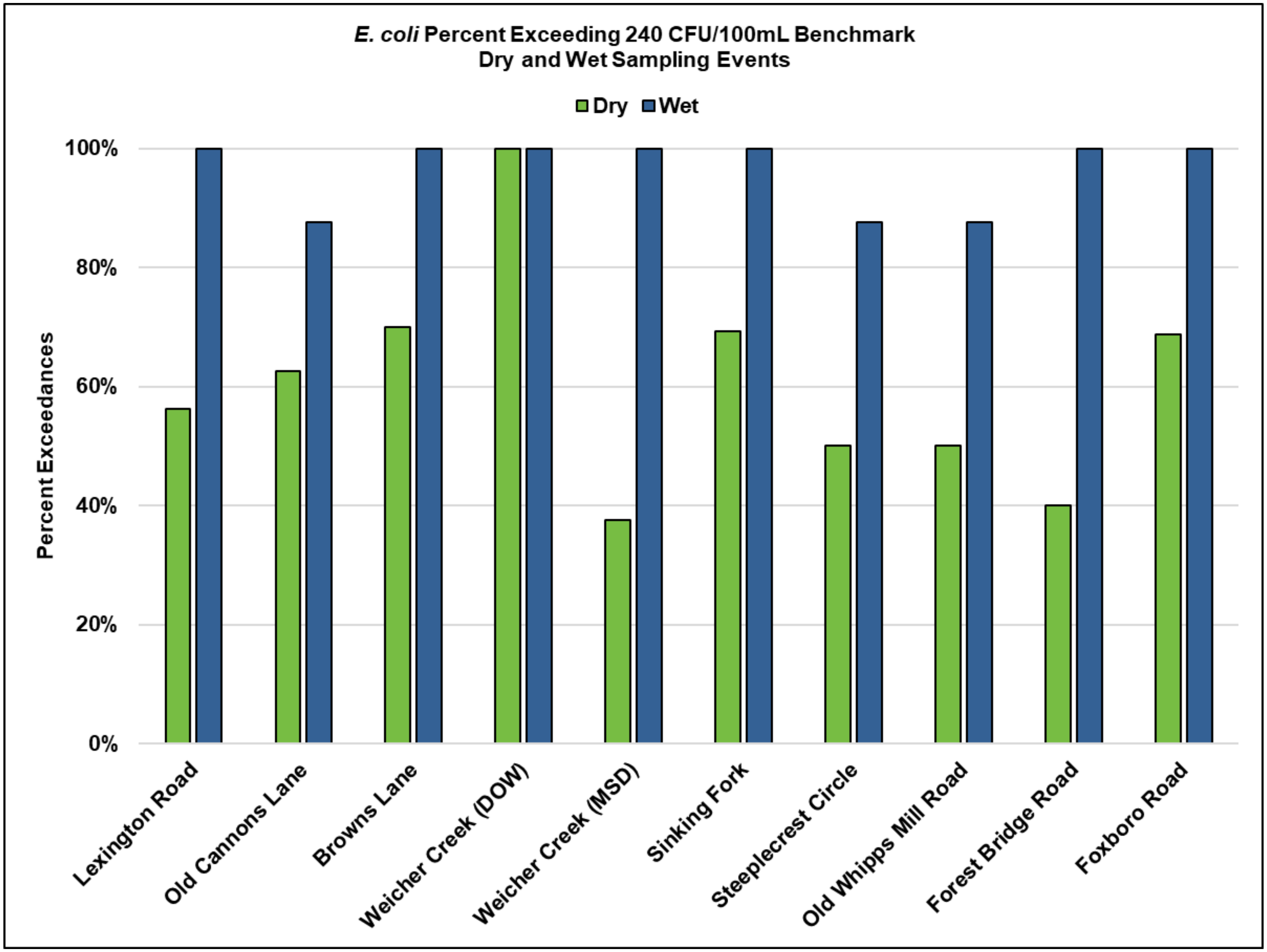

Figure 4.35 *E. coli* Results Comparing Dry and Wet Events

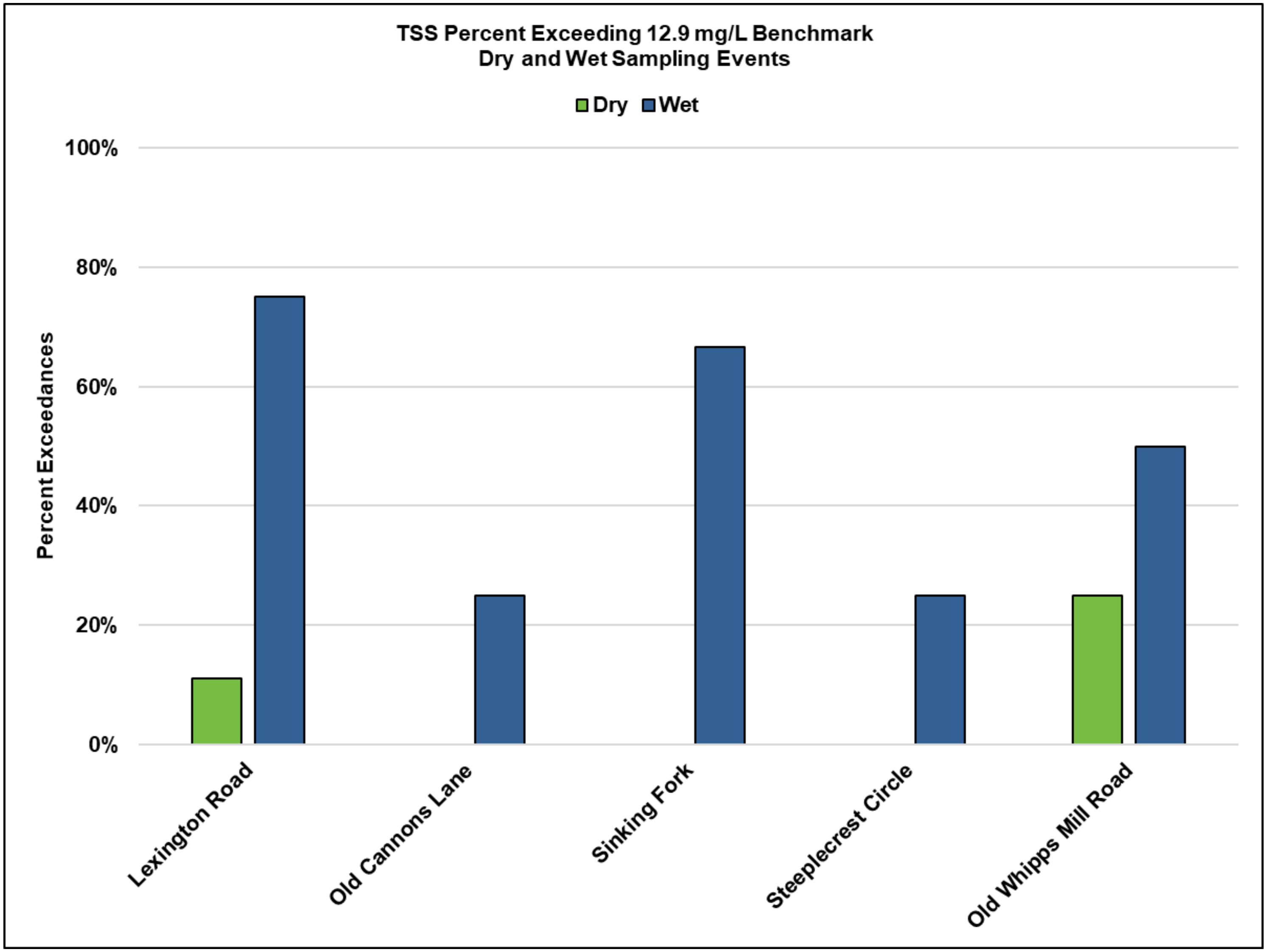

Figure 4.36 TSS Results Comparing Dry and Wet Events

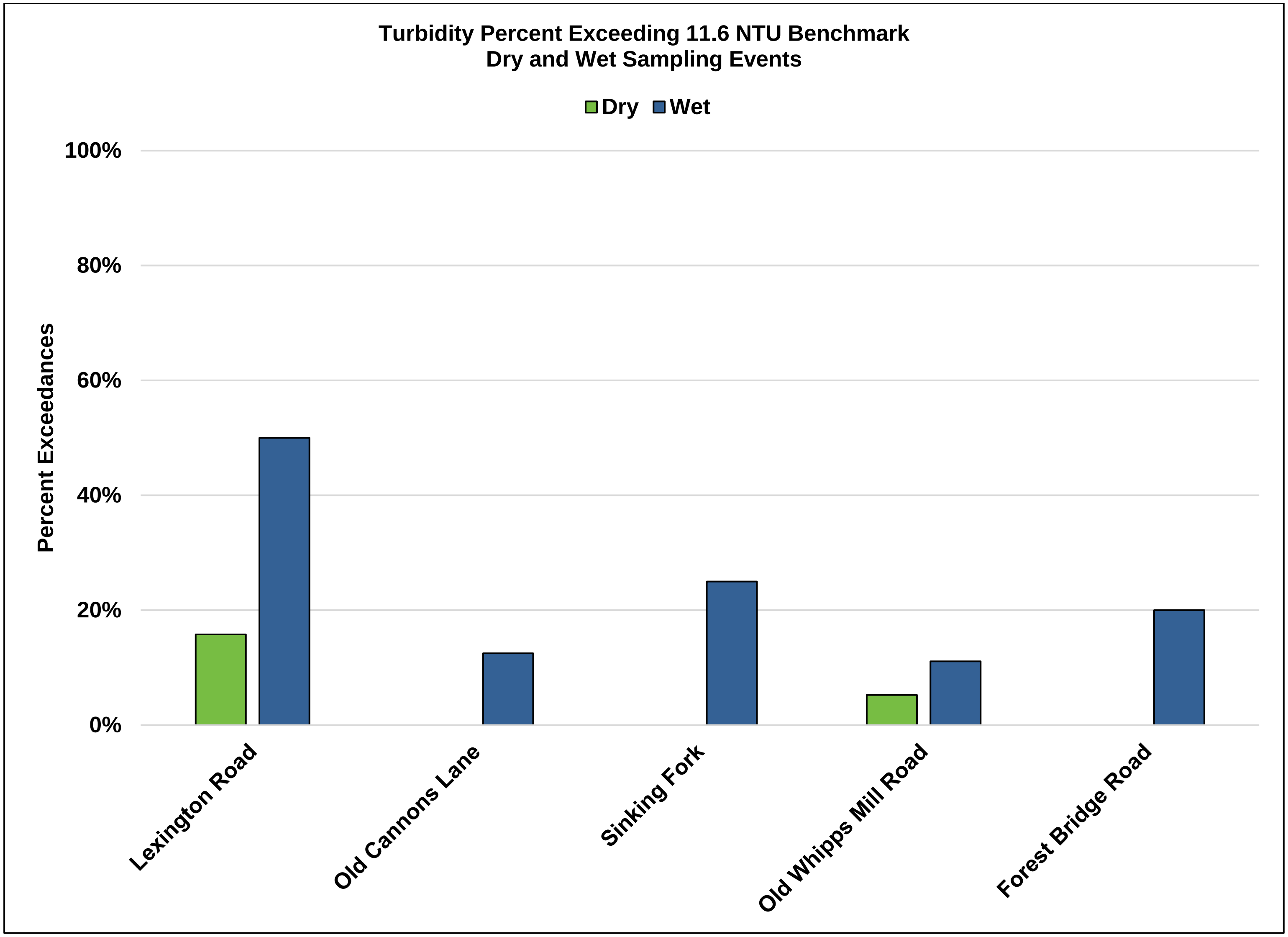

Figure 4.37 Turbidity Results Comparing Dry and Wet Events

4.2.3.3 *Pollutant Loads and Yields*

Pollutant loads provide an estimate of the amount of pollutant by weight that is moving through the stream. Understanding pollutant loading helps balance the results collected at each site by accounting for the difference in concentration and stream flow for a period of time (DOW, 2010). A sample site with low concentration and high flow may have a higher load than a site with high concentrations and low flow. For parameters exceeding the regulatory or non-regulatory benchmark, pollutant loads were calculated, and the load reductions needed per site were determined. The parameters exceeding benchmarks include *E. coli*, TSS, turbidity, ammonia, specific conductivity and total nitrogen. Specific conductivity is a measure of how well water can conduct electricity and is not measured in loads.

To calculate pollutant loads at each site, the concentrations of individual samples were matched with the flow measured at the site on that sampling day. The concentration, flow and a conversion factor were multiplied to calculate a daily load for each sample date. The individual daily loads were multiplied by 365 and then averaged for each site to determine an annual load per site. In order to calculate the target load for each site, this same process was repeated with the benchmark target value replacing the concentration. The target load and the actual load were used to determine the load reduction needed. The load reductions needed in the watershed for each parameter can be found on Table 4.17 Load Reductions Needed.

Table 4.17 Load Reductions Needed

Percent Load Reductions Needed						
Site ID	**Location**	***E. coli***	**TSS**	**Turbidity**	**TN**	**Ammonia (as N)**
1	Lexington Road	98%	38%	N/A*	35%	N/A*
2	Old Cannons Lane	95%	0%	N/A*	42%	N/A*
3	Browns Lane	87%	Not Sampled	N/A*	Not Sampled	N/A*
4	Weicher Creek (DOW)	88%	0%	N/A*	34%	N/A*
5	Weicher Creek (MSD)	72%	Not Sampled	N/A*	Not Sampled	N/A*
6	Sinking Fork	98%	30%	N/A*	24%	N/A*
7	Steeplecrest Circle	96%	26%	N/A*	40%	N/A*
8	Old Whipps Mill Road	95%	0%	N/A*	34%	N/A*
9	Forest Bridge Road	77%	Not Sampled	N/A*	Not Sampled	N/A*
10	Foxboro Road	90%	0%	N/A*	32%	N/A*
Notes: 1. * Non-detectable						

The largest load reductions are for *E. coli* and occur at Site 1 at Lexington Road and Site 6 at Sinking Fork. At both of these sites, 98% to 99% of the load occurred during wet weather events. MSD is currently addressing SSOs and CSOs by implementing projects identified in the Integrated Overflow Abatement Plan (IOAP) as part of the Consent Decree, which includes the Waterway Protection Tunnel project that is expected to be completed in 2022. When fully implemented, these projects are modeled to achieve 95% capture and treatment of wet weather combined sewerage, which exceeds the 85% Presumption Approach criteria in EPA's CSO Control Policy. Turbidity and ammonia have no load reductions needed because the samples that exceeded the benchmark had lower flow and therefore lower loads.

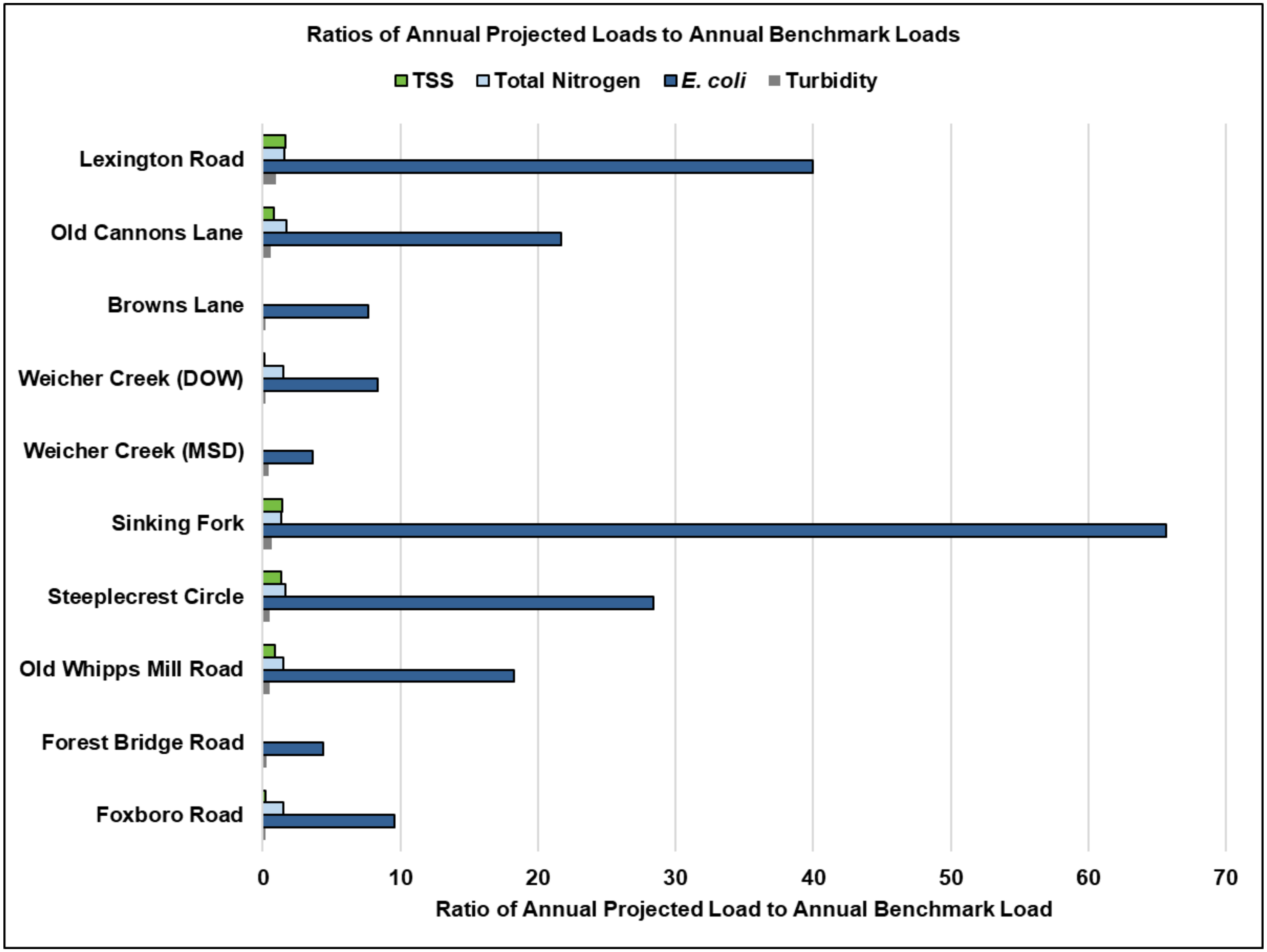

Figure 4.38 Ratios of Annual Projected Loads to Annual Benchmark Loads

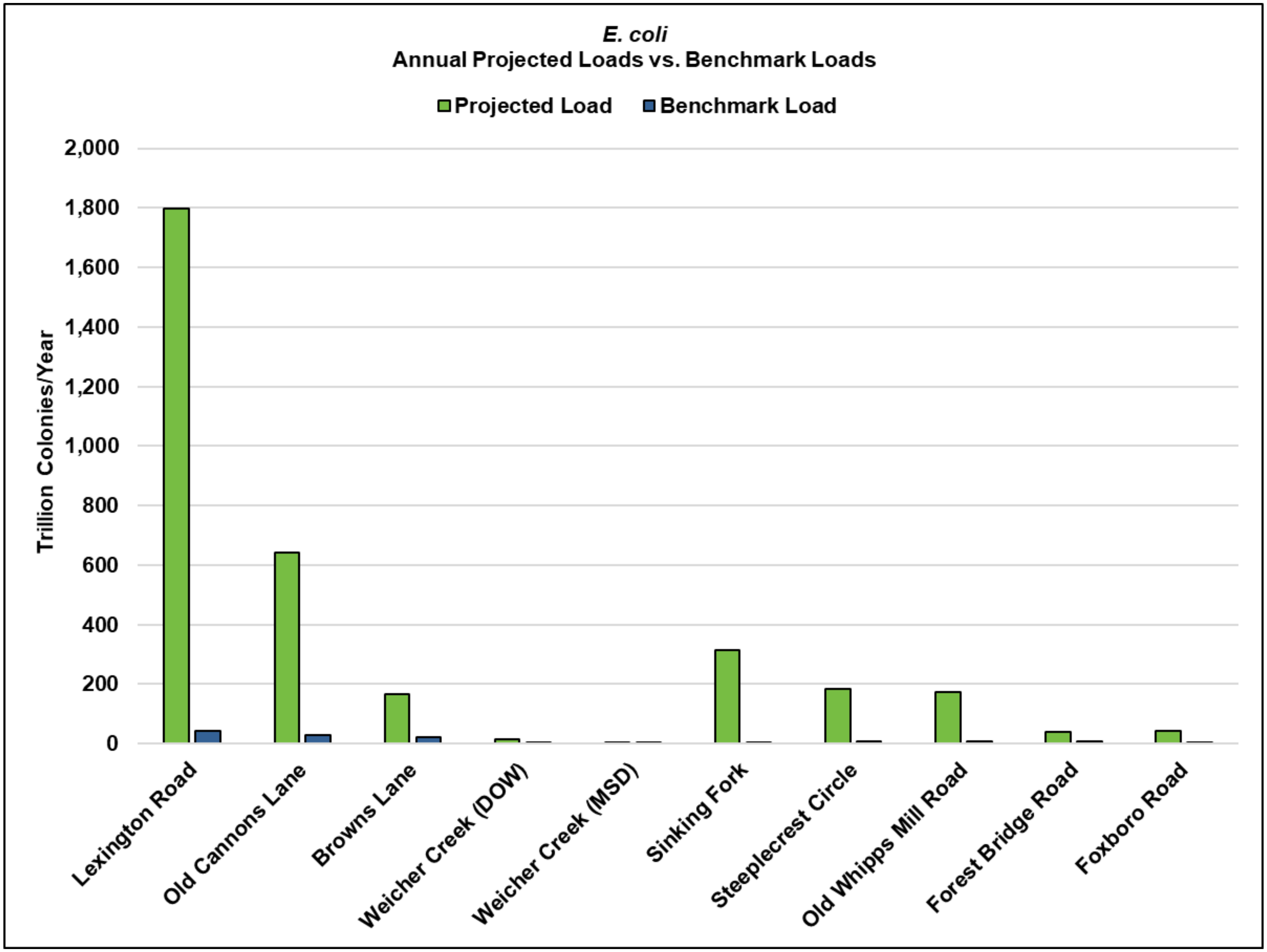

Figure 4.39 *E. coli* Annual Projected Loads vs. Benchmark Loads

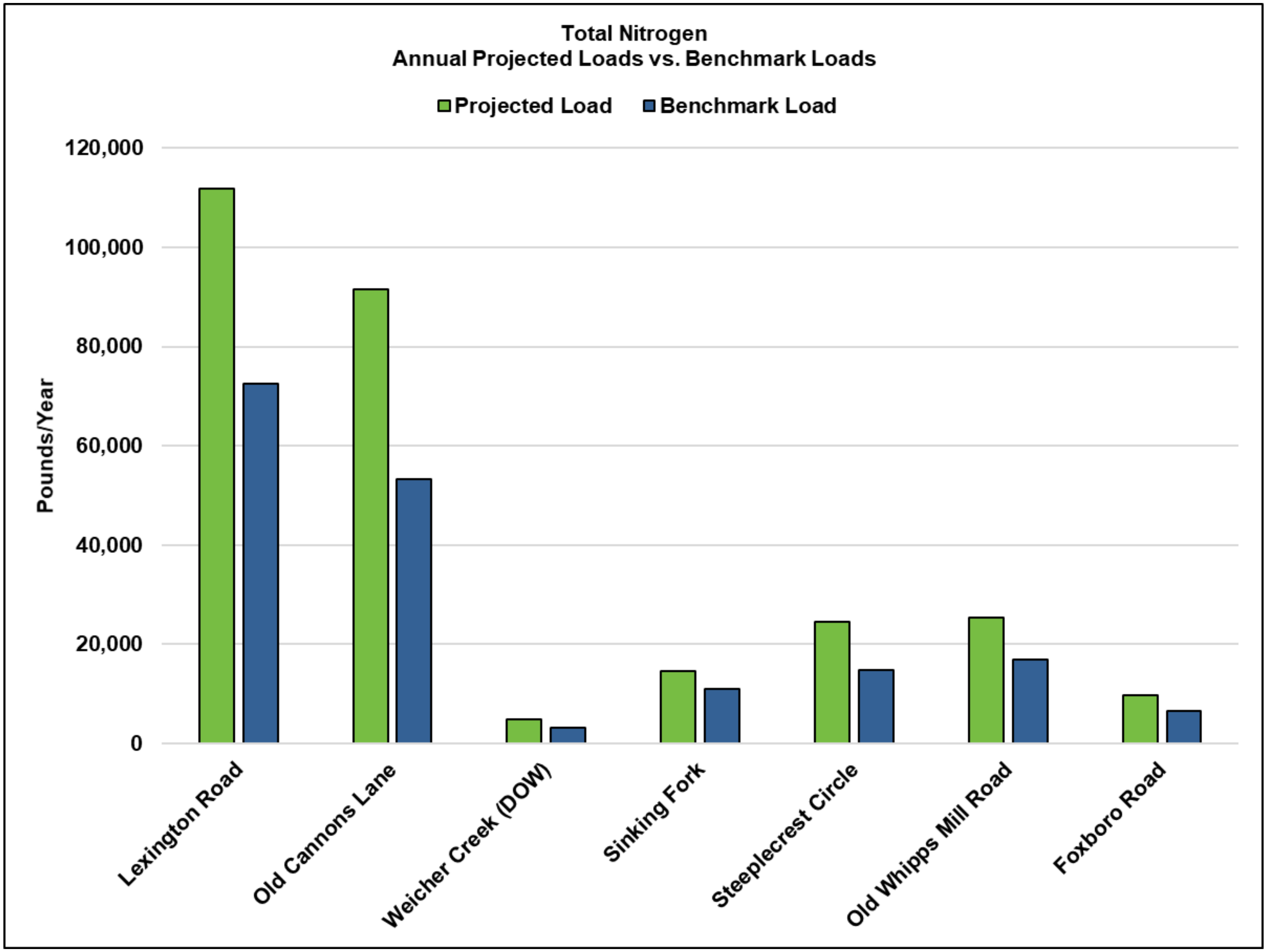

Figure 4.40 Total Nitrogen Annual Projected Loads vs. Benchmark Loads

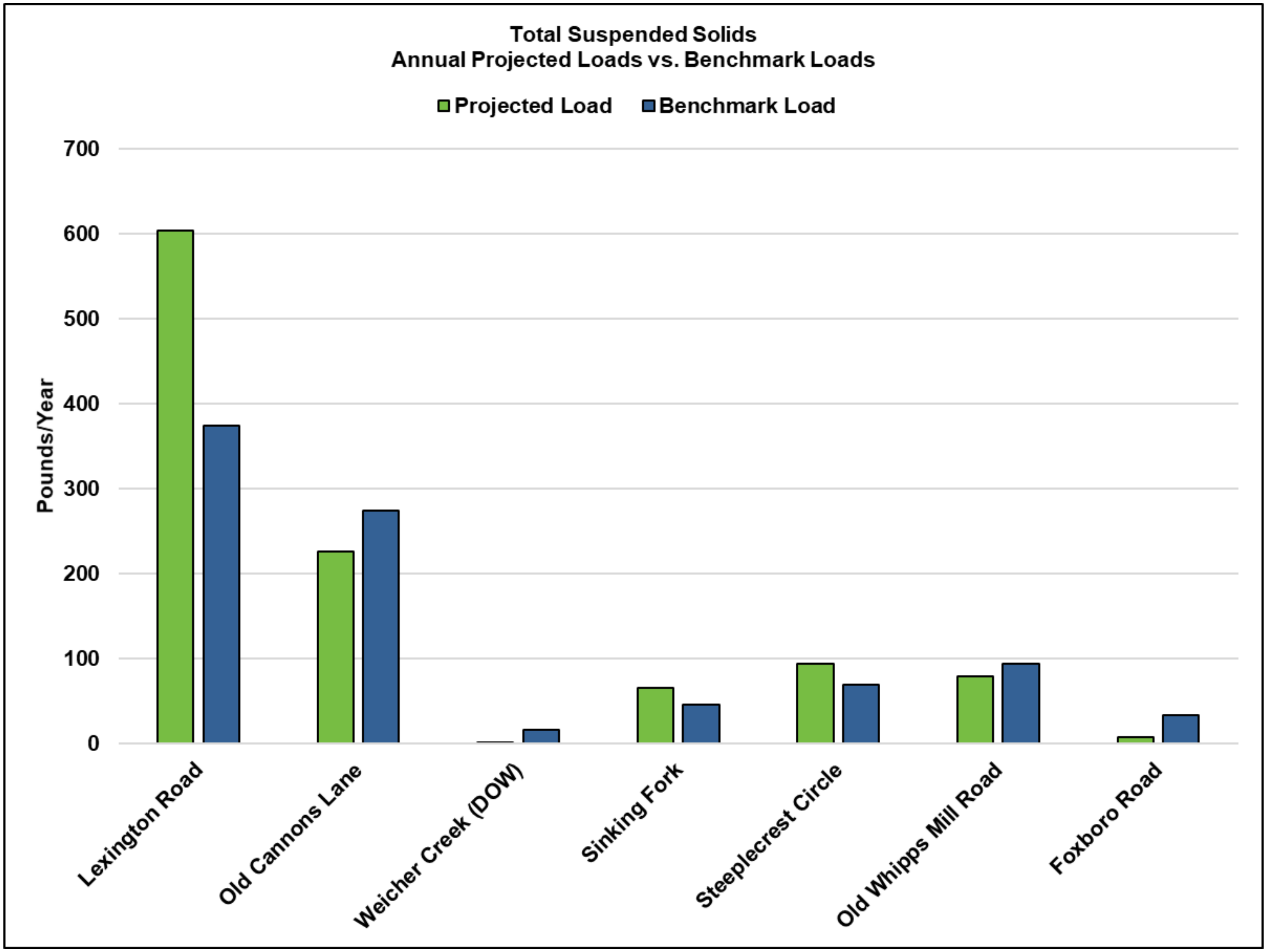

Figure 4.41 Total Suspended Solids Annual Projected Loads vs. Benchmark Loads

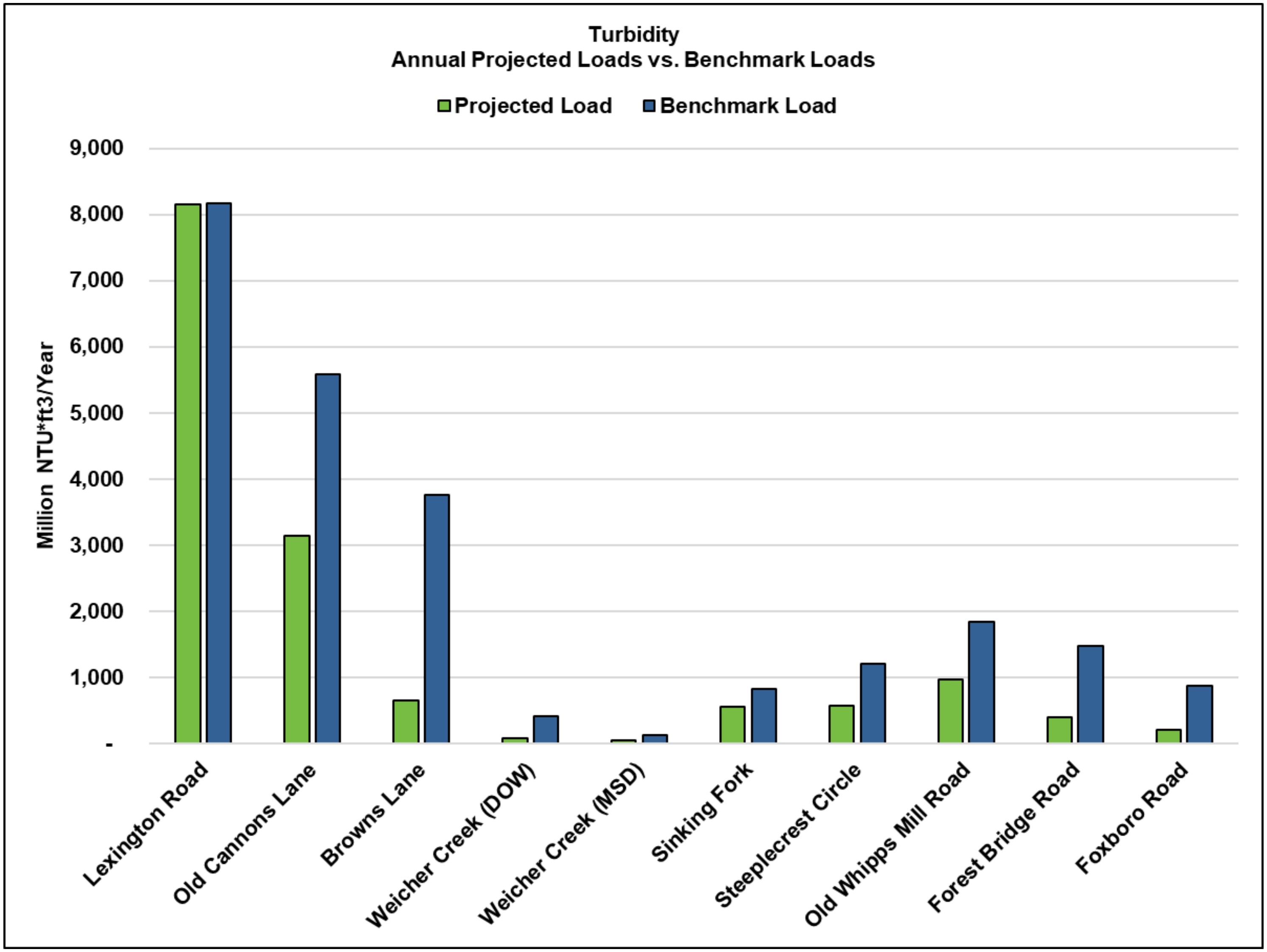

Figure 4.42 Turbidity Annual Projected Loads vs. Benchmark Loads

4.2.3.4 *Evaluation of Potential Sources*

The evaluation of pollutant concentrations and loads in the previous sections is necessary to assess potential sources of nonpoint source pollutants within the watershed. The results outline parameters of concern as well as parameters meeting benchmarks such as unionized ammonia and TP. The results and the following discussion of sources help to target efforts to protect and restore areas in the watershed.

4.2.3.4.1 *E. coli* Sources

As noted above, pollutant load reductions for *E.coli* within the Middle Fork Beargrass Creek watershed are necessary at each site to reach the benchmarking goals established by regulatory standards, ranging from 72% to 98% reductions. The data show that load reductions for *E. coli* during dry weather events were much lower than wet weather events, signifying a connection between stormwater runoff and *E. coli* loads in the streams.

There are a wide range of bacteria sources that may be impacting the concentrations of *E. coli* in the Middle Fork Beargrass Creek watershed, including animal and human sources. Animal sources include pet waste (dogs), as well as wildlife, such as raccoons and waterfowl. Human sources may come from aging or failing septic systems, combined sewer overflows, sanitary sewer overflows, inflow and/or infiltration (I/I) of the sewer system, illicit connections to the sewer system and socio-economic matters. Potential BMPs to address these sources are discussed in Chapter 5.

4.2.3.4.2 TSS Sources

The monitoring results and habitat assessment results demonstrate that TSS is a pollutant of concern in the watershed. TSS concentrations were occasionally above the non-regulatory benchmark, and were visually observed during the stream assessments including heavy to moderate embeddedness of streambeds, unstable and incised banks, and active movement of sediment and bed material, indicating load reductions are needed throughout the system; however, Sites 1, 6 and 7 show significant need. The data only exceeded benchmark loads during wet events, showing a correlation in stormwater runoff and an increase in TSS concentration in the stream. This indicates potential TSS input from the watershed as well as possible bank erosion occurring in the watershed.

Sources of sediment in the Middle Fork Beargrass Creek watershed may come from external loading from overland flows to the stream, or internally, through hydrologic conditions and stream channel erosion. Stream channel erosion can be exacerbated by increased impervious areas and lack of riparian buffers, causing increased water flow velocity and volume. Habitat evaluations indicate poor in-stream habitat for parameters that correlate to TSS such as embeddedness, epifaunal substrate (structures on the streambed that provide surfaces on which animals can live) which is frequently choked by sediment, lack of bank vegetation and sedimentation across the watershed. External sources of sediment include sources such as erosion from construction sites, streets, driveways and unpaved roads, as well as lawns.

4.2.3.4.3 Turbidity

Based on the sampling results, turbidity moderately exceeds the benchmark at several monitoring locations along the main stem and in the middle of the watershed. Generally, increased flow correlates with the turbidity found in the stream. Similar to TSS, sources of sediment and particulates may come from external or internal loading to the stream systems.

4.2.3.4.4 TN Sources

Concentrations of TN observed in the watershed were frequently above the non-regulatory water quality benchmark, with no correlation to stream flow. There are a variety of ways nitrogen can enter the waterways in Middle Fork Beargrass Creek. High nitrogen concentrations are commonly related to sewage-related sources, such as improperly maintained or failing septic systems, combined sewer overflows, sanitary sewer overflows, inflow and/or infiltration of the sewer system, and illicit connections to the sewer system. Nitrogen may also be related to the application, or over-application, of residential and commercial fertilizers. Finally, wash-off of vehicular emissions and atmospheric deposition are also sources of nitrogen in the watershed.

4.2.3.4.5 Conductivity

Sampling for specific conductance resulted in non-regulatory benchmark exceedances across the watershed and does not correlate to changes in stream flow. Increases in conductivity can be caused by natural geology as well as point sources such as septic systems and roadway treatments. Groundwater that is ionized from the dissolved minerals of naturally occurring geology and clay soils may contribute to higher values. Additionally, failing septic and sanitary sewer systems, and other causes, are potential sources.

4.2.3.5 *Additional Phase I Results*

A major contributor to water quality throughout the Middle Fork Beargrass Creek watershed is linked to litter and trash. Litter and improperly managed trash can find its way into creeks and streams in the area and impact water quality and the overall health of the ecosystem. Stream cleanups were conducted as part of the outreach component of this watershed-based plan, and through visual observations—both during these events and regular sampling—trash and debris were often seen along the banks and in the creek.

Trash itself is relatively inert; however, it is a mode of transportation for other nonpoint source pollutants outlined in this plan. In some cases, plastic and other chemicals from trash can leech into the water, which impacts multiple water quality parameters, such as pH, dissolved oxygen and temperature when large quantities of trash are present. These impacts can harm aquatic life and the aquatic ecosystem. In addition to the chemical and biological impacts, trash also takes away from the aesthetic value of the watershed (EPA, 2021).

One way to address trash pollution in the watershed is through source identification and control. The EPA has a Waste Management Hierarchy that ranks waste management strategies based on their effectiveness. The most effective strategy is source reduction and reuse. Source reduction refers to reducing waste at the source which therefore reduces the amount of materials that enter the lifecycle of garbage. Reduction can help to save natural resources, conserve energy, reduce pollution, reduce the toxicity of waste and save money for consumers and businesses. Other strategies ranked from most to least effective on the hierarchy are recycling/composting, energy recovery, and treatment and disposal. More information on these strategies can be found at: https://www.epa.gov/smm/sustainable-materials-management-non-hazardous-materials-and-waste-management-hierarchy

Trash and debris can also be addressed by multiple BMPs that are detailed in Chapters 5 and 6. These BMPs and other efforts, such as source control and relating public behavior to trash in the watershed, can be a part of Phase II monitoring and analysis.

Figure 4.43 Site 3: Brown Park Debris Jam Collecting Trash

4.3 PHASE I – PRIORITIZATION

As recommended in the Guidebook, three subwatersheds will be prioritized for additional monitoring and BMP implementation to better determine pollutant sources and to assist in targeting future efforts in the watershed. Due to the unique and diverse nature of a watershed, subwatersheds can be a useful way to have a more focused look at solutions and consider other factors, such as land use, stakeholder cooperation and even political will. Middle Fork Beargrass Creek was divided into subwatersheds based on the sampling locations that were monitored in Phase I. The sampling sites were selected based on their location in the watershed, safety factors and ease of access. The Guidebook recommends the prioritization for up to three subwatersheds for future monitoring and analysis. There are a number of factors that were considered in the prioritization process, including: results of the analytical data prioritization, the regulatory status of Middle Fork Beargrass Creek and the feasibility factors discussed in the following sections. Per the Watershed Planning Guidebook, the feasibility factors are intended to determine whether the initial priorities for implementation can be accomplished.

4.3.1 Organizing Analytical Data

The monitoring data results for this study were used to compare parameter concentrations to the established regulatory criteria and non-regulatory benchmarks. The monitoring data results were also used to determine which subwatersheds require the most change to bring concentrations for each parameter within an acceptable range. The subwatersheds were ranked by parameter from greatest number of exceedances to the lowest number of exceedances for each parameter to determine the areas in greatest need of restoration. To determine which subwatersheds contribute the most pollution (by weight) within the Middle Fork Beargrass Creek watershed, the subwatersheds were also ranked from greatest to lowest load reduction needed. For DO and conductivity, the ranks for percent exceedances were used. For *E. coli*, TSS, turbidity and TN, the two ranks (one for exceedances and one for loads) were summed for a joint rank and then compiled into a final rank as shown in Table 4.18 Subwatersheds Ranked on Analytical Results.

Table 4.18 Subwatersheds Ranked on Analytical Results

Location	*E. coli*	TSS	Turbidity	TN	DO	Conductivity
Lexington Road	2	1	1	3	1	4
Old Cannons Lane	5	5	Meets Criteria	2	Meets Criteria	6
Browns Lane	7	Not Sampled	Meets Criteria	Not Sampled	Meets Criteria	7
Weicher Creek (DOW)	3	Meets Criteria	2	6	Meets Criteria	10
Weicher Creek (MSD)	10	Not Sampled	Meets Criteria	Not Sampled	Meets Criteria	9
Sinking Fork	1	2	3	7	Meets Criteria	3
Steeplecrest Circle	4	3	Meets Criteria	1	Meets Criteria	5
Old Whipps Mill Road	8	4	Meets Criteria	4	Meets Criteria	2
Forest Bridge Road	9	Not Sampled	Meets Criteria	Not Sampled	Meets Criteria	1
Foxboro Road	6	Meets Criteria	Meets Criteria	5	Meets Criteria	8

4.3.2 Regulatory Status of Waterways

The Kentucky Watershed Planning Guidebook recommends considering the regulatory status of the watersheds when ranking the subwatersheds. The most recent Integrated Report to Congress on the Condition of Water Resources in Kentucky, with data from 2016, was published in 2018 (DOW, 2018). The current regulatory status for waterbodies in the Middle Fork Beargrass Creek watershed is shown on Table 4.19 Regulatory Status of Middle Fork Beargrass Creek Waterbodies.

Table 4.19 Regulatory Status of Middle Fork Beargrass Creek Waterbodies

Waterbody	WAH	Primary Contact	Assessment Category (1)	Causes	Sources (3)
Middle Fork Beargrass Creek River Mile 0.0 to 2.0	5-NS	4A-NS	5	Habitat assessment, fecal coliform, nutrient/ eutrophication biological indicators, organic enrichment (sewage) biological indicators	Channelization, sanitary sewer overflows (collection system failure), urban runoff/ storm sewers
Middle Fork Beargrass Creek River Mile 2.0 to 2.9	2-FS	4A-NS	4A **(2)**	Fecal coliform	Sanitary sewer overflows (collection system failure), urban runoff/storm sewers
Middle Fork Beargrass Creek River Mile 2.9 to 15.3	2-FS	4A-NS	4A **(2)**	Fecal coliform	Illegal dumps or other inappropriate waste disposal, sanitary sewer overflows (collection system failure), urban runoff/storm sewers

Notes:

1. Assessments were not performed for secondary contact and fish consumption.
2. Stream segment in Assessment Category 4A because Total Maximum Daily Load for Fecal Coliform: Six Stream Segments within the Beargrass Creek watershed, Jefferson County, Kentucky, was approved in 2011.
3. Channelization, urban runoff/storm sewers and illegal dumps or other inappropriate waste disposal are classified as nonpoint sources of pollution per DOW, 2019.

4.3.3 Feasibility Factors

In addition to considering the analytical data and the regulatory status of the subwatersheds, the Watershed Planning Guidebook provides several feasibility factors to consider when selecting the subwatersheds for further monitoring and project implementation. During the development of this watershed plan, feasibility factors were assessed from both qualitative and quantitative perspectives. To address nonpoint source pollution control, this section outlines the prioritization process for ranking subwatersheds to inform potential monitoring locations and the types and locations of BMPs that could be used to protect and restore the waterways. The data selected for the feasibility analysis also provide information to assist with the characterization and prioritization for BMPs. The feasibility factors include monitoring considerations, stakeholder cooperation, areas of local concern, watershed management activities, BMP opportunities and subwatershed prioritization. For the purpose of this watershed-based plan, subwatersheds are defined as the areas draining to a sampling point that do not overlap one another. The subwatersheds are identified in Figure 4.44.

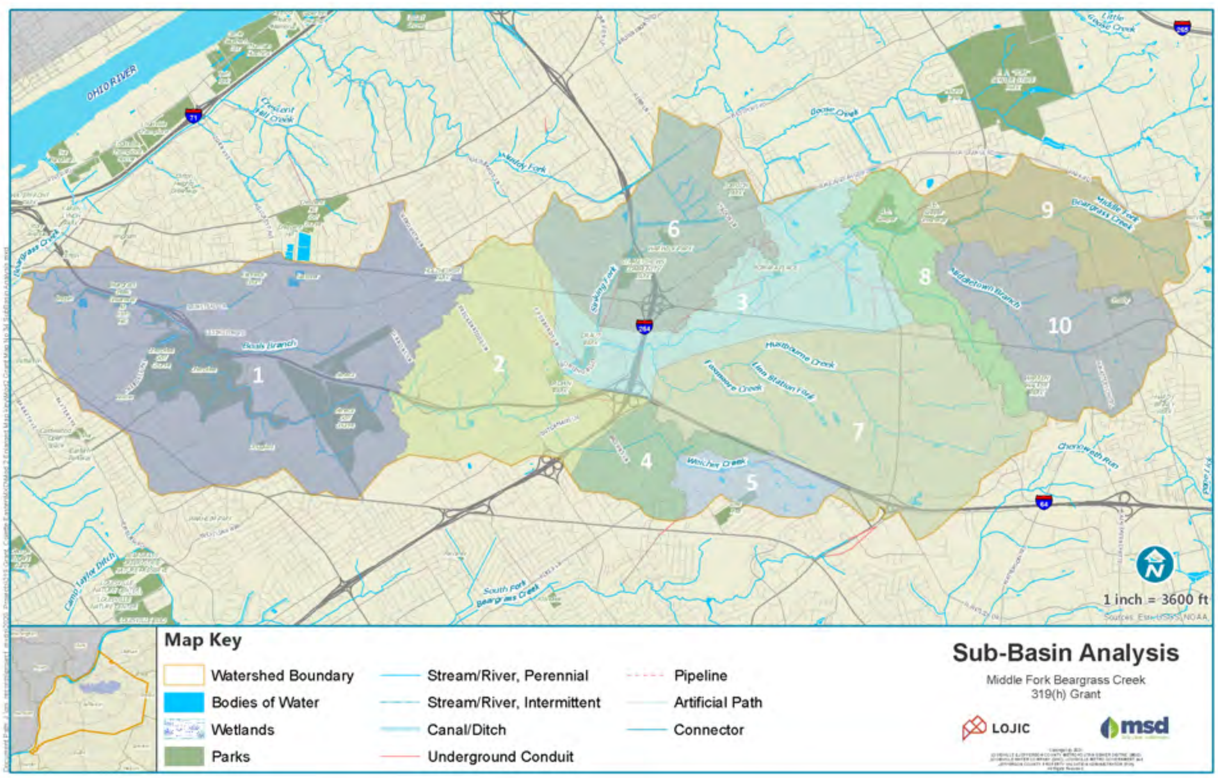

Figure 4.44 Middle Fork Beargrass Creek Watershed Subwatersheds

To impartially discern which subwatersheds would be most appropriate for prioritization, feasibility factors were interpreted into measurable metrics, described in the following sections and on Table 4.20 Subwatersheds Ranked on Feasibility Factors.

4.3.3.1 *Monitoring Considerations*

For Phase I of this project, monitoring sites were selected at the bottom of each subwatershed with the goal of being evenly distributed throughout the watershed. Site accessibility and safety were also considered in identifying the monitoring locations. Additional monitoring will be conducted during Phase II of the project. The additional monitoring will continue to support BMP siting and pre- and post-BMP monitoring. The number of monitoring stations in the watershed, including MSD's LTMN sites, Salt River Watershed Watch (SRWW) sites, and USACE Three Forks stream walk sites were considered. Monitoring locations are depicted in Appendix 2.1. Monitoring data inform the selection of BMPs and evaluate their effectiveness. Subwatersheds that could benefit from more monitoring, or had a lower number of monitoring locations, were ranked higher for prioritization consideration because more data are needed to characterize the subwatershed. For example, Lexington Road had the most monitoring locations in the watershed between the LTMN sites (which for purposes of this analysis included 319(h) monitoring), Three Forks stream walks and SRWW locations; therefore, it was ranked lowest in the watershed due to the number of monitoring stations and availability of data.

4.3.3.2 *Stakeholder Cooperation*

Support from local stakeholders and the community is crucial to the implementation and success of this watershed plan. Measuring stakeholder cooperation by a subwatershed area was performed by gathering data from the crowd-sourced BMP Web Application. The BMP Web Application, available to stakeholders in June 2021, allowed users to suggest and vote on BMPs located in the watershed. This information was parsed by subwatershed to estimate the interest of the stakeholders by subwatershed. In areas where numerous BMPs were suggested and stakeholder interest was high (based on number of votes), the subwatershed was assumed to have a high likelihood of stakeholder cooperation. Examples of the proposed BMP sites and stakeholder project online maps are provided in Figure 4.45 and Figure 4.46, respectively.

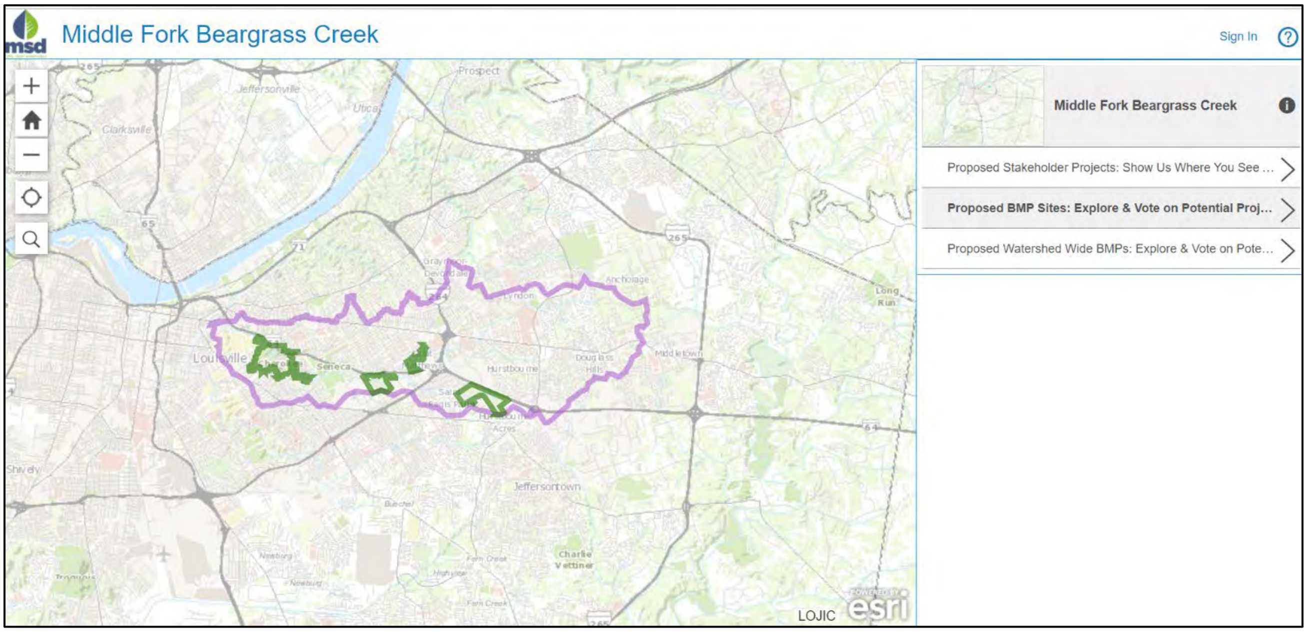

Figure 4.45 Middle Fork Beargrass Creek Online Map Proposed BMP Sites

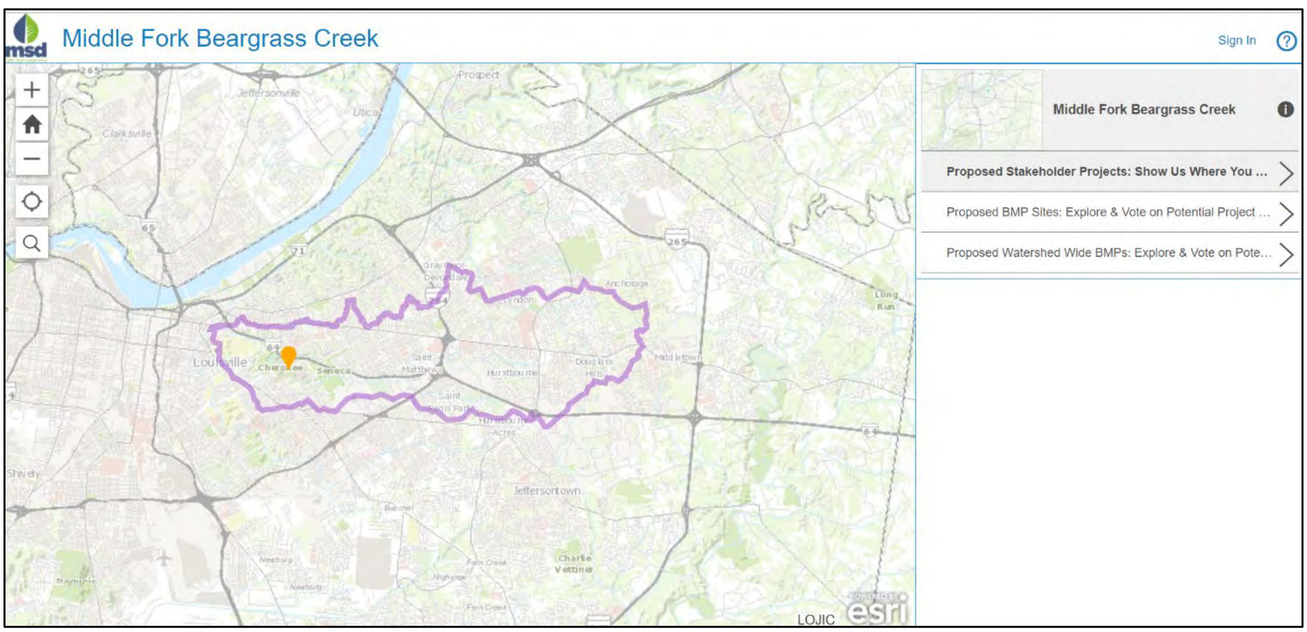

Figure 4.46 Middle Fork Beargrass Creek Online Map Proposed Stakeholder Projects

4.3.3.3 *Areas of Local Concern*

Areas of local concern in the watershed were feasibility factors used to consider specific areas that could be targeted for additional BMPs and outreach. The overall health of the system and being able to interact with the water are considered important throughout the watershed; therefore, for measurable areas of local concern, an analysis of impervious area was completed to indicate the watershed health as well as measure the ability for retrofits. Additionally, given the bacteria concentrations identified in the watershed, the number of septic systems located in each subwatershed were also considered. Areas where greater numbers of septic systems exist may be addressed through outreach, maintenance or sewer-connection. Site 9, at Forest Bridge Road was identified as an area of high priority in regard to septic systems.

4.3.3.4 *Watershed Management Activities*

There are currently two other ongoing initiatives in the watershed that may assist with addressing impairments —projects driven by the Consent Decree and IOAP and projects driven by the USACE Three Forks Study. Subwatersheds with future projects through these initiatives were ranked lower for prioritization purposes for this plan, because the impairments may be addressed through the projects identified in the IOAP and through the USACE Three Forks Study. Sites closer to the headwaters were generally ranked higher for prioritization for consideration of 319(h) funding.

4.3.3.5 *Additional Feasibility Factors*

Additional feasibility factors that were considered included those most likely to make BMP implementation a reality. For example, miles of stream in each subwatershed were measured to determine which subwatersheds had the most potential streams for possible restoration. The riparian buffers of the streams were also reviewed by GIS to determine the impervious area in the riparian buffer, which would indicate a potential for future restoration. Public parks were also included into the prioritization rankings to determine the amount of land available for outreach potential and accessible BMP retrofits. Finally, existing detention basins, constructed prior to 2015, were assessed, as these BMPs were the most likely candidates for potential water quality retrofits.

The results of the feasibility factors analysis provided the following rankings in Table 4.20 Subwatersheds Ranked on Feasibility Factors.

Table 4.20 Subwatersheds Ranked on Feasibility Factors

Site ID	Location	Monitoring Considerations	Stakeholder Cooperation	Areas of Local Concern		Watershed Management Activities			BMP Opportunities					Rank
		Total Monitoring Stations	Proposed BMP from Stakeholders (Votes)	Impervious Area	Septic Systems	IOAP Projects	Three Forks Study	Existing Water Quality BMPs	Total Miles of Stream	Public Parks	Impervious Area in Buffer	Detention Basins	Subwatershed Priority	
1	Lexington Road	10	1	1	4	10	9	8	1	1	5	8	5.3	6
2	Old Cannons Lane	7	2	8	4	1	1	8	5	5	8	9	5.3	6
3	Browns Lane	9	4	2	4	1	1	6	3	6	1	2	3.5	2
4	Weicher Creek (DOW)	3	6	10	4	1	1	1	9	9	10	9	5.7	10
5	Weicher Creek (MSD)	1	5	9	4	1	1	8	10	8	9	6	5.6	9
6	Sinking Fork	2	6	5	4	1	8	3	4	2	2	3	3.6	3
7	Steeplecrest Circle	3	2	4	3	1	1	1	2	9	4	4	3.1	1
8	Old Whipps Mill Road	3	6	6	4	1	1	6	8	3	3	5	4.2	5
9	Forest Bridge Road	3	6	7	1	1	9	3	7	7	7	7	5.3	6
10	Foxboro Road	8	6	3	2	1	1	3	6	4	6	1	3.7	4

4.3.4 Compiled Prioritization Results

The final prioritization of the subwatersheds for BMP implementation and additional monitoring considers the feasibility factors discussed above, as well as the analytical results. This is done to combine the greatest need in the subwatersheds from a water quality standpoint (determined from the analytical results) with the ability to implement BMPs and monitoring. The rankings of the feasibility factors, regulatory status of the waterway and analytical results are shown in Table 4.21 Compiled Prioritization Results based on Analytical Results and Feasibility Factors. These results were combined, averaged and then ranked to estimate the prioritization of each subwatershed.

Based on the data, future monitoring and BMP implementation in the following subwatersheds will have the greatest potential impact on Middle Fork Beargrass Creek's water quality: Sinking Fork, Steeplecrest Circle and Lexington Road. Although Lexington Road is a priority sampling location, further monitoring and BMP implementation will occur upstream in the watershed. By focusing higher in the watershed, the strategy is to target economically feasible projects and implement BMPs that will provide benefits to the downstream waters by addressing them at or nearer the source. As improvements are made upstream, water quality data and BMP data will continue to be analyzed regarding potential impacts lower in the watershed and to assess the feasibility of projects in the highly urbanized areas.

The areas identified as "protect" in the table below are the areas in the watershed where efforts should be made to maintain the water quality. The other subwatersheds are identified as potential restoration areas where there is the potential for BMPs to be implemented to restore water quality.

Table 4.21 Compiled Prioritization Results based on Analytical Results and Feasibility Factors

Site ID	Location	Analytical Results	Regulatory Status of Waterway	Feasibility Factors	Average Score	Final Rank
1	Lexington Road	1	No impact between watersheds	6	3.5	**3**
2	Old Cannons Lane	5		6	5.5	**4**
3	Browns Lane	Protect (9)		2	5.5	**4**
4	Weicher Creek (DOW)	4		10	7	**9**
5	Weicher Creek (MSD)	Protect (10)		9	9.5	**10**
6	Sinking Fork	2		3	2.5	**2**
7	Steeplecrest Circle	3		1	2	**1**
8	Old Whipps Mill Road	6		5	5.5	**4**
9	Forest Bridge Road	7		6	6.5	**8**
10	Foxboro Road	Protect (8)		4	6	**7**

4.3.5 Additional Feasibility Factors Consideration

In addition to the quantitative analysis of the feasibility factors discussed above, additional explanation from a qualitative perspective regarding watershed specifics is provided for regulatory matters, stakeholder cooperation, political will and available funding that may impact future monitoring, selection and siting of BMPs.

4.3.5.1 *Regulatory Matters*

There are two regulatory considerations that factor into improving the water quality in the Middle Fork Beargrass Creek watershed: the Consent Decree and the MS4 permit. MSD entered into a consent decree with the EPA in 2005 to manage Combined Sewer Overflows (CSO) and Sanitary Sewer Overflows (SSO) in the service area, including the Middle Fork Beargrass Creek watershed. Through the MS4 permit, MSD and its co-permittees perform activities to educate the public regarding best practices to improve water quality and implement other practices including structural BMPs to reduce pollutants entering local waterways.

MSD published a modification to the Integrated Overflow Abatement Plan (IOAP) in April 2021, which included a request for an extension of time to implement the remaining projects. The remaining projects will help reduce the wet weather overflows, which will improve bacteria loadings to the watershed. One of these projects, which is currently in the final stages of construction, is the Waterway Protection Tunnel. This innovative project provides a way to store some of the overflow of rainwater and wastewater underground until it can be pumped to a wastewater treatment facility. This is one of the components of MSD's $1.15 billion Consent Decree that will reduce sewer overflows. The IOAP outlined specific projects, budgets and schedules to improve infrastructure to address long-term maintenance and capital needs. This kind of strategic planning and investment is important for achieving MSD's mission to provide quality wastewater, stormwater and flood protection services to protect public health and safety through sustainable solutions, fiscal stewardship and strategic partnerships.

MSD, the Cities of Anchorage, Jeffersontown, and St. Matthews, and Louisville Metro Government are MS4 co-permittees and jointly implement the Stormwater Quality Management Plan (SWQMP) within the Middle Fork Beargrass Creek watershed. The permit and the SWQMP require the co-permittees to implement specific activities to improve water quality, including illicit discharge detection and elimination, erosion prevention and sediment control, and post-construction practices to treat stormwater before leaving a site. Specifically in the Middle Fork Beargrass Creek watershed, the City of St. Matthews has led the design of stream restoration projects in Brown Park, Community Park and Arthur K. Draut Park.

Louisville Metro regulates land uses and development patterns. Louisville Metro ordinances, land development code and long range planning documents define the requirements for development. MSD is responsible for the drainage, sewer and stormwater requirements for development of private and public infrastructure. Additional requirements for the smaller cities are also a regulatory component for development.

4.3.5.2 *Stakeholder Cooperation*

Robust partnerships exist in the Middle Fork Beargrass Creek watershed that provide the support to encourage engagement in watershed activities, to continue education and outreach efforts to the public, and to support the implementation of structural and nonstructural BMPs. There are proven relationships between the MS4 co-permittees working together to successfully implement the MS4 program. MS4 permit implementation requires the co-permittees to meet regularly to discuss programmatic activities, issues, lessons learned and successes.

In addition to the municipal coordination, there are also several non-profit organizations actively engaged in the watershed, including the Beargrass Creek Alliance, Kentucky Waterways Alliance and Salt River Watershed Watch. Long-term ongoing support and engagement has been received from Louisville Metro Council Districts 8 and 9 who have shown interest in improving the water quality and environment within the Beargrass Creek Watershed.

It is anticipated that these partnerships will continue into the future and will support the successful implementation of this watershed plan.

4.3.5.3 *Political Will*

There are three factors that may impact plan implementation in regard to political will: increased acceptance of BMPs, property acquisitions and continued communications with elected officials. Increased acceptance of structural and nonstructural BMPs by the public will support plan implementation. Education and outreach should continue to share the benefits of water quality and stream health and the practices that are required to support watershed protection and improvement. Continued education and outreach regarding the value of native plantings, the benefits of riparian buffers and the role that green infrastructure can serve with improving water quality are important activities to continue during the implementation of this plan to encourage public acceptance of these practices. The MS4 permittees will continue to reinforce the actions that the public can take to improve water quality. It is anticipated that the nonprofit partners will continue to implement BMPs.

Property acquisitions may impact the implementation of structural BMPs. A desktop analysis was performed to identify publicly owned land and large tracts of land for potential structural BMPs to streamline the process of locating and implementing structural BMPs to improve water quality. Outreach to property owners will be conducted to determine whether these locations are viable options for structural water quality BMPs.

The Middle Fork Beargrass Creek watershed covers several Louisville Metro council districts, co-permittees and other small municipalities. Ongoing communications will continue with local officials to identify projects and funding sources.

4.3.5.4 *Available Funding*

Louisville Metro and other municipalities in Jefferson County are like many communities across the United States working to leverage limited budgets to maintain and upgrade infrastructure. Successful partnerships are an important factor to identifying local, state and federal grant funding sources, as well as private funding sources. MSD and project partners will continue to work with other partners to identify funding sources and leverage resources to implement projects that protect and improve water quality.

4.3.6 Summary of Prioritization Results

There are a number of factors that were considered in the prioritization process, including: results of the analytical data prioritization, the regulatory status of Middle Fork Beargrass Creek and the feasibility factors. Per the Guidebook, the feasibility factors are intended to determine whether the initial priorities for implementation can be accomplished. The compiled prioritization results based on analytical results and feasibility factors indicate that Sinking Fork, Steeplecrest and Lexington Road are priority subwatersheds in the Middle Fork Beargrass Creek watershed. These results are iterative and are intended to serve as a road map for future decision-making for future monitoring, including Phase II analysis and BMPs. Furthermore, the data supporting the prioritization results, including the riparian buffer data, septic system locations and others can be used to inform the selection and locations of BMPs. The prioritization is intended to be an iterative process by incorporating and updating data as they are analyzed. In addition to the quantitative factors, the story of the watershed's qualitative factors will also continue to impact future decision-making in the Middle Fork Beargrass Creek.

4.4 PHASE II – ANALYSIS

For the first phase of this project, monitoring locations were selected where easily accessible and in such a way that the variability of watershed characteristics was captured, while considering feasibility and safety. Other considerations include intrinsic knowledge such as the Whipps Mill Dam, understanding flow and other factors affecting sampling results that result in adjusting a few monitoring locations. Additionally, while a select number of sites were visually inspected during the first phase, the Three Forks study provided supplemental riverine and riparian habitat visual observations at many locations throughout the watershed. The number of monitoring stations in the watershed, including MSD's LTMN sites, Salt River Watershed Watch sites and Three Forks stream walk sites were considered. The watershed was subdivided into smaller catchments to focus BMP selection. Subwatersheds that could benefit from additional monitoring, or had a lower number of monitoring locations, were ranked higher for prioritization consideration.

As discussed in the Guidebook, a Phase II analysis is necessary to further understand the prioritized subwatersheds from the Phase I analysis. The watershed monitoring conducted in the Middle Fork Beargrass Creek revealed that BMPs implemented across the watershed would improve water quality, specifically those treating bacteria, but future analysis to target the prioritized watersheds would also be beneficial.

Additional future analysis of the selected prioritized watersheds will likely focus on *E.coli*, TN and TSS, with expanded data collection to include biological and habitat data that will be useful in understanding the full extent of impairment in these watersheds. Monitoring, to include wet and dry weather events, would be conducted to understand the contributions in the watershed during low and high flow conditions. The USACE-MSD Three Forks of Beargrass Ecosystem Restoration Feasibility Study is also occurring in the watershed. The results of this study will be incorporated into the Phase II analysis.

Further analysis may also include the Bank Assessment for Nonpoint Source Consequences of Sediment (BANCS) model to assess stream bank erosion and identify potential areas for mitigation. Based on observations during the stream walks, bank stability and in-stream erosion may be higher than what the TSS and turbidity results indicate. As such, there is a need to better understand what is happening within the banks of the creek to further identify appropriate BMPs. Monitoring proposed for the second phase should consider activities that evaluate geomorphological conditions in stream.

The BANCS model quantifies stream bank erosion potential based on a series of field measurements, and there are two components to this model: Bank Erosion Hazard Index (BEHI) and Near-Bank Stress (NBS). Measurements collected using the BEHI include rooting depth, rooting density, bank angle, bank materials and surface protection. Thalweg, toe depth and bank slope contribute to a sum of indices which indicates the level of near bank shear stress being imparted on the study bank. NBS ratings range from low to extreme. By utilizing the BANCS model, it is possible to estimate the erosion potential, which can then be used to quantify nutrient and sediment reductions associated with incorporating stream restoration activities such as native planting buffers, establishing floodplain connectivity and revegetating/reshaping bank slopes. These assessment tools also provide data and observations that support BMPs selection, which can be targeted in specific locations where bank erosion is the highest and the greatest sediment reduction can be achieved in the watershed.

CHAPTER 5. FINDING SOLUTIONS

5.0 FINDING SOLUTIONS

5.1 OVERVIEW OF BMPS

One of the goals of the Middle Fork Beargrass Creek Watershed Plan is to protect and restore water quality through nonpoint source control throughout the watershed. Management of the nonpoint source pollutants, such as bacteria, sediment and nutrients through structural and nonstructural Best Management Practices (BMPs), creates opportunities for government agencies, schools, business owners, subject matter experts and citizens to work together to achieve the goals set for reducing nonpoint source pollutants and improving water quality. There are many management approaches available to address the water quality problems identified in the Middle Fork Beargrass Creek watershed. This watershed plan is designed to create a road map for watershed partners to select appropriate actions that can be used to address the pollutant sources identified in the watershed. BMPs are an important tool in watershed planning because they identify actions, guidelines and practices that are intended to protect good water quality and improve poor water quality. BMP development and management are the means that watershed planners can use to promote water quality improvements, allowing for an iterative process of continued data collection, planning, project implementation and monitoring.

5.1.1 Structural and Nonstructural BMPs

BMPs are not only built structures, such as rain gardens and detention ponds, but also include other practices and efforts that are not always seen; these are often referred to as nonstructural BMPs. Nonstructural BMPs are practices that usually involve changes in activities or behavior among people in the watershed. Examples include street sweeping programs, ordinances, education, public input, and engagement and outreach campaigns. BMPs that require construction, installation and maintenance are known as structural BMPs. Both practices are more effective when used together, and both will be utilized in the Middle Fork Beargrass Creek watershed to restore and protect water quality (KWA & DOW, 2010).

5.1.2 Water Quantity and Quality BMPs

As demonstrated from the history of this watershed in Chapter 2 and the pollutant analysis in Chapter 4, the Middle Fork Beargrass Creek is an urbanized watershed with impacts caused by stormwater, including increased runoff. A very high percentage of this watershed is covered by impervious surfaces (asphalt, cement, rooftops, etc.). Large stream flow fluctuations during storm events result in impacts on the biological communities and their habitat in the streams. Fast-moving stormwater can scour the stream banks, causing erosion, sedimentation and siltation, resulting in the decline of both water quality and habitat quality. Impacts from extreme weather events can affect water quality through localized flooding and pollutants introduced during flooding. BMPs that manage stormwater runoff by addressing volume, peak discharge and water quality are identified as suitable BMPs for this watershed. By selecting BMPs that address volume and peak discharge, the stormwater flow and associated channel erosion are mitigated. Water quality is inherently improved through volume reduction when filtering, and biological and chemical processes occur. The EPA defined three scale-based and type-based BMPs: (EPA, 2018)

- Point BMPs: practices that capture upstream drainage at a specific location and may use a combination of detention, infiltration, evaporation, settling and transformation to manage flow and remove pollutants.
- Linear BMPs: Narrow linear shapes adjacent to stream channels that provide filtration of runoff, nutrient uptake and ancillary benefits of stream shading, wildlife habitat and aesthetic value.

- Area BMPs: Land-based management practices that affect impervious area, land cover and pollutant input.

5.1.3 BMP Options for Specific Land Uses

Nonpoint source pollution comes from a variety of widespread sources and land uses and is a result of the runoff from the land. Depending on the source of the pollution, the practice to control the pollution can vary. For instance, agricultural BMPs such as conservation coverage and livestock exclusions are excellent BMPs in agricultural regions. The Middle Fork Beargrass Creek watershed is predominantly urban, and it is suspected that the sources of pollutants are mainly generated by applied chemicals, processes and land use practices associated with an urban environment. Therefore, the BMPs for this watershed are focused on those that can be designed, implemented and maintained in an urban environment, rather than an agricultural or forested environment.

Figure 5.1 Rain Garden at the Northeast Regional Library

Urban BMPs can be a key method for identifying and managing urban sources of pollutants such as nonpoint source pollution in stormwater runoff and pollution caused by urban development. Often pollutants from urban environments are intensified due to the amount of pollutants in stormwater runoff as well as the volume and rate of runoff from impervious surfaces. Areas with increased amounts of impervious surfaces can cause changes to water quality as well as hydrology that result in habitat modification and loss, increased flooding, and increased sedimentation and erosion such as that seen in the Middle Fork Beargrass Creek. This is the reason many urban BMPs control the quality and quantity of stormwater runoff, such as those suggested in the Watershed Planning Guidebook for Kentucky Communities, 1st Edition (KWA & DOW, 2010), shown in Table 5.1 Watershed Planning Guidebook BMPs.

Table 5.1 Watershed Planning Guidebook BMPs

Structural Practices	Nonstructural Practices
• Rain gardens • Constructed wetlands • Green wet basins • Green dry basins • Green roofs • Permeable pavers • Porous asphalt • Tree boxes • Rainwater harvesting • Vegetated buffers • Underground storage • Catch basin inserts • Proprietary water quality units • Infiltration trenches • Riparian buffers • Sediment basins	• Planning for reduction of impervious surfaces • Education materials • Erosion prevention and sediment control • Fertilizer management • Nutrient management plans • Pesticide management • Ordinances • Pet waste programs • Pollution prevention plans • Setbacks • Storm drain stenciling • Workshops on proper installation of structural practices • Conservation zoning – overlay districts • Special districts and conservation subdivisions • Preservation of open space • Development of greenways in critical areas

5.2 BMPS AND POLLUTANT SOURCES

A variety of BMPs are available to address water quality issues identified in a watershed. These include structural and nonstructural BMPs. This section provides an overview of the pollutants that exceeded benchmarks within this study, as well as potential BMPs that can be implemented to reduce these pollutants.

5.2.1 Pollutants

Possible BMPs that address the pollutants listed below are detailed in Section 5.2.2 and summarized in Table 5.2 BMPs and the Specific Pollutants They Address.

Figure 5.2 Floatables in Middle Fork Beargrass Creek at Cherokee Park

5.2.1.1 *Bacteria*

Significant reductions of *E. coli* are necessary to meet the regulatory benchmarks for instantaneous concentrations and for recreation standards, with load reductions ranging from 72% to 98%. Concentrations were notably high during wet weather events, indicating potential runoff from sources such as pet waste, wildlife and human sources. Addressing bacteria as a pollutant is a challenge for communities across the United States.

5.2.1.2 *Sediment*

The visual assessment of instream conditions revealed that banks are eroded, and there are indications of highly mobile soils within the system. These observations support that sediment is a current and ongoing nonpoint source pollution within the watershed. Monitoring of total suspended solids and turbidity shows that concentrations captured during sampling events were generally below the benchmarks due to grab sample methods. It is anticipated that during high flow events, which were not captured during sampling, sediment and turbidity may be above benchmark concentrations. This higher sediment concentration would correlate to the visual assessments (highly eroded banks and indications of mobile soils in the system).

5.2.1.3 *Nutrients*

Total nitrogen was the only nutrient that exceeded its benchmark at all monitoring sites. There are many possible sources of total nitrogen that could be contributing to the high concentrations, such as failing septic systems, particulate matter from organic materials and overuse of fertilizers. Nitrogen as a pollutant can often be addressed through nonstructural BMPs.

5.2.1.4 *Specific Conductance*

Measurements of specific conductance exceeded the benchmark developed from ecoregion data. High specific conductance could be caused by natural sources, such as existing geology. Anthropogenic sources may include deicing materials, failing sewage systems or swimming pool discharges. Anthropogenic sources of specific conductance can often be addressed through nonstructural BMPs.

5.2.2 BMPs

This section summarizes BMP options to address nonpoint source pollution in an urban environment, including but not limited to, bacteria, sediment, nutrients and specific conductance.

5.2.2.1 *Wildlife Bacteria Reduction*

Improved watershed conditions are important to support a healthy habitat for wildlife in the watershed; however, while wildlife are a part of the landscape in the Middle Fork watershed, their waste has an impact on water quality. Control measures to reduce wildlife bacteria sources include installation of anti-roosting nets and spikes under structures, vegetation management approaches that deter geese from waterbodies, removing trash, reducing palatable plant species, and using beaver and muskrat controls near the drainage system.

5.2.2.2 *Sanitary Sewer and Infiltration & Inflow Issues*

There are many corrective measures currently undertaken by MSD in the Middle Fork Beargrass Creek to limit bacteria inputs from sewage, and consequently nitrogen, from entering the environment. Practices include preventive maintenance; source control (including enforcement) for illicit discharges and illegal dumping of grease; integrated root control; periodic televising to monitor line condition; point repairs for sags, offsets, protruding laterals, etc.; and rehabilitation or replacement of end-of-life sewers. MSD is implementing these measures to reduce impacts from bacteria and nitrogen; however, with aging infrastructure, there is a backlog, but are scheduled to be completed by 2035. To learn more about these measures currently being undertaken by MSD, see https://www.msdprojectwin.org/

Figure 5.3 Tree Boxes Along Story Avenue

5.2.2.3 *Stormwater Controls*

Runoff from impervious surfaces after precipitation events such as rainfall and snow melt can mobilize pollutants such as sediment and introduce them to local waterways. Impervious surfaces can also cause an increase in the velocity of water entering creeks and streams, which can cause an increase of in-stream erosion. Stormwater BMPs improve water quality by treating stormwater before it enters into streams by capturing, filtering and/or infiltrating stormwater.

There are many types of stormwater BMPs that can be used to address concerns in the watershed. Chapter 18 of the MSD Green Design Manual defines the acceptable stormwater controls for Louisville Metro; this document can be found on MSD's website at: https://louisvillemsd.org/Green.

There are also stormwater controls that can filter or process nitrogen to prevent it from running off into local waterways. These stormwater controls focus on filtration-focused BMPs that provide denitrification benefits, such as constructed wetlands, bioretention, bioswales, etc.

5.2.2.4 *Street Sweeping and Catch Basin Clean Out*

Street sweeping is a BMP that can be used to reduce the sediment, specific conductance and nutrients that build on impervious surfaces by capturing the materials before they enter surface waters. Sediment from roadways can also be captured from catch basins and inlets during clean-out operations. Maintenance of catch basins and stormwater inlets on a regular basis will remove pollutants and reduce high pollutant concentrations during storm events. For both street sweeping and catch basin clean-outs, studies have indicated that the more frequently cleaning occurs, the better the pollutant removal efficiency.

5.2.2.5 *Stream Restoration*

Land use and environmental changes caused by urban activities have constrained, reduced and deteriorated the quality and quantity of natural stream, wetland and riparian ecosystems that provide function and habitat for aquatic plant and animal life. Over the past 100 years, some of Louisville's streams and wetlands have been converted from their natural meandering patterns, native wetlands and bottomland hardwood forests to piped underground networks and defined channels with residential and commercial land usage along Middle Fork Beargrass Creek. These modifications are a byproduct of development. Urbanization can cause an increase in impervious areas, stream velocities and discharge, as well as a reduction in pollutant filtration and storage. With the understanding of historic natural channels and consideration for urban community needs, the application of current stream restoration approaches can be applied to achieve improved water quality in urban watersheds.

Figure 5.4 Catch Basin Insert Removes Debris Underneath an Inlet

Figure 5.5 Native Plants in a Constructed Wetland improve water quality

Stream restoration is based on natural stream channel design techniques that incorporate low-impact implementation methodologies and utilize native materials such as tree roots, trunks, limbs, rocks and plants to establish in-stream and wetland complexes that provide aquatic and terrestrial habitat and native riparian diversity. In addition, they improve stream functions such as sediment transport and management of in-stream stress along stream banks. These practices modify appropriate features such as bank slope, bed slope, in-stream habitat and cross-sectional geometry, such that during high flows, streams have sufficient access to dissipate energy out into the floodplain or into stormwater detention/wetland complexes. These structural BMP designs and practices can help manage smaller storm events that lead to reduced sedimentation and mobilization of soils.

5.2.2.6 *Riparian Buffers*

Riparian buffers can aid in the reduction of energy caused by surface water through the stabilization of erodible stream banks, capturing and filtering sediment and other pollutants, such as nutrients, before entering waterways, and helping to preserve or improve aquatic habitat. Riparian buffers absorb high velocity stream flows, resulting in reduced flooding and regulating the water temperature in streams. The connectivity of corridors can be established through improved riparian buffers, which increases plant and animal species richness and diversity. This is especially important in an urban watershed where the ecological structure has been altered. Additionally, invasive species control in buffer zones can support mid- and understory diversity, which can lead to a more stable bank condition and provide a secondary benefit of enhancing wildlife habitat for aquatic organisms (McNeish, 2017).

5.2.2.7 *Enhanced Erosion and Sediment Control Measures*

Erosion prevention and sediment control (EPSC) practices are required to be implemented during land-disturbing projects in the watershed with a minimum of 2,000 square feet of disturbance or within 50 feet of a sensitive feature. Practices must achieve 80% design removal of total suspended solids that are generated by the site. Ongoing review of EPSC requirements and available technology encourages improved site capture and removal. Additional measures could include enhanced perimeter controls (e.g., compost logs and filtering practices); use of chemical additives in sediment traps and basins to improve settling, filtration and surface outlets; revision of soil stabilization requirements to less than seven days; increased requirements for construction phasing typically required for large projects; and enhancement of internal drainage with passive use of polymers (e.g., floc logs or wattles). Additional education and outreach opportunities could also be offered to ensure contractors, engineers and developers understand the importance of EPSC practices.

5.2.2.8 *Nutrient Management Programs*

Nutrient Management Plans are a programmatic tool used to address the overuse of fertilizers on properties such as residential lawns, athletic fields and golf courses. Plans are developed for specific sites to estimate the needs of the site for major plant nutrients, including nitrogen. Plans take into account soil composition, plant type, karst terrain, areas adjacent to streams, etc.

5.2.2.9 *Deicing Controls*

Deicing salts are the most common product used to reduce icing conditions on roadways and pedestrian walkways to allow for winter travel during adverse conditions. While alternatives for deicing salts do exist, they are not cost-effective or environmentally sound. There are many BMPs focused on improving the performance of winter maintenance practices to reduce the amount of deicing salts necessary to maintain winter travel expectations. These practices include outreach to a number of audiences, such as winter maintenance professionals (plow drivers, mechanics, etc.), business owners, policy makers and the public. Practices may include such things as education programs to contractors and private property owners, training for operators, levels of service discussions/expectations with providers, enhanced handling of salt/brine storage, calibration of equipment, cleaning equipment and containing wastewater, improved application through weather forecasting and surface temperature information, enhanced equipment and technology (plows, surface temperature application rates), and pretreatment.

5.2.2.10 *Chlorinated Swimming Pool Controls*

Allowing chlorinated swimming pools to discharge prior to dechlorination may cause increased concentration of chloride into streams and be otherwise harmful to the environment. Therefore, outreach to pool owners is encouraged to advise and educate owners of proper discharge procedures.

5.2.2.11 *BMP Summary Table*

Table 5.2 BMPs and the Specific Pollutants They Address provides a summary of BMPs specific to pollutants that can improve water quality in the Middle Fork Beargrass Creek watershed.

Table 5.2 BMPs and the Specific Pollutants They Address

BMP	Pollutant			
	Bacteria	Sediment	Nutrients	Specific Conductance
Structural				
Sanitary Sewer and I/I Issues	X		X	
Stormwater Controls		X	X	
Stream Restoration		X	X	
Riparian Buffers		X	X	
Nonstructural				
Wildlife Bacteria Reduction	X			
Street Sweeping		X	X	X
Catch Basin Clean-Out		X	X	
Nutrient Management Programs			X	
Deicing Controls				X
Chlorinated Swimming Pool Controls				X
Enhanced Erosion and Sediment Control Measures		X		

5.3 SELECTING BMPS FOR THE MIDDLE FORK BEARGRASS CREEK WATERSHED

The structural and nonstructural BMPs identified in this chapter to address nonpoint source pollution in the Middle Fork Beargrass Creek watershed were considered and discussed during meetings to develop the BMP table and inform future coordination with stakeholders, which is explained in greater detail in Chapters 6 and 7.

CHAPTER 6. STRATEGY FOR SUCCESS

6.0 STRATEGY FOR SUCCESS

Establishing change in a watershed like Middle Fork of Beargrass Creek requires focus on both behavior and culture change from the community as well as the design and installation of structural BMPs to address nonpoint source pollution. A proven approach for fostering and managing change is by developing a strategy for success. To develop the Strategy for Success for the Middle Fork Beargrass Creek watershed Plan, the team started with the two goals that were identified in the grant application. The two goals for this plan are:

- **Goal 1:** Improve the water quality in the Middle Fork Beargrass Creek watershed by developing a DOW- and EPA-approved watershed plan focused on nonpoint source pollution control measures.
- **Goal 2:** Create greater opportunity for community members to become involved in watershed improvement efforts and solutions.

The watershed goals and objectives were used to identify BMPs that will support protecting and restoring the Middle Fork Beargrass Creek watershed. Most of the BMPs in this plan are new or are in the early stages of development. The majority of the BMPs are focused on education and outreach, which will support Goal 2 for the watershed plan. Structural BMPs, which are discussed in more detail in Chapter 5, will continue to be developed and refined during the implementation of this watershed plan. It is anticipated that the GIS data supporting the prioritization feasibility factors will also support informing the locations and types of BMPs. Additional monitoring will include analysis of the macroinvertebrate data, water quality monitoring, analysis of the data collected during the Three Forks stream walks and geomorphic assessments to better understand pollutant sources and the locations for structural BMPs during Phase II.

In order to improve the water quality in the Middle Fork Beargrass Creek watershed, the BMP workgroup focused on water quality parameters and the associated BMPs that are designed to address specific parameters. To better understand the people who live, work and play in the watershed, a survey was developed as an added touchpoint for the overall communication plan. The survey was shared through social media, council member newsletters and emails with the public. The survey included the following questions:

- If you live in the Middle Fork Beargrass Creek watershed, do you know where the streams are in your neighborhood?
- What activities do you like to do in the Middle Fork Beargrass Creek watershed?
- Are you interested in participating in education and outreach opportunities related to Middle Fork Beargrass Creek?
- How would you like to receive education and outreach materials?

The survey was completed by 150 people. Based on the survey, approximately 69.8% of survey participants enjoy visiting the streams, which provides an opportunity for education. Opportunities for communication with the public include signage regarding litter abatement, water quality and riparian buffers. Figure 6.1 provides a summary of the parks visited in the Middle Fork Beargrass Creek watershed. A summary of survey results is located in Chapter 6 of Appendix, 6.1.

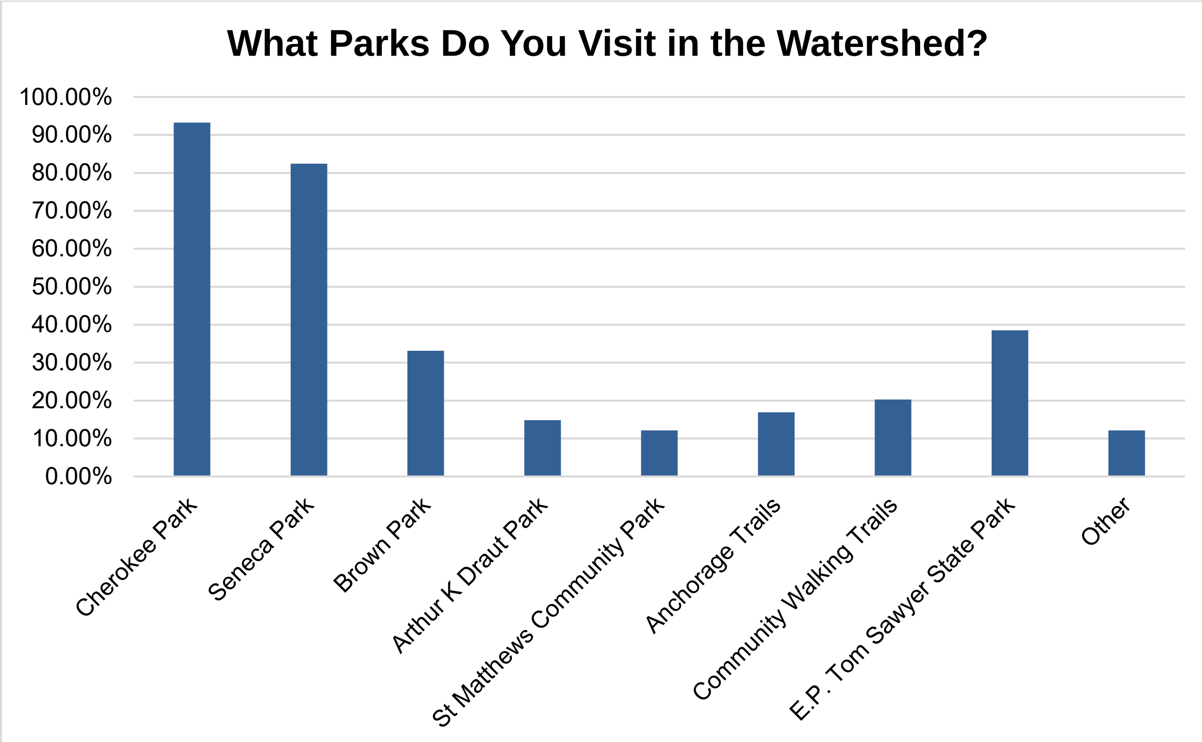

Figure 6.1 Parks Visited in Middle Fork Beargrass Creek Watershed

6.1 IMPLEMENTING BMPs

Based on the understanding of subwatershed characteristics summarized in Chapter 4, BMPs to address nonpoint source pollution have been selected and prioritized. To promote the successful identification and future implementation of BMPs that are known to capture and treat nonpoint source pollutants and address areas that did not meet the benchmark levels summarized in Chapter 5, several tools were utilized. The MSD Green Design Manual was utilized as a guidebook for green infrastructure BMPs that have been successfully implemented in similar urban watersheds within the Louisville area. Additionally, a working group was developed to review the data, discuss watershed-specific knowledge and bring collective subject matter expertise together to further develop the BMP plan. The working group consisted of members with a broad depth of experience with the design, construction, and operation and maintenance of BMPs and the MS4 programmatic requirements. BMPs for this watershed plan include a variety of practices, such as education and outreach, regulation and ordinance review, riparian buffer enhancement, basin retrofits, green infrastructure, stream restoration and further characterization of specific pollution concerns. These BMPs are specific to watershed impairments identified by the monitoring results. The BMPs are summarized in Appendix 6.2.

6.1.1 EDUCATIONAL AND OUTREACH BMPS

Educational programs, public input and public engagement in problem-solving and outreach practices are nonstructural BMPs, and they are crucial for the success of the Middle Fork Beargrass Creek Watershed Plan. Educational and outreach BMPs encourage changes in behavior that will help achieve the goals of this watershed plan and will also support the sustainability of this plan. Educational and outreach practices can include practices such as multi-media marketing style materials, live public events, field trips, open houses, giveaways, mascots, media ads, workshops, online and in-person trainings, and certifications, etc.

6.1.1.1 *Existing Educational and Outreach BMPs*

As described in Chapter 1, a public outreach and involvement plan was developed as part of the grant application for this project; however, due to COVID-19 related stay-at-home orders and social distancing requirements, most of the outreach efforts were canceled in 2020. Alternative outreach projects were conducted, including stream clean-ups and greenway maintenance (including invasive species removal). The first event took place on November 7, 2020, at five locations in the watershed: Cherokee Park at Lexington Road, Cherokee Park near Big Rock, Arthur K. Draut Park, A.B. Sawyer Park and Forest Green Trail. There were a total of 58 volunteers who collected 62 bags of trash along with a shopping cart and plastic playhouse. The second event took place on May 8, 2021, at two locations: Cherokee Park near Big Rock and Arthur K. Draut Park. There were 23 volunteers at this event who collected a total of 10 bags of trash. More information regarding the activities performed are in Chapter 1 Appendix 1.2. These cleanup events served as a good reminder that a contributor to water quality throughout the Middle Fork Beargrass Creek watershed can be linked to litter and trash. Litter and improperly managed trash can find its way into creeks and streams in the area and impact the water quality and the overall health of the ecosystem. These trash pick-up events are a good way to involve the community in protecting the health of the watershed and connect them to the streams. Due to the significant involvement of local entities in this watershed, similar events are proposed to be continued as well as others to promote community awareness focused on addressing pollutants of concern.

It should be noted that several project partners have ongoing public education and outreach programs. Partners include USACE, KWA, BCA, SRWW, etc. Summaries of these partners are included in Chapter 1.

6.1.1.1.1 Current MSD Initiatives

MSD is continually striving to enhance public knowledge of the MSD mission and responsibilities through open, honest communication with our customers and community stakeholders. Many of MSD’s education and outreach programs are associated with regulatory requirements that include the MS4 program and the consent decree. MS4 program activities were not included in the scope of the Middle Fork Beargrass Creek 319(h) Watershed-Based Plan, but the MS4 program activities supported the goal of improving water quality during the implementation of this plan.

6.1.1.1.1.1 MSD MS4 Program

MSD has developed a robust public education and outreach program entitled Public Education, Outreach and Learning Experiences (PEOPLE) as part of the MS4 program to meet MS4 permit requirements. Staff at MSD are subject matter experts regarding successful education and outreach efforts and continue to assess these programs to address pollutants of concern. The intent of these activities is to address pollutants of concern in Louisville Metro streams. The activities identified in the Stormwater Quality Management Plan (SWQMP) include but are not limited to: integrating stormwater quality topics into existing mass media; using social marketing materials with the intent of affecting behavior change; incorporating key messages into community events; facilitating, supporting and encouraging volunteer programs; and conducting outreach to elected officials. These programmatic activities do not qualify for 319(h) funding, but still have a positive impact on the watershed.

6.1.1.1.1.2 Downspout Disconnection

MSD offers an incentivized program to modify and correct improperly installed drainage connections through the Downspout Disconnection Program. Alternatives can include installation of one or more, or a combination of the following: rain barrels, piping away from the house, a French drain—or the most popular alternative, a simple turnout with a splash block.

6.1.1.1.1.3 Rain Garden Handbook

Residential rain gardens provide valuable onsite treatment to improve stormwater quality and limit the volume of stormwater that enters the sewer system. Installation of rain gardens at private residential properties continues to be encouraged through educational campaigns, demonstration projects and incentives to residents. MSD continues to partner with the Kentucky Waterways Alliance Every Drop Program, which works with homeowners to install rain gardens and other practices in the Beargrass Creek watershed.

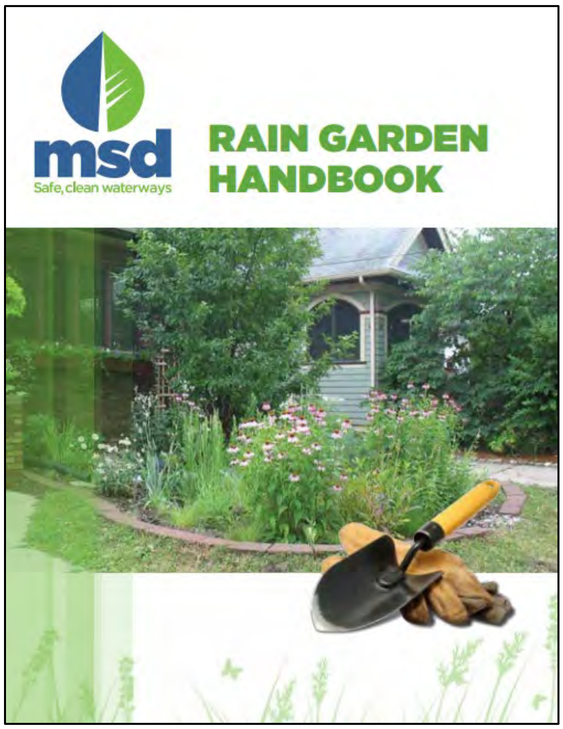

Figure 6.2 MSD Rain Garden Handbook

6.1.1.1.1.4 Fats, Oils and Grease

In an effort to prevent the introduction of fats, oils and grease (FOG) into the MSD sewer collection system and prevent sewer collection system blockages that may result in sewage overflows to the environment, MSD has adopted a FOG Management Policy (MSD, undated). In addition to the policy, MSD adopted FOG Management Guidelines and Design Specifications for Grease Control Equipment (GCE), including grease traps and interceptors.

The FOG management policy, guidelines and design specifications apply to those facilities that prepare and/or serve food for commercial consumption, otherwise known as Food Service Establishments (FSE).

The policy and guidelines require FSEs to control FOG discharges by installing properly sized and maintained grease traps/interceptors.

6.1.1.2 *Additional Proposed Outreach*

In addition to continuing the many educational and outreach programs (nonstructural BMPs) that are currently ongoing in the watershed, others can be introduced to realize further water quality improvements, such as programs to promote pet waste removal, appropriate nutrient application, septic system operation and maintenance, Adopt-A-Drain programs, wildlife management and residential watershed stewardship programs.

6.1.1.2.1 Pet Waste Programs

There are many strategies for pet waste BMPs that may be applicable to the Middle Fork Beargrass Creek watershed. Research indicates that pet waste programs are cost-effective management practices for reducing nutrients in runoff, in addition to the bacteria reductions achieved by limiting pet waste in runoff. Strategies for outreach regarding the management of pet waste include: pet-waste campaigns using social media and traditional media such as radio, billboards, and television; offering free waste bags; printed materials such as brochures; having a mascot to promote community education; providing composters for public or private use; presenting education signage at dog parks, public parks, pet supply stores and veterinary offices; and encouraging pet waste pledges for citizens to clean up after their pets.

Pet Waste Receptacle in Middle Fork Watershed

Pet Waste Receptacle in Middle Fork Watershed

6.1.1.2.2 Nutrient Management Programs

Nutrient Management Plans (NMPs) improve and protect water quality using BMPs to address pollution from private lawns, public parks, golf courses and agricultural settings. NMPs are site-specific plans that address how the major plant nutrients, such as nitrogen and phosphorus, can be managed to avoid unnecessary nutrient applications. NMPs can be used to address overfertilized lands, phosphorus-saturated soils, newly established turf, steep slopes, exposed soils, high water tables, over-irrigated lawns, sandy soils, high use areas (such as athletic fields and golf courses), karst terrain and areas adjacent to streams. NMPs can be prepared by local extension services or trained or certified professionals, and services can be offered or advertised through local nurseries and gardening suppliers, partner affiliates, master gardener clubs, etc. Outreach can also be conducted to lawn care service providers to ensure NMPs are appropriate for their customers.

6.1.1.2.3 SepticSmart

The SepticSmart program is EPA's national public education campaign with resources for homeowners, local organizations and government leaders that provides materials, including an outreach kit, for reaching septic system owners. The outreach communications include campaign materials for a "SepticSmart Week" that can be proclaimed by government leaders as well as education videos that demonstrate the importance of maintenance, monitoring and testing a septic system. Other prepared materials, such as magnets and posters, are also available.

Trash Pickup at Arthur K. Draut Park

6.1.1.2.4 Adopt-A Programs

There are many successful "Adopt-A" programs in watersheds that aim to clean up trash and litter, such as the national Adopt-A-Highway program, which has been adapted to Adopt-A-Drain in communities. Adopt-A-Drain asks residents to adopt a storm drain and pledge to clear debris such as leaves and trash from around the storm drain periodically to ensure that this material does not contribute to pollution in local waterways or cause localized flooding. Additionally, storm drain stenciling or art applications can be a great way to pair art with education and outreach to remind the public that debris and litter can pollute waterways. Storm drain stenciling can be standardized, promoted as an art contest or commissioned from local artists.

6.1.1.2.5 Residential Stewardship Practices

Homeowners can play a large role in addressing water quality needs of the Middle Fork Beargrass Creek watershed by reducing or improving the quality of runoff leaving their homes and yards with practices such as rain gardens, permeable hardscapes, disconnection of roof leaders, impervious cover removal, tree plantings, conservation landscaping, urban nutrient management plans, infiltration trenches and installation of rain barrels. Programs to encourage such practices, such as "River Hero Homes," "RiverSmart Homes," "Riverwise Communities," "Pearl Homes" or "River Star Homes," can help residents adopt a suite of practices to achieve pollutant reductions. Programs can be supported by education from master gardener clubs, purchase

Volunteer Tree Planting

discounts from garden and nursery stores, rate discounts, and native planting workshops offered at local stores or libraries.

6.1.1.3 *Future Potential Partners*

During this first phase of the watershed planning efforts, several partners that were not a part of the original planning efforts were identified. The COVID-19 pandemic made it challenging to engage some of these partners; however, it is anticipated that they would both bring value to the process as well as benefit from the development and implementation of this plan. It is the hope of the team to engage the following partners due to their known missions, visions and historic participation in similar efforts.

6.1.1.3.1 Jefferson County Public Schools, Private and Parochial Schools

Jefferson County Public Schools (JCPS) is the largest public school system in the state, serving 96,000 students. JCPS partners with Jefferson Memorial Forest, which is outside of the watershed, to engage students in environmental and outdoor education. Historically, JCPS has promoted and been engaged in environmental education. There are also a number of private and parochial schools in the watershed, including elementary, middle and high school students.

Tree Planting at a School

Through the implementation of this watershed plan, there are opportunities to engage students in environmental education focused on watershed health, including individual behavior modification to improve water quality and education and outreach efforts. Coordination with JCPS and private/parochial teachers, focusing on encouraging new opportunities with schools in the Middle Fork Beargrass Creek watershed, should be continued. Outreach opportunities may create options for students to complete service hours for general school requirements and requirements for honor societies.

6.1.1.3.2 Soil and Water Conservation District

The Jefferson County Soil and Water Conservation District protects and improves Louisville soil and water resources. As a government agency, the Soil and Water Conservation District provides resources on conservation and management of soil, water and other natural resources. It aims to conserve land, water, forests and wildlife in Kentucky. In addition, the Soil and Water Conservation District Association and the Soil and Water Conservation Society (SWCS) provide conservation support for Louisville residents and businesses.

6.1.1.3.3 Jefferson County Extension Office

Kentucky's two land-grant universities, the University of Kentucky and Kentucky State University, serve as partners in conducting educational programs through Cooperative Extension. Each county has a local office to implement the four program areas. The program areas include:

1. Farms, Gardens and Environment
2. Nutrition, Families and Homes
3. 4-H Youth Development
4. Community and Economic Development

Sustainable agriculture is a component of the farms, gardens and environment programs, including the Master Gardener Program.

4-H Logo

The Jefferson County Extension Office partners with the Jefferson County Soil and Water Conservation District to provide free soil tests. The Soil and Water Conservation District provides up to two soil vouchers per Jefferson County address per year. The vouchers can be used for soil nutrient testing and/or soil lead testing. The soil nutrient voucher covers the cost of one soil nutrient test. Results from the test will list levels of phosphate, potassium, calcium, magnesium, zinc, soil pH, and buffer pH, as well as recommendations for nitrogen, potassium, potash and lime soil amendments. The test is done by University of Kentucky labs. The results of this test can help property owners determine the appropriate amount of fertilizers to use for more efficient fertilizer use.

6.1.2 REGULATORY PROGRAMS

Regulatory programs can have a major impact on the success and the direction of efforts, inform available resources, and impact the types of BMPs and the locations for structural BMPs in the watershed to support water quality protection and restoration. Local regulatory efforts that can impact water quality include the MSD Design Manual, Louisville Metro Floodplain Management Ordinance, Louisville/Jefferson County Erosion Prevention and Sediment Control Ordinance, and the MSD Wastewater/Stormwater Discharge Regulations. MSD is also implementing a watershed-by-watershed approach for regional management of stormwater drainage through the Louisville MSD Watershed Master Plan. Other permits, mandated by the Clean Water Act (CWA), such as the Kentucky Pollutant Discharge Elimination System (KPDES), General Permit for Stormwater Discharges Associated with Construction Activities and the MS4 permit also affect the stormwater policies in Jefferson County. These local programs are often shaped by federal and state requirements. State and federal regulatory programs that impact water quality include:

- Source Water Protection Plans and Groundwater Protection Plans
- Agriculture Water Plans
- Regulations/Programs for Wetlands and In-stream Construction or Disturbance
- Regulations for Floodplain Construction
- Programs and Permits for Managing Wastewater Discharges
- Programs and Permits for Managing Stormwater Discharges
- Programs and Permits for Managing Combined Sewer Overflows (CSO) and Sanitary Sewer Overflows (SSO)
- Special Land Use Planning

The following sections provide a summary of the federal, state and local programs that impact BMPs.

6.1.2.1 *Clean Water Act*

The Clean Water Act (CWA) is the enabling legislation for water quality standards regulations for surface waters and creates a structure for regulating the discharge of pollutants into surface waters of the United States. The origin of the CWA began as the Federal Water Pollution Control Act, enacted in 1948, but was restructured and expanded in 1972 to become known as the CWA. The goal of the CWA is "to restore and maintain the chemical, physical and biological integrity of the Nation's waters." U.S. Code 33 U.S.C §1251(a) has primacy over the CWA permitting program and allows states to establish designated uses assigned to surface waters (e.g., streams, rivers and lakes). For the Commonwealth of Kentucky, these uses are located in 401 KAR 10:026, and water quality standards for these designated uses are established in 401 KAR 10:031. Under the direction of the CWA in Section 303(d), each state is required to develop a list of impaired waters. Kentucky achieves this through the Water Quality Assessment Program, in which the DOW monitors the condition of Kentucky's surface waters, including streams, rivers, lakes, reservoirs, springs and wetlands. The monitoring information collected by Kentucky DOW is used to assess the waterbodies to determine if Kentucky's water quality standards and designated uses are being met. As a requirement of the CWA, results of this assessment are published every two years and are submitted to EPA in the Integrated Report to Congress on the Condition of Water Resources in Kentucky (i.e., 305(b)/303(d) Integrated Report). The EPA and Kentucky Environmental and Public Protection Cabinet have the authority to implement the MS4 Program and the Consent Decree through the CWA enabling legislation.

6.1.2.2 *Municipal Separate Storm Sewer System (MS4) Permits*

Louisville Metro is a Phase I MS4 community that is regulated through the Kentucky DOW. MSD is the primary permit holder and therefore is charged with implementing the stormwater program. MSD is co-permitted with Louisville Metro, Anchorage, Jeffersontown, St. Matthews and Shively to implement the permit and Stormwater Quality Management Plan (SWQMP). Four of the five co-permittees are located in the Middle Fork Beargrass Creek watershed. The City of Anchorage is located at the headwaters of the watershed. Areas of Louisville Metro and Jeffersontown, and the entire City of St. Matthews, are located in the Middle Fork Beargrass Creek watershed. The Louisville MS4 Permit includes over 100 activities and is organized into several program elements including: Illicit Discharge Detection and Elimination, Construction Site Runoff Controls (Erosion Prevention and Sediment Control), Post Construction Site Runoff Controls (Long-term Water Quality Control), Public Involvement and Outreach Programs, Monitoring, Reporting, and Assessment.

The MS4 program elements are accomplished by both the co-permittees and MSD. MSD leads education and outreach efforts for improved water quality throughout Jefferson County, including green infrastructure outreach and education efforts. MSD provides an opportunity for input from co-permittees. MSD also investigates and enforces upon potential illicit discharges through administration of applicable sections of the Wastewater and Stormwater Discharge Regulations; administers post-construction green infrastructure requirements; enforces hazardous material plans and conducts inspections for qualifying industrial and commercial properties; maps the drainage system and outfalls; operates and maintains the drainage system; conducts construction oversight, including plan review and site inspection; administers the Erosion Prevention and Sediment Control Ordinance; conducts the monitoring program and related laboratory analyses; and prepares the annual compliance demonstration report for MSD and co-permittee activities.

Co-permittees of the MS4 permit have responsibility for the following duties within their jurisdictional boundaries: implement education and outreach that complements the education and outreach provided by MSD; map drainage system and outfalls; operate and maintain drainage system; report and refer potential illicit discharge to MSD for investigation and potential enforcement; conduct construction oversight in addition to that provided through Louisville MSD; inspect, operate and maintain permanent (also known as post-construction) water quality devices, controls and management practices; conduct road maintenance including snow and ice removal and related stormwater management activities; implement fleet and facility stormwater pollution prevention plans; and prepare and submit annual compliance demonstration report to MSD according to the agreed upon formats and standards.

The SWQMP, which is a detailed business plan MSD and its co-permittees intend to use as a tool to implement the MS4 permit, was updated in 2017 to coincide with the fifth and current permit, 2017-2022. The intended purpose of the SWQMP is to improve water quality in local streams, creeks and waterways within Jefferson County. The expected water quality benefits include reductions in pollutants of concern and more closely meeting the CWA goals for water quality.

The Wastewater and Stormwater Discharge Regulations, including post-construction requirements for green infrastructure, Erosion Prevention and Sediment Control Ordinance, and education and public outreach programs are described in the following sections.

6.1.2.3 *Local MSD Development Requirements*

MSD is responsible for the planning, design review and inspection of all stormwater systems, flood protection works, sanitary sewers, erosion control structures, small sanitary pump stations and small wastewater treatment plans. MSD is responsible for the Louisville and Jefferson County Hazardous Materials Ordinance and Louisville and Jefferson County Erosion Prevention and Sediment Control Ordinance. The requirements of these programs should be considered when developing in Louisville Metro. This includes the design and construction of structural BMPs.

6.1.2.4 *MSD Design Manual*

The MSD Design Manual is a guide for the planning and design of stormwater systems, flood protection works, sanitary sewers, erosion control structures, small sanitary pump stations, small wastewater treatment plants and associated activities of MSD.

New development in the Middle Fork Beargrass Creek watershed is required to detain proposed stormwater discharge rates to predeveloped conditions for the 2- , 10- , 25- and 100-year storm events through the MSD Design Manual. The NRCS Type II, 24-hour rainfall distribution is required to be used for the modeling. In areas where adequate downstream facilities exist, especially in the lower portion of a watershed where peak flows from the new development will occur substantially prior to the overall peak of the stream, on a case-by-case basis, MSD allows increased runoff to be compensated using a regional facility fee. This regional facility fee is used to construct regional basins.

New development in the combined sewer area is required to limit the 100-year post-developed discharge to the 10-year pre-developed discharge to help alleviate the flows in the system during rain events. Examples of this include building detention basins, oversizing onsite stormwater pipes, and using green solutions such as pervious pavement and rain gardens to reduce peak flows and overall runoff volumes.

In order to promote enhanced water quality and aquatic habitat, natural channel design techniques are the preferred method for the design of streams. Channel improvement projects in blueline streams are required to use natural or “soft” approaches. MSD’s Design Manual outlines natural channel design requirements in Section 10.3.6.

Green infrastructure and post-construction requirements are listed in the MSD Design Manual and Article 6 of the Wastewater Discharge Regulations. MSD is responsible for implementing and enforcing the MS4 post-construction program by administering regulations that require green management practices. Green infrastructure must be designed to manage the required water quality volume rain event of 0.6 inches of runoff and must manage at least 90% of the site’s disturbed area. This volume is to be infiltrated, treated or otherwise managed for new development projects that disturb at least one acre or are part of a greater common development that disturbs at least one acre.

6.1.2.5 *MSD Wastewater/Stormwater Discharge Regulations*

MSD’s Wastewater/Stormwater Discharge Regulations define the requirements for discharges into the public sewer system, including the wastewater collection and treatment system and stormwater drainage system. The Regulations enable MSD to comply with the administrative provisions of the Clean Water Act, Ohio River Valley Water Sanitation Commission (ORSANCO) standards, the water quality requirements set by the Kentucky Energy and Environment Cabinet, and the applicable effluent limitations, national standards, and any other discharge criteria that are required or authorized by state or federal law. The Wastewater/Stormwater Discharge Regulations provide the local regulatory framework for the post-construction program that requires water quality best management practices for development.

6.1.2.6 *Louisville and Jefferson County Hazardous Materials Ordinance*

The Louisville and Jefferson County Hazardous Materials Ordinance requires that businesses that have hazardous materials on site must submit a Hazardous Material Spill Prevention Control (HMPC) Plan. The plan is required for any business that manufactures, uses or stores hazardous materials in minimum designated quantities at their business location. Hazardous materials shall include those contained in the most recent version of 40 CFR 302.4. Hazardous materials shall not include household wastes and other materials excluded by 40 CFR 261.4. Hazardous chemical incidents can range in magnitude from very minor spills causing no adverse health effects to major incidents with the potential to affect a large number of people. The purpose of this ordinance is to emphasize the responsibilities of those businesses that handle hazardous materials in protecting the environment from adverse damage. The ordinance is a continuing effort by local government to improve the environment of Louisville and Jefferson County.

Silt Fence at Active Construction Site

6.1.2.7 *Louisville/Jefferson County Erosion Prevention and Sediment Control Ordinance*

Excessive erosion and sedimentation from land-disturbing activities could lead to negative impacts on the water quality and biodiversity of streams and can cause loss of water-carrying capacity. In 2000, the Jefferson County Fiscal Court adopted an Erosion Prevention and Sediment Control (EPSC) Ordinance. This Ordinance is intended to conserve, preserve and enhance the natural resources of Jefferson County by controlling the adverse impacts and offsite degradation of soil erosion and sedimentation arising from land-disturbing activities. The EPSC Ordinance requires a Site Disturbance Permit for developments with at least 2,000 square feet of disturbance and developments within 50 feet of a sensitive feature, as defined by the ordinance. The Site Disturbance Permit requires an EPSC plan to be developed which achieves 80% design removal of total suspended solids that are generated by the site during construction.

6.1.2.8 *Floodplain Requirements for Construction*

Anyone performing construction and other activities in the 1% annual chance floodplain in Louisville Metro is required to apply and obtain a permit from the DOW Floodplain Management Section and a local permit from MSD pursuant to the Louisville Metro Floodplain Ordinance. The Louisville Metro Floodplain Ordinance provides the regulatory requirements for development in the floodplain throughout Jefferson County. MSD is responsible for the implementation and enforcement for the Louisville Metro Floodplain Ordinance. Typical permitted activities are bridges, culverts, residential and commercial buildings, and grading within the floodplain. DOW also has authority to manage development in a floodplain. Any type of development in, along, or across a stream requires a floodplain permit from DOW. Activities that require a floodplain permit include: residential and commercial structures, stream crossings, fill, stream alterations and relocations, excavations, grading and small stream impoundments. There are two options for DOW permitting, general and individual permits.

Louisville Metro has adopted higher standards than the state for floodplain regulations. Floodplain compensation is required throughout the Middle Fork Beargrass Creek watershed at a ratio of 1.5:1 for any fill placed in the fully developed local regulatory floodplain as required in the Louisville Metro Floodplain Management Ordinance. The ratio may also be increased on a site-specific basis as determined by MSD.

As stated in the Louisville Metro Floodplain Management Ordinance, a natural 25-foot buffer on each side of the stream bank must be preserved on intermittent and perennial streams as defined by the USGS 7.5 minute topographic maps. In addition, intermittent and perennial streams may not be relocated, channelized or stripped, with the exception of public projects such as road crossings, utilities and detention basins that have no other viable alternative.

A minimum buffer is also required by the KPDES General Permit for Stormwater Discharges Associated with Construction Activities (KYR10). A minimum 25-foot buffer is required for discharges to waters categorized as High Quality or Impaired Water (non-construction-related impairment). A minimum 50-foot buffer is required for discharges to waters categorized as Impaired Waters (sediment impaired, but no TMDL). Stream buffers are also required in Louisville's Land Development Code. Stream buffers vary from 25 feet to 100 feet, depending on the form district.

6.1.2.9 *Regulations and Programs for Wetlands and In-stream Construction or Disturbance*

Section 404 of the CWA regulates the discharge of dredged or fill materials into waters of the U.S., including small streams and wetlands adjacent to or connected to regulated waters. The 404 permits and 401 Water Quality Certifications should be considered when selecting BMPs. There are two processes required for a 401 Certification, the state process (401 KAR 9:010) and the federal process (40 CFR 121). More information regarding applying for a 401 Certification is available at https://eec.ky.gov/Environmental-Protection/Water/PermitCert/WQ401Cert/Pages/Apply-for-Certification.aspx.

6.1.2.10 *MSD Consent Decree*

MSD is currently under a consent decree by the U.S. Environmental Protection Agency and the Kentucky Environmental and Public Protection Cabinet to reduce sanitary sewer overflows (SSOs) and combined sewer overflows (CSOs). An Integrated Overflow Abatement Plan (IOAP) has been prepared and modified, most recently in April 2021, by MSD, to address the consent decree. The IOAP is a long-term plan to control combined and separate sewer overflows in the community for MSD to meet federal and state clean water regulations. The IOAP was submitted in 2008 and approved in 2009 and identified $850 million in capital improvements. The goal of the program is to improve water quality and protect the health of the citizens of Louisville Metro.

As described in Chapter 2, the Middle Fork Beargrass Creek experiences both combined sewer overflows and sanitary sewer overflows. MSD is responsible for implementing the Long-Term Control Plan to achieve water quality standards. Bacteria and flow data were collected to compute Event Mean Concentrations (EMCs) in Beargrass Creek during wet weather events; dates of collection include October 2010; September 2013; July 2014; and June 2017. The grab sample data reflect a 70% decrease in *E.coli* concentrations since 2010 in the Middle Fork and South Fork of Beargrass Creek. Figure 6.3 Beargrass Creek Bacteria Trends as Published by Louisville MSD was included in the 2021 IOAP Modification.

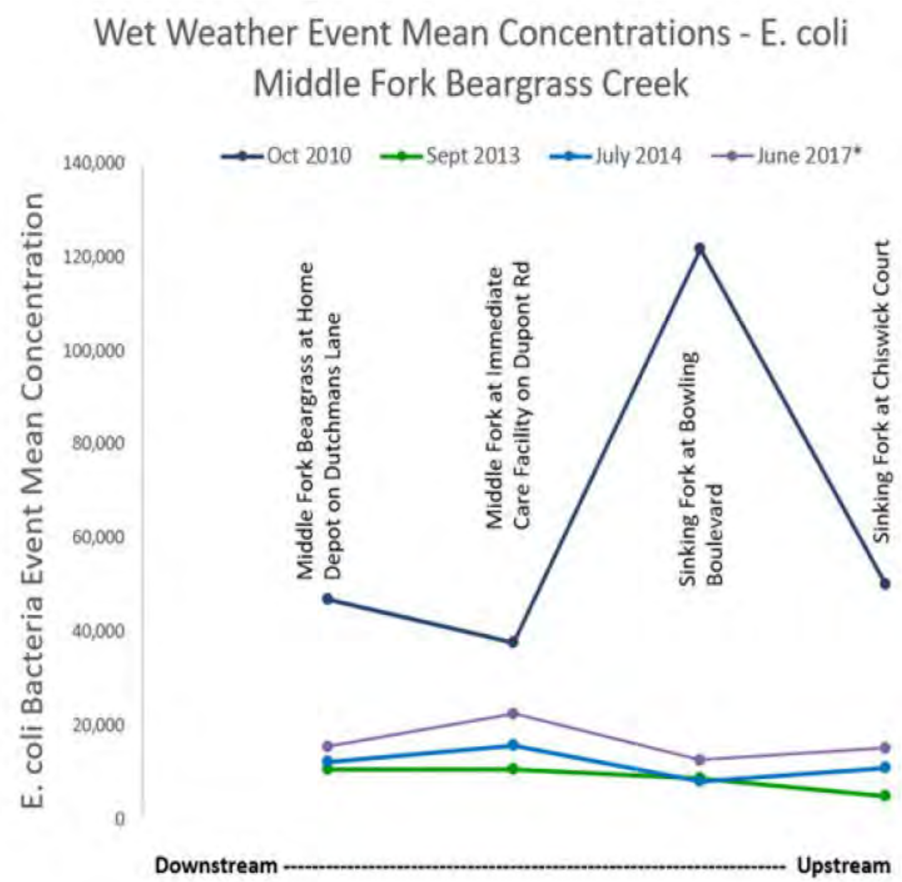

Figure 6.3 Wet Weather Event Mean Concentrations – *E. coli* Middle Fork Beargrass Creek

Remaining projects in the IOAP specific to Middle Fork Beargrass Creek are included as BMPs and are a part of MSD's long-term capital budget.

6.1.3 Other Regulatory Programs

6.1.3.1 *Agriculture Water Quality Plans*

The goal of the Kentucky Agriculture Water Quality Act is to protect surface and groundwater resources from pollutants associated with agriculture and silviculture activities. The Act requires any farm operation on a tract of land with 10 or more contiguous acres to develop and implement a water quality plan. A plan can include BMPs from six different categories, including silviculture, pesticides and fertilizers, farmstead, crops, livestock, and streams and other waters. Agricultural land is limited in this watershed. The largest area in the Middle Fork Beargrass Creek watershed is the Oxmoor Farm which sits along I-64.

6.1.3.2 *Facility Plans for Wastewater*

Wastewater authorities are required to submit plans for the development of their wastewater facilities to the Kentucky Division of Water under Section 201 of the Clean Water Act. Often these documents are called facility or wastewater plans, but they are sometimes referred to as 201 plans. MSD's 201 Facilities Plan provides the framework for planning and design of sanitary sewers in the MSD service area.

6.1.3.3 *Programs and Permits for Managing Wastewater Discharges*

The Kentucky Pollutant Discharge Elimination System (KPDES) permit program regulates water pollution through point source discharges into state waterways. This includes wastewater treatment plants, package plants and industrial facilities. Permitted discharges in the Middle Fork Beargrass Creek watershed are identified in Chapter 2 of this plan.

6.1.3.4 *Groundwater Protection Plans*

Groundwater Protection Plans are documents that define pollutants that may pollute groundwater and the BMPs that are implemented to reduce the risk of groundwater contamination from a site. The Kentucky Administrative Regulations (KAR), 401 KAR 5:037, provides the circumstances when a Groundwater Protection Plan is required.

6.1.3.5 *Special Land Use Planning*

The Land Development Code is the regulatory document created to implement the goals, objectives and policies set forth in Louisville Metro's comprehensive plan, Plan 2040.

The other municipalities located in the watershed also have planning requirements. The communities include but are not limited to: Douglass Hills, Hurstbourne, Middletown, Jeffersontown, St. Matthews and St. Regis Park, among others.

6.1.3.6 *Community Rating System*

Louisville Metro participates in the Community Rating System (CRS) which was developed by FEMA and provides discounts on flood insurance premiums for communities that go above and beyond the minimum requirements of the National Flood Insurance Program. Currently, Louisville Metro has a Class 3 rating, which provides a 35% discount on flood insurance premiums. Green infrastructure, erosion prevention and sediment control regulations, land development requirements, water quality education, and outreach programs are components of the CRS program.

6.1.4 Other Planning Efforts

6.1.4.1 *MSD 20-Year Comprehensive Facility Plan – Critical Repair and Reinvestment Plan*

The MSD 20-Year Comprehensive Facility Plan – Critical Repair and Reinvestment Plan was a two-year effort completed in 2017. The plan identifies rehabilitation needs for aging infrastructure, including pipes, pumps, treatment plants and flood control systems. The estimated cost for meeting the critical needs of the community is $4.3 billion over the next two decades.

The intent of the Facility Plan is to accomplish the following:

- Consolidate MSD's planning and prioritization for facility rehabilitation, renewal, replacement, upgrade and expansion across all its service areas.
- Recommend and prioritize projects and programs to achieve the following objectives:
    - Protect the public health and safety of the community.
    - Protect our aquatic and terrestrial environment.
    - Meet customer expectations for a consistent level of service.
    - Comply with federal and state laws, regulations, orders and standards.

6.1.4.2 *Beargrass Creek Trail Conceptual Shared Use Path and Ecological Restoration Plan*

Louisville Parks and Recreation and the USACE partnered in the planning effort entitled: “Beargrass Creek Trail Conceptual Shared Use Path and Ecological Restoration Plan.” The planning area for the project extends along Beargrass Creek from its confluence with the Ohio River to the area of the Grinstead Drive/Lexington Road intersection. The planning effort considered the possibility of utilizing the creek as a connector between two existing trail systems (Beargrass Creek Greenway and Butchertown Greenway) and explored conceptual ideas to improve water quality, create habitat for increased wildlife and mitigate current bank erosion. The wildlife corridor would be re-established and appeal of the creek as an amenity would be restored.

6.1.4.3 *Three Forks Beargrass Creek Ecosystem Restoration Feasibility Study*

In partnership with MSD, USACE is developing the Three Forks Beargrass Creek Ecosystem Restoration Feasibility Study. The project is scheduled to be completed in 2022 and is funded through competitive nationwide federal grant funding. This project was leveraged with the Middle Fork Beargrass Creek Watershed-Based Plan to incorporate the Three Forks stream walks and data collection for analysis in Phase II monitoring. These projects did not have identical goals and objectives, but there was a benefit to leveraging some of the Three Forks data collection. The Three Forks project investigated the options to restore riparian and riverine habitat that has been lost over time in the watershed. Historically straightened streams, urban environment, current lack of riparian buffers and wetlands adjacent to some areas of Beargrass Creek have contributed to ecosystem degradation.

The draft integrated feasibility report prepared as part of the Three Forks project was released in April 2021 for public comment. The stated purpose of the project is ecological restoration to “provide habitat of the highest form and function for various fish and wildlife species.” Restoration efforts will focus on the following impacts:

- Altered hydrology and hydraulics
- Increased colonization of invasive species
- Urbanization pressures
- Fragmentation of the ecosystem

The intent for the aquatic ecosystem restoration is to re-establish and repair wetland, riparian and in-stream habitat within the Beargrass Creek watershed, which will increase localized plant and animal species richness and diversity. Due to the size and complexity of the study area, the initial site selection began with over 200 locations throughout the watershed. Through site screening and iterative plan formulation, twelve project sites were selected on the Three Forks of Beargrass Creek, including five on Middle Fork. The design and implementation phase, which includes additional design studies, development of plans and specifications, contracting for construction, overall supervision during construction, preparation of an operation and maintenance manual, and participation in a portion of the post-construction monitoring, will be a future phase of the project.

6.2 DEVELOPING A PLAN OF ACTION

After the identification of BMPs suitable for the watershed, action items were developed for each BMP to provide additional details supporting implementation. The watershed team solicited the input of community and subject matter experts to develop the BMP table which provides the initial roadmap for implementing the Middle Fork Beargrass Creek Watershed-Based Plan. A spreadsheet was developed to identify the following categories: concerns, source/cause/pollutant, priorities, BMP, action items, responsible party, technical assistance, costs and funding mechanisms. The plan of action includes structural and nonstructural BMPs. Based on the data analyzed to date, including DOW and MSD water quality and field observation data and DOW habitat data, the nonstructural projects were prioritized higher. Structural BMPs may be reprioritized in the future based on additional water quality and habitat data collection during a Phase II watershed planning effort.

The following process was used to develop the BMP Plan summarized in Appendix 6.2.

Three virtual meetings were scheduled with the BMP Development Committee, which included subject matter experts, to identify potential BMPs for implementation. The first meeting, on April 7, 2021, provided an overview of the data collection and monitoring locations, a summary of potential sources, a list of potential BMPs from the Kentucky Watershed Planning Guidebook and BMPs identified from Chapter 18 of MSD's Design Manual that are feasible options for the watershed. During the second BMP Development Committee meeting on April 21, 2021, the participants were divided into small groups to discuss BMPs specific to particular pollutants, and one group focused on programmatic activities. The pollutant breakout groups were categorized as follows: bacteria, nutrients and dissolved oxygen; total suspended solids and turbidity; and specific conductance. Each group documented potential BMPs that informed the BMP table. The third meeting was held on April 28, 2021, and provided the opportunity for the BMP Stakeholder Committee to review the BMPs from the prior meeting and identify additional BMPs from another category. The data were compiled and are included in Appendix 6.3.

The BMPs that were developed by the BMP Development Committee were discussed with the larger Middle Fork Beargrass Creek Watershed Planning Workgroup in an online setting on June 3, 2021. MSD provided an overview of the data collected in the watershed and provided the opportunity for comment and discussion regarding BMPs. The draft BMPs were distributed to the BMP Development Committee with proposed time frames, and an online map was shared with the group to vote on the prioritization of site-specific BMPs, identify new BMPs and document additional locations for future BMPs as stakeholder projects. The map was open from Thursday, June 3, 2021, until Sunday, June 13, 2021. The data submitted through the online maps were also used in the subwatershed prioritization discussed in Chapter 5.

6.2.1 Developing Action Items

Actions items are the measurable steps to implement BMPs and provide the opportunity to quantify progress. Priority action items are identified in the BMP plan for each BMP and will help to encourage, plan, install, maintain and monitor the success of the BMP and associated water quality improvements.

Each BMP includes a summary of the following information for project implementation:

- BMP description
- Type of BMP/pollutant addressed
- Target audience or area
- Additional priorities, goals and objectives
- Priority action items
- Impairment/pollutant addressed
- Responsible parties
- Technical assistance

- Estimated load reductions
- Estimated costs
- Potential funding sources or programs
- Short- , mid- , and long-term milestones

As the plan is implemented, thorough watershed studies may be conducted to observe factors contributing to pollutant sources in the watershed and possible BMPs to address sources, such as:

- Pet ownership estimates
- Septic system ownership and estimated age
- Inflow and infiltration studies
- Existing structural BMPs
- Open construction site permits
- Open water for waterfowl presence
- Existing riparian buffers
- Impervious area
- Downspout connection
- Tree canopy cover
- Street sweeping practices
- Land use

Finally, targeted conversations with the public will occur focusing on these targeted watersheds to understand local conditions from residents' perspectives. Information from the public will include acceptance of BMPs, conversations with property owners regarding potential projects, and public education and outreach activities.

6.2.2 Plan Examples

The Wolf Run Watershed Plan and the Gunpowder Creek Watershed Plan were used to inform the development of this watershed plan. Chesapeake Bay documents were also referenced for load reductions due to the experience the regulated entities have with design and construction, as well as the operation and maintenance of BMPs in the Chesapeake Bay watershed.

6.3 FINDING THE RESOURCES

Securing and managing financial resources is a crucial part of implementation. Potential funding sources available for the implementation of the proposed control measures and practices have been identified from a variety of sources. Funding options vary in applicability to specific watershed conditions, including pollutant sources and land uses, as well as the potential project sponsors. Potential funding sources are summarized in the following sections.

6.3.1 Federal Resources

6.3.1.1 *Environmental Education Grants*

The Environmental Education Grants Program through the EPA supports environmental education projects that promote environmental awareness and stewardship and help provide people with the skills to take responsible actions to protect the environment. This grant program provides support for projects that design, demonstrate and/or disseminate environmental education practices, methods or techniques.

6.3.1.2 *FEMA Hazard Mitigation Assistance*

The FEMA Hazard Mitigation Grant Program is a funding source for eligible mitigation actions that reduce disaster losses and protect life and property from disaster damages, including the Hazard Mitigation Grant Program (HMGP), Flood Mitigation Assistance (FMA), and Building Resilient Infrastructure Communities (BRIC). FEMA's hazard mitigation assistance program goals include reducing vulnerability of communities to disasters and their effects; promoting individual and community safety and their ability to adapt to changing conditions and withstand and rapidly recover from disruption due to emergencies; promoting community vitality after a disaster; and lessening response and recovery resource requirements after a disaster, resulting in safer communities that are less reliant on external financial assistance. Projects can be nature-based solutions, which are defined by FEMA as "sustainable planning, design, environmental management and engineering practices that weave natural features or processes into the built environment to build more resilient communities" (FEMA 2020).

6.3.1.3 *National Fish and Wildlife Foundation (NFWF)*

Grant proposals for this funding source are accepted throughout the year and processed during fixed sign-up periods. There are two decision cycles per year. Each cycle consists of a pre-proposal evaluation, a full proposal evaluation and a Board of Directors' decision. Grants generally range between $10,000 and $150,000. Grants are awarded for the purpose of conserving fish, wildlife and plants, as well as their habitats. Special grant programs are listed and described on the NFWF website (http://www.nfwf.org). If the project does not fall into the criteria of any special grant programs, a proposal may be submitted as a general grant if it falls under the following guidelines: (1) it promotes fish, wildlife and habitat conservation, (2) it involves other conservation and community interests, (3) it leverages available funding and (4) project outcomes are evaluated.

The Five Star and Urban Waters Restoration Grant Program is one of the grants administered by NFWF and has been successfully utilized in the Louisville area. This NFWF program seeks to develop nationwide community stewardship of local natural resources, preserving these resources for future generations and enhancing habitat for local wildlife. Projects seek to address water quality issues in priority watersheds, such as erosion due to unstable streambanks, pollution from stormwater runoff and other water quality impacts caused by development. The program requires the establishment and/or enhancement of diverse partnerships and an education/outreach component that will help shape and sustain behavior to achieve conservation goals. The Five Star program provides $20,000 to $50,000 grants with an average award size of $25,000. Grants that are in the $30,000 to $50,000 range are typically two years and are in urban areas.

6.3.1.4 *319(h) Nonpoint Source Funds*

Through Section 319(h) of the Federal Clean Water Act, Kentucky is awarded grant funds through EPA to implement watershed management plans. Stakeholder organizations can apply on a competitive basis through a Request for Proposals process directed by Kentucky DOW for 319 grants to implement BMPs and educational components included in an approved watershed plan.

6.3.1.5 *United States Fish and Wildlife Service*

The Fish and Wildlife Service administers a variety of natural resource assistance grants to governmental, public and private organizations, groups and individuals. Natural resource assistance grants are available to state agencies, local governments, conservation organizations and private individuals.

6.3.1.6 *USACE Planning Assistance to States*

Eligible entities may submit a request for a Planning Assistance to States (PAS) study. The USACE accepts as many studies as the funding cycle allows. These studies are planning level studies; detailed design for construction programs is not eligible for funding through the PAS studies. The scope of work for these projects generally involves the analysis of existing data, although some data collection may occur. Funding allocations to states are limited to $5 million annually, but tend to be less. Studies generally range in costs from $35,000 to over $100,000 per year. Typical studies include:

- Water supply and demand
- Water quality
- Environmental conservation and/or recreation
- Dam safety
- Flood risk and/or floodplain management
- Land use
- Master planning
- Brownfield assessment
- Navigation
- Recreational master planning
- GIS development
- Engineering analysis
- Erosion and sedimentation

These studies are cost shared 50% federal and 50% non-federal. The non-federal costs share may consist of in-kind contributions, cash or a mixture of both. The Floyds Fork Ecosystem Restoration Study was funded through this program. The focus of the effort was a feasibility study to identify ecosystem restoration opportunities along Floyds Fork to create, enhance and/or protect wetland and wildlife habitat within the Floyds Fork watershed. A master plan for bicycle access for the Louisville Loop was also funded through this program.

6.3.1.7 *USACE Section 206 of the 1996 Water Restoration Development Act*

Section 206 of the 1996 Water Restoration Development Act (206 project) provides funding to the USACE to conduct aquatic ecosystem restoration and protection projects. Typical projects include environmental restoration of aquatic and floodplain areas that include the creation and/or restoration of wetlands and riparian areas and dam removal. Additional projects that may be funded include water management, planting of hardwood trees and/or native grasses, and other types of restoration to improve and enrich aquatic habitat. Some recreational aspects can also be included in projects as long as they are consistent with the ecosystem components. A planning study is necessary prior to receiving a 206 project.

Up to $100,000 of the study is federally funded. The remainder of the study is cost shared at 50% federal and 50% non-federal. The cost share for design and implementation is 50% federal and 50% non-federal. The non-federal cost share can consist of cash, in-kind contributions, and lands, easements, rights-of-way, relocations and disposal areas (LERRDs). The federal cost cannot exceed $10,000,000, with a national program limit of $40,000,000 per year.

The local sponsor is responsible for the LERRDs necessary for the projects. A Feasibility Cost Sharing Agreement (FCSA) is required for studies in excess of $100,000. A Project Partnership Agreement is also required. The USACE will oversee the project construction, but the operation and maintenance are the responsibility of the project sponsor.

6.3.2 State Resources

6.3.2.1 *Kentucky Department of Fish and Wildlife Resources – In-Lieu Fee Program for Stream and Wetland Mitigation*

The Kentucky Department of Fish and Wildlife administers the In-Lieu Fee Program for Stream and Wetland Mitigation Program. The program uses funds collected from mining or other activities that impact streams to finance stream or wetland restoration and enhancement projects to compensate for the loss of aquatic habitat.

The Kentucky Department of Fish and Wildlife Resources in-lieu fee program provides landowners the opportunity to restore streams and wetlands. KRS 150.255 authorizes the Kentucky Department of Fish and Wildlife Resources to conduct stream and wetland mitigation. Selection criteria include sediment pollution from stream bank erosion and slumping with trees removed from the bank. Sewer improvements or utility lines do not qualify for the program. At least 1,000 feet of stream is required to develop projects. Generally, projects are small streams that may go dry during the late summer months to streams that have permanent flow. Both sides of the stream are required to be available for work. Projects can be located on private or public lands. Projects that occur on private lands are conditioned on landowner approval. All projects are required to be permanently protected. Projects that are on private lands must be protected by a permanent easement that restricts development and must be at least 50 feet wide on each side of the stream restoration project. Projects are screened by the Department of Fish and Wildlife to determine if a project location is appropriate.

6.3.2.2 *Kentucky Clean Water Revolving Loan Fund*

EPA awards grants to states to capitalize their Clean Water State Revolving Funds (CWSRFs). The states, through the CWSRF, make loans for high-priority water quality activities. As loan recipients make payments back into the fund, money is available for new loans to be issued to other recipients. Eligible projects include point source, nonpoint source and estuary protection projects. Point source projects typically include building wastewater treatment facilities, combined sewer overflow and sanitary sewer overflow correction, urban stormwater control, and water quality aspects of landfill projects. Nonpoint source projects include agricultural, silvicultural, rural and some urban runoff control; on-site wastewater disposal systems (septic tanks); land conservation and riparian buffers; and leaking underground storage tank remediation, etc.

6.3.3 Regional and Private Resources

6.3.3.1 *Kentucky Aquatic Resource Fund (KARF)*

The Kentucky Aquatic Resource Fund (KARF) is a funding source from a partnership between the Kentucky Waterways Alliance and the United States Fish and Wildlife Service's Kentucky Field Office. KARF provides the opportunity for multiple agencies and partners to contribute funding as well as other resources toward stream and wetlands projects including restoration, research, surveys, monitoring, stream/riverbank area management, threatened species propagation and introductions, and BMP installation. More information can be found at: https://www.kwalliance.org/karf.html

6.3.3.2 *MSD Rates, Rentals and Charges Credits – Monthly Drainage Service Credit*

Green infrastructure BMPs that exceed minimum requirements established by local ordinance and the MSD Design Manual may be eligible for a potential credit for peak flow rate reduction, total site runoff reduction, water quality benefits, and green infrastructure outreach and education. For more information regarding this program, the most recent version of the MSD Rates, Rentals and Charges should be consulted.

6.3.3.3 *MSD Rates, Rentals and Charges – Capital Recovery Stipend*

Capital Recovery Stipends are payments from MSD to defray the costs of implementing green infrastructure components that exceed the minimum requirements established by local ordinance and the MSD Design Manual. For more information regarding the Capital Recovery Stipend, the most recent version of the MSD Rates, Rentals and Charges should be consulted.

CHAPTER 7. MAKING IT HAPPEN

7.0 MAKING IT HAPPEN

7.1 Advocating for the Middle Fork Beargrass Creek Watershed Plan

The key to a successful advocacy plan is having a clear and concise message tailored specifically for Middle Fork Beargrass Creek watershed stakeholders:

Improve water quality throughout Middle Fork Beargrass Creek through nonpoint source pollution control BMPs, outreach, and engagement.

Messaging is based on an understanding of the watershed's history, characterization of the nonpoint source pollution, identified needs and goals of the community, watershed resources, and partners. During the Phase II efforts, an advocacy plan with audience-specific messaging and tools will be developed.

7.1.1 Community Outreach

Communication of this watershed plan is a key component of success for improving nonpoint source pollution concerns in Middle Fork. This plan will be shared on partners' websites, such as MSD, KWA, and DOW. Project partners detailed in Chapter 1 played a vital role in the watershed plan development and are also key to the success of the implementation of this plan. Throughout the project timeline, communication pertaining to Middle Fork was shared with their contacts and members and proved to be a vital avenue to increasing understanding, engagement, and outreach opportunities.

Regular communication, through multimedia, will be required to leverage the efforts of these partners to encourage more public participation and share information regarding their efforts to improve water quality in the next phase of this plan; therefore, social media posts will provide links to the plan on the various websites. For successful implementation, frequent and consistent communication between those implementing the plan and the public will be required. Previously approved and implemented watershed plans in Kentucky have proven that a dedicated Watershed Coordinator has increased the level of success of implementation of not only outreach and engagement activities, but supporting project development as well. The establishment of a Watershed Coordinator is anticipated to be one of the first steps in the implementation of this plan.

7.1.2 Communication Alternatives

During the development of this plan, virtual and social media platforms were used to communicate with the public, including the use of a public survey to better understand public interaction and knowledge of the watershed. The survey results indicated that sharing information through social media platforms and websites is the preferred method to receive information in the watershed. It is anticipated that collaboration among the Steering Committee will continue and will include sharing messages, events, and opportunities for public engagement on their social media platforms to maximize public outreach and engagement. Figure 7.1 provides a summary of the results regarding the receipt of education and outreach materials.

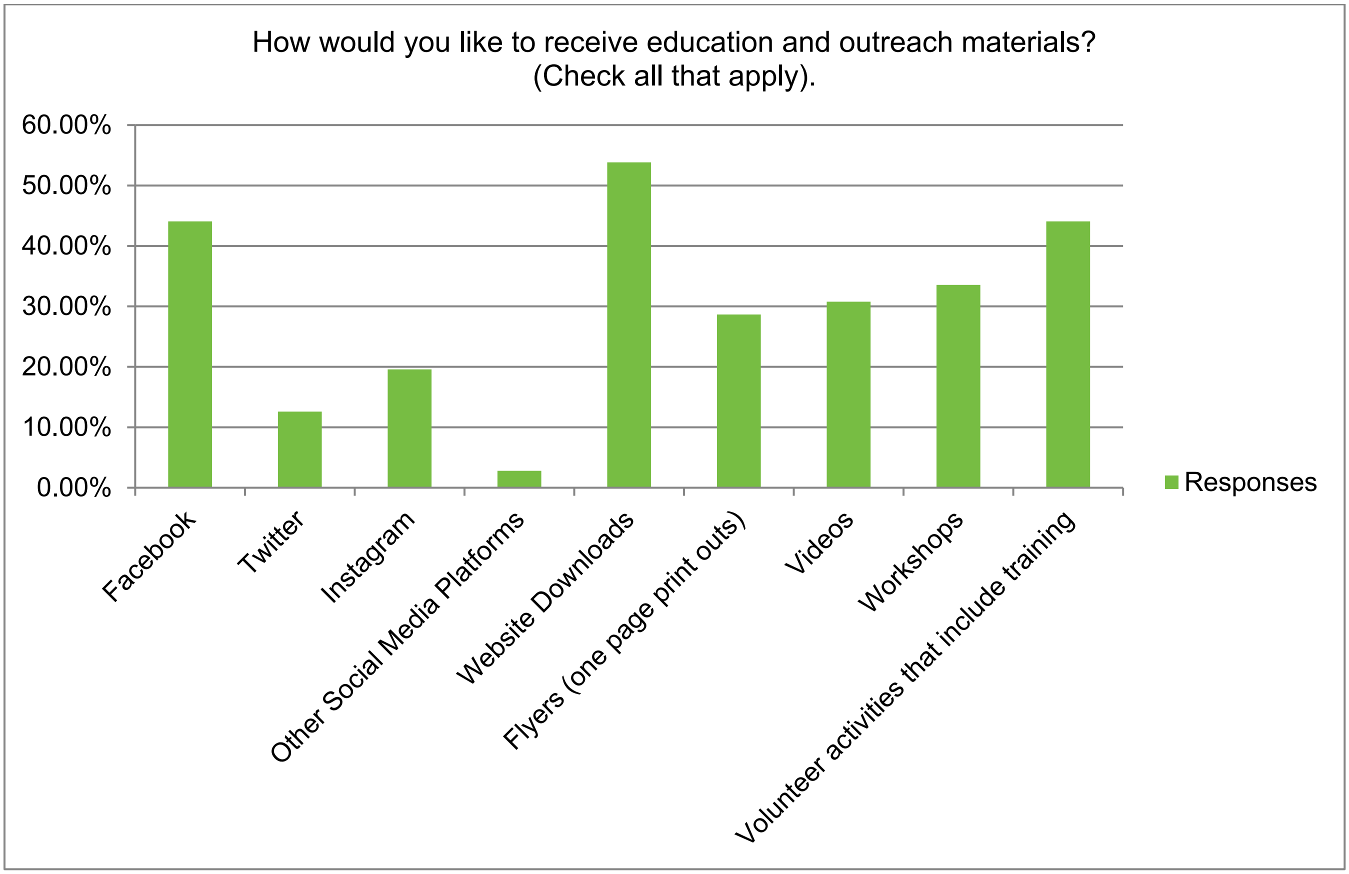

Figure 7.1 Survey Participant Preferences for Receiving Education and Outreach Materials

There is also an opportunity to communicate with the public directly during park activities within the watershed, supported by the understanding that 70% of survey participants enjoy visiting the streams that can be accessed in local parks and public green spaces. Opportunities for communication with the public include signage regarding litter abatement, water quality, pet owner responsibilities, and riparian buffers. Figure 6.1 provides a summary of the parks visited in the Middle Fork Beargrass Creek watershed. Survey results are located in Appendix 6.1.

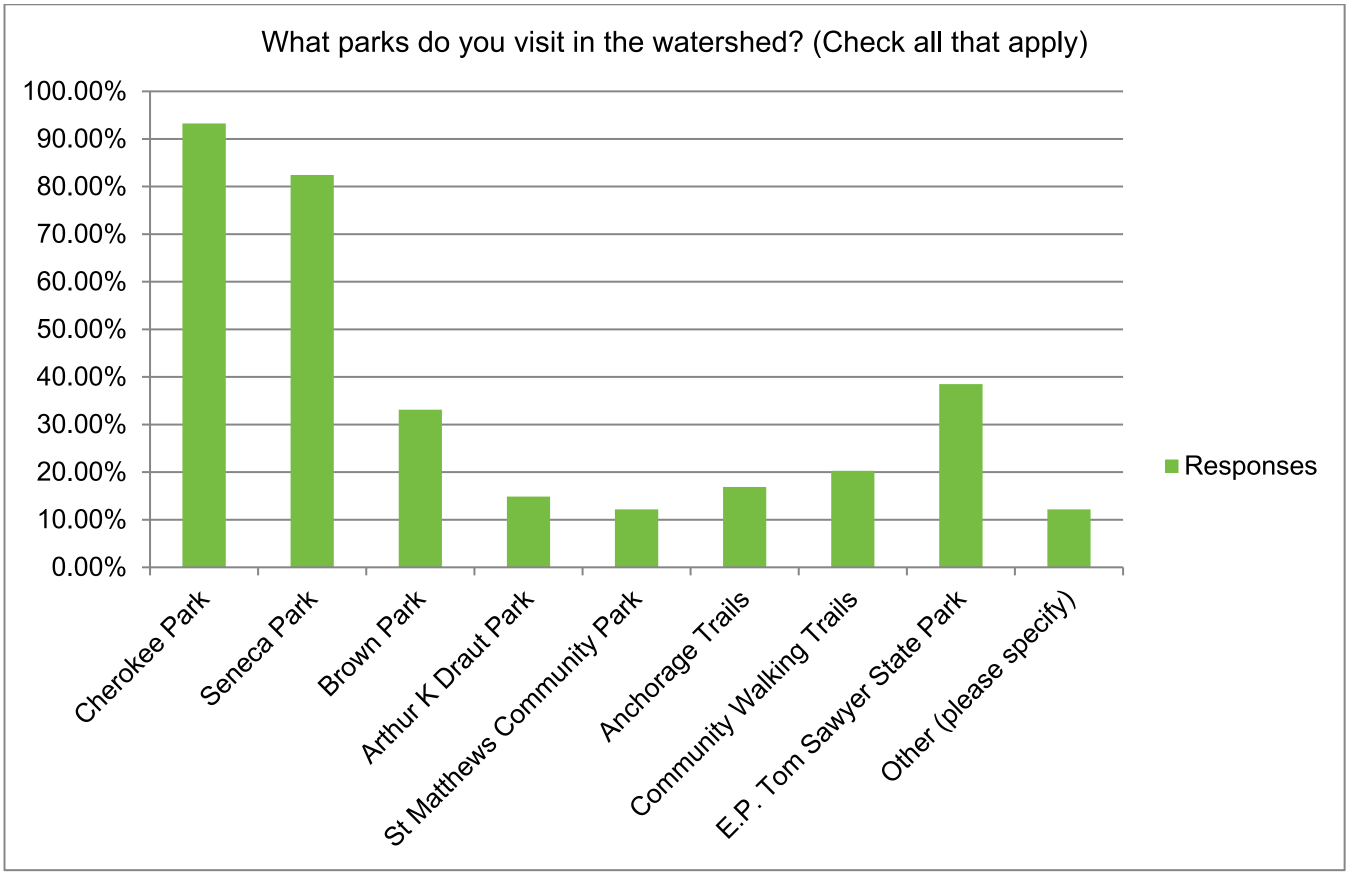

Figure 7.2 Parks Visited in Middle Fork Beargrass Creek Watershed

7.2 SECURING AND MANAGING FINANCIAL RESOURCES

The Middle Fork Beargrass Creek Watershed Plan was funded primarily through a 319(h) grant and included matching funds from non-federal sources. It is anticipated that the Watershed Coordinator will be the lead in developing new relationships to assist with securing and managing further financial resources. Watershed-based fundraising and grant writing will be important in executing this plan. Therefore, it is important that the Watershed Coordinator is skilled in identifying and compiling the information necessary for competitive grant submittals. MSD is committed to being a key partner for this watershed plan and will continue to collaborate with partners to find additional funding sources to assist with the implementation of this plan once approved. Potential funding sources are included in the BMP Plan, which is summarized in Chapter 6.

7.3 IMPLEMENTATION FUNCTIONS AND ROLES

Successful implementation of the Middle Fork Beargrass Creek Watershed Plan requires well-defined roles and responsibilities. The Middle Fork Beargrass Creek Steering Committee, Watershed Work Group, Education and Outreach Focus Group, and BMP Development Group met as needed during the development of this plan to provide updates regarding the plan development, modifications to the education and outreach activities, and identifying BMPs, including new education and outreach opportunities. It is anticipated that the Steering Committee will continue with a representative from the following organizations:

- MSD
- DOW
- Louisville Metro Parks
- Municipalities
- KWA
- Salt River Watershed Watch

The Watershed Coordinator will serve as the primary point of contact for Middle Fork Beargrass Creek Watershed Plan implementation. Responsibilities for the Watershed Coordinator will include: plan implementation according to the BMP timetable, communication with the Steering Committee and subject matter experts regarding projects and technical data, coordinating ongoing monitoring efforts, working with the public and stakeholders to implement BMPs, tracking project progress and implementation, and completing an annual progress report. The Watershed Coordinator will continue engagement with the community through outreach to those who live, work, and play in the watershed.

In order to have a functioning and effective Steering Committee, bylaws will be created for its organization and operation. It is proposed that the Steering Committee will meet quarterly and will have the following responsibilities: reviewing project progress and implementation, supporting outreach through various organizations, providing technical assistance, identifying subject matter experts to support technical and educational BMPs, and reviewing monitoring data, pollutant load reductions, and future BMPs.

7.4 ADAPTING TO CHANGES AND CHALLENGES

One of the goals of the Middle Fork Beargrass Creek Watershed Plan is to create greater opportunity for community members to become involved in watershed improvement efforts and solutions. Three objectives related to education, engagement, and outreach were identified pursuant to this goal:

- Objective 1: Continue to work with the Steering Committee and the Watershed Work Group
- Objective 2: Support a watershed group for the Middle Fork Beargrass Creek
- Objective 3: Provide outreach and engagement opportunities for the local community, focused on nonpoint source pollution and related environmental issues in their watershed

BMPs in this plan also support continued public education and outreach as well as expanding engagement through education and outreach efforts with new approaches. The COVID-19 pandemic has taught us that volunteering and advocacy is changing; therefore, the use of modern technology and communication methods is critical for engagement of volunteers. Traditional education and outreach activities will also continue to be utilized. The BMP plan presented in Chapter 6 summarizes several engagement and outreach activities that have been customized for this watershed. These BMPs should be and will be evaluated and updated with the needs of the community throughout the watershed implementation phases of this plan.

Even though the planning process was impacted by COVID-19 public health and executive orders, successful clean-ups were conducted that met the social distancing requirements while still encouraging public engagement. An action item that resulted from the focus group was to conduct a survey to better understand citizens' knowledge of the watershed as well as watershed-related activities that they enjoy. Additional recommendations that came from the focus group include:

- Cleanups
- Paddling
- Showing of *Beargrass: The Creek in Our Backyard* under the stars at a local park

- Developing kits for neighborhood clean-ups and distribute them to local HOAs and volunteers
- Advertising clean-ups and kits to schools and other community organizations in the watershed
- Encouraging activities with the public to engage with the watershed, including games or smart phone applications that can include plant and animal identification tools

These opportunities will be considered as funding is available. During the writing of this plan, social distancing and mask-wearing orders expired. As citizens are once again able to participate in group activities, consideration is being given to re-establishing some of the activities that were previously canceled.

Watershed planning is an iterative process. It is recognized that the data collected during this watershed planning effort are a baseline for project development; however, the need for continued data collection, monitoring, and public engagement is anticipated to be ongoing to address nonpoint source pollution control and to identify any emerging concerns within the watershed. With the completion of a Phase II watershed assessment and ongoing engagement activities, it is anticipated that this watershed plan will be updated after the Phase II study.

The watershed plan will be reviewed regularly, and an annual assessment will be performed to evaluate BMP implementation and effectiveness, funding opportunities, Phase II monitoring data, and messaging to target audiences. It is also expected that the watershed plan will be reviewed, updated, and submitted to the State for review every five years.

7.5 MEASURING PROGRESS AND SUCCESS

Continued public education and outreach assessment tools and water quality monitoring will be used to measure the progress and success of the Middle Fork Beargrass Creek Watershed Plan. The Steering Committee, MSD, and the Watershed Coordinator will develop a BMP tracking plan that will summarize actions, projects, investments, and water quality monitoring data. This progress will be reported on partners' websites such as MSD, KWA, and DOW.

7.5.1 Tracking Progress

Tracking progress will include tracking plan implementation. The Steering Committee and Watershed Coordinator will track the BMPs that are identified in this plan. As BMPs are added or modified, the BMP table will be updated to reflect changes.

The Watershed Coordinator will track education and outreach efforts. For public outreach events, tracking will include the specifics of each event, including the date, number of participants, type of event, type of messaging, and whether there is a measurable impact from the event. For example, for a neighborhood or park litter clean-up, the Watershed Coordinator will track the number of participants and the number of trash bags collected. If a community group participates in an adopt-a-storm-drain program, the number of storm drains and locations for each responsible group will be identified and reported on annually. Pre- and post-surveys for education and outreach are also an option to assess knowledge and behaviors in the watershed.

In order to implement structural BMPs in the watershed, it will be necessary to communicate with landowners. A tracking spreadsheet will be maintained regarding the communications with the landowners and outcomes.

7.5.2 Improvement in Watershed Health or Practices

MSD and the Watershed Coordinator will assess monitoring data and track improvements in watershed health through water quality sampling and visual assessments. The sharing of outreach messaging to the general public regarding water quality; targeted outreach materials education and outreach events; number of participants in outreach events; implementation and maintenance of structural BMPs; and Phase II monitoring will also be utilized.

7.5.3 Improvements in Water Quality

Improvements in water quality will be documented by continued data collection by MSD through the quarterly and recreational monitoring at the three LTMN locations in Middle Fork Beargrass Creek to assess water quality as well as field, biological, and habitat conditions. It is anticipated that SRWW will continue its volunteer monitoring program at the active SRWW locations in the watershed. Additional monitoring is specified in the monitoring plan that is under development. The monitoring plan for the Middle Fork Beargrass Creek watershed will be implemented after DOW approval and when additional funding is identified and secured. Additional water quality sampling, an assessment of the stream banks using the BEHI, and an analysis of the Three Forks stream walks are proposed as components of Phase II monitoring. Monitoring may also include tracing bacteria sources as well as the sources of other pollutants as needed, and can include inspections performed and data collected as part of the MS4 program.

As structural BMPs, including stream restoration and green infrastructure projects, are implemented in the watershed, monitoring data will be used to assess the effectiveness of the BMPs. Data collection, both prior to and after the implementation of structural BMPs will be considered. Monitoring will be developed based on the nature of the BMP.

7.6 GROUP VITALITY

To support the functionality, longevity, and group vitality of the Steering Committee, it is proposed that the structure includes representatives from MSD, DOW, municipalities, subject matter experts, and nonprofit participants. The Steering Committee will develop bylaws that ensure historical and institutional knowledge is retained and that diverse representation from all partners is maintained. Documents will be maintained according to the bylaws. Updates will be provided to participants and shared with the public through social media and websites.

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APPENDIX 1.1 APPROVED GRANT APPLICATION

FFY 2018 Project Application
Kentucky Nonpoint Source Pollution Control Program

***Refer to the 2018 Grant Guidance document and the Application Instructions for instructions on completing this application.**

1. Project Title: Middle Fork Beargrass Creek Watershed-based Plan (Louisville, KY)

		2. Lead Agency & Primary Contact		3. Project Manager
Name		David Johnson		Erin Wagoner
Agency		Louisville Metropolitan Sewer District		Louisville Metropolitan Sewer District
Street Address		700 West Liberty Street		700 West Liberty Street
City		Louisville		Louisville
State		Kentucky		Kentucky
Zip		40203		40203
Telephone Number		502-540-6392		502-540-6307
Fax Number				
Email Address		David.Johnson@louisvillemsd.org		Erin.Wagoner@louisvillemsd.org

4. Project Start Date: September 1, 2019 **5. Project End Date:** September 1, 2021

6. Fiscal Summary

319 Funding	$133,938.00	60%
Non-Federal Match	$89,292.00	40%
Total Budget	$223,230.00	100%

7. Type of Project

☒	Watershed Plan
☐	WSP Implementation
☐	BMP Technology Demonstration
☐	Education/Outreach Technology Transfer
☐	Other:

8. River Basin

☐ Statewide	☐ Tygarts	☒ Ohio Tributary	☐ Little Sandy
☐ Kentucky	☐ Green	☐ Lower Cumberland	☐ Mississippi
☒ Salt	☐ Tradewater	☐ Upper Cumberland	
☐ Licking	☐ Tennessee	☐ Big Sandy	

9. Geographic Coverage

☐ Statewide
☐ Regional
☒ Watershed

10. NPS Pollutant(s) to be addressed

☐ Low Dissolved Oxygen	☐ Pesticides
☒ Sedimentation/Siltation	☐ Oil and Grease
☐ Suspended Solids	☒ Nutrients
☒ Pathogens/Bacteria	☐ pH
☒ Organic Enrichment	
☐ Other:	

11. Nonpoint Pollution Source(s) to be addressed. Select up to five sources and include the percentage to which the project addresses the source. Total must equal 100%.			
Percent		Percent	
	NPS All		Resource Extraction
	Agriculture	33.3	Habitat Modification
	Construction		Improper Waste Disposal (including onsite Waste Issues)
	Silviculture	33.3	Hydrologic Modification
33.3	Urban Runoff		Recreation
			Other:

12. Project Area	Yes	No
Project deals directly with groundwater, springs or karst?	☐	☒
Watershed Projects Only, Complete the following:		
Project Implements a TMDL	☒	☐
Project address a TMDL that is under development	☒	☐
Project is on the 2010 Integrated Report, Assessment Category 5A	☒	☐
Nonsupport Stream	☒	☐
Partial Support Stream	☐	☒
Project is on a Special Use Water with identified threat.	☐	☒
Project has other impairments or identified treats (describe in app.)	☐	☒

Map Attached: Yes☒ N/A☐

13. Location

Watershed Name	HUC#	County1	County2	Drainage Area
Middle Fork Beargrass Creek	HUC 14: 05140101250010	Jefferson	NA	25.2

The Middle Fork of Beargrass Creek is one of three streams (Muddy Fork, Middle Fork, and South Fork) that join to form the larger Beargrass Creek watershed. The 25 square mile watershed is located in the north central portion of Jefferson County. Headwaters originate in Middletown and flow in a westerly direction through St. Matthews. The stream continues into the Highlands via Seneca and Cherokee Parks, to finally outlet into the South Fork Beargrass Creek just south of Main Street. The major streams in the Middle Fork Beargrass Creek Watershed are Middle Fork and Weicher Creek.

14. Project Summary (Two-page limit):

Problem:

The Middle Fork of Beargrass Creek is a nonpoint source priority watershed in need of restoration. A Fecal Coliform Total Maximum Daily Load (TMDL) was approved in 2011 (KDOW, 2011a), a proposed draft Organic Enrichment TMDL was published in 2011 (KDOW, 2011b) and one segment extending from River Mile 0.0 to 2.0 was listed as Assessment Category 5A (Nonsupport) in 2014. Despite these water quality impairments, the Middle Fork of Beargrass Creek is home to many parks, trails and a local favorite swimming hole at Big Rock. Many project partners and stakeholders are actively engaged in improving this watershed and enthusiastically support development of the watershed plan.

Middle Fork of Beargrass Creek is a historic landmark in the development of Louisville Metro since its establishment in 1778. Middle Fork of Beargrass Creek has a history of water quality impairments dating back to early settlement days. Historians have noted that slaughter houses drained waste directly into Beargrass Creek in the early 1800's and by the 1820's the first sewer was built along Second Street that drained into Beargrass Creek; downstream of the Middle Fork confluence. Since that time, the Middle Fork Beargrass Creek watershed has undergone urban, suburban and commercial development and impervious surfaces now cover about 23 percent of this watershed (MSD, 2016).

The Kentucky Division of Water (KDOW) identified impairments in the Middle Fork of Beargrass Creek (KDOW, 2010). As of the 2010 Integrated Report to Congress on the Condition of Water Resources in Kentucky, three segments were identified as impaired (List 5A). The downstream segment (river mile 0.0 to 2.0) was listed as impaired because warm water aquatic habitat and primary contact recreation uses were not supported. The middle segment (river mile 2.0 to 2.9) and the upper segment (river mile 2.9 to 15.3) were listed as impaired because primary contact recreation (i.e., swimming) uses were not supported.

Causes for the impairments were identified as habitat assessment (streams), fecal coliform, nutrients/eutrophication biological indicators and organic enrichment (sewage) biological indicators. Suspected sources for these impairments were listed as channelization, sanitary sewer overflows (collection system failures) and urban runoff/storm sewers and illegal dumps (KDOW, 2015).

To address the recreational designated use impairments, KDOW developed a Fecal Coliform Total Maximum Daily Load (TMDL) (KDOW, 2011a). This TMDL included target reductions of fecal coliform bacteria needed to achieve the water quality standards. A proposed draft TMDL was developed for organic enrichment impairments (KDOW, 2011b). Both of the TMDLs included development of a Beargrass Creek Watershed Plan as an important strategy to enable more effective targeting of restoration funds and resources, thus improving environmental benefit, protection, and recovery.

In addition to these impairments, sedimentation and loss or lack of riparian habitat are also of concern. MSD's 2016 Synthesis Report documented fair and declining habitat at Lexington Road (0.0-2.0), good and stable habitat at Old Cannons Lane (2.9-15.3) and fair and improving habitat at Browns Lane (2.9-15.3). Field investigations have identified unstable banks near stream crossings and other locations which may lead to downstream sedimentation. While engineering approaches and technology have changed over the last two centuries, one thing is certain, Middle Fork continues to fight the battle against pollution.

15. Introduction/Background (Two-page limit):

The KDOW NPS Grant Guidance includes a flow chart to identify nonpoint source priority watersheds (KDOW, 2018). The Middle Fork of Beargrass Creek is a priority watershed requiring restoration based upon the following characteristics:

- Approved TMDL, 2014 Integrated Report Category 4A: three segments were classified as 4A-NS in 2014 after completion of the Beargrass Creek Fecal coliform TMDL in 2011.
- TMDLs under Development: one segment (river mile 0.0 to 2.0) is classified as TMDL under development due to the proposed draft status of the Organic Enrichment TMDL
- 2014 Integrated Report Assessment Category 5A (Nonsupport): one segment (river mile 0.0 to 2.0) is classified as 5A-NS for Warm Water Aquatic Habitat impairment

As outlined in Section 14, the Middle Fork of Beargrass Creek has endured a long history of pollution since the time that Louisville was initially settled. Many programs and projects have been implemented to reduce pollution. The early installation of sewers dramatically reduced the direct discharge of human sewage. MSD is continuing to make progress toward this goal with numerous projects to reduce the frequency and volume of combined sewer overflows, eliminate sanitary sewer overflows and to minimize impacts of stormwater to the maximum extent practicable.

These programs and projects have resulted in several notable improvements in water quality. MSD summarized water quality data collected over the 20-year history of the Long-Term Monitoring Network and published the results in the 2016 Water Quality Synthesis Report (MSD, 2016). The findings for Middle Fork Beargrass Creek include:

- A 34% reduction in fecal coliform bacteria at Lexington Road between 2004 and 2015
- A 24% and 12% improvement in fish community scores at Browns Lane and Lexington Road, respectively
- An 11% improvement in aquatic insect scores at Old Cannons Lane
- Aquatic habitat was rated as good and stable at Old Cannons Lane
- Nitrogen, phosphorus and total suspended solids were generally low at Browns Lane and Old Cannons Lane
- Dissolved oxygen met water quality criteria in 98% of the time between 2013 and 2015 and improved by 15% since 2005 at Old Cannons Lane and fair and improving at Browns Lane
- Although dissolved oxygen met water quality criteria only 76% of the time at Lexington Road, between 2013 and 2015, it had improved by 10% since 2005

These findings highlight the combined positive effects of ongoing programs and projects on water quality. However, much work remains to be done. The 2016 Synthesis Report included the following negative findings:

- Fish communities were rated as fair or poor at the three monitoring sites in 2015
- Aquatic insect communities were rated as fair at the three monitoring sites in 2015
- Aquatic habitat was rated as fair and declining at Lexington Road
- Fecal coliform levels were elevated above water quality standards at all three monitoring sites, were increasing at Browns Lane, and were unchanged at Old Cannons Lane
- Nitrate levels were elevated at Browns Lane and Old Cannons Lane

- Total phosphorus and total suspended solids were elevated at Lexington Road

Extensive water quality modeling was performed to develop the Fecal Coliform TMDL for Beargrass Creek. The modeling was used to apportion existing loadings of bacteria to sanitary sewer overflows, combined sewer overflows, stormwater and nonpoint source / groundwater. The model was then used to simulate elimination of sanitary sewer overflows, reductions in combined sewer overflows as specified in the Long-Term Control Plan, and reductions in remaining stormwater and nonpoint source / groundwater. To achieve the TMDL goal of meeting water quality standards for fecal coliform bacteria, CSO sources must be reduced by 98%, stormwater MS4 sources by 95% and nonpoint source / groundwater by 88% to 91%.

The Organic Enrichment TMDL remains in proposed draft status and is therefore subject to change. However, extensive modeling was also performed to develop this TMDL and the results can be used as initial information for watershed planning purposes. The proposed draft TMDL recommended 40% reductions in oxygen demanding substances from nonpoint source / groundwater.

MSD has ongoing programs and projects that are designed to reduce or eliminate bacteria and oxygen demanding substances from combined and sanitary sewer overflows and MS4 stormwater. The focus of this watershed plan is to work with Project Partners and Watershed Stakeholders to identify and reduce the nonpoint sources of bacteria and oxygen demanding substances identified in the TMDLs focusing on the following nonpoint sources of pollution: urban runoff, habitat modification, and hydrologic modification.

A recent major planning effort was completed as a partnership between Louisville Metro Parks, USACE Louisville District, and TetraTech's consultant team in 2017 to evaluate the Beargrass Creek Trail Conceptual Shared Use Path and Ecological Restoration opportunities. This report outlines several restoration opportunities within the Beargrass Creek watershed, specifically along Middle Fork of Beargrass Creek and can be found on Louisville Metro Parks' website. Restoration opportunities include stream relocation and restoration, bank stabilization, and other storm water management through green practices.

One of the keys to successful development and implementation of watershed plans is the consistent involvement of project partners and stakeholders throughout the project. MSD formed the Steering Committee and Watershed Workgroup to assist with the initial grant application in 2017. Project partners such as Louisville Metro Parks, River City Paddle Sports, Kentucky Waterways Alliance, Louisville MSD, Salt River Watershed Watch, and others are committed to and enthusiastically support the development and implementation of this watershed plan.

In addition, this watershed has a local volunteer organization, Beargrass Creek Alliance, which actively works to engage the community to improve the watershed. Middle Fork Beargrass Creek is highly traveled by the community and individuals who love the outdoors. There are several paved trails along Middle Fork used for recreational activities and by commuters. Accessibility to the creek in some areas provides high visibility for potential outreach and education opportunities. With the support of project partners, work group, and consultants, we are proposing to develop a Watershed Plan to establish a framework for implementing projects that will improve water quality.

16. NPS Pollution Control Project Goal, Objectives, and Activities:

Goal 1: Improve water quality in the Middle Fork of Beargrass Creek by developing a Kentucky Division of Water (DOW) and Environmental Protection Agency (EPA) approved watershed plan that meets EPA A-I criteria.

- Objective 1: Compile available background information about the Middle Fork of Beargrass Creek watershed.
    - Activity 1: Compile available GIS data including aerial imagery and land use data.
    - Activity 2: Gather existing water quality data from relevant sources. Analyze and interpret historical data for general trend analysis.
    - Activity 3: Assemble and evaluate information about natural features in the watershed, including geology, topography, soil types, rare and invasive species, important habitats, as well as social and demographic information.
    - Activity 4: Draft and final Watershed Plan Chapter 2. Exploring Middle Fork Beargrass Creek
- Objective 2: Determine current conditions of the Middle Fork of Beargrass Creek watershed through interpretation of collected water quality data and visual assessment.
    - Activity 1: Finalize QAPP and submit to DOW for review and approval.
    - Activity 2: Monitor water quality as described in Section 18 of this grant application.
    - Activity 3: Analyze and interpret monitoring data for as described in Section 17 of this grant application.
    - Activity 4: Using GIS data and visual assessment, evaluate the current conditions of the riparian habitat and buffer zones.
    - Activity 5: Calculate annual pollutant loads from each sampling location and determine the load reductions needed to meet water quality standards or benchmarks for parameters included in the Watershed Planning Guidebook.
    - Activity 6: Draft and final Watershed Plan Chapter 3. Monitoring.
    - Activity 7: Draft and final Watershed Plan Chapter 4. Analysis.
- Objective 3: Develop a Best Management Practices Implementation Plan for the Middle Fork of Beargrass Creek watershed.
    - Activity 1: Identify probable causes and sources of nonpoint source pollution based off analysis of the collected water quality data and visual assessment.
    - Activity 2: Select Best Management Practices (BMPs) that could be implemented to address the different sources of pollutants identified.
    - Activity 3: Estimate the load reductions that can be achieved for pollutants, and the number of BMPs needed to achieve desired load reductions.
    - Activity 4: Estimate the costs expected for implementation.
    - Activity 5: Estimate the timeline needed for implementing the plan.
    - Activity 6: Prioritize areas for implementation of BMPs while considering feasibility factors, including local concerns, landowner cooperation, load reductions needed to meet water quality goals, funding, etc.

  - Activity 7: Draft and final Watershed Plan Chapter 5. Finding Solutions
  - Activity 8: Draft and final Watershed Plan Chapter 6. Strategy for Success
- Objective 4: Develop measurable milestones and evaluation criteria for determining the long-term success of the watershed planning and implementation efforts.
  - Activity 1: Develop plan for a long-term water-quality monitoring effort within the Middle Fork of Beargrass Creek watershed to assess whether progress towards meeting water quality standards is being made.
  - Activity 2: Develop a set of measurable milestones that can be used to gauge the overall progress of implementation over time.
  - Activity 3: Draft and final Watershed Plan Chapter 7. Implementation and Success Monitoring

Goal 2: Create greater opportunity for community members to become involved in watershed-improvement efforts and solutions.

- Objective 1: Continue to work with the Steering Committee and the Watershed Work Group.
  - Activity 1: Hold four Steering Committee meetings during the project timeframe.
  - Activity 2: Hold two Watershed Work Group meetings during the project timeframe.
- Objective 2: Support a watershed group for the Middle Fork of Beargrass Creek.
  - Activity 1: Form or update existing group about the watershed planning project
  - Activity 2: Hold monthly watershed group meetings
- Objective 3: Provide outreach to the local community on nonpoint source pollution and related environmental issues in their watershed.
  - Activity 1: Partner with other water quality education organizations
  - Activity 2: Perform education and outreach events such as but not limited to: stream clean ups, Every Drop events, storm drain marking projects, showings of “Beargrass: The Creek in Our Backyard,” celebration tours, social media campaigns, volunteer events, public interpretive programs, invasive species removal events, and canoe trips.
  - Activity 3: Develop (or edit existing) and distribute handouts, online information, public service announcements/commercials, etc., as needed.
  - Activity 4: Draft and Final Executive Summary and Watershed Plan Chapter 1. Getting Started

17. Describe the NPS Pollution Control Plan of Work:

The Plan of Work describes the specific tasks that will be completed in order to develop KDOW and USEPA approved Watershed Plan that includes a BMP Implementation Plan. Roles and responsibilities are outlined below and further documented in the Budget.

Task 1 – Exploring Middle Fork Beargrass Creek: A consultant will compile existing GIS data from LOJIC, KY GeoNet, reports and other relevant resources to summarize background information about the watershed, including:

- Water Resources: hydrology, groundwater, flooding, regulatory status, geomorphic data, climate
- Natural Features: geology, topography, soils, ecoregions, riparian vegetation, flora, fauna
- Human Influences and Impacts: demographics, economy, water use, land use, watershed disturbances, hazardous materials, regulatory framework

A consultant will gather water quality data from relevant sources including MSD, KDOW, TMDL studies. Salt River Watershed Watch will summarize their data and provide to the consultant. The consultant will update water quality trends in Middle Fork Beargrass Creek previously reported in the 2016 Synthesis Report. A consultant will use the results of this task to develop the draft Watershed Plan Chapter 2. Exploring Middle Fork Beargrass Creek for MSD and Project Partner review. MSD will then submit the Chapter to KDOW to review. MSD and a consultant will revise the draft per KDOW review.

Task 2 – Monitoring and Visual Assessment: Monitoring for this watershed plan will be performed by MSD and KDOW at three (3) LTMN sites and five additional (5) KDOW sites. MSD, KDOW and a consultant will finalize a QAPP describing the monitoring to be performed in support of this watershed plan as described in Section 18. A consultant will use the results of this task to develop the draft Watershed Plan Chapter 3. Monitoring Middle Fork Beargrass Creek for MSD and Project Partner review. MSD will then submit the Chapter to KDOW to review. MSD and a consultant will revise the draft per KDOW review.

A consultant will analyze and interpret the monitoring data collected by MSD and KDOW using a tiered approach. The analysis will focus on bacteria, hydromodification and parameters included in the Watershed Planning Guidebook (i.e., Tier 1), supplemented by analysis of the additional parameters included in Section 18 (Supplemental).

MSD and the Project Partners will develop water quality benchmarks using applicable numeric water quality criteria, existing final and draft TMDLs and reasonable targets for Tier 1 parameters. A consultant will use stream monitoring results to estimate annual pollutant loads from each monitoring site and compare them to benchmarks. Benchmarks and pollutant loads will be analyzed for Supplemental parameters that exceed numeric water quality criteria.

A consultant will perform a desktop assessment of riparian habitat and adjacent stream buffers using GIS data and the most recent available aerial photography. MSD will perform stream walks to visually assess riparian and buffer zones. MSD will perform geomorphic assessments in selected locations that may be candidates for stream projects such as stabilization or restoration. A consultant will interpret the biological and habitat results in the context of historical data for the 3 LTMN sites and integrate the findings of the riparian and buffer assessments and stream walks. An initial list of priority areas will be identified by MSD, Project Partners and the consultant. A consultant will use the results of this task to develop the draft Watershed Plan Chapter 4. Analysis for MSD and Project Partner review. MSD will then submit the Chapter to KDOW to review. MSD and a consultant will revise the draft per KDOW review.

Task 3 – Best Management Practices Implementation Plan: MSD, Project Partners and a consultant will use the data and information compiled in Chapters 2 through 4 of the Watershed Plan to identify probable causes and sources of nonpoint source pollution, focusing on the subwatersheds contributing to the priority areas identified in Chapter 4 of the Watershed Plan. A list of BMPs that minimize and reduce causes and sources will be identified by the consultant. The consultant will use the International BMP database and if available, local data, to estimate pollutant load reductions that can be achieved on a per BMP basis and the range of costs and timeline associated with implementation. MSD and Project Partners will host a BMP Workshop to gather input from a variety of local entities regarding the Initial BMP matrix. Materials used to advertise and host the BMP Workshop will be provided in advance to KDOW for review and approval. The BMP Workshop will provide a forum to gauge local support and identify local concerns regarding BMPs. The consultant will compile and synthesize the information gathered from the BMP Workshop. A consultant will use the results of this task to develop the draft Watershed Plan Chapter 5. Finding Solutions for MSD and Project Partner review. MSD will then submit the Chapter to KDOW to review. MSD and a consultant will revise the draft per KDOW review.

The consultant will use the results of Chapter 5 to evaluate initial BMP feasibility, including opportunities for landowner cooperation, costs and benefits. The consultant will draft the initial BMP matrix to identify priority areas for BMP implementation, responsible entities and partnerships, potential funding sources and implementation approaches. MSD and Project Partners will review the BMP Matrix. A consultant will use the results of this task to develop the draft Watershed Plan Chapter 6. Strategy for Success for MSD and Project Partner review. MSD will then submit the Chapter to KDOW to review. MSD and a consultant will revise the draft per KDOW review.

Task 4. Measurable Milestones: MSD and the consultant will develop a draft document describing roles and responsibilities for watershed plan implementation, communication and outreach strategy, a financial resources plan, monitoring, evaluating and updating the watershed plan. The monitoring plan will describe tracking BMP implementation and monitoring water quality. Periodic trends assessments will be conducted to evaluate the effectiveness of BMP implementation in the context of on-going changes in the watershed. A consultant will use the results of this task to develop the draft Watershed Plan Chapter 7. Implementation and Success Monitoring for MSD and Project Partner review. MSD will then submit Chapter 7 for KDOW review. MSD and a consultant will revise per KDOW review. The Executive Summary and Draft Final Watershed Plan will be submitted to KDOW for review, MSD will revise per comments to finalize the plan.

Task 5. Project Management and Reporting: MSD will prepare quarterly project reports and corresponding 319H invoices every quarter the project is open. MSD will institute a mechanism to track budget and match. Other tasks will include internal coordination meetings, phone and email communications and contracting with the consultant, KWA and other entities as needed for this project.

Public Involvement: Public involvement for this project is described in Section 19.

18. Environmental Data Collection:

Monitoring for this watershed plan will be performed by MSD at two (2) LTMN sites and six (6) 319H sites. MSD, KDOW and a consultant will finalize a QAPP describing the monitoring to be performed in support of this watershed plan. A consultant will modify the draft QAPP to describe monitoring and quality assurance for monitoring performed by MSD. The consultant will provide the draft QAPP to MSD and KDOW for review. Monitoring locations are summarized on Table 1.

Table 1. Monitoring Sites

Station ID (KDOW, MSD, USGS)	Waterbody	Location	River Mile	Drainage Area mi^2)	Latitude	Longitude
DOW08047007 EMIMI010 03293500	Middle Fork Beargrass Creek	Lexington Rd.	0.9	24.8	38.250276	-85.716868
DOW08047008 EMIMI002 03293000	Middle Fork Beargrass Creek	Below Old Cannons Ln.	5.4	18.7	38.23729	-85.66468
EMIMI009	Middle Fork Beargrass Creek **(1)**	At Browns Lane		15.2	38.2403	-85.6345
DOW08047009	Weicher Creek	Above Blossom-wood Dr.	0.55	1.3	38.23016	-85.63071
DOW08047010	Middle Fork Beargrass Creek UT 8.45 (Sinking Fork)	Below Bowling Blvd.	0.3	2.6	38.24683	-85.62881
DOW08047011	Middle Fork Beargrass Creek UT 9.1	Off Steeplecrest Circle	0.2	3.9	38.24093	-85.61867
DOW08047012	Middle Fork Beargrass Creek	Off Old Whipps Mill Rd.	11.7	5.0	38.25984	-85.58529
DOW08047013	Middle Fork Beargrass Creek UT 12.8	Above Foxboro Rd.	0.2	2.2	38.25867	-85.56680

Notes: 1. This site sampled only by MSD, KDOW does not sample this site
3 MSD Long Term Monitoring Network sites: EMIMI010, EMIMI002, EMIMI009.
2 USGS Gages record stream discharge, pH, DO, temperature, conductivity on 15-minute intervals: 03293500, 03293000

KDOW - Sampling will be performed monthly by KDOW at 7 of the 8 sites for the parameters listed below. KDOW will analyze samples at the State laboratory in Frankfort, KY. Parameters identified in bold below are included in the Watershed Planning Guidebook. Additional parameters were included by KDOW due to the urban environment in this watershed.

- **Bacteria: E. coli bacteria**
- **Bulk: biological oxygen demand**, bromide, chloride, fluoride, nitrate, nitrite, sulfate, turbidity, total dissolved solids, total suspended solids

- **Nutrients:** ammonia (as N), **nitrate-nitrite**, **total Kjeldahl nitrogen**, total organic carbon, **total phosphorus**
- **Orthophosphorus: ortho-phosphorus** (field filtered)
- **Sediment (in Bulk): Total Suspended Solids**
- **Alkalinity:** acidity, alkalinity, alkalinity-carbonate, alkalinity-bicarbonate
- **Metals:** aluminum, antimony, arsenic, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, molybdenum, nickel, potassium, selenium, silver, sodium, thallium, total hardness, vanadium, zinc
- **Field Parameters: Turbidity, pH, Dissolved Oxygen, Dissolved Oxygen % Saturation (calculated) Conductivity, Temperature**, collected at each sample event.
- **Stream Flow: Stream flow** (measured by USGS flow gages at 2 sites with gages noted on Table 1. Measured manually using KDOW protocols at 7 sites, collected at each sample event).
- **Biology & Habitat: Benthic Macroinvertebrates, Habitat Assessment**

MSD - MSD has developed a draft QAPP. After KDOW approves the QAPP, MSD will sample the 8 sites listed on Table 1 for the parameters listed below. MSD will analyze bacteria samples at the MSD Laboratory located at the Morris Forman Water Quality Treatment Center. Parameters identified in bold below are included in the Watershed Planning Guidebook.

- **Bacteria: E. coli bacteria** (monthly for up to 11 months), and 5 times per month for 1 month during the recreation season of May 1 to October 31
- **Field Parameters: Turbidity, pH, Dissolved Oxygen, Dissolved Oxygen % Saturation (calculated) Conductivity, Temperature,** collected at each sample event.
- **Stream Flow: Stream Flow** (measured by USGS flow gages at 2 sites with gages noted on Table 1. Measured manually using KDOW protocols at 7 sites, collected at each sample event).

Quality Control: Quality control sampling includes field duplicates and field blanks, lab duplicates and lab blanks. In general, 10 % of samples will be quality control samples. The details of the quality control sampling will be established in the QAPP.

Data Management: MSD data will be stored in the MSD Laboratory Information Management System (LIMS). KDOW and MSD will share the data collected in this project for use in watershed plan development.

The analysis and interpretation of this data is described in Section 17. Task 2.

19. Public Involvement:

This section describes efforts to support Goal 2: Create greater opportunity for community members to become involved in watershed improvement efforts and solutions.

As a continuation of planning efforts that lead to the development of this grant application, four (4) Steering Committee meetings and two Watershed Workgroup meetings will be planned and held during the 2-year project time frame. Monthly updates regarding watershed planning efforts will be provided to the existing watershed group – Beargrass Creek Alliance, which has working to improve Beargrass Creek for many years.

Partnerships with numerous agencies and organizations were formed or strengthened during the development of this grant application. These groups will assist with providing outreach and education to the Beargrass Creek Watershed community through the following opportunities:

- Develop Public Outreach & Involvement Plan – A consultant will develop a public outreach plan outlining the activities and schedule for outreach and education events during the project period
- Kentucky Waterways Alliance will host 2 creek cleanups (3 hours each), 2 Every Drop events, 2 Storm drain marking events (2 hours each), 2 bicycle or walking tours for watershed residents (2 hours each) and host 4 showings of the film, "Beargrass: The Creek in Our Backyard." KWA will also provide monthly social media updates.
- River City Paddle Sports will host 3 canoe trips (3 hours each)
- Louisville Metro Parks will host 2 invasive species removal events, 4 annual volunteer events, 2 public interpretive programs and perform 15 8-hour cycles of Greenway maintenance

All meeting materials and handouts used for committee meetings and education and outreach events will be provided to KDOW for review and approval prior to distribution.

20. Project Partners: *Letters of participation are required from all partners (see 2016 Grant Guidance Document). Attach letters of participation as an appendix to this application.*

Include the following information for each project partner:

Agency Name: AECOM
Agency Address: 500 West Jefferson Street, Suite 1600, Louisville, KY 40202
Role/Contribution to Project: Technical assistance, monitoring, public outreach, volunteering, plan development, and program assistance.
Contact Person: Meghan Dunn Brown
Phone No: (502) 569-2301
E-mail address: Meghan.Brown@aecom.com

Agency Name: Jacobs
Agency Address: One Riverfront Plaza, 401 West Main Street, Suite 800, Louisville, KY 40202
Role/Contribution to Project: Technical knowledge and results from sampling efforts, volunteering, public outreach and education, creek cleanups, and other activities that help meet the goals and vision of the watershed plan.
Contact Person: Nicholas Winnike
Phone No: (513) 595-7922
E-mail address: Nicholas.Winnike@Jacobs.com

Agency Name: Kentucky Waterways Alliance
Agency Address: 120 Webster Street, Suite 217, Louisville, KY 40206
Role/Contribution to Project: Lead public outreach and engagement, publicity, participation in watershed planning review, and in-kind contributions such as creek cleanups, Every Drop events, storm drain marking, and celebration bicycle tours.
Contact Person: Ward Wilson
Phone No: (502) 589-8008
E-mail address: ward@kwalliance.org

Agency Name: Louisville Department of Metro Parks and Recreation
Agency Address: PO Box 37280
Role/Contribution to Project: Public education, volunteer events, maintenance activities associated with the Louisville Loop from Beargrass Creek Greenway to River Road, and the recently completed Beargrass Creek Trail Conceptual Shared Use Path and Ecological Restoration report which evaluated potential trail paths and ecosystem restoration opportunities.
Contact Person: Bennett Knox
Phone No: (502) 366-2913
E-mail address: bennett.knox@louisvilleky.gov

Agency Name: Office of Sustainability Develop Louisville
Agency Address: 527 West Jefferson Street, Suite 606, Louisville, KY 40202
Role/Contribution to Project: Project endorsement of support.
Contact Person: Maria Koetter

Phone No: (502) 574-4148
E-mail address: maria.koetter@louisvilleky.org

Agency Name: River City Paddle Sports
Agency Address: 6215 Deep Creek Court, Prospect, KY 40059
Role/Contribution to Project: Environmental field trips through the watershed and promotion of the documentary: The Creek in Our Backyard.
Contact Person: David Wicks
Phone No: (502) 671-3595
E-mail address: dwicks1@gmail.com

Agency Name: Salt River Watershed Watch
Agency Address: KDOW Watershed Watch Program 300 Sower Blvd, 3rd Floor, Frankfort, KY 40601
Role/Contribution to Project: Provide Salt River Watershed Watch (SRWW) sampling data for screening purposes, screening level water quality sampling, interpretation of screening level data and environmental education.
Contact Person: Karen Schaffer
Phone No: (502) 298-1932
E-mail address: kschaf4321@gmail.com

Agency Name: Stantec
Agency Address: 10509 Timberwood Circle, Suite 100, Louisville, KY 40223
Role/Contribution to Project: Technical assistance with developing watershed plan including knowledge from previous sampling efforts, coordination to identify mitigation opportunities, and historic knowledge of projects within the Middle Fork of Beargrass Creek watershed.
Contact Person: Melissa Tucker
Phone No: (502) 212-5048
E-mail address: melissa.tucker@stantec.com

Agency Name: Third Rock
Agency Address: 2526 Regency Rd # 180, Lexington, KY 40503
Role / Contribution to Project: Technical assistance with assessment and integration of biological and habitat assessments, technical assistance with visual surveys and geormorphic assessments, and identification of priority areas and BMPs to address hydromodification BMPs
Contact Person: Bert Remley
Phone No.: (859) 977-2000
E-mail address: bremley@thirdrockconsultants.com

Letters of Participation for each agency are provided in Appendix A.

21. Project Measures of Success:

Goal 1: Improve water quality by developing a KDOW and EPA approved watershed plan.

- Objective 1: Compile available background information about the Middle Fork of Beargrass Creek watershed.
    - Deliverable 1: Background information compiled (Chapters 1 and 2 developed and approved).
- Objective 2: Determine current conditions of the Middle Fork of Beargrass Creek watershed through interpretation of collected water -quality data and visual assessment.
    - Deliverable 1: finalization of an approved QAPP.
    - Deliverable 2: monitoring per Section 18 complete.
    - Deliverable 3: riparian buffer assessment complete.
    - Deliverable 4: historic and current monitoring data compiled, analyzed, and load reductions calculated (Chapters 3 and 4 developed and approved).
- Objective 3: Develop a Best Management Practices Implementation Plan and Strategy for the Middle Fork of Beargrass Creek watershed.
    - Deliverable 1: BMP implementation plan developed (Chapters 5 and 6 developed and approved).
- Objective 4: Develop measurable milestones and evaluation criteria for determining the long-term success of the watershed planning and implementation efforts.
    - Deliverable 1: Set of milestones and long-term water quality monitoring plan developed (Chapter 7 developed and approved).

Goal 2: Create greater opportunity for community members to become involved in watershed improvement efforts and solutions.

- Objective 1: Continue to work with the Steering Committee and the Watershed Work Group.
    - Deliverable 1: Number of Steering Committee Meetings held.
    - Deliverable 2: Number of Watershed Work Group meetings held.
- Objective 2: Support a watershed group for the Middle Fork of Beargrass Creek.
    - Deliverable 1: Number of watershed group meetings held.
- Objective 3: Provide outreach to the local community on nonpoint source pollution and related environmental issues in their watershed.
    - Deliverable 1: Number of education and outreach events held.
    - Deliverable 2: Number of education and outreach materials developed or distributed.
    - Deliverable 3. Watershed Plan Chapter 1 developed and approved

22. Milestone Schedule		
Milestone	**Date**	
	Expected Begin	**Expected Completion**
1. Receipt of Grant Funding	9/1/2019	10/1/2019
2. Facilitate internal and cross-departmental planning meetings and workshops as needed.	Duration	Duration
3. Select and secure contractors to perform necessary technical services for the project.	9/1/2019	1/31/2020
4. Select and secure contractors or organizations to perform necessary education and outreach services for the project.	9/1/2019	1/31/2020
5. Hold four Steering Committee meetings.	Duration	Duration
6. Hold two Watershed Work Group meetings.	Duration	Duration
7. Hold monthly watershed group meetings	Duration	Duration
8. Hold and/or facilitate education and outreach events. Submit advanced written notice to NPS Program staff for all educational public meetings, field days, workshops, etc.	Duration	Duration
9. Develop and/or distribute education materials. Submit to NPS Program staff for review and approval before distribution.	Duration	Duration
10. Finalize QAPP and submit to DOW for review and approval.	9/1/2019	12/31/2019
11. Conduct monitoring as described in Section 18	1/1/2020	12/31/2020
12. DOW Water Quality Branch and Nonpoint Source Program staff to conduct monitoring as described in Section 18	2/1/2019	1/31/2020
13. Gather background information and compose **Chapters 1-2**	2/1/2020	8/30/2020
14. Use GIS data and visual assessment, evaluate the current conditions of the riparian habitat and buffer zones.	2/1/2020	8/30/2020
15. Analyze and interpret historical data from previous water quality monitoring and compose **Chapter 3**	2/1/2020	8/30/2020
16. Analyze and interpret new data from water quality monitoring and compose **Chapter 4**	2/1/2020	3/31/2021
17. Calculate pollutant loads from each sampling location, determine load reductions to meet water quality standards or benchmarks, include in **Chapter 4**.	2/1/2020	3/31/2021
18. Develop BMP Implementation Plan (**Chapters 5 and 6**)	6/30/2020	3/30/2021
19. Develop measurable milestones and evaluation criteria for determining the long-term success of watershed planning and implementation (**Chapter 7**)	6/30/2020	3/30/2021
20. Finalize WSP and submit to DOW for review **(Executive Summary & Final Plan)**	4/1/2021	6/30/2021
21. Once DOW approves of the WSP, DOW will submit the WSP to EPA for review. MSD will address EPA's comments as necessary.	7/1/2021	9/1/2021
22. Develop and submit Final Report upon completion of the project	7/1/2021	9/1/2021

23. Reference/Literature Cited:

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Metro Parks. 2017. Beargrass Creek Trail Conceptual Shared Use Path and Ecological Restoration Plan. https://louisvilleky.gov/government/parks/beargrass-creek-trail-conceptual-shared-use-path-ecological-restoration-plan

24. Budget Summary							
Category	**BMP Implementation**	**Project Management**	**Education, Training, or Outreach**	**Monitoring**	**Technical Assistance**	**Other**	**Total Amount**
Personnel		$2,848	$43,486	$24,775	$13,870		$84,979
Supplies							
Equipment							
Travel							
Contractual **(1)**		$9,360	$27,453	$14,100	$82,320	$705	$133,938
Operating Costs **(2)**			$1,600				$1,600
Other **(3)**				$2,713			$2,713
TOTAL		**$12,208**	**$72,539**	**$41,588**	**$96,190**	**$705**	**$223,230**

Notes
1. Contractual Other category includes $705 for Supplies, shown here to document that Section 319H funds are proposed to cover these expenses.
2. City of St. Matthews donated meeting space valued at $1,600 as Non-Federal Match
3. Louisville MSD donated E. coli bacteria sample analysis valued at $2,713 as Non-Federal Match. MS4 Permit samples are not included in this match.

25. Detailed Budget			
Budget Categories (Itemize all Categories)	**§319(h) (60% of funds)**	**Non-Federal Match (40% of funds)**	**TOTAL**
Personnel		$77,179	$77,179
Supplies	$705		$705
Equipment			
Travel			
Contractual	$133,233	$7,800	$141,033
Operating Cost		$1,600	$1,600
Other		$2,713	$2,713
TOTAL	**$133,938**	**$89,292**	**$223,230**

26. Budget Narrative: Describe in detail the Federal and Non-Federal match for each of the following Budget Categories.

The following assumptions were used for this budget narrative:
- A 2,000-hour work year was used to calculate person years (PY); 4,000 hours over the 2-year project period.
- Monitoring includes visual and geomorphic assessments as well as water quality sampling, as described in Section 17, Task 2 and Section 18, and will be summarized in Watershed Plan Chapter 3
- Education, Outreach and Training is described in Section 19 and will be summarized in Watershed Plan Executive Summary and Chapter 1
- Budget for work associated with development of Watershed Plan Chapters 2, 4, 5, 6 and 7 was grouped under Technical Assistance

Personnel:
Federal
- ***Project Management*** – Not Applicable
- ***Education, Training or Outreach –*** *See Federal Contractual*
- ***Monitoring***– *See Federal Contractual*
- ***Technical Assistance*** – *See Federal Contractual*
- ***Other*** – Not Applicable

Non-Federal Match
- ***Project Management ($2,848)***
  - MSD Project Manager – 32 hours at $89 per hour (0.008 PY) ($2,848)
- ***Education, Training or Outreach ($43,686)***
  - Louisville MSD Project Manager – 46 hours at $89 per hour (0.0115 PY) ($4,094)
  - Metro Parks – 440 hours at $25 per hour (0.11 PY) ($11,000)
  - Metro Office of Sustainability – 16 hours at $25 per hour (0.004 PY) ($400)
  - Louisville Metro Health Department – 16 hours at $25 per hour (0.004 PY) ($400)
  - City of St. Matthews – 16 hours at $25 per hour (0.004 PY) ($400)
  - KWA Executive Director 40 hours at $48 per hour (0.01 PY) ($1,920)
  - Salt River Watershed Watch – 64 hours at $21 per hour ($1,344)
  - River City Paddle Sports – 16 hours at $21 per hour ($336)
  - Volunteer participation in education and outreach events - 752 hours at $21 per hour (0.188 PY) ($15,792)
  - Senior Consultant support for Project Partner meetings 60 hours at $130 per hour (0.015 PY) ($7,800)
- ***Monitoring ($24,777)***
  - Louisville MSD
    - Project Manager – 12 hours at $89 per hour (0.003 PY) ($1,068)
    - Field Supervisor – 12 hours at $96 per hour (0.003 PY) ($1,152)
    - Field Technicians – 292 hours at $65 per hour (0.073 PY) ($18,980)
    - Lab Supervisor – 20 hours at $96 per hour (0.005 PY) ($1,920)
    - Assistant Director – 8 hours at $131 per hour (0.002 PY) ($1,048)
  - Salt River Watershed Watch – 28.9 hours at $21 per hour (0.007 PY) ($607)

- ***Technical Assistance ($13,870)***
  - Louisville MSD
    - Project Manager – 118 hours at $89 per hour (0.0295 PY) ($10,502)
    - Field Supervisor – 8 hours at $96 per hour (0.002 PY) ($768)
    - Field Technicians – 40 hours at $65 per hour (0.01 PY) ($2,600)

- ***Operating – ($1,600)***
  - City of St. Matthews will provide the meeting space for four (4) 2-hour project partner meetings (8 hours total), valued at $200 per hour

- ***Other – ($2,713)***
  - Louisville MSD will conduct analysis of 119 E. coli samples (108 project samples + 11 QC samples (10 %) valued at $2713 as Non-Federal Match. Analysis of 36 MS4 samples collected at 3 sites was excluded from the Match.

<u>Travel</u>: – Not Applicable

<u>Contractual</u>:
Federal
- ***Project Management – ($9,630)***
  - Consultant Project Manager – 24 hours at $150 per hour (0.006 PY)
  - Senior Consultant – 48 hours at $120 per hour (0.012 PY)
- ***Education, Training or Outreach – ($27,453)***
  - Consultant Project Manager – 6 hours at $150 per hour (0.0015 PY) ($900)
  - Senior Consultant – 150 hours at $120 per hour (0.0375 PY) ($18,000)
  - GIS Consultant – 14 hours at $90 per hour (0.0035 PY) ($1,260)
  - Kentucky Waterways Alliance – 136 hours at $48 per hour (0.034 PY) ($6,528)
  - River City Paddle Sports – 18 hours at $42.50 per hour (0.0045 PY) ($765)
- ***Monitoring – ($14,100)***
  - Consultant Project Manager – 2 hours at $150 per hour (0.0005 PY) ($300)
  - Senior Consultant – 106 hours at $120 per hour (0.0265 PY) (12,720)
  - GIS Consultant – 12 hours at $90 per hour (0.003 PY) ($1,080)
- ***Technical Assistance – ($82,320)***
  - Consultant Project Manager – 40 hours at $150 per hour (0.01 PY) ($6,000)
  - Senior Consultant – 588 hours at $120 per hour (0.147 PY) ($70,560)
  - Consultant – 18 hours at $90 per hour (0.0045 PY) ($1,620)
  - GIS Consultant – 46 hours at $90 per hour (0.0115 PY) ($4,140)
- ***Other (Contractual Equipment and Supplies purchased with Section 319H funds) ($705)***
  - **<u>Supplies</u>:**
    - ***Education, Training or Outreach ($575)***
      - Kentucky Waterways Alliance
        - Every Drop Event - $300 for plantings
        - Creek Cleanups - $150 for shovels, wheelbarrow, supplies
        - Storm Drain Marking - $125 for approx. 36 marking kits @ $3.50 each
        - Truck Rental and Sod Cutter - $130 for three (3) Every Drop events

Operating Costs: – Not Applicable

Other: – Not Applicable

27. Grant Application Conditions

Completion of this section is required in order to receive funding consideration.

- Applicant agrees that the proposed project will comply with all applicable state laws and rules ☒Yes ☐N/A
- Applicant agrees to obtain all applicable permits. ☒ Yes ☐ N/A
- Reporting will be conducted in accordance with the legal contract. ☒ Yes ☐ N/A
- All Project Partners have agreed to participate. ☒ Yes ☐ N/A

I have read and agree to comply with all applicable conditions as specified in the Application Instructions

- Watershed Plan Condition (See Section 27 , Page 15) ☒ Yes ☐ N/A
- Required Training Condition (See Section 27, Page 15) ☒ Yes ☐ N/A
- Education Materials Condition (See Section 27, Page 15) ☒ Yes ☐ N/A
- Material Review Condition (See Section 27, Page 15) ☒ Yes ☐ N/A
- Quality Assurance Condition (See Section 27, Page 15) ☒ Yes ☐ N/A
- BMP Implementation Plan Condition (See Section 27, Page 16) ☒ Yes ☐ N/A
- Onsite Wastewater Condition (See Section 27, Page 16) ☒ Yes ☐ N/A
- AFO Condition (See Section 27, Page 16) ☒ Yes ☐ N/A
- Stream Restoration Condition (See Section 27, Page 17) ☒ Yes ☐ N/A
- GIS Condition (See Section 27, Page 17) ☒ Yes ☐ N/A
- Annual Report Condition (See Section 27, Page 18) ☒ Yes ☐ N/A
- Project Partners Condition (See Section 27, Page 18) ☒ Yes ☐ N/A

<u>WARNING:</u> Any application which is determined to be deficient, not eligible or missing KEY components will not be considered for funding.

28. Application Signature:

I certify that the information contained in this document is complete and accurate to the best of my knowledge and agree to comply with all conditions of funding.

		7/5/18
Signature of Lead Agency's Authorized Representative		Date
David Johnson, Development & Stormwater Services Director		502.540.6392
Typed Name and Title		Telephone Number

APPENDIX 1.2 REVISED OUTREACH AND COMMUNICATION PLAN

Middle Fork Beargrass Creek Communication Plan

To communicate the purpose and progress of the 319 grant for Middle Fork Beargrass Creek to the watershed working group, stakeholders, and community. Ensure watershed stakeholder involvement in the project by creating opportunities for participation in education and outreach, as well as opportunities to provide input for solutions to address non-point source pollution and its sources within the watershed.

Target Audiences (Partners)

- Kentucky Division of Water
- Kentucky Waterways Alliance
- Beargrass Creek Alliance
- Louisville Department of Metro Parks and Recreation
- Olmsted Parks Conservancy
- Salt River Watershed Watch
- River City Paddle Sports
- United States Army Corps of Engineers
- United States Geological Survey (USGS)
- University of Louisville
- Engineering and Environmental Science Firms and Professionals
- Professional Organizations
- Environmental Activist Groups

Target Audiences (Stakeholders)

- Metro Council District Representatives and Staff
    - District 8
    - District 9
    - District 11
    - District 17
    - District 18
    - District 19
    - District 26
- MS4 Co-permittees
    - Anchorage
    - Jeffersontown
    - Middletown
    - St Matthews
    - Louisville MSD
- Schools

  - Jefferson County Public Schools (JCPS)
  - Private
- Country Clubs and Golf Courses
  - Hurstbourne Country Club
  - Big Spring Country Club
  - Oxmoor Country Club
  - Cherokee Golf Course
  - Seneca Golf Course
- Malls
  - Oxmoor Mall
  - Mall St Matthews

Events

Watershed community engagement and participation is recognized as a vital part of addressing non-point source pollution within urban watersheds. In the original schedule for the Middle Fork Beargrass Creek 319 grant, partners committed to hosting outreach opportunities in support of the watershed planning efforts through engagement and outreach activities.

A year into the project in March 2020, the governor of the Commonwealth of Kentucky issued a stay-at-home order for all non-essential employees due to the health risks associated with the spread of COVID-19. The stay-at-home order affected MSD's internal operations and put a hindrance on MSD's ability to reach out to other organizations and consultants to continue to facilitate the community education and outreach activities. Project partners also had to adjust their mission and day-to-day activities in order to protect the health and safety of staff and the public. They adapted to virtual platforms when possible and encouraged participation through digital and virtual means. As a result, the original outreach schedule was modified to adjust to the new precautions in place while maintaining the original intent to create educational opportunities for the community.

Original Outreach Schedule

- Creek Cleanups (KWA, 2 events)
- Every Drop Events (KWA, 2 events)
- Storm Drain Marking Events (KWA, 2 events)
- Bicycle or Walking Tours for Watershed Residents (KWA, 2 events)
- Film Showings for "Beargrass: The Creek in Our Backyard" (KWA, 4 events)
- Monthly Updates to Beargrass Creek Alliance (KWA, 24 updates)
- Monthly Social Media Updates (KWA, 24 during project)
- Canoe Trips (River City Paddle Sports, 3 events)
- Invasive Species Removal Events (Metro Parks, 2 events)
- Annual Volunteer Events (Metro Parks, 2 events)

- Public Interpretive Programs (Metro Parks, 2 events)
- Beargrass Creek Greenway Maintenance (Metro Parks, 15 events)

Kentucky Waterways Alliance

In 2019, Kentucky Waterways Alliance (KWA) proposed to perform community outreach, engagement, and planning services for the Middle Fork Beargrass Creek 319 project. However, the original proposed outreach schedule was modified in the presence of the COVID-19 pandemic. While the planned events were modified, KWA and the Beargrass Creek Alliance (BCA) were able to contribute over 1,100 volunteer hours through creek cleanups and education/outreach events. The following activities were completed in support of the watershed plan by KWA and BCA.

- Beargrass Creek Alliance Monthly Watershed Meetings (virtual and in person when allowed)
- Cleanups
    - Beargrass Creek Cleanup with Butchertown Neighborhood Association at Butchertown Greenway
    - Beargrass Creek Cleanup Friends of Forecastle Foundation at Big Rock
    - Beargrass Creek Cleanup with Lackadazee at Butchertown Greenway
    - Beargrass Creek Cleanup with BCA and Olmsted Parks
    - Beargrass Creek Cleanup with MSD, Metro Parks, City of St. Matthews
    - Middle Fork of Beargrass Creek Cleanup with MSD
    - Beargrass Creek Cleanup with BCA in Cherokee Park
    - Beargrass Creek Cleanup with West Sixth, Hilltop Tavern, and Against the Grain in Cherokee Park
- Outreach/Environmental Education
    - Pollinator Garden Planting with BCA
    - Ramsey Middle School Field Day in Brown Park
    - BCA Table at Louisville Sustainability Council
    - Earth Day at Home
- Social Media Campaigns and Updates

Louisville Metro Parks and Recreation

In the original proposal, Louisville Metro Parks and Recreation committed to invasive species removal events, volunteer events, public programs, and Greenway maintenance. Due to COVID-19, the volunteer events and public programs were hard to put on and many of their contributed hours were for invasive species removal and maintenance. Hours spent at

Butchertown Greenway were for path clearing of overgrowth and litter cleanup, hours spent at Beargrass Greenway were for cleanups of litter, and hours spent at Forest Green Greenway were for litter cleanup, fixing eroded sections of path, invasive species control, and preparation for planting a pollinator meadow. The hours for the three Greenways are included below.

- Butchertown Greenway (8 dates)
- Beargrass Creek Greenway (15 dates)

- Forest Green Greenway (31 dates)

River City Paddle Sports

River City Paddle Sports committed to hosting three canoe trips on Beargrass Creek in the original proposal. Unfortunately, due to COVID-19, none of these trips were able to occur and no other events took their place.

Revised Outreach Schedule

- Creek Cleanups
    - KWA, 6 events
    - Metro Parks, 3 events
    - MSD, KWA, and Metro Parks, 2 events
    - Stantec, 1 event
- Monthly Updates to Beargrass Creek Alliance (KWA, 12 events)
- Monthly Social Media Updates (KWA, 11 events)
- Beargrass Creek Greenway Maintenance (Metro Parks, 12 events)
- Butchertown Greenway Maintenance (Metro Parks, 8 events)
- Forest Green Greenway Maintenance (Metro Parks, 31 events)
- Community Survey (MSD, 1 event)
- Pollinator Garden Planting (KWA and BCA, 1 event)
- Public Outreach (KWA, 3 events)
- Stakeholder Meetings (MSD, 3 events)
- Partners Meetings (MSD, 11 events)
- Salt River Watershed Watch Annual Meeting (SRWW, 1 event)

Community Survey

With the challenges COVID created for hosting outreach activities, the ability to obtain community input and engagement was limited. In the fall of 2020, an online community survey was distributed to the stakeholder group via email and social media to gather information specific to the Middle Fork Beargrass Creek Watershed community. The survey included questions that asked if the community knows where the streams are in their neighborhood, what parks they visit in the watershed, what activities they like to do in the watershed, and what kind of education and outreach opportunities they would be interested in. Responses were downloaded in February 2021.

Trash Cleanups

MSD partnered with Louisville Metro Parks and Recreation, Kentucky Waterways Alliance, and Olmsted Parks to put on two trash collection events. The first event took place on November 7, 2020 at five locations in the watershed: Cherokee Park at Lexington Road, Cherokee Park near Big Rock, Arthur K. Draut Park, A.B. Sawyer Park, and Forest Green Trail. There were a total of 58 volunteers who collected 62 bags of trash along with a shopping cart and plastic playhouse. There was a media presence at this event and the MSD project manager communicated the importance of picking up trash to prevent harm to the creek ecosystem.

The second trash cleanup event took place on May 8, 2021 at two locations: Cherokee Park near Big Rock and Arthur K. Draut Park. There were 23 volunteers at this event who collected a total of 10 bags of trash. These cleanup events served as a good reminder that a major contributor to water quality throughout the Middle Fork Beargrass Creek watershed is linked right back to litter and trash. These trash pickup days are a way to involve the community in protecting the health of the watershed and connect them to the streams. Each of these events followed COVID safety guidelines provided by Louisville Metro Parks to ensure the safety of volunteers.

Kentucky Waterways Alliance and Beargrass Creek Alliance also hosted and participated in trash cleanup events, contributing 700 volunteer hours for eight creek cleanups in Beargrass Creek.

Best Management Practices (BMP) Web Application

The BMP Web Application was created as an innovative way to allow stakeholders to review and provide input on the BMP plan for MFBGC Watershed Plan. At a stakeholder meeting held on June 3, 2021, the application was introduced to the group. In this app, stakeholders were asked to vote on potential BMP sites and partnerships as well as potential watershed-wide BMPs. They also were asked to submit their own suggested BMPs for specific locations. This application was available to the partners and stakeholders for a week and a half. The results of this application were downloaded in June 2021 and will be considered when prioritizing BMPs for the next phase of the watershed plan.

Communications Strategy

Communications Goals

1. **Educate the community** on how a 319(h) grant functions and where funding for projects comes from.
2. **Ensure that project partners** have planned activities to contribute their resources and expertise.
3. **Engage new partners** in the watershed planning effort who can contribute unique expertise and potentially increase the ability to implement projects.
4. **Create greater opportunity** for community members to become involved in watershed improvement efforts and solutions specifically through education and outreach activities.
5. **Educate the community** on non-point source pollution in the watershed so that they are aware of the challenges present in the watershed and how they could be contributing to them.
6. **Continue to engage the watershed community** in the watershed planning effort so that after the grant project is finished, they will want to continue bettering the watershed. While there may not be any more funding from the grant, a plan for best management practices to target problems in the watershed will exist if and when funding becomes available. Community support for these projects is critical for their success.

Key Messages

Key Message and Purpose	Delivery Method	Desired Result
In partnership with watershed groups, MSD hosts creek cleanups at parks throughout the watershed.	Website; Flyer	Community learns the importance of picking up trash and keeping it out of the creek.
To learn about the watershed community's prior knowledge when it comes to water quality and watershed health.	Email; Survey	Determine what educational opportunities to provide to the community.
To learn what locations in the watershed and activities are most important to the community and where they want to see improvements.	Email; Survey	Plan where projects will be most successful and accepted.
To learn what education and outreach opportunities the community is interested in participating in.	Email; Survey	Determine what education and outreach opportunities to plan and put on for the community.
To include stakeholder group in the BMP planning process and learn what options are favored by the community.	Email; Web Application	Prioritize potential BMP projects in the watershed.
Update stakeholders on the progress of the Middle Fork Beargrass Creek grant at events/meetings hosted by MSD, Salt River Watershed Watch, Beargrass Creek Alliance, and MS4 Co-permittees.	Presentation	Keep the watershed community and stakeholders up to date with the progress of the grant.

APPENDIX 1.3 CHAPTER 1 MAPS

The Three Forks of Beargrass Creek & Corresponding Watersheds

Middle Fork Beargrass Creek
319(h) Grant

Map Key

- Middle Fork BGC
- Muddy Fork BGC
- South Fork BGC
- State & Local Parks
- Bodies of Water
- Wet Areas
- Stream/River, Perennial
- Stream/River, Intermittent
- Canal/Ditch
- Canal/Ditch
- Underground Conduit
- Underground Conduit
- Pipeline
- Artificial Path
- Connector

msd Safe, clean waterways

LOJIC

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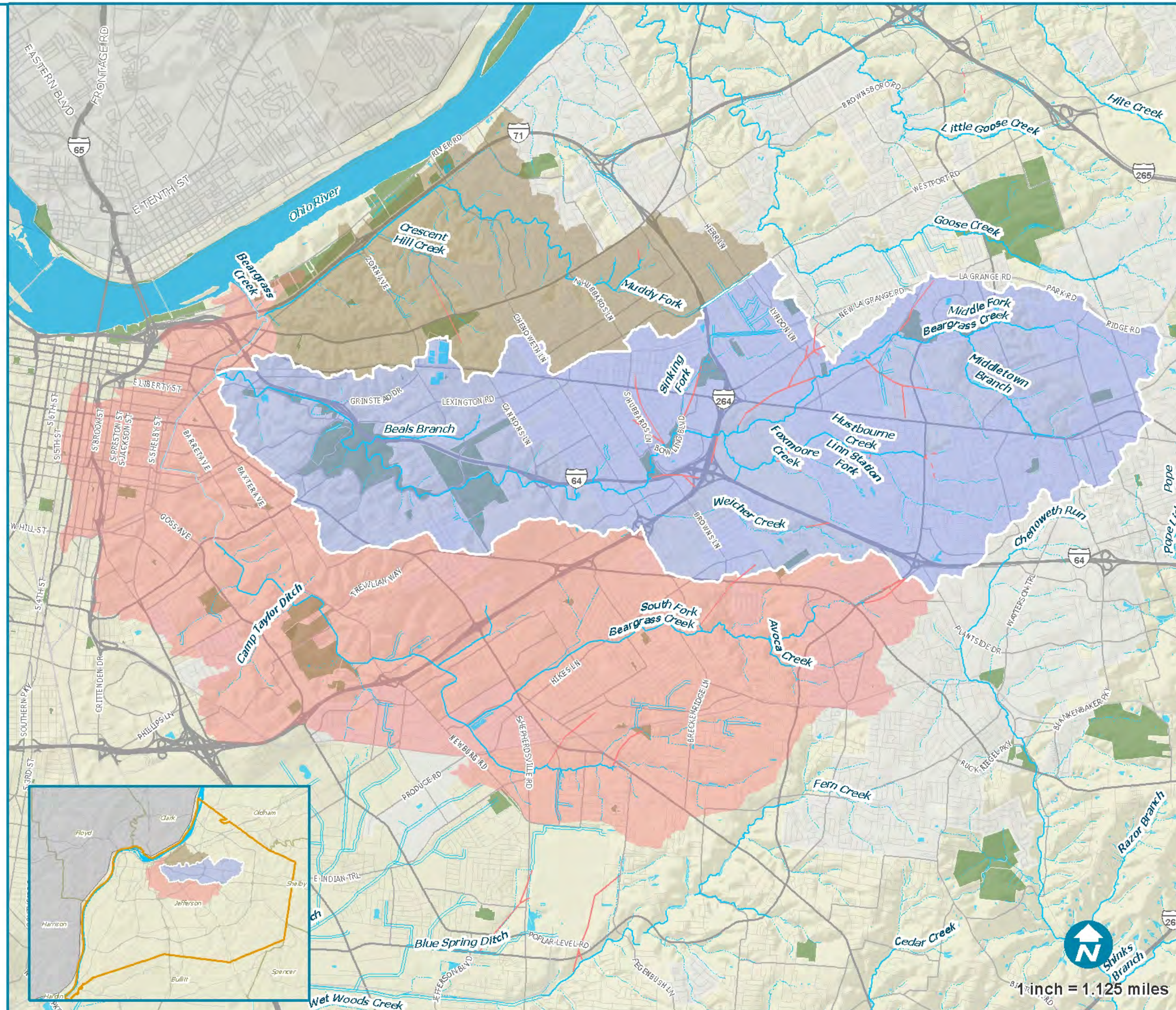


Salt River Watershed

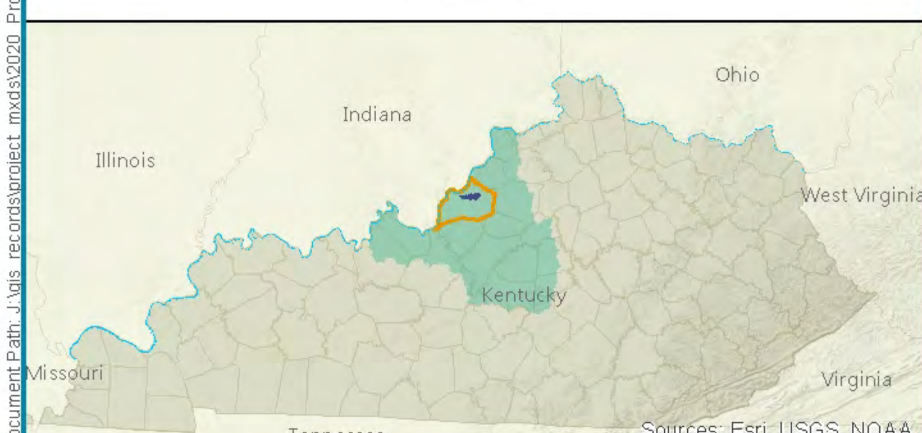
Middle Fork Beargrass Creek
319(h) Grant

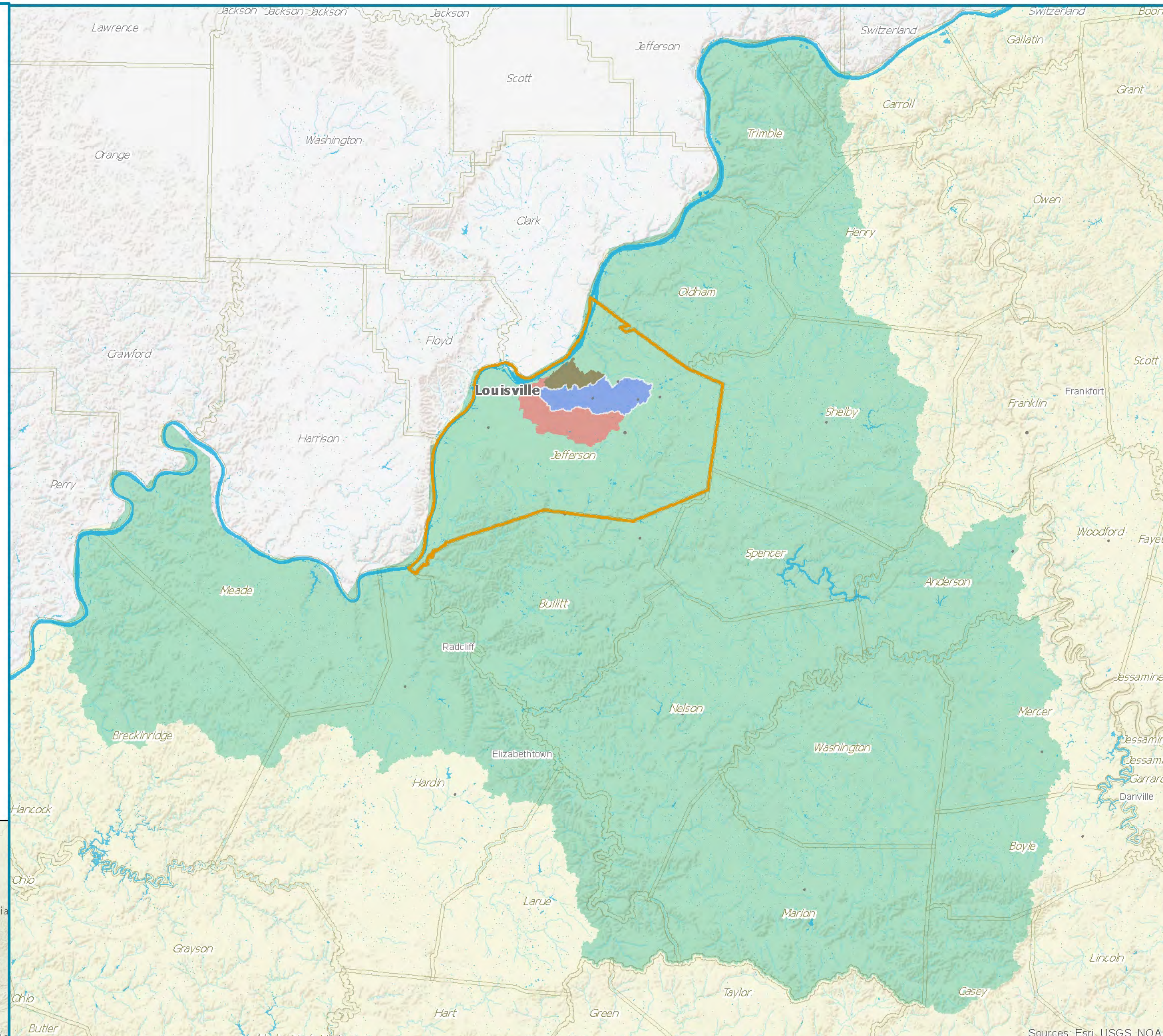
Map Key

- Middle Fork Beargrass Creek
- Muddy Fork Beargrass Creek
- South Fork Beargrass Creek
- Salt River Watershed
- Jefferson County Boundary

1 inch = 15 Miles

LOJIC msd





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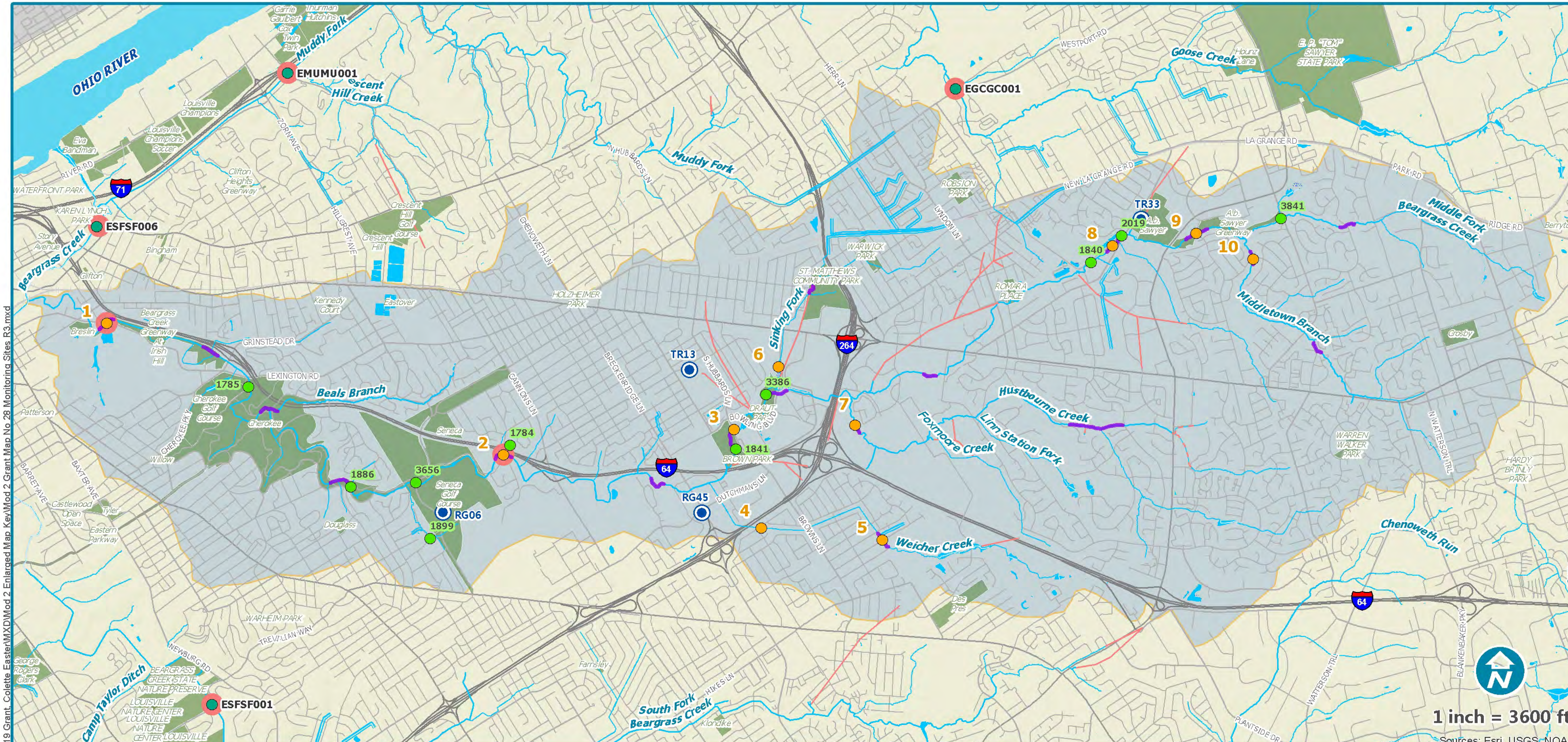

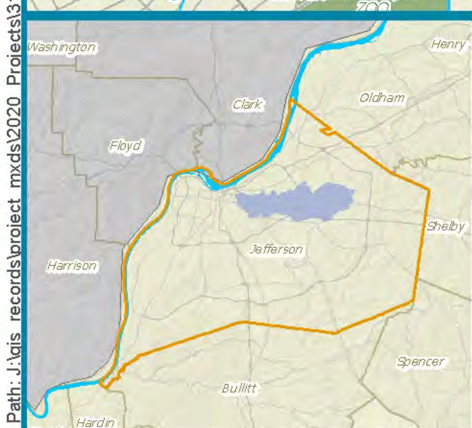

Map Key

- Watershed Boundary
- Bodies of Water
- Wetlands
- Parks
- Stream Walk Sites
- Rain Gauges
- LTMN Only Site
- Combination Mon. Site
- SRWW Monitoring Site
- USGS Monitoring Sites
- Connector
- Stream/River, Perennial
- Stream/River, Intermittent
- Canal/Ditch
- Underground Conduit
- Pipeline
- Artificial Path

NOTE: See Table for additional detail regarding Monitoring Sites 1-10

Monitoring Sites

Middle Fork Beargrass Creek
319(h) Grant

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APPENDIX 2.1 SALT RIVER WATERSHED WATCH MIDDLE FORK BEARGRASS CREEK DATA

Salt River Watershed Watch Middle Fork Beargrass Creek Data

Site ID	Stream Name	Site Location	Sample Date	Latitude NAD83	Longitude NAD83	COC ID	Sample Date	Sample Time	Flow Rate (0-5 Scale)	Rainfall (inches)
3841	Middle Fork Beargr	Middle Fork Beargrass Creek along Forest Green Trail, Louisville,	5/11/2019	38.26297	-85.56329	13940	5/11/2019	7:20:00	3	0
3841	Middle Fork Beargr	Middle Fork Beargrass Creek along Forest Green Trail, Louisville,	7/13/2019	38.26297	-85.56329	14752	7/13/2019	9:30:00	3	0
3841	Middle Fork Beargr	Middle Fork Beargrass Creek along Forest Green Trail, Louisville,	9/26/2020	38.26297	-85.56329	16596	9/26/2020	9:05:00	3	0
3386	Middle Fork Beargr	Arthur Draut Park	5/16/2015	38.24378	-85.63026	4607	5/16/2015	6:40:00	2	0
3386	Middle Fork Beargr	Arthur Draut Park	7/11/2015	38.24378	-85.63026	4976	7/11/2015	7:00:00	3	0.5
3386	Middle Fork Beargr	Arthur Draut Park	5/14/2016	38.24378	-85.63026	6415	5/14/2016	6:45:00	3	0.1
3386	Middle Fork Beargr	Arthur Draut Park	7/9/2016	38.24378	-85.63026	6986	7/9/2016	6:30:00	3	0.1
3386	Middle Fork Beargr	Arthur Draut Park	6/29/2017	38.24378	-85.63026	8440	6/29/2017	8:00:00	2	0.1
3386	Middle Fork Beargr	Arthur Draut Park	9/9/2017	38.24378	-85.63026	9998	9/9/2017	7:00:00	2	0.1
3386	Middle Fork Beargr	Arthur Draut Park	5/12/2018	38.24378	-85.63026	11307	5/12/2018	6:30:00	2	0
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	7/12/2014	38.238	-85.634	3944	7/12/2014	8:15:00	3	0
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/13/2014	38.238	-85.634	3474	9/13/2014	9:55:00		0.1
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/13/2014	38.238	-85.634	3474	9/13/2014	9:55:00		0.1
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/13/2014	38.238	-85.634	3474	9/13/2014	9:55:00		0.1
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/13/2014	38.238	-85.634	3474	9/13/2014	9:55:00		0.1
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/13/2014	38.238	-85.634	3474	9/13/2014	9:55:00		0.1
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/13/2014	38.238	-85.634	3474	9/13/2014	9:55:00		0.1
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/13/2014	38.238	-85.634	3474	9/13/2014	9:55:00		0.1
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/13/2014	38.238	-85.634	3474	9/13/2014	9:55:00		0.1
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/13/2014	38.238	-85.634	3474	9/13/2014	9:55:00		0.1
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	7/11/2015	38.238	-85.634	4963	7/11/2015	10:45:00	4	1
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/12/2015	38.238	-85.634	5433	9/12/2015		3	0.5
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/12/2015	38.238	-85.634	5433	9/12/2015		3	0.5
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/12/2015	38.238	-85.634	5433	9/12/2015		3	0.5
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/12/2015	38.238	-85.634	5433	9/12/2015		3	0.5
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/12/2015	38.238	-85.634	5433	9/12/2015		3	0.5
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/12/2015	38.238	-85.634	5433	9/12/2015		3	0.5
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/12/2015	38.238	-85.634	5433	9/12/2015		3	0.5
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/12/2015	38.238	-85.634	5433	9/12/2015		3	0.5
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/12/2015	38.238	-85.634	5433	9/12/2015		3	0.5
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	7/9/2016	38.238	-85.634	6993	7/9/2016	10:00:00	3	0.5
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/10/2016	38.238	-85.634	7367	9/10/2016	8:30:00	2	0
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/10/2016	38.238	-85.634	7367	9/10/2016	8:30:00	2	0
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/10/2016	38.238	-85.634	7367	9/10/2016	8:30:00	2	0
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/10/2016	38.238	-85.634	7367	9/10/2016	8:30:00	2	0
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	7/8/2017	38.238	-85.634	9540	7/8/2017	9:00:00	4	1
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/8/2017	38.238	-85.634	9569	9/8/2017	13:05:00	3	0

Salt River Watershed Watch Middle Fork Beargrass Creek Data

Site ID	Stream Name	Site Location	Sample Date	Latitude NAD83	Longitude NAD83	COC ID	Sample Date	Sample Time	Flow Rate (0-5 Scale)	Rainfall (inches)
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	5/12/2018	38.238	-85.634	11087	5/12/2018	12:00:00	3	
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	6/18/2018	38.238	-85.634	8677	6/18/2018	10:50:00	2	0
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	7/13/2018	38.238	-85.634	11043	7/13/2018	12:00:00	2	0
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/14/2018	38.238	-85.634	11060	9/14/2018	9:55:00	3	0
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	5/9/2019	38.238	-85.634	13852	5/9/2019	10:00:00	3	0
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	7/13/2019	38.238	-85.634	14770	7/13/2019	8:40:00	2	0
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/13/2019	38.238	-85.634	15168	9/13/2019	10:09:00	2	0
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/25/2020	38.238	-85.634	16606	9/25/2020	10:45:00	2	0
1784	Middle Fork Beargr	Old Cannons Lane.	6/7/2014	38.2383	-85.6638	3259	6/7/2014	8:30:00	2	
1784	Middle Fork Beargr	Old Cannons Lane.	6/7/2014	38.2383	-85.6638	2603	6/7/2014		3	
1784	Middle Fork Beargr	Old Cannons Lane.	5/16/2015	38.2383	-85.6638	4628	5/16/2015	8:28:00	3	0.1
1784	Middle Fork Beargr	Old Cannons Lane.	9/15/2018	38.2383	-85.6638	12875	9/15/2018	8:15:00	3	0
1899	Bowman Field Sprir	Intersection of Seneca Valley Rd and PeeWee Reese Ln	5/16/2015	38.228	-85.674	4611	5/16/2015	6:56:00	2	0.1
1899	Bowman Field Sprir	Intersection of Seneca Valley Rd and PeeWee Reese Ln	9/12/2015	38.228	-85.674	5654	9/12/2015	8:30:00	3	0.5
1899	Bowman Field Sprir	Intersection of Seneca Valley Rd and PeeWee Reese Ln	9/12/2015	38.228	-85.674	5654	9/12/2015	8:30:00	3	0.5
1899	Bowman Field Sprir	Intersection of Seneca Valley Rd and PeeWee Reese Ln	9/12/2015	38.228	-85.674	5654	9/12/2015	8:30:00	3	0.5
1899	Bowman Field Sprir	Intersection of Seneca Valley Rd and PeeWee Reese Ln	9/12/2015	38.228	-85.674	5654	9/12/2015	8:30:00	3	0.5
1899	Bowman Field Sprir	Intersection of Seneca Valley Rd and PeeWee Reese Ln	9/12/2015	38.228	-85.674	5654	9/12/2015	8:30:00	3	0.5
1899	Bowman Field Sprir	Intersection of Seneca Valley Rd and PeeWee Reese Ln	9/12/2015	38.228	-85.674	5654	9/12/2015	8:30:00	3	0.5
1899	Bowman Field Sprir	Intersection of Seneca Valley Rd and PeeWee Reese Ln	9/12/2015	38.228	-85.674	5654	9/12/2015	8:30:00	3	0.5
1899	Bowman Field Sprir	Intersection of Seneca Valley Rd and PeeWee Reese Ln	9/12/2015	38.228	-85.674	5654	9/12/2015	8:30:00	3	0.5
1899	Bowman Field Sprir	Intersection of Seneca Valley Rd and PeeWee Reese Ln	9/12/2015	38.228	-85.674	5654	9/12/2015	8:30:00	3	0.5
1899	Bowman Field Sprir	Intersection of Seneca Valley Rd and PeeWee Reese Ln	5/14/2016	38.228	-85.674	6762	5/14/2016	8:00:00	4	0.5
3656	Middle Fork Beargr	Seneca Park, about two tenths of a mile from Pee Wee Reese Wa	6/20/2017	38.23427	-85.67595	9093	6/20/2017	12:00:00	3	0
3656	Middle Fork Beargr	Seneca Park, about two tenths of a mile from Pee Wee Reese Wa	7/8/2017	38.23427	-85.67595	9281	7/8/2017	9:45:00	3	1.99
3656	Middle Fork Beargr	Seneca Park, about two tenths of a mile from Pee Wee Reese Wa	9/9/2017	38.23427	-85.67595	9941	9/9/2017	11:05:00	3	0
3656	Middle Fork Beargr	Seneca Park, about two tenths of a mile from Pee Wee Reese Wa	5/11/2018	38.23427	-85.67595	11082	5/11/2018	11:00:00	3	0
3656	Middle Fork Beargr	Seneca Park, about two tenths of a mile from Pee Wee Reese Wa	7/13/2018	38.23427	-85.67595	11038	7/13/2018	10:00:00	3	0
3656	Middle Fork Beargr	Seneca Park, about two tenths of a mile from Pee Wee Reese Wa	9/15/2018	38.23427	-85.67595	11055	9/15/2018	9:30:00	4	0
3656	Middle Fork Beargr	Seneca Park, about two tenths of a mile from Pee Wee Reese Wa	5/11/2019	38.23427	-85.67595	13676	5/11/2019	10:10:00	4	0.1
3656	Middle Fork Beargr	Seneca Park, about two tenths of a mile from Pee Wee Reese Wa	7/13/2019	38.23427	-85.67595	14387	7/13/2019	9:40:00	3	0
3656	Middle Fork Beargr	Seneca Park, about two tenths of a mile from Pee Wee Reese Wa	9/14/2019	38.23427	-85.67595	15103	9/14/2019	8:30:00	2	0
2030	Beargrass Creek	Big Rock	5/19/2012	38.21694	-85.68333	4019	5/19/2012	8:14:00	3	0.1
2030	Beargrass Creek	Big Rock	7/14/2012	38.21694	-85.68333	4062	7/14/2012	7:45:00	2	0
2030	Beargrass Creek	Big Rock	9/8/2012	38.21694	-85.68333	3974	9/8/2012	8:38:00	4	1.99
2030	Beargrass Creek	Big Rock	9/8/2012	38.21694	-85.68333	3974	9/8/2012	8:38:00	4	1.99
2030	Beargrass Creek	Big Rock	9/8/2012	38.21694	-85.68333	3974	9/8/2012	8:38:00	4	1.99

Salt River Watershed Watch Middle Fork Beargrass Creek Data

Site ID	Stream Name	Site Location	Sample Date	Latitude NAD83	Longitude NAD83	COC ID	Sample Date	Sample Time	Flow Rate (0-5 Scale)	Rainfall (inches)
2030	Beargrass Creek	Big Rock	9/8/2012	38.21694	-85.68333	3974	9/8/2012	8:38:00	4	1.99
2030	Beargrass Creek	Big Rock	9/8/2012	38.21694	-85.68333	3974	9/8/2012	8:38:00	4	1.99
2030	Beargrass Creek	Big Rock	9/8/2012	38.21694	-85.68333	3974	9/8/2012	8:38:00	4	1.99
2030	Beargrass Creek	Big Rock	9/8/2012	38.21694	-85.68333	3974	9/8/2012	8:38:00	4	1.99
2030	Beargrass Creek	Big Rock	9/8/2012	38.21694	-85.68333	3974	9/8/2012	8:38:00	4	1.99
2030	Beargrass Creek	Big Rock	9/8/2012	38.21694	-85.68333	3974	9/8/2012	8:38:00	4	1.99
2030	Beargrass Creek	Big Rock	5/18/2013	38.21694	-85.68333	1811	5/18/2013	8:05:00	3	0.5
2030	Beargrass Creek	Big Rock	7/13/2013	38.21694	-85.68333	1848	7/13/2013	9:02:00	3	0
2030	Beargrass Creek	Big Rock	9/14/2013	38.21694	-85.68333	966	9/14/2013		2	0.1
2030	Beargrass Creek	Big Rock	9/14/2013	38.21694	-85.68333	966	9/14/2013		2	0.1
2030	Beargrass Creek	Big Rock	9/14/2013	38.21694	-85.68333	966	9/14/2013		2	0.1
2030	Beargrass Creek	Big Rock	9/14/2013	38.21694	-85.68333	966	9/14/2013		2	0.1
2030	Beargrass Creek	Big Rock	9/14/2013	38.21694	-85.68333	966	9/14/2013		2	0.1
2030	Beargrass Creek	Big Rock	9/14/2013	38.21694	-85.68333	966	9/14/2013		2	0.1
2030	Beargrass Creek	Big Rock	9/14/2013	38.21694	-85.68333	966	9/14/2013		2	0.1
2030	Beargrass Creek	Big Rock	9/14/2013	38.21694	-85.68333	966	9/14/2013		2	0.1
2030	Beargrass Creek	Big Rock	9/14/2013	38.21694	-85.68333	966	9/14/2013		2	0.1
2030	Beargrass Creek	Big Rock	6/7/2014	38.21694	-85.68333	2677	6/7/2014	8:00:00	3	0
2030	Beargrass Creek	Big Rock	7/15/2014	38.21694	-85.68333	3277	7/15/2014	9:00:00	4	0.1
2030	Beargrass Creek	Big Rock	9/13/2014	38.21694	-85.68333	3660	9/13/2014	9:00:00	4	0
2030	Beargrass Creek	Big Rock	9/13/2014	38.21694	-85.68333	3660	9/13/2014	9:00:00	4	0
2030	Beargrass Creek	Big Rock	9/13/2014	38.21694	-85.68333	3660	9/13/2014	9:00:00	4	0
2030	Beargrass Creek	Big Rock	9/13/2014	38.21694	-85.68333	3660	9/13/2014	9:00:00	4	0
2030	Beargrass Creek	Big Rock	9/13/2014	38.21694	-85.68333	3660	9/13/2014	9:00:00	4	0
2030	Beargrass Creek	Big Rock	9/13/2014	38.21694	-85.68333	3660	9/13/2014	9:00:00	4	0
2030	Beargrass Creek	Big Rock	9/13/2014	38.21694	-85.68333	3660	9/13/2014	9:00:00	4	0
2030	Beargrass Creek	Big Rock	9/13/2014	38.21694	-85.68333	3660	9/13/2014	9:00:00	4	0
2030	Beargrass Creek	Big Rock	9/13/2014	38.21694	-85.68333	3660	9/13/2014	9:00:00	4	0
2030	Beargrass Creek	Big Rock	5/16/2015	38.21694	-85.68333	4584	5/16/2015	8:30:00	2	0
2030	Beargrass Creek	Big Rock	7/11/2015	38.21694	-85.68333	5064	7/11/2015	9:30:00	4	1
2030	Beargrass Creek	Big Rock	9/12/2015	38.21694	-85.68333	5645	9/12/2015	9:15:00	2	0.1
2030	Beargrass Creek	Big Rock	9/12/2015	38.21694	-85.68333	5645	9/12/2015	9:15:00	2	0.1
2030	Beargrass Creek	Big Rock	9/12/2015	38.21694	-85.68333	5645	9/12/2015	9:15:00	2	0.1
2030	Beargrass Creek	Big Rock	9/12/2015	38.21694	-85.68333	5645	9/12/2015	9:15:00	2	0.1
2030	Beargrass Creek	Big Rock	9/12/2015	38.21694	-85.68333	5645	9/12/2015	9:15:00	2	0.1
2030	Beargrass Creek	Big Rock	5/14/2016	38.21694	-85.68333	5976	5/14/2016	8:30:00	3	0.5
2030	Beargrass Creek	Big Rock	7/9/2016	38.21694	-85.68333	7156	7/9/2016	9:30:00	3	0.5

Salt River Watershed Watch Middle Fork Beargrass Creek Data

Site ID	Stream Name	Site Location	Sample Date	Latitude NAD83	Longitude NAD83	COC ID	Sample Date	Sample Time	Flow Rate (0-5 Scale)	Rainfall (inches)
2030	Beargrass Creek	Big Rock	9/10/2016	38.21694	-85.68333	7630	9/10/2016	9:20:00	2	0
2030	Beargrass Creek	Big Rock	9/10/2016	38.21694	-85.68333	7630	9/10/2016	9:20:00	2	0
2030	Beargrass Creek	Big Rock	9/10/2016	38.21694	-85.68333	7630	9/10/2016	9:20:00	2	0
2030	Beargrass Creek	Big Rock	9/10/2016	38.21694	-85.68333	7630	9/10/2016	9:20:00	2	0
2030	Beargrass Creek	Big Rock	7/8/2017	38.21694	-85.68333	9372	7/8/2017	10:15:00	3	1.5
2030	Beargrass Creek	Big Rock	5/12/2018	38.21694	-85.68333	11310	5/12/2018	9:44:00	2	0
2030	Beargrass Creek	Big Rock	7/13/2018	38.21694	-85.68333	11393	7/13/2018	9:33:00	2	0
1886	Middle Fork Beargr	Big Rock pavilion in Cherokee Park.	6/7/2014	38.23375	-85.6846	2659	6/7/2014		3	0
1886	Middle Fork Beargr	Big Rock pavilion in Cherokee Park.	5/11/2019	38.23375	-85.6846	13842	5/11/2019	8:29:00	3	0
1785	Middle Fork Beargr	Cherokee Park Road and Lexington Road.	7/13/2013	38.24395	-85.69812	1824	7/13/2013	10:00:00	3	0.5
1785	Middle Fork Beargr	Cherokee Park Road and Lexington Road.	5/12/2018	38.24395	-85.69812	11510	5/12/2018	9:49:00	3	0
1785	Middle Fork Beargr	Cherokee Park Road and Lexington Road.	7/13/2018	38.24395	-85.69812	12381	7/13/2018	7:00:00	2	0
1785	Middle Fork Beargr	Cherokee Park Road and Lexington Road.	5/11/2019	38.24395	-85.69812	13846	5/11/2019	10:49:00	2	0
1785	Middle Fork Beargr	Cherokee Park Road and Lexington Road.	7/13/2019	38.24395	-85.69812	14406	7/13/2019	11:47:00	2	0
3361	Middle Fork Beargr	On Beargrass Creek Road about a half mile before it meets with L	5/16/2015	38.24669	-85.70149	4635	5/16/2015	9:39:00	3	0
3361	Middle Fork Beargr	On Beargrass Creek Road about a half mile before it meets with L	7/11/2015	38.24669	-85.70149	4947	7/11/2015	10:45:00	4	1
3361	Middle Fork Beargr	On Beargrass Creek Road about a half mile before it meets with L	9/12/2015	38.24669	-85.70149	5646	9/12/2015		2	0.1
3361	Middle Fork Beargr	On Beargrass Creek Road about a half mile before it meets with L	9/12/2015	38.24669	-85.70149	5646	9/12/2015		2	0.1
3361	Middle Fork Beargr	On Beargrass Creek Road about a half mile before it meets with L	9/12/2015	38.24669	-85.70149	5646	9/12/2015		2	0.1
3361	Middle Fork Beargr	On Beargrass Creek Road about a half mile before it meets with L	9/12/2015	38.24669	-85.70149	5646	9/12/2015		2	0.1
3361	Middle Fork Beargr	On Beargrass Creek Road about a half mile before it meets with L	9/12/2015	38.24669	-85.70149	5646	9/12/2015		2	0.1
3361	Middle Fork Beargr	On Beargrass Creek Road about a half mile before it meets with L	5/14/2016	38.24669	-85.70149	5977	5/14/2016	9:00:00	3	0.5
3361	Middle Fork Beargr	On Beargrass Creek Road about a half mile before it meets with L	7/9/2016	38.24669	-85.70149	6023	7/9/2016	9:10:00	3	0.5
3361	Middle Fork Beargr	On Beargrass Creek Road about a half mile before it meets with L	9/10/2016	38.24669	-85.70149	6024	9/10/2016	10:15:00	2	0
3361	Middle Fork Beargr	On Beargrass Creek Road about a half mile before it meets with L	9/10/2016	38.24669	-85.70149	6024	9/10/2016	10:15:00	2	0
3361	Middle Fork Beargr	On Beargrass Creek Road about a half mile before it meets with L	9/10/2016	38.24669	-85.70149	6024	9/10/2016	10:15:00	2	0
3361	Middle Fork Beargr	On Beargrass Creek Road about a half mile before it meets with L	9/10/2016	38.24669	-85.70149	6024	9/10/2016	10:15:00	2	0
3361	Middle Fork Beargr	On Beargrass Creek Road about a half mile before it meets with L	7/8/2017	38.24669	-85.70149	9373	7/8/2017	11:14:00	3	1.5
2068	Middle Fork Beargr	Bridge at Payne Street	9/13/2014	38.25126	-85.71973	3881	9/13/2014	10:55:00	3	0.1
2068	Middle Fork Beargr	Bridge at Payne Street	9/13/2014	38.25126	-85.71973	3881	9/13/2014	10:55:00	3	0.1
2068	Middle Fork Beargr	Bridge at Payne Street	9/13/2014	38.25126	-85.71973	3881	9/13/2014	10:55:00	3	0.1
2068	Middle Fork Beargr	Bridge at Payne Street	9/13/2014	38.25126	-85.71973	3881	9/13/2014	10:55:00	3	0.1
2068	Middle Fork Beargr	Bridge at Payne Street	9/13/2014	38.25126	-85.71973	3881	9/13/2014	10:55:00	3	0.1
2068	Middle Fork Beargr	Bridge at Payne Street	9/13/2014	38.25126	-85.71973	3881	9/13/2014	10:55:00	3	0.1
2068	Middle Fork Beargr	Bridge at Payne Street	9/13/2014	38.25126	-85.71973	3881	9/13/2014	10:55:00	3	0.1
2068	Middle Fork Beargr	Bridge at Payne Street	9/13/2014	38.25126	-85.71973	3881	9/13/2014	10:55:00	3	0.1
2068	Middle Fork Beargr	Bridge at Payne Street	9/13/2014	38.25126	-85.71973	3881	9/13/2014	10:55:00	3	0.1

Salt River Watershed Watch Middle Fork Beargrass Creek Data

Site ID	Stream Name	Site Location	Sample Date	Latitude NAD83	Longitude NAD83	COC ID	Sample Date	Sample Time	Flow Rate (0-5 Scale)	Rainfall (inches)
2068	Middle Fork Beargr	Bridge at Payne Street	9/12/2015	38.25126	-85.71973	5434	9/12/2015	9:30:00	3	0.1
2068	Middle Fork Beargr	Bridge at Payne Street	9/12/2015	38.25126	-85.71973	5434	9/12/2015	9:30:00	3	0.1
2068	Middle Fork Beargr	Bridge at Payne Street	9/12/2015	38.25126	-85.71973	5434	9/12/2015	9:30:00	3	0.1
2068	Middle Fork Beargr	Bridge at Payne Street	9/12/2015	38.25126	-85.71973	5434	9/12/2015	9:30:00	3	0.1
2068	Middle Fork Beargr	Bridge at Payne Street	9/12/2015	38.25126	-85.71973	5434	9/12/2015	9:30:00	3	0.1
2068	Middle Fork Beargr	Bridge at Payne Street	9/12/2015	38.25126	-85.71973	5434	9/12/2015	9:30:00	3	0.1
2068	Middle Fork Beargr	Bridge at Payne Street	9/12/2015	38.25126	-85.71973	5434	9/12/2015	9:30:00	3	0.1
2068	Middle Fork Beargr	Bridge at Payne Street	9/12/2015	38.25126	-85.71973	5434	9/12/2015	9:30:00	3	0.1
2068	Middle Fork Beargr	Bridge at Payne Street	9/12/2015	38.25126	-85.71973	5434	9/12/2015	9:30:00	3	0.1
2068	Middle Fork Beargr	Bridge at Payne Street	5/13/2017	38.25126	-85.71973	8676	5/13/2017	12:00:00	3	1

Salt River Watershed Watch Middle Fork Beargrass Creek Data

Site ID	Stream Name	Site Location	Sample Date	Turbidity (0-3 Scale)	Dissolved Oxygen (mg/L)	pH (Std. Units)	Water Temp (Deg. C)	Conductivity (uS/cm)	Conductivity Meter Calibration Date
3841	Middle Fork Beargr	Middle Fork Beargrass Creek along Forest Green Trail, Louisville, .	5/11/2019	0	7.6	8	12	630	5/10/2019
3841	Middle Fork Beargr	Middle Fork Beargrass Creek along Forest Green Trail, Louisville, .	7/13/2019	0	6.2	8	18	660	7/13/2019
3841	Middle Fork Beargr	Middle Fork Beargrass Creek along Forest Green Trail, Louisville, .	9/26/2020	0	5.2	7.5	16	590	9/25/2020
3386	Middle Fork Beargr	Arthur Draut Park	5/16/2015	1	4	7.5	13	630	5/16/2015
3386	Middle Fork Beargr	Arthur Draut Park	7/11/2015	1	7.3	7	13	620	7/11/2015
3386	Middle Fork Beargr	Arthur Draut Park	5/14/2016	1	7.5	7	10	740	
3386	Middle Fork Beargr	Arthur Draut Park	7/9/2016	1	7.5	7.5	12	740	7/9/2016
3386	Middle Fork Beargr	Arthur Draut Park	6/29/2017	1	7.5	7.5	14	520	
3386	Middle Fork Beargr	Arthur Draut Park	9/9/2017	1	4.4	7.5	14	620	9/9/2017
3386	Middle Fork Beargr	Arthur Draut Park	5/12/2018	1	7	7	10	670	5/12/2018
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	7/12/2014	0	5.7	8.6	20	750	7/12/2014
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/13/2014	1	7	7.6	16	730	
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/13/2014	1	7	7.6	16	730	
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/13/2014	1	7	7.6	16	730	
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/13/2014	1	7	7.6	16	730	
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/13/2014	1	7	7.6	16	730	
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/13/2014	1	7	7.6	16	730	
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/13/2014	1	7	7.6	16	730	
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/13/2014	1	7	7.6	16	730	
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/13/2014	1	7	7.6	16	730	
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	7/11/2015	2	6.3	8.7	21	560	7/10/2015
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/12/2015	1	6.4	8.2	19	690	9/12/2015
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/12/2015	1	6.4	8.2	19	690	9/12/2015
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/12/2015	1	6.4	8.2	19	690	9/12/2015
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/12/2015	1	6.4	8.2	19	690	9/12/2015
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/12/2015	1	6.4	8.2	19	690	9/12/2015
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/12/2015	1	6.4	8.2	19	690	9/12/2015
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/12/2015	1	6.4	8.2	19	690	9/12/2015
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/12/2015	1	6.4	8.2	19	690	9/12/2015
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/12/2015	1	6.4	8.2	19	690	9/12/2015
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	7/9/2016	1	6	7.35	20	470	7/9/2016
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/10/2016	0	6	5.25	22.5	470	9/9/2016
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/10/2016	0	6	5.25	22.5	470	9/9/2016
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/10/2016	0	6	5.25	22.5	470	9/9/2016
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/10/2016	0	6	5.25	22.5	470	9/9/2016
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	7/8/2017	2	8.2	7.2	21	270	7/7/2017
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/8/2017	1	10	7.8	20	440	

Site ID	Stream Name	Site Location	Sample Date	Turbidity (0-3 Scale)	Dissolved Oxygen (mg/L)	pH (Std. Units)	Water Temp (Deg. C)	Conductivity (uS/cm)	Conductivity Meter Calibration Date
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	5/12/2018	3	2	6.5	20	560	
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	6/18/2018	1	6	8	22.5	590	0618/2018
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	7/13/2018	1	2.6	8.5	23	440	7/12/2018
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/14/2018	1	4	7.8	20	630	9/14/2018
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	5/9/2019	1	5		17.9	53	5/9/2019
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	7/13/2019	0	10	8.2	22		
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/13/2019	0	6	7.6	23	630	
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/25/2020	1		7	19	570	
1784	Middle Fork Beargr	Old Cannons Lane.	6/7/2014	1	5.5	7.6	23	780	7/12/2014
1784	Middle Fork Beargr	Old Cannons Lane.	6/7/2014	1	7	7.75	20	640	6/6/2014
1784	Middle Fork Beargr	Old Cannons Lane.	5/16/2015	0	4		20		
1784	Middle Fork Beargr	Old Cannons Lane.	9/15/2018	1	8	8	21	74	
1899	Bowman Field Sprir	Intersection of Seneca Valley Rd and PeeWee Reese Ln	5/16/2015	1	3	7.5	21	720	5/15/2015
1899	Bowman Field Sprir	Intersection of Seneca Valley Rd and PeeWee Reese Ln	9/12/2015	0	5.5	7.5	21	580	9/11/2015
1899	Bowman Field Sprir	Intersection of Seneca Valley Rd and PeeWee Reese Ln	9/12/2015	0	5.5	7.5	21	580	9/11/2015
1899	Bowman Field Sprir	Intersection of Seneca Valley Rd and PeeWee Reese Ln	9/12/2015	0	5.5	7.5	21	580	9/11/2015
1899	Bowman Field Sprir	Intersection of Seneca Valley Rd and PeeWee Reese Ln	9/12/2015	0	5.5	7.5	21	580	9/11/2015
1899	Bowman Field Sprir	Intersection of Seneca Valley Rd and PeeWee Reese Ln	9/12/2015	0	5.5	7.5	21	580	9/11/2015
1899	Bowman Field Sprir	Intersection of Seneca Valley Rd and PeeWee Reese Ln	9/12/2015	0	5.5	7.5	21	580	9/11/2015
1899	Bowman Field Sprir	Intersection of Seneca Valley Rd and PeeWee Reese Ln	9/12/2015	0	5.5	7.5	21	580	9/11/2015
1899	Bowman Field Sprir	Intersection of Seneca Valley Rd and PeeWee Reese Ln	9/12/2015	0	5.5	7.5	21	580	9/11/2015
1899	Bowman Field Sprir	Intersection of Seneca Valley Rd and PeeWee Reese Ln	9/12/2015	0	5.5	7.5	21	580	9/11/2015
1899	Bowman Field Sprir	Intersection of Seneca Valley Rd and PeeWee Reese Ln	5/14/2016	1	9	7.5	7	690	5/14/2016
3656	Middle Fork Beargr	Seneca Park, about two tenths of a mile from Pee Wee Reese Wa	6/20/2017	1	8	8	26	550	
3656	Middle Fork Beargr	Seneca Park, about two tenths of a mile from Pee Wee Reese Wa	7/8/2017	2			24	480	
3656	Middle Fork Beargr	Seneca Park, about two tenths of a mile from Pee Wee Reese Wa	9/9/2017	0	6	8.3	22	660	9/8/2017
3656	Middle Fork Beargr	Seneca Park, about two tenths of a mile from Pee Wee Reese Wa	5/11/2018	0	10	7.5	24	480	5/10/2018
3656	Middle Fork Beargr	Seneca Park, about two tenths of a mile from Pee Wee Reese Wa	7/13/2018	0	6	7.5	25	580	7/12/2018
3656	Middle Fork Beargr	Seneca Park, about two tenths of a mile from Pee Wee Reese Wa	9/15/2018	0	9	8	23	740	9/14/2018
3656	Middle Fork Beargr	Seneca Park, about two tenths of a mile from Pee Wee Reese Wa	5/11/2019	0	9	8	15	640	5/10/2019
3656	Middle Fork Beargr	Seneca Park, about two tenths of a mile from Pee Wee Reese Wa	7/13/2019	0	8	7.5	25	590	7/12/2019
3656	Middle Fork Beargr	Seneca Park, about two tenths of a mile from Pee Wee Reese Wa	9/14/2019	0	7.1	7.5	24	580	9/14/2019
2030	Beargrass Creek	Big Rock	5/19/2012	0	7.6	7.5	16	710	
2030	Beargrass Creek	Big Rock	7/14/2012	0	3.8	7.5	22	690	
2030	Beargrass Creek	Big Rock	9/8/2012	3	6.6	7	19	230	
2030	Beargrass Creek	Big Rock	9/8/2012	3	6.6	7	19	230	
2030	Beargrass Creek	Big Rock	9/8/2012	3	6.6	7	19	230	

Salt River Watershed Watch Middle Fork Beargrass Creek Data

Site ID	Stream Name	Site Location	Sample Date	Turbidity (0-3 Scale)	Dissolved Oxygen (mg/L)	pH (Std. Units)	Water Temp (Deg. C)	Conductivity (uS/cm)	Conductivity Meter Calibration Date
2030	Beargrass Creek	Big Rock	9/8/2012	3	6.6	7	19	230	
2030	Beargrass Creek	Big Rock	9/8/2012	3	6.6	7	19	230	
2030	Beargrass Creek	Big Rock	9/8/2012	3	6.6	7	19	230	
2030	Beargrass Creek	Big Rock	9/8/2012	3	6.6	7	19	230	
2030	Beargrass Creek	Big Rock	9/8/2012	3	6.6	7	19	230	
2030	Beargrass Creek	Big Rock	9/8/2012	3	6.6	7	19	230	
2030	Beargrass Creek	Big Rock	5/18/2013	0	7	7.5	14	610	
2030	Beargrass Creek	Big Rock	7/13/2013	1	8.2	7.5	15	520	
2030	Beargrass Creek	Big Rock	9/14/2013	0	6.4	7	12	630	
2030	Beargrass Creek	Big Rock	9/14/2013	0	6.4	7	12	630	
2030	Beargrass Creek	Big Rock	9/14/2013	0	6.4	7	12	630	
2030	Beargrass Creek	Big Rock	9/14/2013	0	6.4	7	12	630	
2030	Beargrass Creek	Big Rock	9/14/2013	0	6.4	7	12	630	
2030	Beargrass Creek	Big Rock	9/14/2013	0	6.4	7	12	630	
2030	Beargrass Creek	Big Rock	9/14/2013	0	6.4	7	12	630	
2030	Beargrass Creek	Big Rock	9/14/2013	0	6.4	7	12	630	
2030	Beargrass Creek	Big Rock	9/14/2013	0	6.4	7	12	630	
2030	Beargrass Creek	Big Rock	6/7/2014	1	6.9	7	20	770	6/7/2014
2030	Beargrass Creek	Big Rock	7/15/2014	2	6.2	8	22	480	
2030	Beargrass Creek	Big Rock	9/13/2014	2	8.2	8	18	700	9/12/2014
2030	Beargrass Creek	Big Rock	9/13/2014	2	8.2	8	18	700	9/12/2014
2030	Beargrass Creek	Big Rock	9/13/2014	2	8.2	8	18	700	9/12/2014
2030	Beargrass Creek	Big Rock	9/13/2014	2	8.2	8	18	700	9/12/2014
2030	Beargrass Creek	Big Rock	9/13/2014	2	8.2	8	18	700	9/12/2014
2030	Beargrass Creek	Big Rock	9/13/2014	2	8.2	8	18	700	9/12/2014
2030	Beargrass Creek	Big Rock	9/13/2014	2	8.2	8	18	700	9/12/2014
2030	Beargrass Creek	Big Rock	9/13/2014	2	8.2	8	18	700	9/12/2014
2030	Beargrass Creek	Big Rock	9/13/2014	2	8.2	8	18	700	9/12/2014
2030	Beargrass Creek	Big Rock	5/16/2015	1	3.7	8	22	670	
2030	Beargrass Creek	Big Rock	7/11/2015	1	7.6	8	22	480	7/11/2015
2030	Beargrass Creek	Big Rock	9/12/2015	0	8.2	7.5	19	680	9/12/2015
2030	Beargrass Creek	Big Rock	9/12/2015	0	8.2	7.5	19	680	9/12/2015
2030	Beargrass Creek	Big Rock	9/12/2015	0	8.2	7.5	19	680	9/12/2015
2030	Beargrass Creek	Big Rock	9/12/2015	0	8.2	7.5	19	680	9/12/2015
2030	Beargrass Creek	Big Rock	9/12/2015	0	8.2	7.5	19	680	9/12/2015
2030	Beargrass Creek	Big Rock	5/14/2016	0	8	7.5	16	650	5/14/2016
2030	Beargrass Creek	Big Rock	7/9/2016	0	8.5	8.5	24	660	7/8/2016

Site ID	Stream Name	Site Location	Sample Date	Turbidity (0-3 Scale)	Dissolved Oxygen (mg/L)	pH (Std. Units)	Water Temp (Deg. C)	Conductivity (uS/cm)	Conductivity Meter Calibration Date
2030	Beargrass Creek	Big Rock	9/10/2016	0	6.1	8	25	780	9/10/2016
2030	Beargrass Creek	Big Rock	9/10/2016	0	6.1	8	25	780	9/10/2016
2030	Beargrass Creek	Big Rock	9/10/2016	0	6.1	8	25	780	9/10/2016
2030	Beargrass Creek	Big Rock	9/10/2016	0	6.1	8	25	780	9/10/2016
2030	Beargrass Creek	Big Rock	7/8/2017	0	6.9	8	22	430	7/8/2017
2030	Beargrass Creek	Big Rock	5/12/2018	0	6.2	8		700	5/12/2018
2030	Beargrass Creek	Big Rock	7/13/2018	0	7.2	7.5		580	7/13/2018
1886	Middle Fork Beargr	Big Rock pavilion in Cherokee Park.	6/7/2014	0	4	8	19	730	
1886	Middle Fork Beargr	Big Rock pavilion in Cherokee Park.	5/11/2019	0	7.6	8	14		
1785	Middle Fork Beargr	Cherokee Park Road and Lexington Road.	7/13/2013	1	6	8	20	720	
1785	Middle Fork Beargr	Cherokee Park Road and Lexington Road.	5/12/2018	1	4	7.7	21.5	560	5/12/2018
1785	Middle Fork Beargr	Cherokee Park Road and Lexington Road.	7/13/2018	0	4.65	8	23.5	620	7/12/2018
1785	Middle Fork Beargr	Cherokee Park Road and Lexington Road.	5/11/2019	1	8.6	6.5	15	610	5/11/2019
1785	Middle Fork Beargr	Cherokee Park Road and Lexington Road.	7/13/2019	1	6.2	8		590	
3361	Middle Fork Beargr	On Beargrass Creek Road about a half mile before it meets with L	5/16/2015	1		7.5	20	660	5/16/2015
3361	Middle Fork Beargr	On Beargrass Creek Road about a half mile before it meets with L	7/11/2015	3	7.6	7.5	20	470	7/11/2015
3361	Middle Fork Beargr	On Beargrass Creek Road about a half mile before it meets with L	9/12/2015	0	3	7.25	20	570	9/12/2015
3361	Middle Fork Beargr	On Beargrass Creek Road about a half mile before it meets with L	9/12/2015	0	3	7.25	20	570	9/12/2015
3361	Middle Fork Beargr	On Beargrass Creek Road about a half mile before it meets with L	9/12/2015	0	3	7.25	20	570	9/12/2015
3361	Middle Fork Beargr	On Beargrass Creek Road about a half mile before it meets with L	9/12/2015	0	3	7.25	20	570	9/12/2015
3361	Middle Fork Beargr	On Beargrass Creek Road about a half mile before it meets with L	9/12/2015	0	3	7.25	20	570	9/12/2015
3361	Middle Fork Beargr	On Beargrass Creek Road about a half mile before it meets with L	5/14/2016	1	7.8	7.5	16	630	5/14/2016
3361	Middle Fork Beargr	On Beargrass Creek Road about a half mile before it meets with L	7/9/2016	2	6.2	7.8	22	680	7/9/2016
3361	Middle Fork Beargr	On Beargrass Creek Road about a half mile before it meets with L	9/10/2016	0	3.8	7.6	24.5	670	9/10/2016
3361	Middle Fork Beargr	On Beargrass Creek Road about a half mile before it meets with L	9/10/2016	0	3.8	7.6	24.5	670	9/10/2016
3361	Middle Fork Beargr	On Beargrass Creek Road about a half mile before it meets with L	9/10/2016	0	3.8	7.6	24.5	670	9/10/2016
3361	Middle Fork Beargr	On Beargrass Creek Road about a half mile before it meets with L	9/10/2016	0	3.8	7.6	24.5	670	9/10/2016
3361	Middle Fork Beargr	On Beargrass Creek Road about a half mile before it meets with L	7/8/2017	2	5.4	8	22	390	7/8/2017
2068	Middle Fork Beargr	Bridge at Payne Street	9/13/2014	2	6.4	8.4	17.9	690	9/12/2014
2068	Middle Fork Beargr	Bridge at Payne Street	9/13/2014	2	6.4	8.4	17.9	690	9/12/2014
2068	Middle Fork Beargr	Bridge at Payne Street	9/13/2014	2	6.4	8.4	17.9	690	9/12/2014
2068	Middle Fork Beargr	Bridge at Payne Street	9/13/2014	2	6.4	8.4	17.9	690	9/12/2014
2068	Middle Fork Beargr	Bridge at Payne Street	9/13/2014	2	6.4	8.4	17.9	690	9/12/2014
2068	Middle Fork Beargr	Bridge at Payne Street	9/13/2014	2	6.4	8.4	17.9	690	9/12/2014
2068	Middle Fork Beargr	Bridge at Payne Street	9/13/2014	2	6.4	8.4	17.9	690	9/12/2014
2068	Middle Fork Beargr	Bridge at Payne Street	9/13/2014	2	6.4	8.4	17.9	690	9/12/2014
2068	Middle Fork Beargr	Bridge at Payne Street	9/13/2014	2	6.4	8.4	17.9	690	9/12/2014

Salt River Watershed Watch Middle Fork Beargrass Creek Data

Site ID	Stream Name	Site Location	Sample Date	Turbidity (0-3 Scale)	Dissolved Oxygen (mg/L)	pH (Std. Units)	Water Temp (Deg. C)	Conductivity (uS/cm)	Conductivity Meter Calibration Date
2068	Middle Fork Beargr	Bridge at Payne Street	9/12/2015	1	4.2	7.7	20	520	9/12/2015
2068	Middle Fork Beargr	Bridge at Payne Street	9/12/2015	1	4.2	7.7	20	520	9/12/2015
2068	Middle Fork Beargr	Bridge at Payne Street	9/12/2015	1	4.2	7.7	20	520	9/12/2015
2068	Middle Fork Beargr	Bridge at Payne Street	9/12/2015	1	4.2	7.7	20	520	9/12/2015
2068	Middle Fork Beargr	Bridge at Payne Street	9/12/2015	1	4.2	7.7	20	520	9/12/2015
2068	Middle Fork Beargr	Bridge at Payne Street	9/12/2015	1	4.2	7.7	20	520	9/12/2015
2068	Middle Fork Beargr	Bridge at Payne Street	9/12/2015	1	4.2	7.7	20	520	9/12/2015
2068	Middle Fork Beargr	Bridge at Payne Street	9/12/2015	1	4.2	7.7	20	520	9/12/2015
2068	Middle Fork Beargr	Bridge at Payne Street	9/12/2015	1	4.2	7.7	20	520	9/12/2015
2068	Middle Fork Beargr	Bridge at Payne Street	5/13/2017	1	8.2	7.8	17		

Salt River Watershed Watch Middle Fork Beargrass Creek Data

Site ID	Stream Name	Site Location	Sample Date	Analyte Name	Analysis Date	Analysis Time	ResultModifier	Result Value
3841	Middle Fork Beargr	Middle Fork Beargrass Creek along Forest Green Trail, Louisville, .	5/11/2019	E. coli	5/11/2019	14:20:00		398.6
3841	Middle Fork Beargr	Middle Fork Beargrass Creek along Forest Green Trail, Louisville, .	7/13/2019	E. coli	7/13/2019	13:09:00		457
3841	Middle Fork Beargr	Middle Fork Beargrass Creek along Forest Green Trail, Louisville, .	9/26/2020	E. coli	9/26/2020	13:45:00		340
3386	Middle Fork Beargr	Arthur Draut Park	5/16/2015	E. coli	5/16/2015	9:00:00		426
3386	Middle Fork Beargr	Arthur Draut Park	7/11/2015	E. coli	7/11/2015	9:15:00		880
3386	Middle Fork Beargr	Arthur Draut Park	5/14/2016	E. coli	5/14/2016	12:00:00		426
3386	Middle Fork Beargr	Arthur Draut Park	7/9/2016	E. coli	7/9/2016	9:30:00		486
3386	Middle Fork Beargr	Arthur Draut Park	6/29/2017					
3386	Middle Fork Beargr	Arthur Draut Park	9/9/2017	E. coli	9/9/2017	14:27:00		275
3386	Middle Fork Beargr	Arthur Draut Park	5/12/2018	E. coli	5/12/2018	14:26:00		307.6
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	7/12/2014	E. coli	7/12/2014	10:00:00		1024
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/13/2014	Ammonia (as N)	9/13/2014	12:00:00		0.022
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/13/2014	Chloride	9/13/2014	12:00:00		80.14
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/13/2014	Conductivity	9/13/2014	12:00:00		727
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/13/2014	Nitrate & Nitrite (as N)	9/13/2014	12:00:00		1.521
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/13/2014	Nitrogen, Total	9/13/2014	12:00:00		2.566
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/13/2014	Phosphorus, Total	9/13/2014	12:00:00		0.144
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/13/2014	Solids, Total Suspended	9/13/2014	12:00:00		6.1
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/13/2014	Sulfate	9/13/2014	12:00:00		40.09
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/13/2014	Total Hardness	9/13/2014	12:00:00		278
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	7/11/2015	E. coli	7/11/2015	11:20:00		1000
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/12/2015	Ammonia (as N)	9/12/2015	16:00:00	<	0.05
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/12/2015	Chloride	9/12/2015	16:00:00		69
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/12/2015	Nitrate & Nitrite	9/12/2015	16:00:00		1
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/12/2015	Phosphorus, Total	9/12/2015	16:00:00	<	0.125
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/12/2015	Solids, Total Suspended	9/12/2015	16:00:00		15
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/12/2015	Sulfate	9/12/2015	16:00:00		45
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/12/2015	Total Hardness	9/12/2015	16:00:00		250
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/12/2015	Total Kjeldhal Nitrogen	9/12/2015	16:00:00	<	1
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/12/2015	Turbidity	9/12/2015	16:00:00		1
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	7/9/2016	E. coli	7/9/2016	10:45:00		398
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/10/2016	Ammonia (as N)	9/10/2016	13:00:00	<	0.05
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/10/2016	Nitrate & Nitrite	9/10/2016	13:00:00	<	1
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/10/2016	Phosphorus, Total	9/10/2016	13:00:00	<	0.125
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/10/2016	Total Kjeldhal Nitrogen	9/10/2016	13:00:00	<	1
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	7/8/2017	E. coli	7/8/2017	14:00:00		1291
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/8/2017	E. coli	9/8/2017	16:20:00		209.8

Site ID	Stream Name	Site Location	Sample Date	Analyte Name	Analysis Date	Analysis Time	ResultModifier	Result Value
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	5/12/2018	E. coli	5/12/2018	15:06:00		249.5
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	6/18/2018					
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	7/13/2018	E. coli	7/13/2018	17:17:00		1395.8
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/14/2018	E. coli	9/14/2018	15:53:00		495.9
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	5/9/2019	E. coli	5/9/2019	16:47:00		738
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	7/13/2019	E. coli	7/13/2019	12:41:00		683
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/13/2019	E. coli	9/13/2019	15:30:00		663
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/25/2020					
1784	Middle Fork Beargr	Old Cannons Lane.	6/7/2014	E. coli	7/12/2014	10:00:00		194
1784	Middle Fork Beargr	Old Cannons Lane.	6/7/2014	E. coli	6/7/2014	9:35:00		370
1784	Middle Fork Beargr	Old Cannons Lane.	5/16/2015	E. coli	5/16/2015	9:20:00		194
1784	Middle Fork Beargr	Old Cannons Lane.	9/15/2018	E. coli	9/15/2018	14:36:00		1049.7
1899	Bowman Field Sprir	Intersection of Seneca Valley Rd and PeeWee Reese Ln	5/16/2015	E. coli	5/16/2015	9:00:00		216
1899	Bowman Field Sprir	Intersection of Seneca Valley Rd and PeeWee Reese Ln	9/12/2015	Ammonia (as N)	9/12/2015	16:00:00	<	0.05
1899	Bowman Field Sprir	Intersection of Seneca Valley Rd and PeeWee Reese Ln	9/12/2015	Chloride	9/12/2015	16:00:00		68
1899	Bowman Field Sprir	Intersection of Seneca Valley Rd and PeeWee Reese Ln	9/12/2015	Nitrate & Nitrite	9/12/2015	16:00:00	<	1
1899	Bowman Field Sprir	Intersection of Seneca Valley Rd and PeeWee Reese Ln	9/12/2015	Phosphorus, Total	9/12/2015	16:00:00	<	0.125
1899	Bowman Field Sprir	Intersection of Seneca Valley Rd and PeeWee Reese Ln	9/12/2015	Solids, Total Suspended	9/12/2015	16:00:00	<	2
1899	Bowman Field Sprir	Intersection of Seneca Valley Rd and PeeWee Reese Ln	9/12/2015	Sulfate	9/12/2015	16:00:00		42
1899	Bowman Field Sprir	Intersection of Seneca Valley Rd and PeeWee Reese Ln	9/12/2015	Total Hardness	9/12/2015	16:00:00		215
1899	Bowman Field Sprir	Intersection of Seneca Valley Rd and PeeWee Reese Ln	9/12/2015	Total Kjeldhal Nitrogen	9/12/2015	16:00:00	<	1
1899	Bowman Field Sprir	Intersection of Seneca Valley Rd and PeeWee Reese Ln	9/12/2015	Turbidity	9/12/2015	16:00:00		0
1899	Bowman Field Sprir	Intersection of Seneca Valley Rd and PeeWee Reese Ln	5/14/2016	E. coli	5/14/2016	12:00:00		196
3656	Middle Fork Beargr	Seneca Park, about two tenths of a mile from Pee Wee Reese Wa	6/20/2017					
3656	Middle Fork Beargr	Seneca Park, about two tenths of a mile from Pee Wee Reese Wa	7/8/2017	E. coli	7/8/2017	17:15:00		1529
3656	Middle Fork Beargr	Seneca Park, about two tenths of a mile from Pee Wee Reese Wa	9/9/2017	E. coli	9/9/2017	14:27:00		109
3656	Middle Fork Beargr	Seneca Park, about two tenths of a mile from Pee Wee Reese Wa	5/11/2018	E. coli	5/11/2018	16:13:00		74.9
3656	Middle Fork Beargr	Seneca Park, about two tenths of a mile from Pee Wee Reese Wa	7/13/2018	E. coli	7/13/2018	17:17:00		295.4
3656	Middle Fork Beargr	Seneca Park, about two tenths of a mile from Pee Wee Reese Wa	9/15/2018	E. coli	9/15/2018	15:40:00		882.3
3656	Middle Fork Beargr	Seneca Park, about two tenths of a mile from Pee Wee Reese Wa	5/11/2019	E. coli	5/11/2019	14:20:00		201.1
3656	Middle Fork Beargr	Seneca Park, about two tenths of a mile from Pee Wee Reese Wa	7/13/2019	E. coli	7/13/2019	13:09:00		161
3656	Middle Fork Beargr	Seneca Park, about two tenths of a mile from Pee Wee Reese Wa	9/14/2019	E. coli	9/14/2019	16:05:00		426
2030	Beargrass Creek	Big Rock	5/19/2012					
2030	Beargrass Creek	Big Rock	7/14/2012	E. coli	7/14/2012	11:30:00		280
2030	Beargrass Creek	Big Rock	9/8/2012	Ammonia (as N)	9/8/2012	13:00:00		0.269
2030	Beargrass Creek	Big Rock	9/8/2012	Chloride	9/8/2012	13:00:00		13.58
2030	Beargrass Creek	Big Rock	9/8/2012	Conductivity	9/8/2012	13:00:00		184

Salt River Watershed Watch Middle Fork Beargrass Creek Data

Site ID	Stream Name	Site Location	Sample Date	Analyte Name	Analysis Date	Analysis Time	ResultModifier	Result Value
2030	Beargrass Creek	Big Rock	9/8/2012	Nitrate & Nitrite (as N)	9/8/2012	13:00:00		0.993
2030	Beargrass Creek	Big Rock	9/8/2012	Nitrogen, Total	9/8/2012	13:00:00		1.646
2030	Beargrass Creek	Big Rock	9/8/2012	Phosphorus, Total	9/8/2012	13:00:00		0.111
2030	Beargrass Creek	Big Rock	9/8/2012	Solids, Total Suspended	9/8/2012	13:00:00		41.8
2030	Beargrass Creek	Big Rock	9/8/2012	Sulfate	9/8/2012	13:00:00		5.3
2030	Beargrass Creek	Big Rock	9/8/2012	Total Hardness	9/8/2012	13:00:00		138
2030	Beargrass Creek	Big Rock	5/18/2013	E. coli	5/18/2013	10:00:00		342
2030	Beargrass Creek	Big Rock	7/13/2013	E. coli	7/13/2013	12:00:00		466
2030	Beargrass Creek	Big Rock	9/14/2013	Ammonia (as N)	9/14/2013	13:00:00		0.155
2030	Beargrass Creek	Big Rock	9/14/2013	Chloride	9/14/2013	13:00:00		71.3
2030	Beargrass Creek	Big Rock	9/14/2013	Conductivity	9/14/2013	13:00:00		621
2030	Beargrass Creek	Big Rock	9/14/2013	Nitrate & Nitrite (as N)	9/14/2013	13:00:00		0.344
2030	Beargrass Creek	Big Rock	9/14/2013	Nitrogen, Total	9/14/2013	13:00:00		0.874
2030	Beargrass Creek	Big Rock	9/14/2013	Phosphorus, Total	9/14/2013	13:00:00		0.089
2030	Beargrass Creek	Big Rock	9/14/2013	Solids, Total Suspended	9/14/2013	13:00:00		3.2
2030	Beargrass Creek	Big Rock	9/14/2013	Sulfate	9/14/2013	13:00:00		55.9
2030	Beargrass Creek	Big Rock	9/14/2013	Total Hardness	9/14/2013	13:00:00		228
2030	Beargrass Creek	Big Rock	6/7/2014	E. coli	6/7/2014	9:35:00		808
2030	Beargrass Creek	Big Rock	7/15/2014	E. coli	7/15/2014	10:50:00		824
2030	Beargrass Creek	Big Rock	9/13/2014	Ammonia (as N)	9/13/2014	12:00:00		0.114
2030	Beargrass Creek	Big Rock	9/13/2014	Chloride	9/13/2014	12:00:00		105.78
2030	Beargrass Creek	Big Rock	9/13/2014	Conductivity	9/13/2014	12:00:00		686
2030	Beargrass Creek	Big Rock	9/13/2014	Nitrate & Nitrite (as N)	9/13/2014	12:00:00		1.727
2030	Beargrass Creek	Big Rock	9/13/2014	Nitrogen, Total	9/13/2014	12:00:00		2.382
2030	Beargrass Creek	Big Rock	9/13/2014	Phosphorus, Total	9/13/2014	12:00:00		0.102
2030	Beargrass Creek	Big Rock	9/13/2014	Solids, Total Suspended	9/13/2014	12:00:00		2.4
2030	Beargrass Creek	Big Rock	9/13/2014	Sulfate	9/13/2014	12:00:00		36.91
2030	Beargrass Creek	Big Rock	9/13/2014	Total Hardness	9/13/2014	12:00:00		274
2030	Beargrass Creek	Big Rock	5/16/2015	E. coli	5/16/2015	11:10:00		564
2030	Beargrass Creek	Big Rock	7/11/2015	E. coli	7/11/2015	12:00:00		2020
2030	Beargrass Creek	Big Rock	9/12/2015	Ammonia (as N)	9/12/2015	16:00:00	<	0.05
2030	Beargrass Creek	Big Rock	9/12/2015	Nitrate & Nitrite	9/12/2015	16:00:00	<	1
2030	Beargrass Creek	Big Rock	9/12/2015	Phosphorus, Total	9/12/2015	16:00:00	<	0.125
2030	Beargrass Creek	Big Rock	9/12/2015	Total Kjeldhal Nitrogen	9/12/2015	16:00:00	<	1
2030	Beargrass Creek	Big Rock	9/12/2015	Turbidity	9/12/2015	16:00:00		0
2030	Beargrass Creek	Big Rock	5/14/2016	E. coli	5/14/2016	12:00:00		728
2030	Beargrass Creek	Big Rock	7/9/2016	E. coli	7/9/2016	10:40:00		320

Site ID	Stream Name	Site Location	Sample Date	Analyte Name	Analysis Date	Analysis Time	ResultModifier	Result Value
2030	Beargrass Creek	Big Rock	9/10/2016	Ammonia (as N)	9/10/2016	13:00:00		0.06
2030	Beargrass Creek	Big Rock	9/10/2016	Nitrate & Nitrite	9/10/2016	13:00:00	<	1
2030	Beargrass Creek	Big Rock	9/10/2016	Phosphorus, Total	9/10/2016	13:00:00	<	0.125
2030	Beargrass Creek	Big Rock	9/10/2016	Total Kjeldhal Nitrogen	9/10/2016	13:00:00		2
2030	Beargrass Creek	Big Rock	7/8/2017	E. coli	7/8/2017	17:15:00		1081
2030	Beargrass Creek	Big Rock	5/12/2018	E. coli	5/12/2018	15:06:00		185
2030	Beargrass Creek	Big Rock	7/13/2018	E. coli	7/13/2018	17:17:00		1968.3
1886	Middle Fork Beargr	Big Rock pavilion in Cherokee Park.	6/7/2014	E. coli	6/7/2014	9:35:00		320
1886	Middle Fork Beargr	Big Rock pavilion in Cherokee Park.	5/11/2019	E. coli	5/11/2019	14:20:00		259
1785	Middle Fork Beargr	Cherokee Park Road and Lexington Road.	7/13/2013	E. coli	7/13/2013	12:00:00		538
1785	Middle Fork Beargr	Cherokee Park Road and Lexington Road.	5/12/2018	E. coli	5/12/2018	15:06:00		191.8
1785	Middle Fork Beargr	Cherokee Park Road and Lexington Road.	7/13/2018	E. coli	7/13/2018	14:40:00		7701
1785	Middle Fork Beargr	Cherokee Park Road and Lexington Road.	5/11/2019	E. coli	5/11/2019	14:20:00		253
1785	Middle Fork Beargr	Cherokee Park Road and Lexington Road.	7/13/2019	E. coli	7/13/2019	13:09:00		495
3361	Middle Fork Beargr	On Beargrass Creek Road about a half mile before it meets with L	5/16/2015	E. coli	5/16/2015	11:10:00		124
3361	Middle Fork Beargr	On Beargrass Creek Road about a half mile before it meets with L	7/11/2015	E. coli	7/11/2015	12:00:00		2380
3361	Middle Fork Beargr	On Beargrass Creek Road about a half mile before it meets with L	9/12/2015	Ammonia (as N)	9/12/2015	16:00:00	<	0.05
3361	Middle Fork Beargr	On Beargrass Creek Road about a half mile before it meets with L	9/12/2015	Nitrate & Nitrite	9/12/2015	16:00:00	<	1
3361	Middle Fork Beargr	On Beargrass Creek Road about a half mile before it meets with L	9/12/2015	Phosphorus, Total	9/12/2015	16:00:00	<	0.15
3361	Middle Fork Beargr	On Beargrass Creek Road about a half mile before it meets with L	9/12/2015	Total Kjeldhal Nitrogen	9/12/2015	16:00:00	<	1
3361	Middle Fork Beargr	On Beargrass Creek Road about a half mile before it meets with L	9/12/2015	Turbidity	9/12/2015	16:00:00		0
3361	Middle Fork Beargr	On Beargrass Creek Road about a half mile before it meets with L	5/14/2016	E. coli	5/14/2016	12:00:00		422
3361	Middle Fork Beargr	On Beargrass Creek Road about a half mile before it meets with L	7/9/2016	E. coli	7/9/2016	10:40:00		1578
3361	Middle Fork Beargr	On Beargrass Creek Road about a half mile before it meets with L	9/10/2016	Ammonia (as N)	9/10/2016	13:00:00		0.1
3361	Middle Fork Beargr	On Beargrass Creek Road about a half mile before it meets with L	9/10/2016	Nitrate & Nitrite	9/10/2016	13:00:00		1
3361	Middle Fork Beargr	On Beargrass Creek Road about a half mile before it meets with L	9/10/2016	Phosphorus, Total	9/10/2016	13:00:00	<	0.125
3361	Middle Fork Beargr	On Beargrass Creek Road about a half mile before it meets with L	9/10/2016	Total Kjeldhal Nitrogen	9/10/2016	13:00:00	<	1
3361	Middle Fork Beargr	On Beargrass Creek Road about a half mile before it meets with L	7/8/2017	E. coli	7/8/2017	17:15:00		1119
2068	Middle Fork Beargr	Bridge at Payne Street	9/13/2014	Ammonia (as N)	9/13/2014	13:00:00		0.124
2068	Middle Fork Beargr	Bridge at Payne Street	9/13/2014	Chloride	9/13/2014	13:00:00		106.57
2068	Middle Fork Beargr	Bridge at Payne Street	9/13/2014	Conductivity	9/13/2014	13:00:00		662
2068	Middle Fork Beargr	Bridge at Payne Street	9/13/2014	Nitrate & Nitrite (as N)	9/13/2014	13:00:00		1.664
2068	Middle Fork Beargr	Bridge at Payne Street	9/13/2014	Nitrogen, Total	9/13/2014	13:00:00		2.597
2068	Middle Fork Beargr	Bridge at Payne Street	9/13/2014	Phosphorus, Total	9/13/2014	13:00:00		0.121
2068	Middle Fork Beargr	Bridge at Payne Street	9/13/2014	Solids, Total Suspended	9/13/2014	13:00:00		3.3
2068	Middle Fork Beargr	Bridge at Payne Street	9/13/2014	Sulfate	9/13/2014	13:00:00		37.62
2068	Middle Fork Beargr	Bridge at Payne Street	9/13/2014	Total Hardness	9/13/2014	13:00:00		274

Salt River Watershed Watch Middle Fork Beargrass Creek Data

Site ID	Stream Name	Site Location	Sample Date	Analyte Name	Analysis Date	Analysis Time	ResultModifier	Result Value
2068	Middle Fork Beargr	Bridge at Payne Street	9/12/2015	Ammonia (as N)	9/12/2015	16:00:00		0.07
2068	Middle Fork Beargr	Bridge at Payne Street	9/12/2015	Chloride	9/12/2015	16:00:00		50
2068	Middle Fork Beargr	Bridge at Payne Street	9/12/2015	Nitrate & Nitrite	9/12/2015	16:00:00	<	1
2068	Middle Fork Beargr	Bridge at Payne Street	9/12/2015	Phosphorus, Total	9/12/2015	16:00:00		0.21
2068	Middle Fork Beargr	Bridge at Payne Street	9/12/2015	Solids, Total Suspended	9/12/2015	16:00:00	<	2
2068	Middle Fork Beargr	Bridge at Payne Street	9/12/2015	Sulfate	9/12/2015	16:00:00		31
2068	Middle Fork Beargr	Bridge at Payne Street	9/12/2015	Total Hardness	9/12/2015	16:00:00		171
2068	Middle Fork Beargr	Bridge at Payne Street	9/12/2015	Total Kjeldhal Nitrogen	9/12/2015	16:00:00	<	1
2068	Middle Fork Beargr	Bridge at Payne Street	9/12/2015	Turbidity	9/12/2015	16:00:00		1
2068	Middle Fork Beargr	Bridge at Payne Street	5/13/2017					

Site ID	Stream Name	Site Location	Sample Date	Result Units	MDL	RL	Method	QAFlag
3841	Middle Fork Beargr	Middle Fork Beargrass Creek along Forest Green Trail, Louisville, .	5/11/2019	MPN/100mL	10	10	SM9223B	
3841	Middle Fork Beargr	Middle Fork Beargrass Creek along Forest Green Trail, Louisville, .	7/13/2019	MPN/100mL	0	10	SM9223B	
3841	Middle Fork Beargr	Middle Fork Beargrass Creek along Forest Green Trail, Louisville, .	9/26/2020	MPN/100ml	0	10	SM9223B	
3386	Middle Fork Beargr	Arthur Draut Park	5/16/2015	MPN/100mL	1	1	SM9223B	
3386	Middle Fork Beargr	Arthur Draut Park	7/11/2015	MPN/100mL	1	1	SM9223B	
3386	Middle Fork Beargr	Arthur Draut Park	5/14/2016	MPN/100mL	1	1	SM9223B	
3386	Middle Fork Beargr	Arthur Draut Park	7/9/2016	MPN/100mL	1	1	SM9223B	
3386	Middle Fork Beargr	Arthur Draut Park	6/29/2017					
3386	Middle Fork Beargr	Arthur Draut Park	9/9/2017	MPN/100mL	1		Colilert	
3386	Middle Fork Beargr	Arthur Draut Park	5/12/2018	MPN/100mL	1	1	SM9223B	
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	7/12/2014	MPN/100mL	1	1	SM9223B (ColilertMPN)	
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/13/2014	mg/L	0.02		SM4500NH3-G	
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/13/2014	mg/L	1		SM4500CL-G	
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/13/2014	uS/cm	5		SM2510B	
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/13/2014	mg/L	0.01		SM4500NO3-F	
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/13/2014	mg/L	0.1		SM4500N-C	
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/13/2014	mg/L	0.01		SM4500P-F	
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/13/2014	mg/L	1		SM2540D	
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/13/2014	mg/L	1.5		SM4500SO4-F	
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/13/2014	mg/L	10		SM2340C	
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	7/11/2015	MPN/100mL	1	1	SM9223B	
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/12/2015	mg/L	0.00703	0.05	Hach 10205	
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/12/2015	mg/L	0.05		SM4110B	
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/12/2015	mg/L	0.05		Hach 10206	
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/12/2015	mg/L	0.00829	0.033	SM4500P-E	
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/12/2015	mg/L	3		EPA 160.2	
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/12/2015	mg/L	0.05		SM4110B	
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/12/2015	mg/L	10			
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/12/2015	mg/L	0.288	1	Hach 10242	
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/12/2015	NTU	0.08		SM2130B	
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	7/9/2016	MPN/100mL	1	1	SM9223B	
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/10/2016	mg/L	0.00703	0.05	Hach 10205	
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/10/2016	mg/L	0.2	1	Hach 10206	
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/10/2016	mg/L	0.02487	0.125	SM4500P-E	
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/10/2016	mg/L	0.288	1	Hach 10242	
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	7/8/2017	MPN/100mL	1		Colilert	
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/8/2017	MPN/100mL	1		Colilert	

Site ID	Stream Name	Site Location	Sample Date	Result Units	MDL	RL	Method	QAFlag
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	5/12/2018	MPN/100mL	1	1	SM9223B	
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	6/18/2018					
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	7/13/2018	MPN/100mL	1	10	SM9223B	
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/14/2018	MPN/100mL	1	10	SM9223B	
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	5/9/2019	MPN/100mL	10	10	SM9223B	
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	7/13/2019	MPN/100mL	0	10	SM9223B	
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/13/2019	MPN/100ml	0	10	SM9223B	
1841	Middle Fork Beargr	J. Graham Brown Park, downstream from Browns Ln bridge.	9/25/2020					
1784	Middle Fork Beargr	Old Cannons Lane.	6/7/2014	MPN/100mL	1	1	SM9223B (ColilertMPN)	S
1784	Middle Fork Beargr	Old Cannons Lane.	6/7/2014	MPN/100mL	1	1	SM9223B	
1784	Middle Fork Beargr	Old Cannons Lane.	5/16/2015	MPN/100mL	1	1	SM9223B	
1784	Middle Fork Beargr	Old Cannons Lane.	9/15/2018	MPN/100mL	1	10	SM9223B	
1899	Bowman Field Sprir	Intersection of Seneca Valley Rd and PeeWee Reese Ln	5/16/2015	MPN/100mL	1	1	SM9223B	
1899	Bowman Field Sprir	Intersection of Seneca Valley Rd and PeeWee Reese Ln	9/12/2015	mg/L	0.00703	0.05	Hach 10205	
1899	Bowman Field Sprir	Intersection of Seneca Valley Rd and PeeWee Reese Ln	9/12/2015	mg/L	0.05		SM4110B	
1899	Bowman Field Sprir	Intersection of Seneca Valley Rd and PeeWee Reese Ln	9/12/2015	mg/L	0.05		Hach 10206	
1899	Bowman Field Sprir	Intersection of Seneca Valley Rd and PeeWee Reese Ln	9/12/2015	mg/L	0.00829	0.033	SM4500P-E	
1899	Bowman Field Sprir	Intersection of Seneca Valley Rd and PeeWee Reese Ln	9/12/2015	mg/L	3		EPA 160.2	
1899	Bowman Field Sprir	Intersection of Seneca Valley Rd and PeeWee Reese Ln	9/12/2015	mg/L	0.05		SM4110B	
1899	Bowman Field Sprir	Intersection of Seneca Valley Rd and PeeWee Reese Ln	9/12/2015	mg/L	10			
1899	Bowman Field Sprir	Intersection of Seneca Valley Rd and PeeWee Reese Ln	9/12/2015	mg/L	0.288	1	Hach 10242	
1899	Bowman Field Sprir	Intersection of Seneca Valley Rd and PeeWee Reese Ln	9/12/2015	NTU	0.08		SM2130B	
1899	Bowman Field Sprir	Intersection of Seneca Valley Rd and PeeWee Reese Ln	5/14/2016	MPN/100mL	1	1	SM9223B	
3656	Middle Fork Beargr	Seneca Park, about two tenths of a mile from Pee Wee Reese Wa	6/20/2017					
3656	Middle Fork Beargr	Seneca Park, about two tenths of a mile from Pee Wee Reese Wa	7/8/2017	MPN/100mL	1		Colilert	
3656	Middle Fork Beargr	Seneca Park, about two tenths of a mile from Pee Wee Reese Wa	9/9/2017	MPN/100mL	1		Colilert	
3656	Middle Fork Beargr	Seneca Park, about two tenths of a mile from Pee Wee Reese Wa	5/11/2018	MPN/100mL	1	1	SM9223B	
3656	Middle Fork Beargr	Seneca Park, about two tenths of a mile from Pee Wee Reese Wa	7/13/2018	MPN/100mL	1	10	SM9223B	
3656	Middle Fork Beargr	Seneca Park, about two tenths of a mile from Pee Wee Reese Wa	9/15/2018	MPN/100mL	1	10	SM9223B	
3656	Middle Fork Beargr	Seneca Park, about two tenths of a mile from Pee Wee Reese Wa	5/11/2019	MPN/100mL	10	10	SM9223B	
3656	Middle Fork Beargr	Seneca Park, about two tenths of a mile from Pee Wee Reese Wa	7/13/2019	MPN/100mL	0	10	SM9223B	
3656	Middle Fork Beargr	Seneca Park, about two tenths of a mile from Pee Wee Reese Wa	9/14/2019	MPN/100ml	0	10	SM9223B	
2030	Beargrass Creek	Big Rock	5/19/2012					
2030	Beargrass Creek	Big Rock	7/14/2012	MPN/100mL	1	1	SM9223B	
2030	Beargrass Creek	Big Rock	9/8/2012	mg/L	0.02		SM4500NH3-G	
2030	Beargrass Creek	Big Rock	9/8/2012	mg/L	1		SM4500CL-G	
2030	Beargrass Creek	Big Rock	9/8/2012	uS/cm	5		SM2510B	

Site ID	Stream Name	Site Location	Sample Date	Result Units	MDL	RL	Method	QAFlag
2030	Beargrass Creek	Big Rock	9/8/2012	mg/L	0.01		SM4500NO3-F	
2030	Beargrass Creek	Big Rock	9/8/2012	mg/L	0.1		SM4500N-C	
2030	Beargrass Creek	Big Rock	9/8/2012	mg/L	0.01		SM4500P-F	
2030	Beargrass Creek	Big Rock	9/8/2012	mg/L	1		SM2540D	
2030	Beargrass Creek	Big Rock	9/8/2012	mg/L	1.5		SM4500SO4-F	
2030	Beargrass Creek	Big Rock	9/8/2012	mg/L	10		SM2340C	
2030	Beargrass Creek	Big Rock	5/18/2013	MPN/100mL	1	1	Colilert	
2030	Beargrass Creek	Big Rock	7/13/2013	MPN/100mL	1	1	Colilert	
2030	Beargrass Creek	Big Rock	9/14/2013	mg/L	0.02		SM4500NH3-G	
2030	Beargrass Creek	Big Rock	9/14/2013	mg/L	1		SM4500CL-G	
2030	Beargrass Creek	Big Rock	9/14/2013	uS/cm	5		SM2510B	
2030	Beargrass Creek	Big Rock	9/14/2013	mg/L	0.01		SM4500NO3-F	
2030	Beargrass Creek	Big Rock	9/14/2013	mg/L	0.1		SM4500N-C	
2030	Beargrass Creek	Big Rock	9/14/2013	mg/L	0.01		SM4500P-F	
2030	Beargrass Creek	Big Rock	9/14/2013	mg/L	1		SM2540D	
2030	Beargrass Creek	Big Rock	9/14/2013	mg/L	1.5		SM4500SO4-F	
2030	Beargrass Creek	Big Rock	9/14/2013	mg/L	10		SM2340C	
2030	Beargrass Creek	Big Rock	6/7/2014	MPN/100mL	1	1	SM9223B	
2030	Beargrass Creek	Big Rock	7/15/2014	MPN/100mL	1	1	SM9223B (ColilertMPN)	
2030	Beargrass Creek	Big Rock	9/13/2014	mg/L	0.02		SM4500NH3-G	
2030	Beargrass Creek	Big Rock	9/13/2014	mg/L	1		SM4500CL-G	
2030	Beargrass Creek	Big Rock	9/13/2014	uS/cm	5		SM2510B	
2030	Beargrass Creek	Big Rock	9/13/2014	mg/L	0.01		SM4500NO3-F	
2030	Beargrass Creek	Big Rock	9/13/2014	mg/L	0.1		SM4500N-C	
2030	Beargrass Creek	Big Rock	9/13/2014	mg/L	0.01		SM4500P-F	
2030	Beargrass Creek	Big Rock	9/13/2014	mg/L	1		SM2540D	
2030	Beargrass Creek	Big Rock	9/13/2014	mg/L	1.5		SM4500SO4-F	
2030	Beargrass Creek	Big Rock	9/13/2014	mg/L	10		SM2340C	
2030	Beargrass Creek	Big Rock	5/16/2015	MPN/100mL	1	1	SM9223B	
2030	Beargrass Creek	Big Rock	7/11/2015	MPN/100mL	1	1	SM9223B	
2030	Beargrass Creek	Big Rock	9/12/2015	mg/L	0.00703	0.05	Hach 10205	
2030	Beargrass Creek	Big Rock	9/12/2015	mg/L	0.05		Hach 10206	
2030	Beargrass Creek	Big Rock	9/12/2015	mg/L	0.00829	0.033	SM4500P-E	
2030	Beargrass Creek	Big Rock	9/12/2015	mg/L	0.288	1	Hach 10242	
2030	Beargrass Creek	Big Rock	9/12/2015	NTU	0.08		SM2130B	
2030	Beargrass Creek	Big Rock	5/14/2016	MPN/100mL	1	1	SM9223B	
2030	Beargrass Creek	Big Rock	7/9/2016	MPN/100mL	1	1	SM9223B	

Site ID	Stream Name	Site Location	Sample Date	Result Units	MDL	RL	Method	QAFlag
2030	Beargrass Creek	Big Rock	9/10/2016	mg/L	0.00703	0.05	Hach 10205	
2030	Beargrass Creek	Big Rock	9/10/2016	mg/L	0.2	1	Hach 10206	
2030	Beargrass Creek	Big Rock	9/10/2016	mg/L	0.02487	0.125	SM4500P-E	
2030	Beargrass Creek	Big Rock	9/10/2016	mg/L	0.288	1	Hach 10242	
2030	Beargrass Creek	Big Rock	7/8/2017	MPN/100mL	1		Colilert	
2030	Beargrass Creek	Big Rock	5/12/2018	MPN/100mL	1	1	SM9223B	
2030	Beargrass Creek	Big Rock	7/13/2018	MPN/100mL	1	10	SM9223B	
1886	Middle Fork Beargr	Big Rock pavilion in Cherokee Park.	6/7/2014	MPN/100mL	1	1	SM9223B	
1886	Middle Fork Beargr	Big Rock pavilion in Cherokee Park.	5/11/2019	MPN/100mL	10	10	SM9223B	
1785	Middle Fork Beargr	Cherokee Park Road and Lexington Road.	7/13/2013	MPN/100mL	1	1	Colilert	
1785	Middle Fork Beargr	Cherokee Park Road and Lexington Road.	5/12/2018	MPN/100mL	1	1	SM9223B	
1785	Middle Fork Beargr	Cherokee Park Road and Lexington Road.	7/13/2018	MPN/100mL	1	10	SM9223B	
1785	Middle Fork Beargr	Cherokee Park Road and Lexington Road.	5/11/2019	MPN/100mL	10	10	SM9223B	
1785	Middle Fork Beargr	Cherokee Park Road and Lexington Road.	7/13/2019	MPN/100mL	0	10	SM9223B	
3361	Middle Fork Beargr	On Beargrass Creek Road about a half mile before it meets with L	5/16/2015	MPN/100mL	1	1	SM9223B	
3361	Middle Fork Beargr	On Beargrass Creek Road about a half mile before it meets with L	7/11/2015	MPN/100mL	1	1	SM9223B	
3361	Middle Fork Beargr	On Beargrass Creek Road about a half mile before it meets with L	9/12/2015	mg/L	0.00703	0.05	Hach 10205	
3361	Middle Fork Beargr	On Beargrass Creek Road about a half mile before it meets with L	9/12/2015	mg/L	0.05		Hach 10206	
3361	Middle Fork Beargr	On Beargrass Creek Road about a half mile before it meets with L	9/12/2015	mg/L	0.00829	0.033	SM4500P-E	
3361	Middle Fork Beargr	On Beargrass Creek Road about a half mile before it meets with L	9/12/2015	mg/L	0.288	1	Hach 10242	
3361	Middle Fork Beargr	On Beargrass Creek Road about a half mile before it meets with L	9/12/2015	NTU	0.08		SM2130B	
3361	Middle Fork Beargr	On Beargrass Creek Road about a half mile before it meets with L	5/14/2016	MPN/100mL	1	1	SM9223B	
3361	Middle Fork Beargr	On Beargrass Creek Road about a half mile before it meets with L	7/9/2016	MPN/100mL	1	1	SM9223B	
3361	Middle Fork Beargr	On Beargrass Creek Road about a half mile before it meets with L	9/10/2016	mg/L	0.00703	0.05	Hach 10205	
3361	Middle Fork Beargr	On Beargrass Creek Road about a half mile before it meets with L	9/10/2016	mg/L	0.2	1	Hach 10206	
3361	Middle Fork Beargr	On Beargrass Creek Road about a half mile before it meets with L	9/10/2016	mg/L	0.02487	0.125	SM4500P-E	
3361	Middle Fork Beargr	On Beargrass Creek Road about a half mile before it meets with L	9/10/2016	mg/L	0.288	1	Hach 10242	
3361	Middle Fork Beargr	On Beargrass Creek Road about a half mile before it meets with L	7/8/2017	MPN/100mL	1		Colilert	
2068	Middle Fork Beargr	Bridge at Payne Street	9/13/2014	mg/L	0.02		SM4500NH3-G	
2068	Middle Fork Beargr	Bridge at Payne Street	9/13/2014	mg/L	1		SM4500CL-G	
2068	Middle Fork Beargr	Bridge at Payne Street	9/13/2014	uS/cm	5		SM2510B	
2068	Middle Fork Beargr	Bridge at Payne Street	9/13/2014	mg/L	0.01		SM4500NO3-F	
2068	Middle Fork Beargr	Bridge at Payne Street	9/13/2014	mg/L	0.1		SM4500N-C	
2068	Middle Fork Beargr	Bridge at Payne Street	9/13/2014	mg/L	0.01		SM4500P-F	
2068	Middle Fork Beargr	Bridge at Payne Street	9/13/2014	mg/L	1		SM2540D	
2068	Middle Fork Beargr	Bridge at Payne Street	9/13/2014	mg/L	1.5		SM4500SO4-F	
2068	Middle Fork Beargr	Bridge at Payne Street	9/13/2014	mg/L	10		SM2340C	

Site ID	Stream Name	Site Location	Sample Date	Result Units	MDL	RL	Method	QAFlag
2068	Middle Fork Beargr	Bridge at Payne Street	9/12/2015	mg/L	0.00703	0.05	Hach 10205	
2068	Middle Fork Beargr	Bridge at Payne Street	9/12/2015	mg/L	0.05		SM4110B	
2068	Middle Fork Beargr	Bridge at Payne Street	9/12/2015	mg/L	0.05		Hach 10206	
2068	Middle Fork Beargr	Bridge at Payne Street	9/12/2015	mg/L	0.00829	0.033	SM4500P-E	
2068	Middle Fork Beargr	Bridge at Payne Street	9/12/2015	mg/L	3		EPA 160.2	
2068	Middle Fork Beargr	Bridge at Payne Street	9/12/2015	mg/L	0.05		SM4110B	
2068	Middle Fork Beargr	Bridge at Payne Street	9/12/2015	mg/L	10			
2068	Middle Fork Beargr	Bridge at Payne Street	9/12/2015	mg/L	0.288	1	Hach 10242	
2068	Middle Fork Beargr	Bridge at Payne Street	9/12/2015	NTU	0.08		SM2130B	
2068	Middle Fork Beargr	Bridge at Payne Street	5/13/2017					

APPENDIX 2.2 SALT RIVER WATERSHED WATCH BIG ROCK FINAL REPORT

Big Rock Bacteria Monitoring Project
1999-2008

Final Report

Salt River Watershed Watch
Louisville, Kentucky
December 2008

Acknowledgments

Salt River Watershed Watch recognizes these citizen volunteers who participated as water quality monitors in the project:

- Jean Fenn
- Stephanie Glasford
- Dorothy Gray
- Ken Machtolff
- Trina Palma
- Conrad Selle
- Lynn Schmidt
- Sandy Shroerlucke
- Dan and Anne Siebert
- Jack Still

Bruce Scott coordinated the volunteers, kept records, and prepared this report in addition to monitoring.

In turn, the citizen monitors thank the following people and their organizations for supporting the project:

- Sarah Wolfe and Katie Green, Olmsted Parks Conservancy
- Bud Shardein, Executive Director of the Louisville and Jefferson County Metropolitan Sewer Department
- Beckmar Environmental Laboratory, Louisville, Kentucky
- Judy Petersen, Kentucky Waterways Alliance
- Russ Barnett, Chair of the Steering Committee of Salt River Watershed Watch
- Ken Cooke and Kathy Ward, Water Watch, Kentucky Division of Water

We are grateful to Karen Schaffer, the current Science Coordinator for the SRWW Steering Committee, for her review of this report prior to publication.

We would like to dedicate our report to the late Dr. Jeff Jack who, as a member of the Biology Department of the University of Louisville, advised Salt River Watershed Watch and the Big Rock volunteers on the design of their studies.

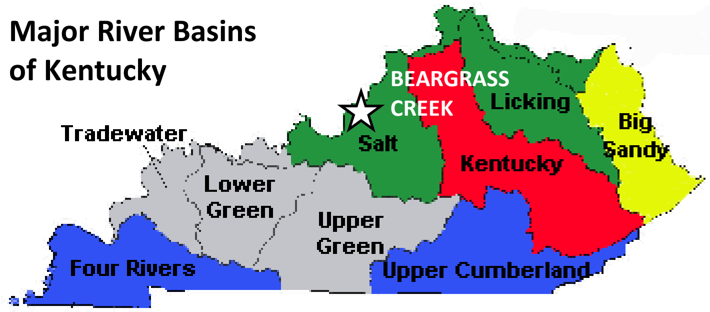
Printed copies are available for purchase, using the code number on the rear cover, at:
www.lulu.com
To request an electronic copy of the report and/or data:
bwscott@fewpb.net

Big Rock Bacteria Monitoring Project
1999-2008
Final Report

For nine years (June 1999– May 2008), citizen volunteers associated with Salt River Watershed Watch monitored bacteria that pollutes “Big Rock,” an area in Louisville’s Cherokee Park that is used for wading and swimming. This is a final report on the project.

Salt River Watershed Watch

Salt River Watershed Watch (SRWW) is one of eight regional citizen monitoring programs that together span Kentucky’s watersheds. SRWW concentrates on the Salt River basin and watersheds of the minor Ohio River tributaries that neighbor it.



Source: Kentucky Division of Water

SRWW and its sister programs are based on the concept of watershed health. In addition to natural conditions such as soils, precipitation, and geology, a stream is affected by human activities on its watershed. A stream is also affected by groundwater flows, especially in areas of karst where underlying bedrock has been dissolved and permits the rapid transport of water (and pollutants) underground.

For the most part, SRWW monitors streams at locations chosen by volunteers. In addition to gathering information about dissolved oxygen, pH, temperature, and flow, volunteers sample for herbicides and pesticides in the spring, bacteria in the summer, and “low-flow” parameters in the fall. SRWW also may authorize volunteer teams to undertake “focus studies,” such as the Big Rock study.

Children swimming at Big Rock, 1998. Photo credit: Karen Cairns

Big Rock

Big Rock is a streamside recreational area in Cherokee Park in Louisville, Kentucky. Opened in 1892, the park was laid out along the Middle Fork of Beargrass Creek by its designer, noted American landscape architect Frederick Law Olmsted. The “big rock” itself fell from a cliff above; scouring from floods has created a pool enjoyed by summertime swimmers.

Upstream from the big rock, the level limestone shelves of the stream bottom attract waders of all ages who visit a picnic and play area overlooking the stream. A nearby trailhead demonstrates Best

Management Practices for stormwater. The area is posted with signs warning against contact with the water after storms.

Beargrass Creek

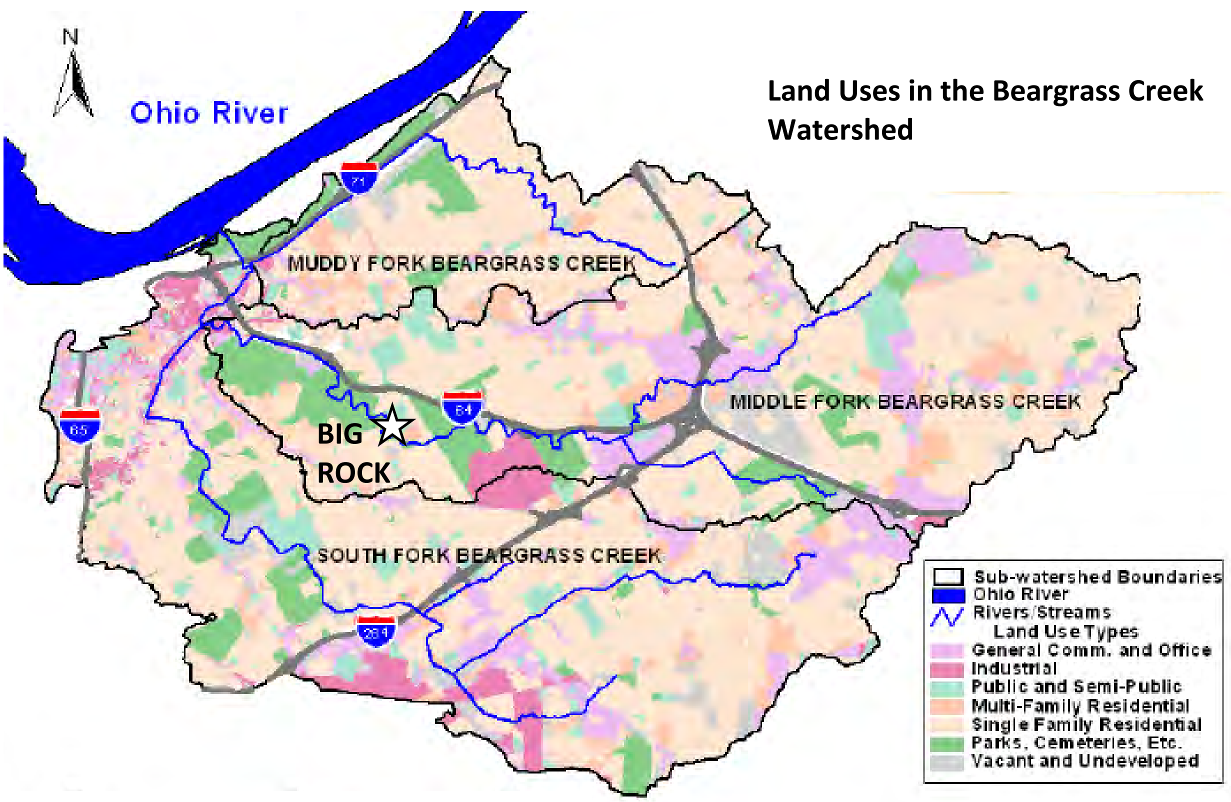
Beargrass Creek lies entirely within Jefferson County, Kentucky. Its political jurisdiction is primarily Metro Louisville, the combined city-county government, but several smaller cities including St. Matthews and Lyndon are other jurisdictions that its streams traverse.

The stream system consists of three major forks: the Muddy Fork (6.9 miles), the Middle Fork (15.8 miles), and the South Fork (13.6 miles). The three forks converge on a channel that formerly flowed across downtown Louisville; the original channel was closed in the 1850s and flow was diverted north through a new channel, called the Main Stem, to the point where it now joins the Ohio River near Eva Bandman Park. The entire watershed of Beargrass Creek covers 60 square miles, and is home to about 200,000 people. (1)

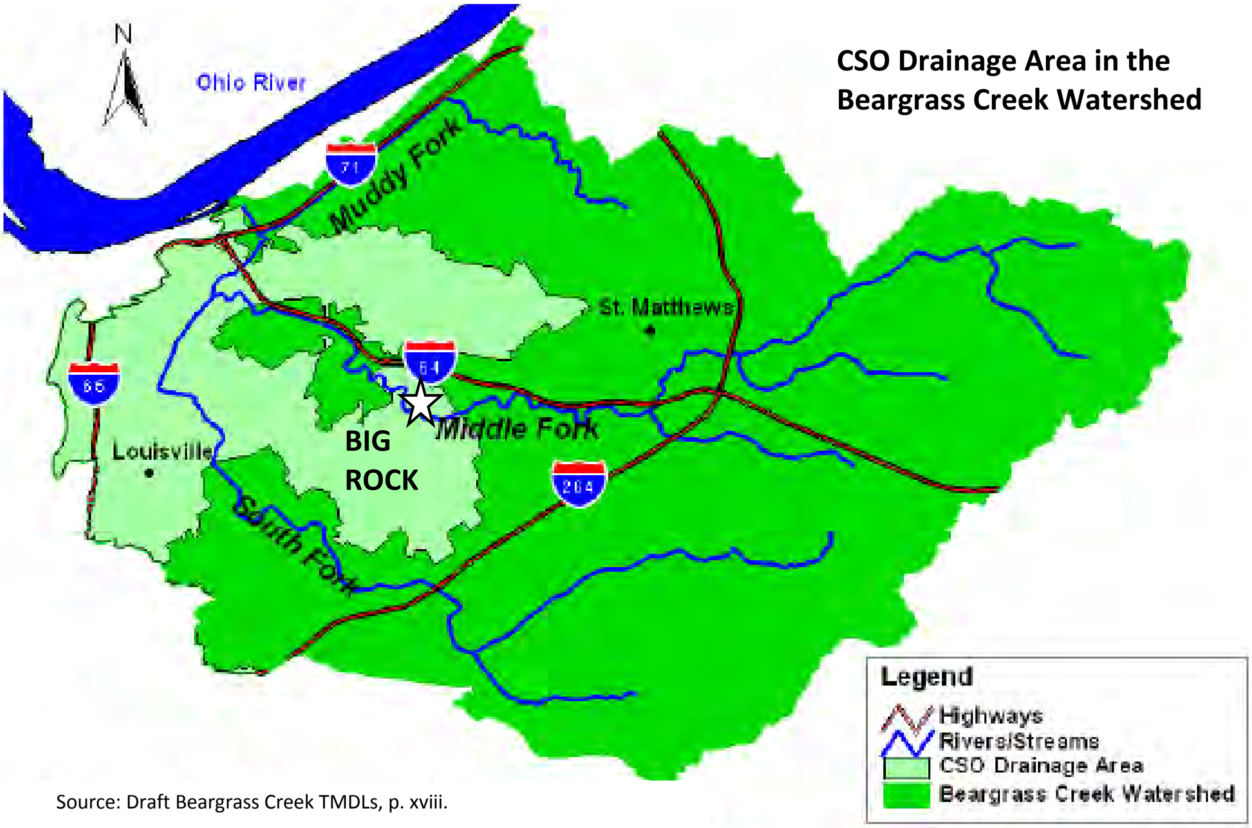
Big Rock is located in the Middle Fork watershed, which drains a surface area of 25 square miles. Land uses are primarily residential (see map, below). Extensive stretches of the stream are bordered by parklands including two of Louisville's historically significant "Olmsted Parks," Seneca and Cherokee, as well as newer parks and greenways developed by the cities of St. Matthews and Lyndon. About ten percent of the watershed is categorized as industrial. (2)

The watershed at and upstream of Big Rock is characterized by karst. Therefore, groundwater is an important consideration in the stream's hydrology.

Land Uses in the Beargrass Creek Watershed



Source: draft Beargrass Creek TMDLs, p. 11.



Source: Draft Beargrass Creek TMDLs, p. xviii.

One of the biggest challenges facing an urbanizing watershed like Beargrass is the extent of impervious surfaces such as roads, parking lots, and building roofs. Impervious surfaces prevent stormwater from recharging aquifers; furthermore, rainfall is more likely to sweep pollutants, including significant amounts of pathogens, from impervious surfaces to streams without benefit of treatment from a vegetative buffer. The overall imperviousness of the Middle Fork was estimated in 1998 by MSD as 39 percent (3). A more recent study identified several subwatersheds with imperviousness in the range of 10-25 percent, although large areas including the headwaters in the City of Hurstbourne exceeded 25 percent, a threshold value in the literature that indicates that water quality becomes poor if Best Management Practices aren't installed to mitigate the effects of impervious surfaces. (4)

Another major influence on water quality in the Middle Fork of Beargrass Creek is the city's sewer system. Developed areas around Big Rock are within the combined sewer system built previous to World War II that carries both stormwater and sanitary waste (see map, above). During storms, stormwater overwhelms the system and strategically located overflows discharge the excess to the creek so that sewage doesn't back up into homes.

Combined sewer overflow (CSO) volumes in the Middle Fork are dwarfed by the volume of stormwater carrying pathogens that flows off the watershed during storms. A 2008 draft document estimating the Total Maximum Daily Load (TMDL) permissible for pathogens in Beargrass Creek estimated that CSO discharges, themselves consisting of wastewater and stormwater, account for only seventeen percent of the flow of the Middle Fork of Beargrass Creek. (5). The report also identifies aging sewer pipes as sources of pathogens during wet and dry weather. (6) It is important to note that no CSOs are located upstream of Big Rock; in addition, MSD has surveyed stormwater facilities to eliminate sanitary-storm system cross-connections.

Table 1.7 Aggregate Summary of Wastewater and Stormwater Statistics by Sub-basin

SUB-WATERSHED	Area (sqmi)	% Impervious	# Documented SSO Locations	# Documented CSO Locations	# Detention Basins
BEARGRASS					
	1.9	10.3	0	10	0
MIDDLE FORK BEARGRASS CREEK					
	25.0	22.2	132	12	17
MUDDY FORK BEARGRASS CREEK					
	7.5	11.4	15	0	3
SOUTH FORK BEARGRASS CREEK					
	26.4	29.1	110	38	23

Ruling out CSO and SSO contributions, potential sources of elevated pathogens at Big Rock would include:

- Stormwater from impervious surfaces;
- Animal feces from pets and wildlife;
- Failing or poorly sited septic tanks;
- Sanitary sewer overflows; and
- Aging, cracked sanitary sewers.

Water Quality Studies

When the project began, not much data was available about the water quality of the Middle Fork of Beargrass Creek. MSD had intermittently monitored pathogen and other parameters, mostly to assess the functioning of its combined sewer system. Still, the efforts established baseline conditions for further study of the stream's overall health.

In 2003, four years after SRWW's Big Rock project began, MSD established a comprehensive monitoring program in their service area's watersheds. In the Beargrass Creek watershed, five monitoring stations were established to gather data on flow, dissolved oxygen, temperature, and other basic parameters every fifteen minutes. Pathogens are sampled at the sites five times monthly to develop information for regulatory compliance. The diversity of aquatic life-forms, including fish, macro-invertebrates, and algae, are sampled every two years.

MSD's monitoring sites on the Middle Fork are at the intersection of Park and Beals Branch roads in Cherokee Park, downstream from Big Rock, and at Old Cannons Lane and Seneca Park Road, which is upstream. An additional site was established more recently in the lower reach of the Middle Fork where it joins the main stem to assist in the development of the TMDL for pathogens.

A report issued by MSD in 2005 summarized data collected from Beargrass stations in MSD's new monitoring network. The findings for pathogens were not quantified, but displayed in pie charts that show that the percent of samples that did not meet state single-sample standard for primary contact range from approximately 20 percent in the headwaters to about 45 percent in the lowlands. Dissolved oxygen problems were rare in the headwaters but increased to approximately 25 percent of samples in the lowlands. Aquatic life had been measured in two locations: at Old Cannons Lane, where biodiversity was rated “poor,” and at Browns Lane, somewhat upstream, where it was rated “fair.” (7)

Based primarily on data provided by MSD, the Kentucky Division of Water considers the stretch of the Middle Fork of Beargrass Creek where Big Rock is located “impaired” for primary recreation contact due to elevated pathogens. (8)

History of the Project

In its planning meetings in the winter of 1999, the Steering Committee of SRWW identified a monitoring program at Big Rock as a desirable focus study. The committee suggested at least the minimum number of samples required by regulation (9) to characterize the stream’s condition in respect to pathogens.

The regulation governing recreational contact establishes a two-fold standard:

1. A single sample cannot exceed 400 colonies/ 100 ml; *and*
2. A geometric mean of at least five samples in a month cannot exceed 200 colonies/ 100 ml. A geometric mean is the square root of the sum of the squares of the items; it serves to “calm” a wide range of values and usually results in a lower number than an average.

Because of the second standard, five samples per month were ideal. Five volunteers were trained to sample the stream once a month according to a schedule established by the coordinator for the project.

The regulation identifies May through October as the “recreational season” when the standards apply, so monitoring was planned to begin in May, 1999; it actually began in June. That summer was unusual, marked by drought when the standards do not apply, creating a desire for more information; furthermore, volunteer samplers in the project were highly motivated and wanted the sampling to continue. Therefore, the Steering Committee authorized the indefinite continuation of the project.

MSD Biologist Jerry Terhune trains project samplers at the Big Rock picnic pavilion. From left, Conrad Selle, Dorothy Gray, and Trina Palmer.

Turnover among volunteer samplers at the end of the first and second summers required special recruitment and training for citizens from the adjoining neighborhoods who observed sampling activities and volunteered. Two special trainings were provided, in October 1999 and September 2000.

Monitoring results were shared with the community in a variety of ways. Reports on the project were made to SRWW’s annual conferences in 2000, 2003, and 2006. The Friends of Beargrass Creek, now defunct, published results in its quarterly newsletters for the first several years of the project.

At the invitation of the Jefferson County Health Department, a presentation on the results was made in 2002 to the Health Board. A poster developed with support from MSD was displayed at the “Big Rock Jazz Festival” in 2003. The project also received coverage in Louisville’s daily newspaper, the *Courier Journal*.

The project provided a platform for participation by volunteers in planning for the Beargrass Creek watershed. Two volunteers, Kenny Machtolff and Bruce Scott, were members of the Beargrass Creek Watershed Council that met under MSD auspices from 2002 to 2004. One tangible result of the Council's work was the installation in 2005 of a kiosk at Big Rock where the project's results could be posted. The kiosk was a cooperative project among the Council, MSD, Metro Parks, Kentucky Waterways Alliance, and the EPA, which provided matching funds.

The kiosk at Big Rock, where project data and water quality information were posted in cooperation with Metro Parks.

Design of the Study

The hypothesis of the study was that pathogen concentrations in the stream increase during storms. We believed this would occur because of two factors:

- Urban runoff of rainfall during storms is known to have high concentrations of pathogens and
- While there are no combined sewer overflows upstream of the study area, the aging sewers in the area as well as overflows from infiltration into upstream sanitary sewers will also contribute pathogens, again during storms.

In keeping with SRWW's sampling protocols, the study included the collection of these streamside parameters:

- Water temperature in degrees Centigrade;
- Characterization of flow (ponded, low, normal, bank full, flood);

The monitoring site, downstream of the Belknap Bridge and below Big Rock picnic pavilion. This shot is looking east and upstream.

- Characterization of recent rainfall in half-inch ranges;
- Dissolved oxygen in milligrams per liter; and
- pH.

Data for dissolved oxygen and pH were obtained using LaMotte kits. During the visit, streamside data were recorded on a standard SRWW chain of custody form (see Appendix). Samples were collected in accordance with Watershed Watch procedures. (10) Samples with chain of custody forms were transported to Beckmar Environmental Laboratory immediately after sample collection. Beckmar, which is certified by the Kentucky Division of Water to perform bacteria analysis, sent its analysis report with the chain of custody document to the coordinator of the project, who entered the data on a spreadsheet.

Original documents were sent by the coordinator to the Water Watch program of the Kentucky Division of Water in Frankfort, Kentucky, where they are archived.

Results

The tables below show whether monitoring results each month during the recreation season met the two-fold regulatory standard established by the Kentucky Division of Water (summarized in this report on page seven). "OK" means that the two-fold standard was met; "Fail" means that one or both of the standards were not met. (Results for 1999 are not included because the year was marked by drought, when the standards don't apply.)

At Big Rock, Beargrass Creek almost never meets water quality standards for primary contact recreation (swimming); of the 49 months included in the study, the standard was met only during one month, or two percent of the time. However, the stream often met standards for secondary contact (canoeing, wading, fishing but not for consumption); in 21 of the 49 months, or forty percent of the time, secondary contact standards were met.

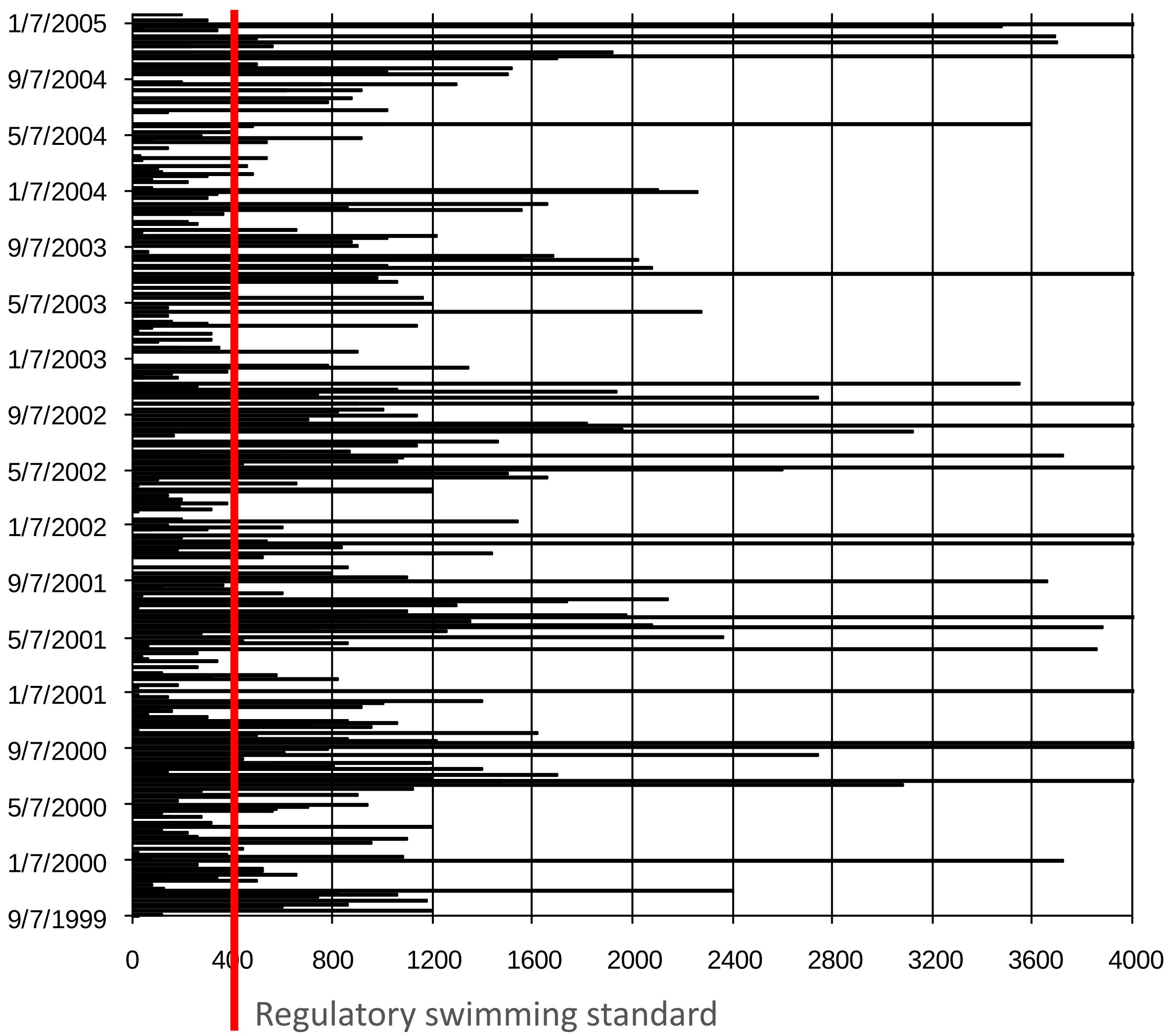
Primary Contact Recreation (Swimming)

	2000	2001	2002	2003	2004	2005	2006	2007	2008
May	Fail	Fail	Fail	Fail	Fail	OK	Fail	Fail	Fail
June	Fail	Fail	Fail	Fail	Fail	Fail	Fail	Fail	
July	Fail	Fail	Fail	Fail	Fail	Fail	Fail	Fail	
August	Fail	Fail	Fail	Fail	Fail	Fail	Fail	Fail	
September	Fail	Fail	Fail	Fail	Fail	Fail	Fail	Fail	
October	Fail	Fail	Fail	Fail	Fail	Fail	Fail	Fail	

Secondary Contact Recreation (Canoeing, Fishing, etc.)

	2000	2001	2002	2003	2004	2005	2006	2007	2008
May	OK	Fail	Fail	OK	Fail	OK	OK	OK	OK
June	Fail	Fail	Fail	OK	OK	Fail	Fail	Fail	
July	OK	Fail	Fail	Fail	OK	OK	Fail	Fail	
August	Fail	OK	Fail	Fail	OK	Fail	OK	Fail	
September	Fail	Fail	Fail	OK	OK	Fail	Fail	Fail	
October	OK	OK	Fail	OK	Fail	OK	OK	Fail	

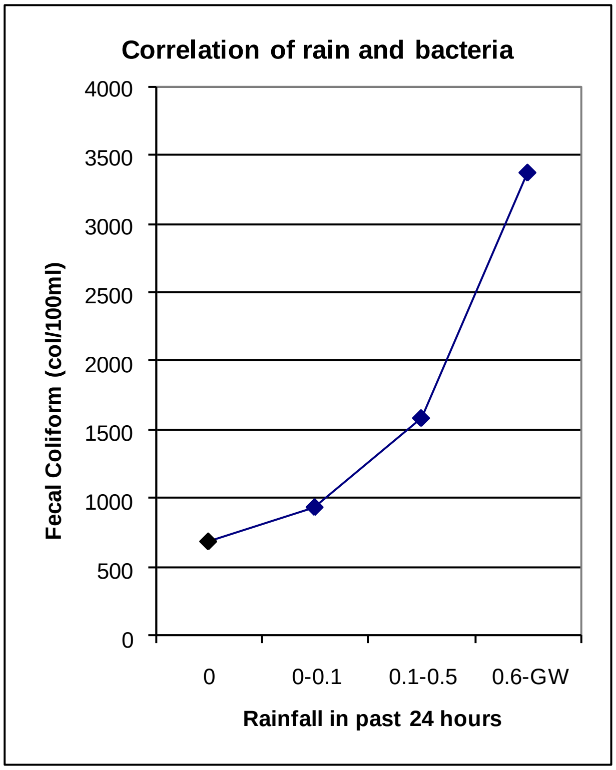
Fecal coliform colonies/ 100 ml, 1999-2004

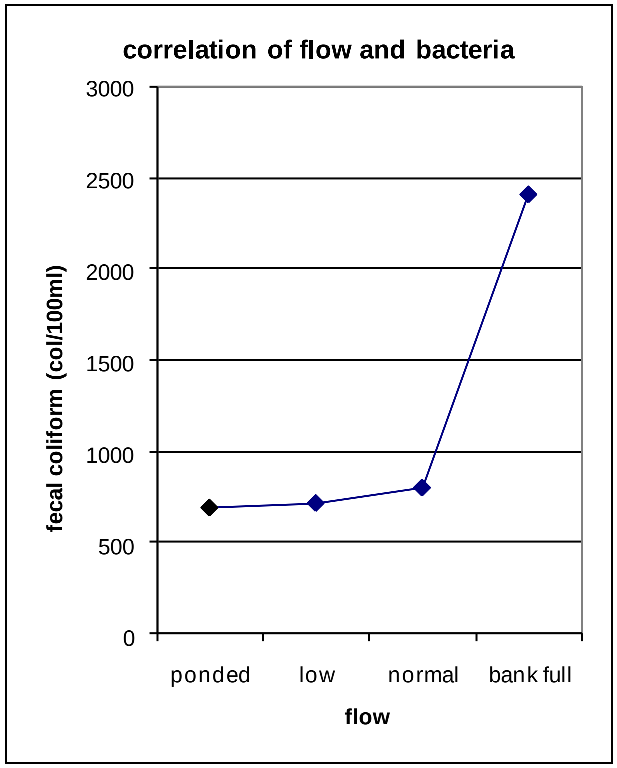


A closer look at the data (chart, above) reveals the nature of the measure we used to measure pathogen pollution in the stream. The chart includes all data from the first six years of the project, and is not limited to the recreation months. To preserve the scale, values exceeding 4000 are cut off.

As can be observed in the chart, pathogen counts vary widely. While variation is certainly due to differences in flow and recent rainfall, limitations on the accuracy of the measure were observed. On eight occasions duplicate samples were taken because of the random nature of the schedules of some volunteers), and the table to the right reveals the range in their values.

date	first value	second value
12/28/01	300	80
6/19/02	600	870
2/27/03	140	320
10/20/04	760	1700
5/31/05	180	40
12/15/06	180	580
2/28/07	100	90
12/19/07	800	440





Analysis of correspondences between average fecal coliform colonies and flow and recent rainfall (N=274). In the chart on the left, rainfall is in inches; "GW" indicates "gullywasher," a major downpour.

Although values ranged widely, trends emerged that validated our hypothesis when results were aggregated by "recent rainfall" or "flow" (charts, above).

Consistent with our findings about primary contact recreation, the average number of fecal coliform colonies at times of no **recent rainfall** exceeded the single sample standard of 400, but was less than the secondary contact standard of 2000. The secondary contact standard was only exceeded when recent rainfall exceeded 0.5 inches.

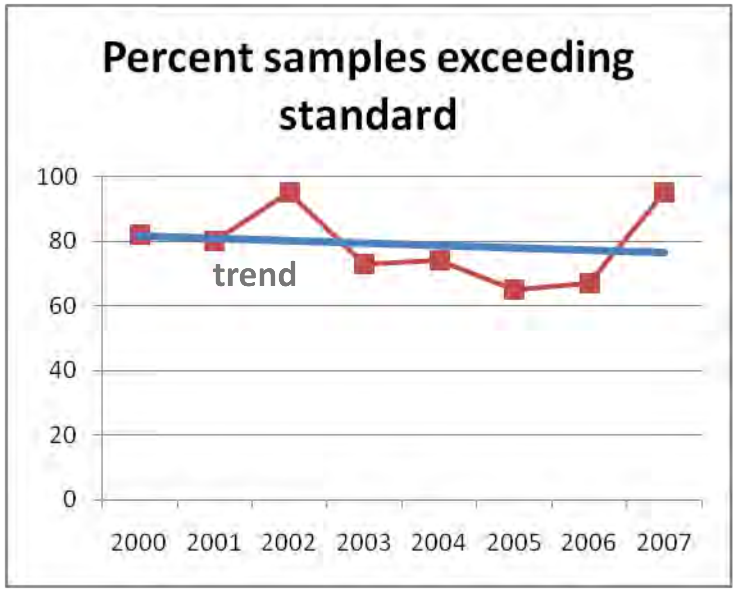
A similar finding occurred when the number of fecal coliform colonies was compared to the characterization of **flow**. The secondary contact standard was met, on average, until flow exceeded normal conditions and the banks of the stream were full. (Flood conditions were rarely sampled for safety reasons.)

With nine years of weekly data points, it was inevitable to ask the data whether pathogen concentrations were increasing or decreasing over time. MSD had made efforts during the project period to reduce flows from sewer overflows and septic tanks, Metro Parks was reducing mowing along stream banks to help filter stormwater runoff, and various public education campaigns on nonpoint sources like dog droppings had occurred.

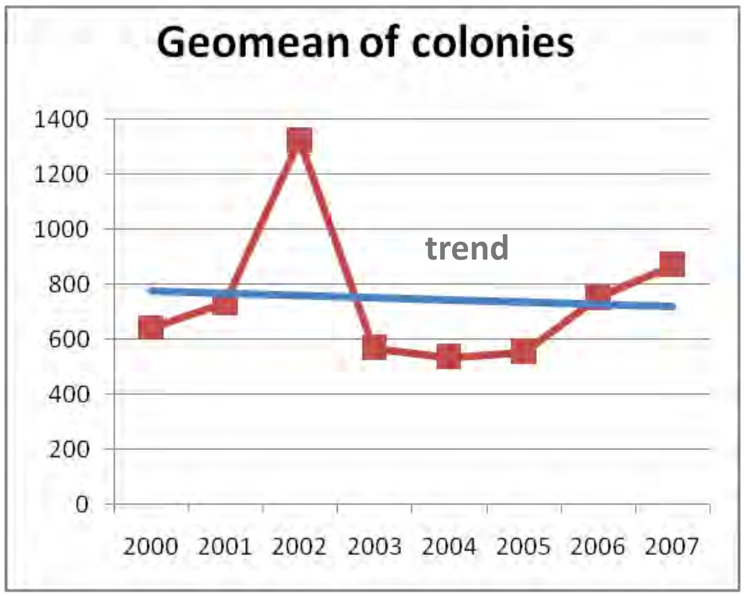
By arraying data from 174 data points for low and normal flows over the nine years of the project, a definite trend of improvement appeared in water quality as plotted by the MS Excel program we used (see charts on next page). The trend was apparent when the data was arrayed by percent exceeding the single-sample standard and by geometric means of the data. The year 2002 was an outlier in the data, but did not effect the trend lines when eliminated from the analysis.

Several caveats are necessary when discussing these results.

First, no Quality Assurance Project Plan was developed for the study. Neither duplicate nor blank samples were obtained for quality assurance purposes, although some duplicates were unintentionally generated as noted above and may be useful for quality analysis.



Second, when an average of our data is said to attain a standard, it must be understood that many of the values included in that average grossly exceed it. In a study prepared for the SRWW Annual Conference in January, 2007, a subset of 63 samples were selected where recent rainfall was zero and flow was characterized as normal. The samples had a geometric mean of 349, but ranged between 0 and 6240. Seventy percent (44 of the 63 samples) were below the primary contact single sample standard of 400; however, 21 percent (n = 14) were in the 400-2000 range, and nine percent (n = 6) exceeded the secondary contact single sample standard of 2000.



A final caution is the relationship of fecal coliform colonies to health risk. EPA studies estimate a risk of six additional illnesses per thousand people who have full body contact with water exceeding the state regulatory criteria used by the study. There is no certainty that someone who contacts the water under any circumstances will get sick; at the same time, a person with open wounds or a compromised immune system will be at greater risk than healthy individuals.

Conclusions

Our study's hypothesis was that pathogen concentrations increase during storms. We found that pathogen concentrations increase during wet weather and the higher flows that result.

We also made these findings:

- Standards for primary recreational contact (swimming, full immersion baptism, etc.) are rarely met during normal flow conditions;

- Standards for secondary recreational contact (wading, canoeing, recreational fishing, etc.) are often met during normal flow conditions; and
- The stream always exceeds primary and secondary recreational contact standards for 48 hours following one half inch of rainfall.

In addition, the large amount of data from a single site permitted us to make several preliminary observations about laboratory analysis results:

- Concentrations of fecal coliform in samples taken under similar flow conditions, and even among samples taken within hours of one another, vary widely. To obtain a consistent analytical result, approximately 20 samples taken under similar flow or recent rainfall conditions may be necessary to characterize concentrations of pathogens using fecal coliform analysis; and
- Because concentrations increase rapidly with recent rainfall and the resulting higher flows, flow and recent rainfall are crucial factors in designing studies of pathogen concentrations. A single month of the five-sample regimen, or five samples taken across an entire recreational season, may not adequately characterize pathogen loads.

Recommendations and Next Steps

People's continuing use of Big Rock for primary and secondary recreation indicates the following next steps:

- Results from MSD's pathogen monitoring station upstream of the site at the Old Cannons Lane crossing should be posted at the streamside kiosk used by the project, now that new project data is no longer becoming available.
- MSD should partner with Metro Parks to use the kiosk to educate the public about nonpoint sources of pollution to Beargrass Creek, consistent with its public education requirements under MSD's municipal stormwater (MS4) permit.
- The plans of MSD to reduce CSOs and SSOs through its Consent Decree should be implemented. Because private citizens can reduce the burden on overloaded sewer systems during storms by installing rain gardens, rain barrels, etc., the kiosk may provide an educational resource also for MSD's Consent Decree programming.
- MSD's next municipal stormwater permit should include pathogen reduction strategies with the long-term goal of meeting targets for pathogens in stormwater in the draft TMDL.
- Metro Louisville should educate citizens and implement ordinances that control pet waste.
- Metro Parks and other streamside landowners and land managers should continue to reduce mowing along streams and install native streamside vegetation to intercept runoff and increase infiltration into groundwater, improving dry-weather flows.

References

(1) Kentucky Department for Environmental Protection, "Fecal Coliform TMDLs for Middle Fork, Muddy Fork, and South Fork of Beargrass Creek in Jefferson County, Kentucky," proposed draft, September 2008, p. 1. Online at: www.water.ky.gov/sw/tmdl/TMDLs+Under+Development.htm

(2) *Ibid*., p. 10

(3) Louisville and Jefferson County Metropolitan Sewer District (MSD), "Beargrass Creek Watershed." Online at: www.msdlouky.org/insidemsd/wwwq/watershed/beargrass.htm

(4) MSD, "Beargrass Creek Watershed, A community lifeline in critical condition," pamphlet, 2003.

(5) "Fecal Coliform TMDLs," *op. cit*., p. 45.

(6) *Ibid*., p. 42.

(7) MSD, "Beargrass Creek Watershed, State of the Streams," pamphlet, 2005. Online at: www.beargrasswatershed.org/pdfs/BCW_State_of_the_Streams2005.pdf

(8) Kentucky Division of Water, "Final 2008 Integrated Report on the Conditions of Water Resources in Kentucky," p. 139. Online at: www.water.ky.gov/sw/tmdl/303d.htm

(9) Kentucky Administrative Regulations, 401 KAR 10:031, Surface water standards:

Section 7. Recreational Waters. (1) Primary contact recreation water. The following criteria shall apply to waters designated as primary contact recreation use:

(a) Fecal coliform content or Escherichia coli content shall not exceed 200 colonies per 100 ml or 130 colonies per 100 ml respectively as a geometric mean based on not less than five (5) samples taken during a thirty (30) day period. Content also shall not exceed 400 colonies per 100 ml in twenty (20) percent or more of all samples taken during a thirty (30) day period for fecal coliform or 240 colonies per 100 ml for Escherichia coli. These limits shall be applicable during the recreation season of May 1 through October 31. Fecal coliform criteria listed in subsection (2)(a) of this section shall apply during the remainder of the year.

(b) pH shall be between six and zero-tenths (6.0) to nine and zero-tenths (9.0) and shall not change more than one and zero-tenths (1.0) pH unit within this range over a period of twenty-four (24) hours.

(2) Secondary contact recreation water. The following criteria shall apply to waters designated for secondary contact recreation use during the entire year:

(a) Fecal coliform content shall not exceed 1,000 colonies per 100 ml as a thirty (30) day geometric mean based on not less than five (5) samples; nor exceed 2,000 colonies per 100 ml in twenty (20) percent or more of all samples taken during a thirty (30) day period.

(b) pH shall be between six and zero-tenths (6.0) to nine and zero-tenths (9.0) and shall not change more than one and zero-tenths (1.0) pH unit within this range over a period of twenty-four (24) hours.

(10) Watershed Watch in Kentucky, "Standard Operating Procedures for Grab Sample Collection."Online at http://kywater.net/01-Watershed%20Watch/06_Sampling/2005-QAPP/01-WSW-Sampling-SOP-4.doc

Appendix

Salt River Watershed Watch
Chain of Custody Record
Big Rock Monitoring Program

Sample #	Stream Name	Date	Time
S77	Middle Fork Beargrass Creek		
Watershed	Sampling Location	Sampler Name	Telephone
S39	Big Rock pavilion in Cherokee Park		
County	Description of general water conditions		Supervsng Sampler
Jefferson			Bruce W. Scott
Flow (m/sec)			

Flow Rate	Rain in last 48 hrs?	Water Chemistry				
◊ 0-Dry ◊ 1-Ponded ◊ 2-Low ◊ 3-Normal ◊ 4-Bank full ◊ 5-Flood!	◊ Zero ◊ Less than 0.1 inch ◊ 0.1-0.5 inch ◊ 0.6-1.0 inch ◊ 1.1-1.5 inches ◊ Gullywasher!	O2	pH	Temp	Cndvty	

General comments, questions, concerns, or suggestions:	Sample for analysis:
	Fecal Coliform

When a sample's custody changes, the person relinquishing the sample and the person receiving it must sign below and provide the date and time:

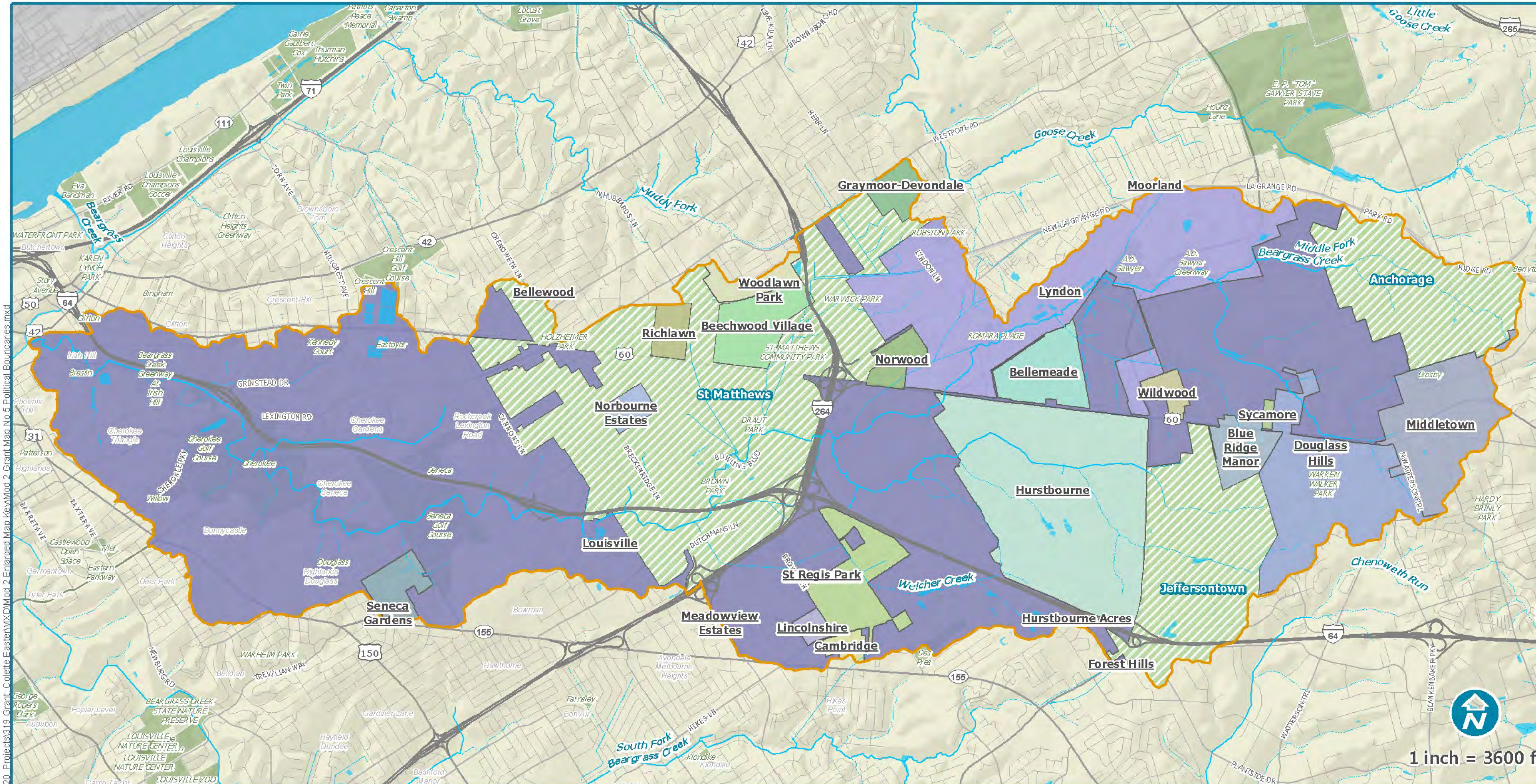
Relinquished by (signature)	Date/Time	Received by (signature)	Date/Time

SAMPLER: Do your best to complete the unshaded parts of the form. This form must accompany your sample to the lab. When delivered, ask the lab to make a copy for you.

LABORATORY: Please mail the original of this form with the fecal coliform result to:
Bruce Scott

Frankfort, KY 40601
Questions or concerns?
Call Bruce at the number up above or
Ken Cooke at Water Watch

APPENDIX 2.3 CHAPTER 2 MAPS



Map Key

Watershed Boundary

Bodies of Water

Wet Areas

Rivers & Streams

Cities Outside of MSD's Drainage Service Area **

** Labels shown in alternate text.

Political Boundaries

Middle Fork Beargrass Creek
319(h) Grant

LOJIC

msd Safe clean waterways

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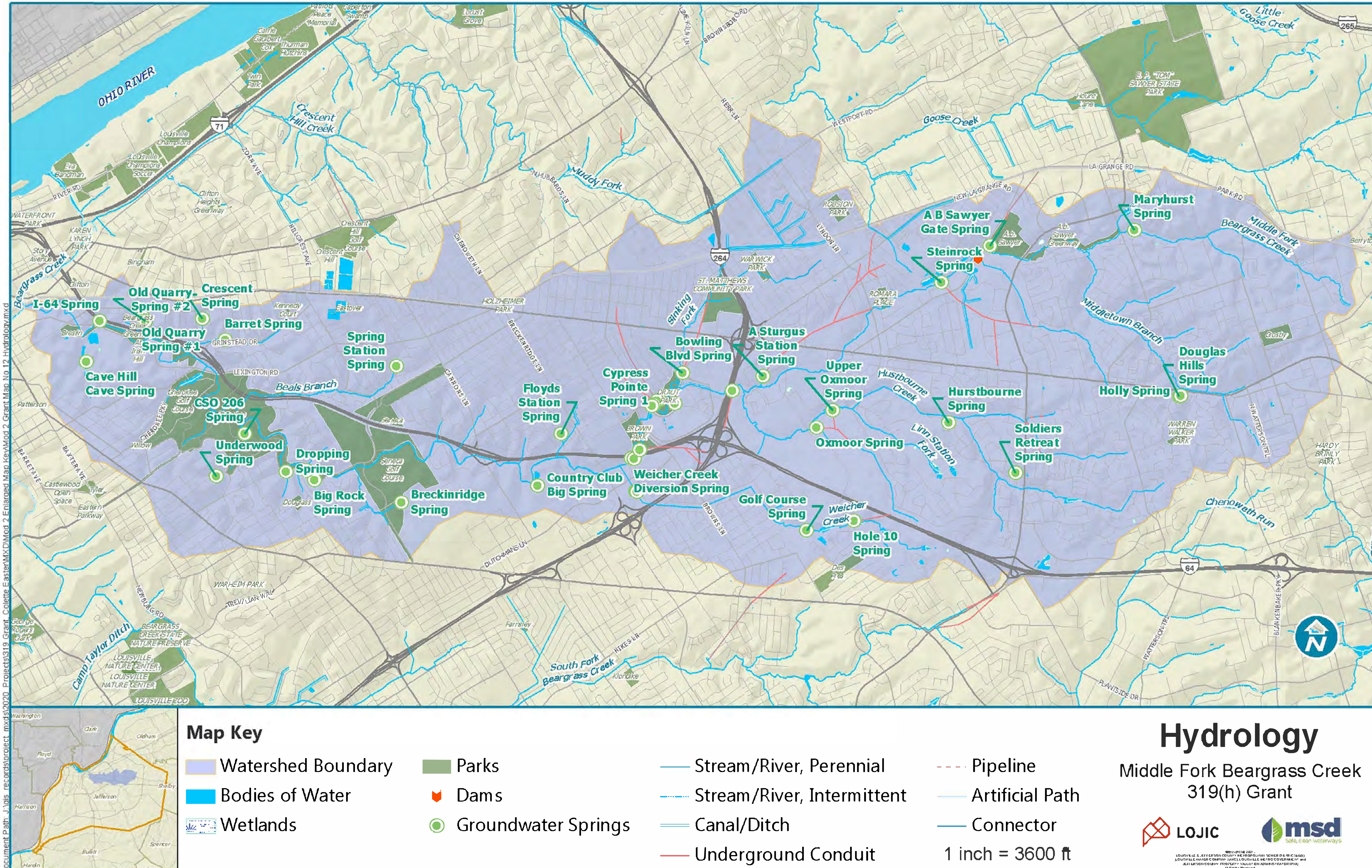
OHIO RIVER
Crescent Hill Creek
Muddy Fork
Goose Creek
Little Goose Creek
E. P. "TOM" SAWYER STATE PARK
Beargrass Creek
Beals Branch
Sinking Fork
Middle Fork Beargrass Creek
Middletown Branch
Hurstbourne Creek
Linn Station Fork
Weicher Creek
Chenoweth Run
South Fork Beargrass Creek
Camp Taylor Ditch
I-64 Spring
Old Quarry Spring #2
Crescent Spring
Barret Spring
Old Quarry Spring #1
Cave Hill Cave Spring
CSO 206 Spring
Underwood Spring
Dropping Spring
Big Rock Spring
Breckinridge Spring
Spring Station Spring
Floyds Station Spring
Country Club Big Spring
Cypress Pointe Spring 1
Bowling Blvd Spring
A Sturgus Station Spring
Weicher Creek Diversion Spring
Golf Course Spring
Hole 10 Spring
Upper Oxmoor Spring
Oxmoor Spring
Hurstbourne Spring
Soldiers Retreat Spring
A B Sawyer Gate Spring
Steinrock Spring
Maryhurst Spring
Douglas Hills Spring
Holly Spring
Map Key
Watershed Boundary
Bodies of Water
Wetlands
Parks
Dams
Groundwater Springs
Stream/River, Perennial
Stream/River, Intermittent
Canal/Ditch
Underground Conduit
Pipeline
Artificial Path
Connector
1 inch = 3600 ft
Hydrology
Middle Fork Beargrass Creek
319(h) Grant
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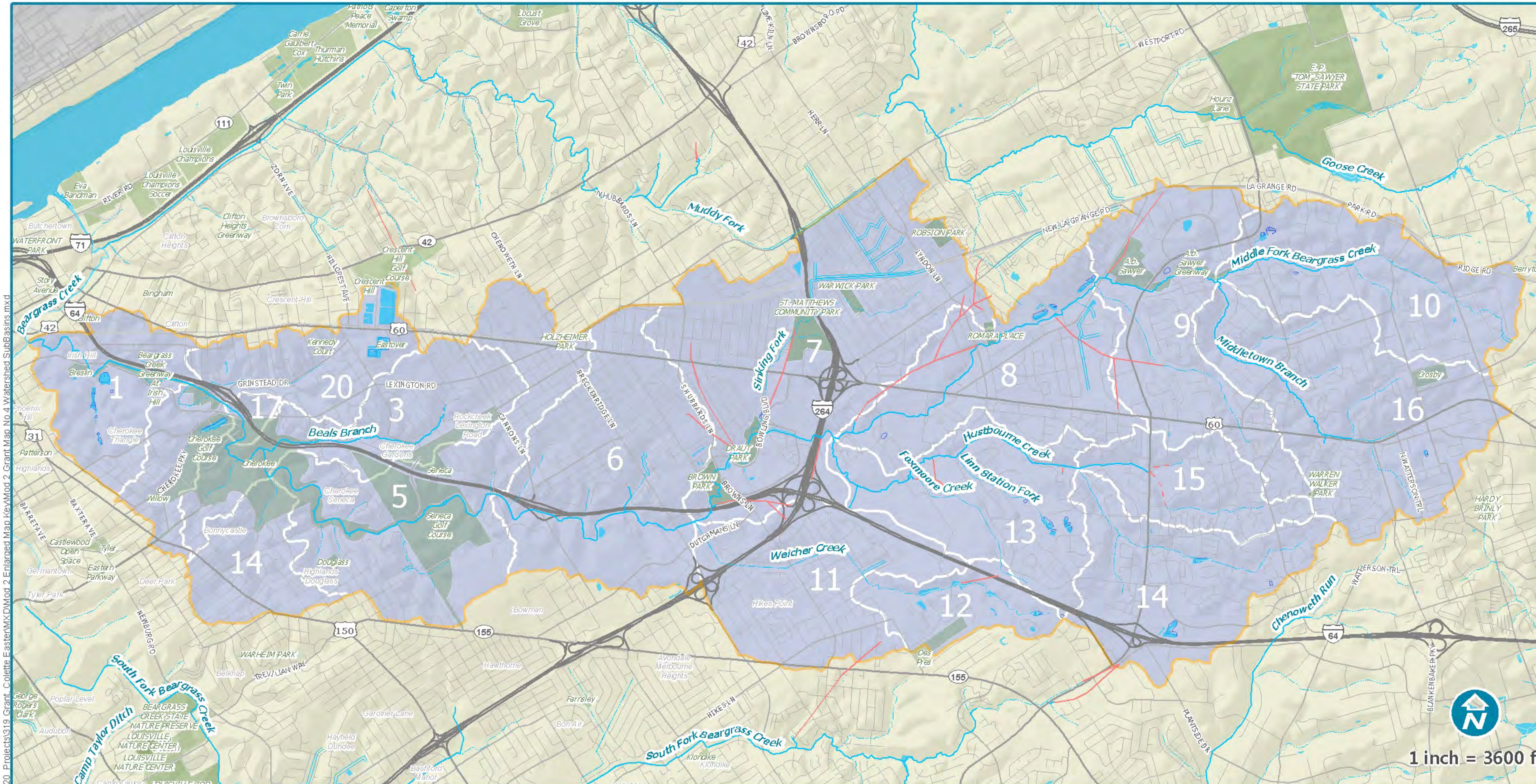
msd



Map Key

Watershed Boundary
Mid Fork BGC Sub Basins
Parks
Bodies of Water
Wetlands
Stream/River, Perennial
Stream/River, Intermittent
Canal/Ditch
Underground Conduit
Pipeline
Artificial Path
Connector

Watershed Boundary & Sub-Basins

Middle Fork Beargrass Creek
319(h) Grant

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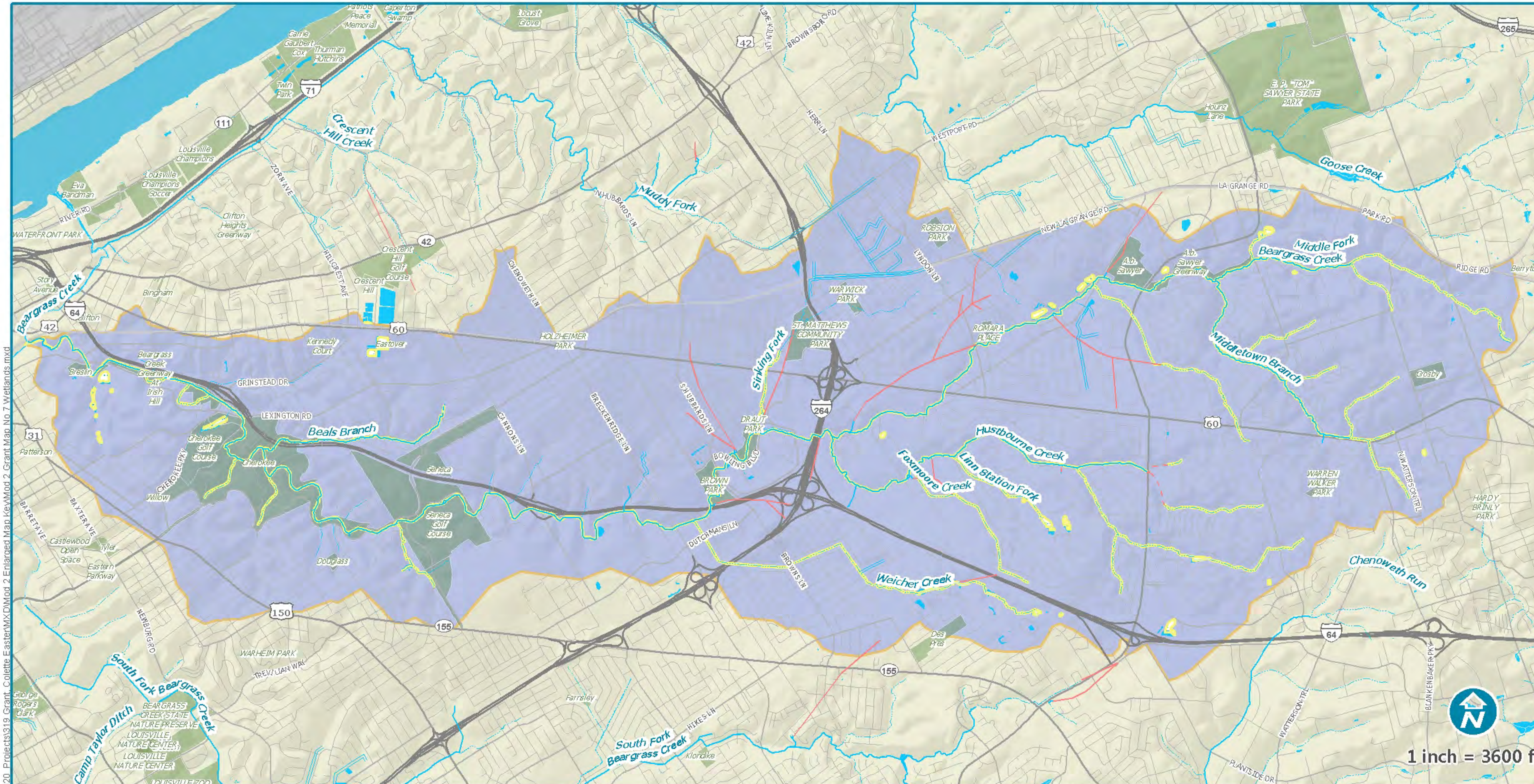

Map Key

Watershed Boundary	Parks
Bodies of Water	Stream/River, Perennial
Wetlands	Stream/River, Intermittent
Canal/Ditch	Artificial Path
Underground Conduit	Connector
Pipeline	

Wetlands

Middle Fork Beargrass Creek
319(h) Grant

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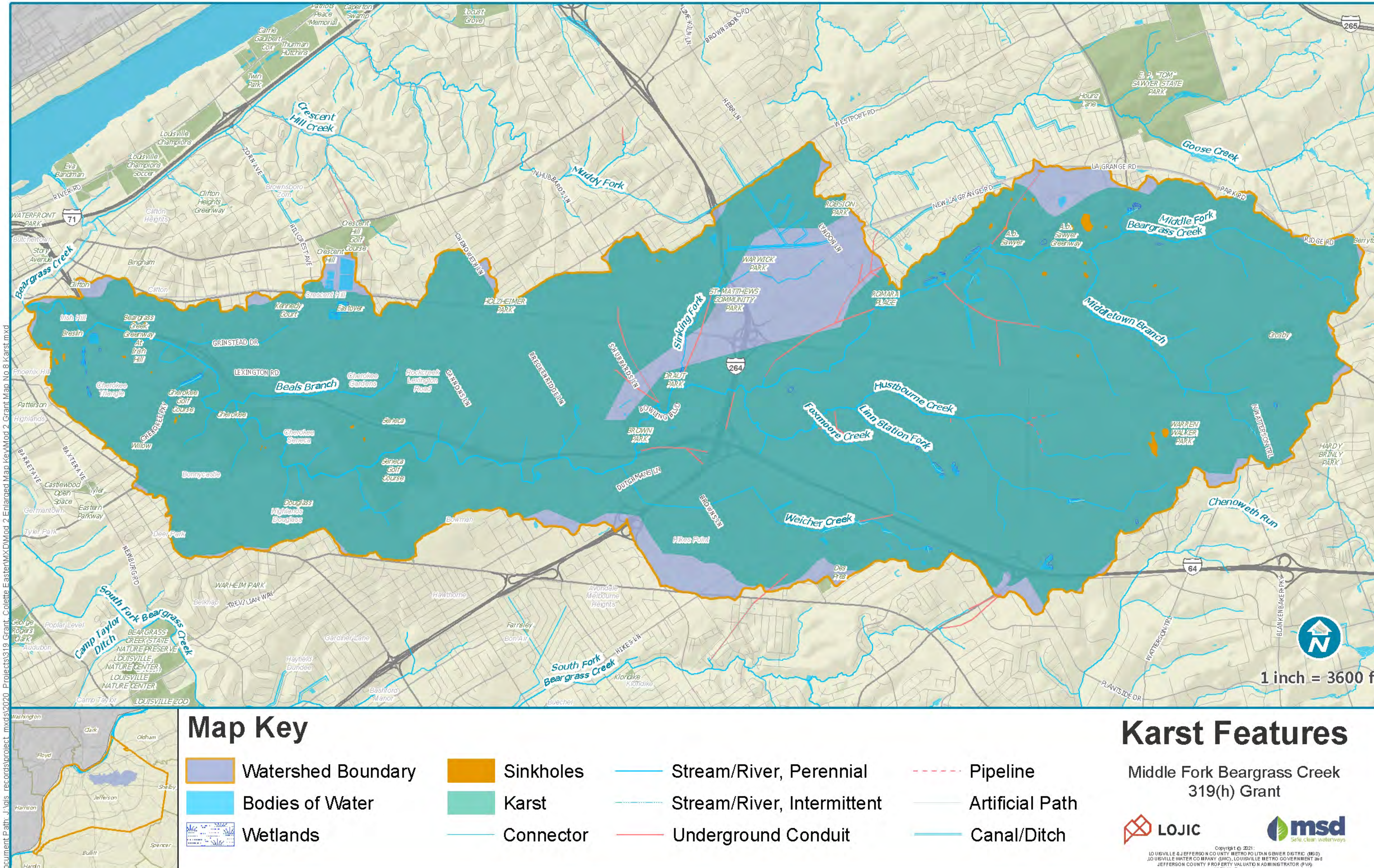

Map Key

- Watershed Boundary
- Bodies of Water
- Wetlands
- Sinkholes
- Karst
- Connector
- Stream/River, Perennial
- Stream/River, Intermittent
- Underground Conduit
- Pipeline
- Artificial Path
- Canal/Ditch

Karst Features

Middle Fork Beargrass Creek
319(h) Grant

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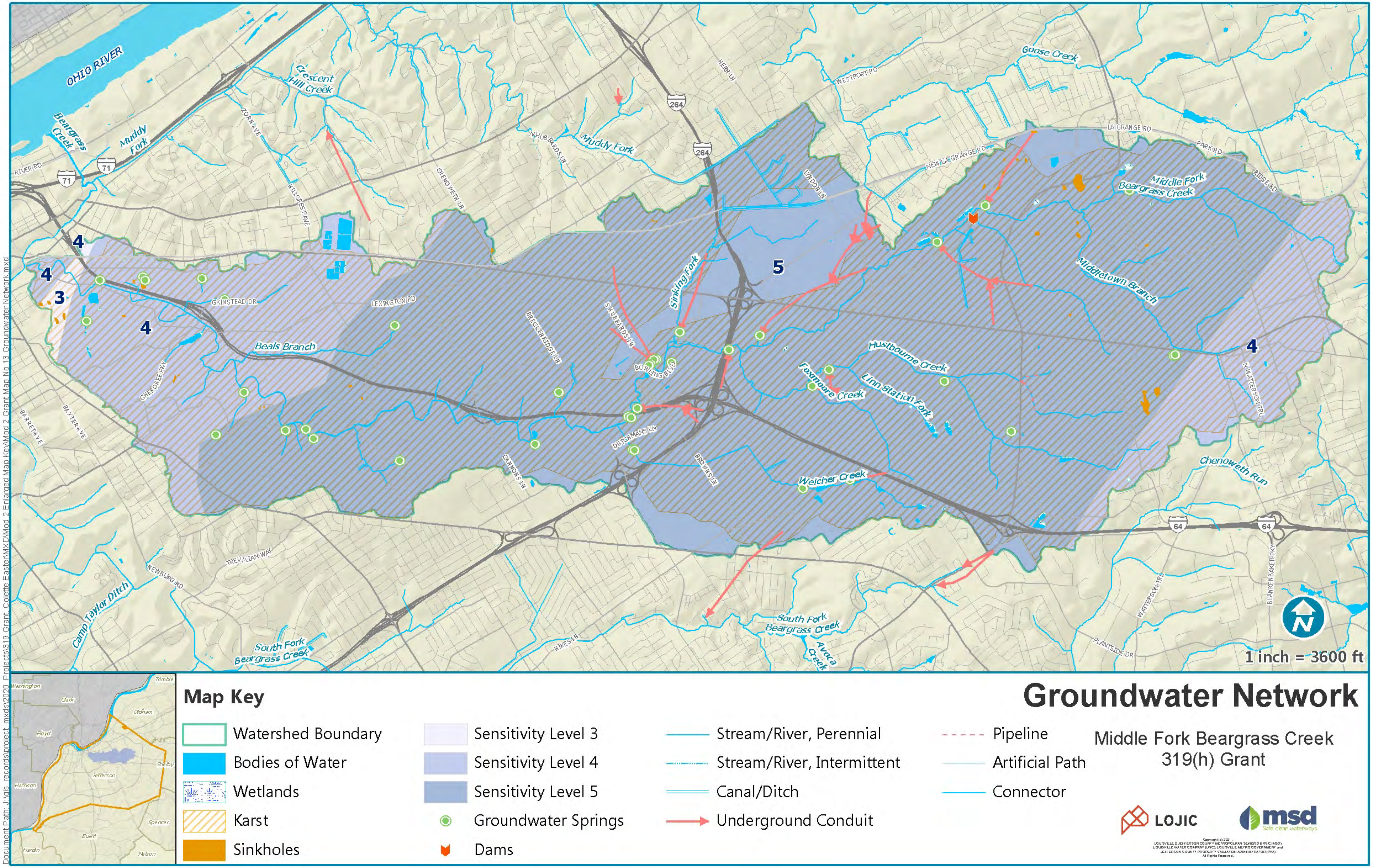

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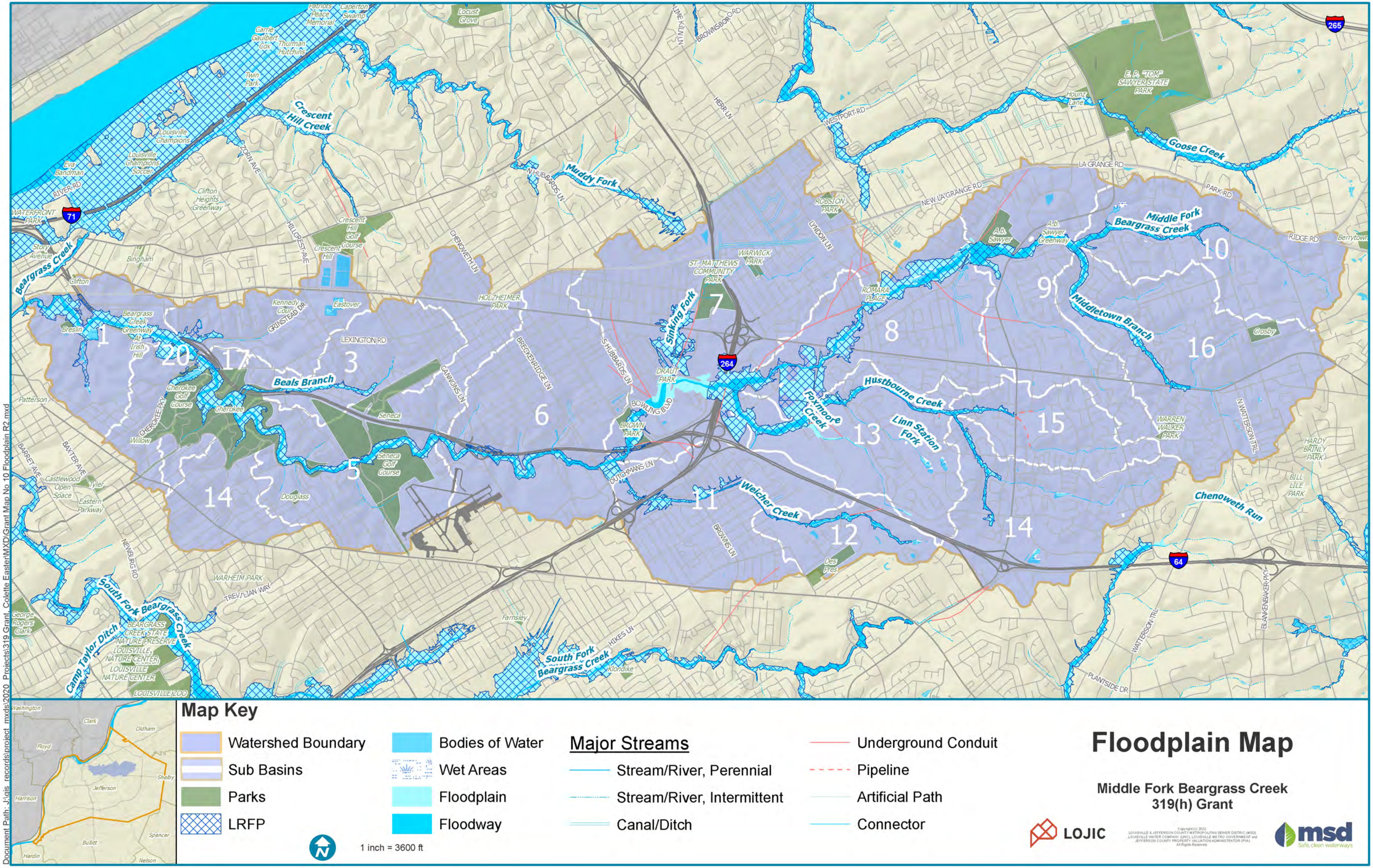

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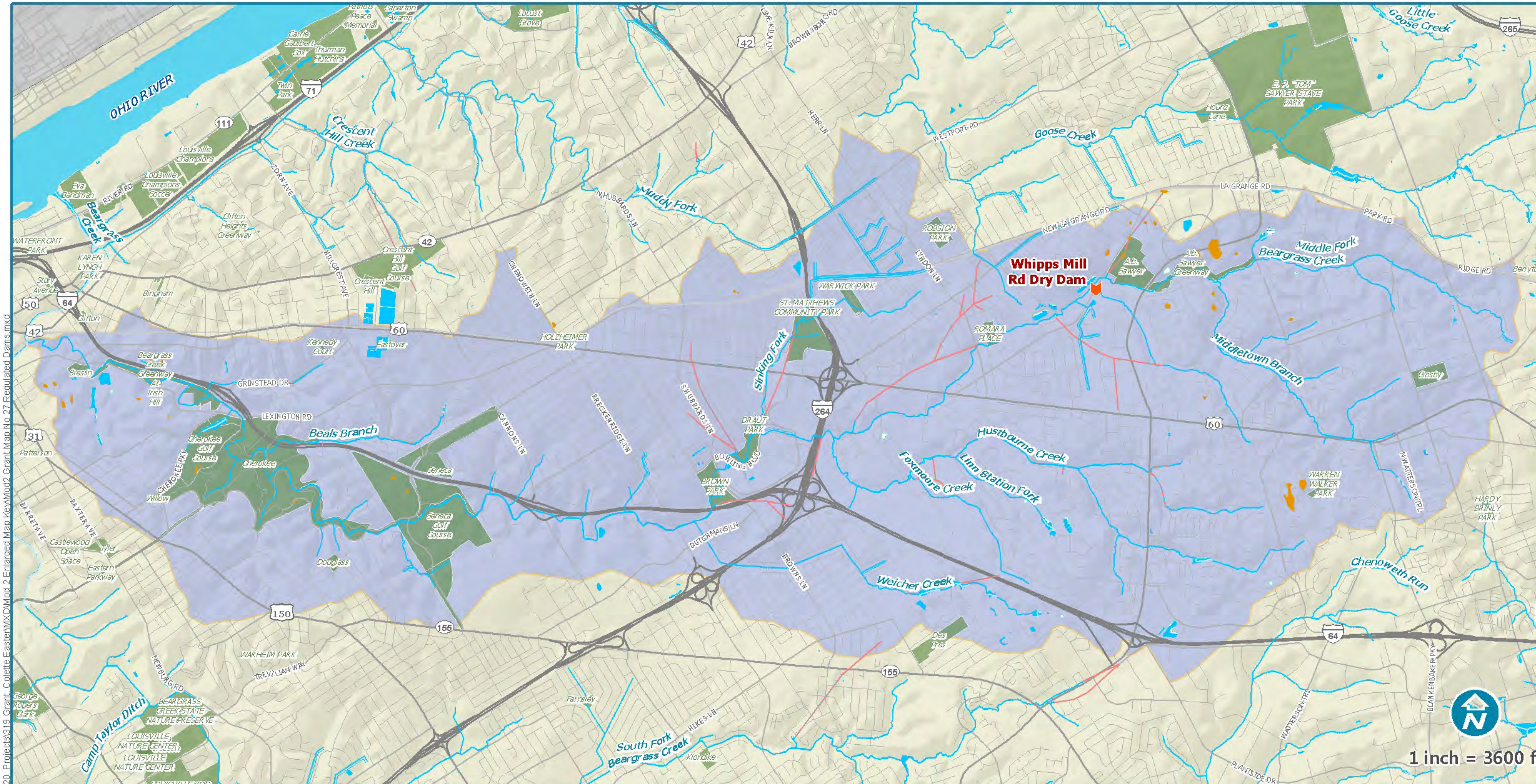

Map Key

- Watershed Boundary
- Sinkholes
- Parks
- Bodies of Water
- Wetlands
- Dams
- Stream/River, Perennial
- Stream/River, Intermittent
- Canal/Ditch
- Underground Conduit
- Pipeline
- Artificial Path
- Connector

Regulated Dams

Middle Fork Beargrass Creek
319(h) Grant

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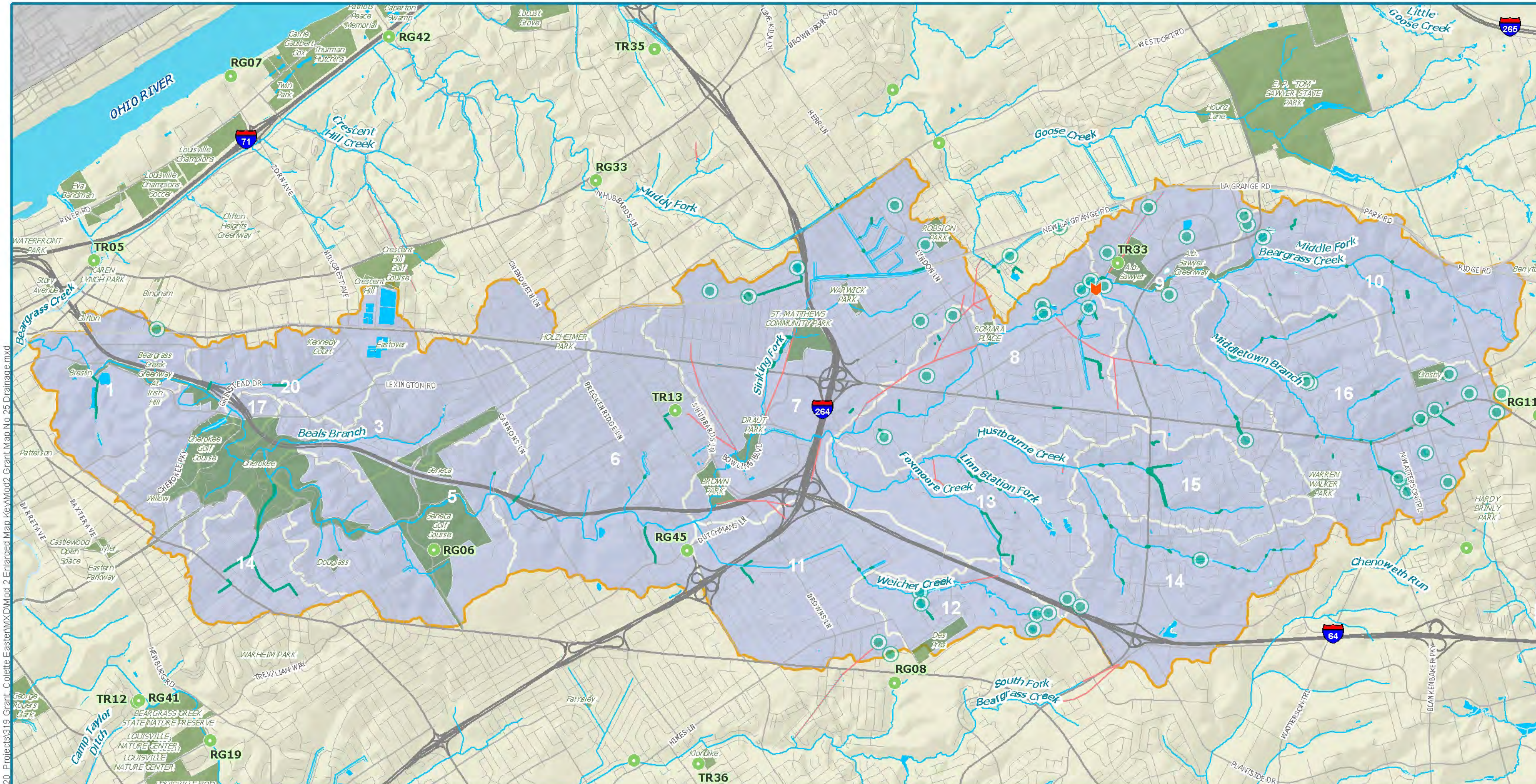

Map Key

- Watershed Boundary
- MF BGC Sub-Basins
- Parks
- Bodies of Water
- Wetlands
- Detention Basin
- Rain Gauges
- Dams
- Stream/River, Perennial
- Stream/River, Intermittent
- Canal/Ditch
- Underground Conduit
- Pipeline
- Artificial Path
- Connector

Drainage Mains, by Dia

- 48 - 96"
- 96 - 240"

Drainage & Detention

Middle Fork Beargrass Creek
319(h) Grant

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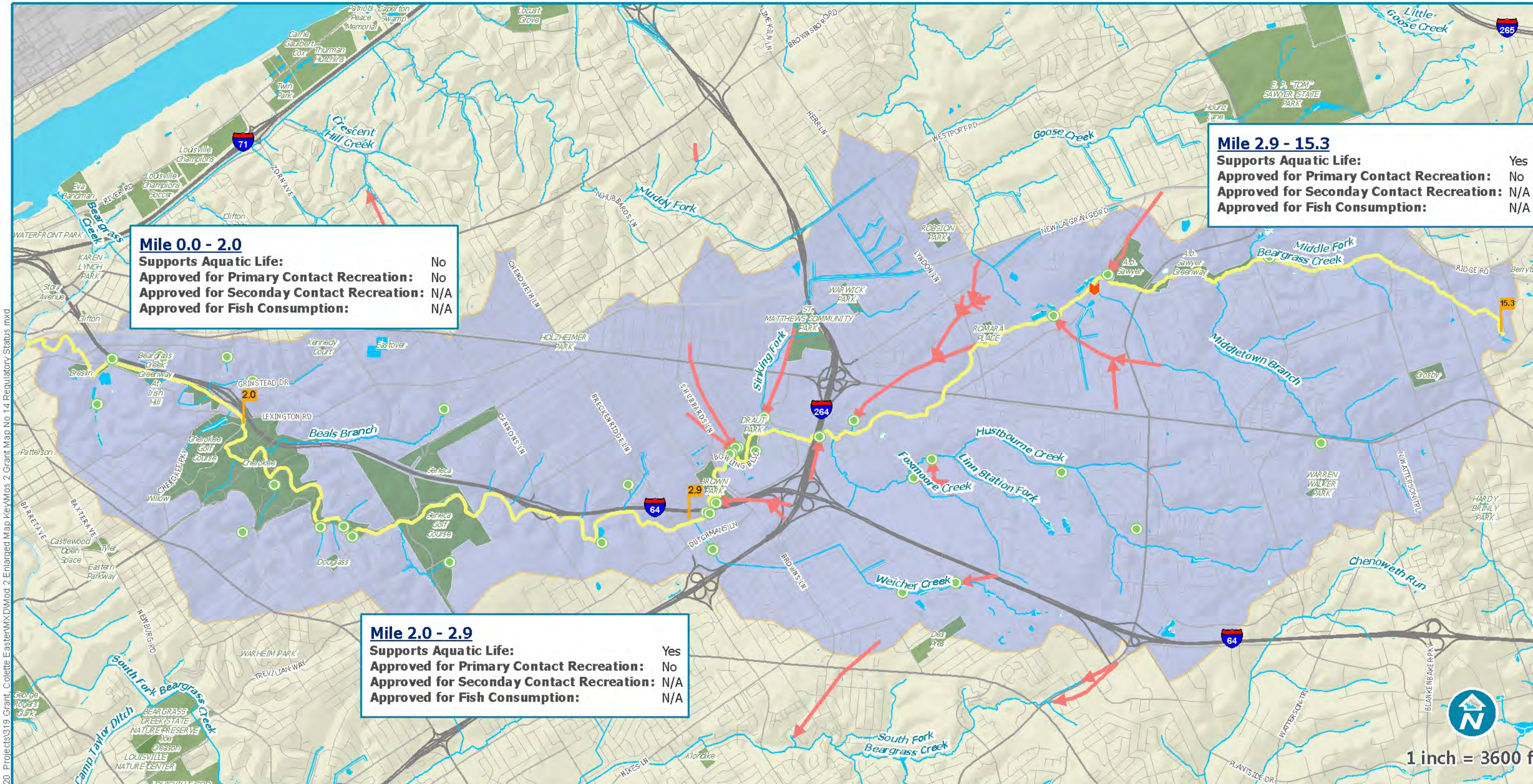
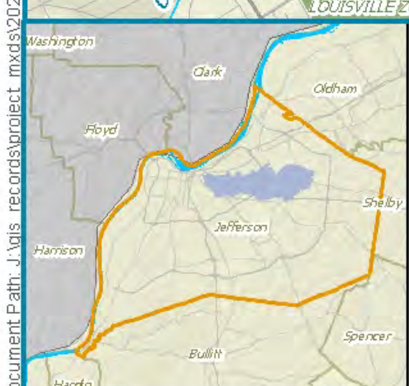
Safe, clean waterways





Map Key

- Watershed Boundary
- Bodies of Water
- Wetlands
- Parks
- Dams
- Groundwater Springs
- TMDL Impairment
- Fecal Coliform
- Stream/River, Perennial
- Stream/River, Intermittent
- Canal/Ditch
- Underground Conduit
- Pipeline
- Artificial Path
- Connector

Regulatory Status

Middle Fork Beargrass Creek
319(h) Grant

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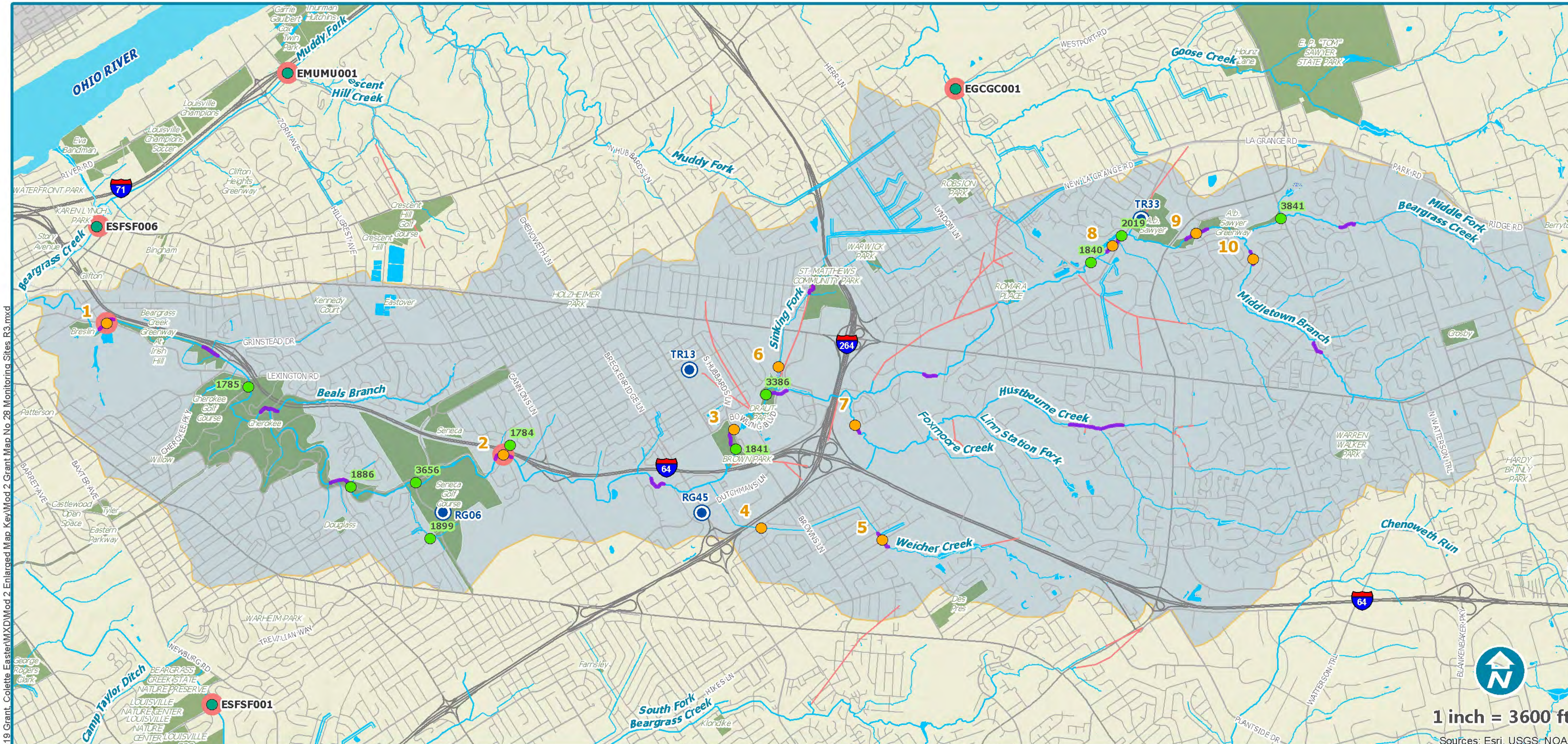

Map Key

Watershed Boundary	Rain Gauges
Bodies of Water	LTMN Only Site
Wetlands	Combination Mon. Site
Parks	SRWW Monitoring Site
Stream Walk Sites	USGS Monitoring Sites
	Connector

Stream/River, Perennial
Stream/River, Intermittent
Canal/Ditch
Underground Conduit
Pipeline
Artificial Path

Monitoring Sites

Middle Fork Beargrass Creek
319(h) Grant

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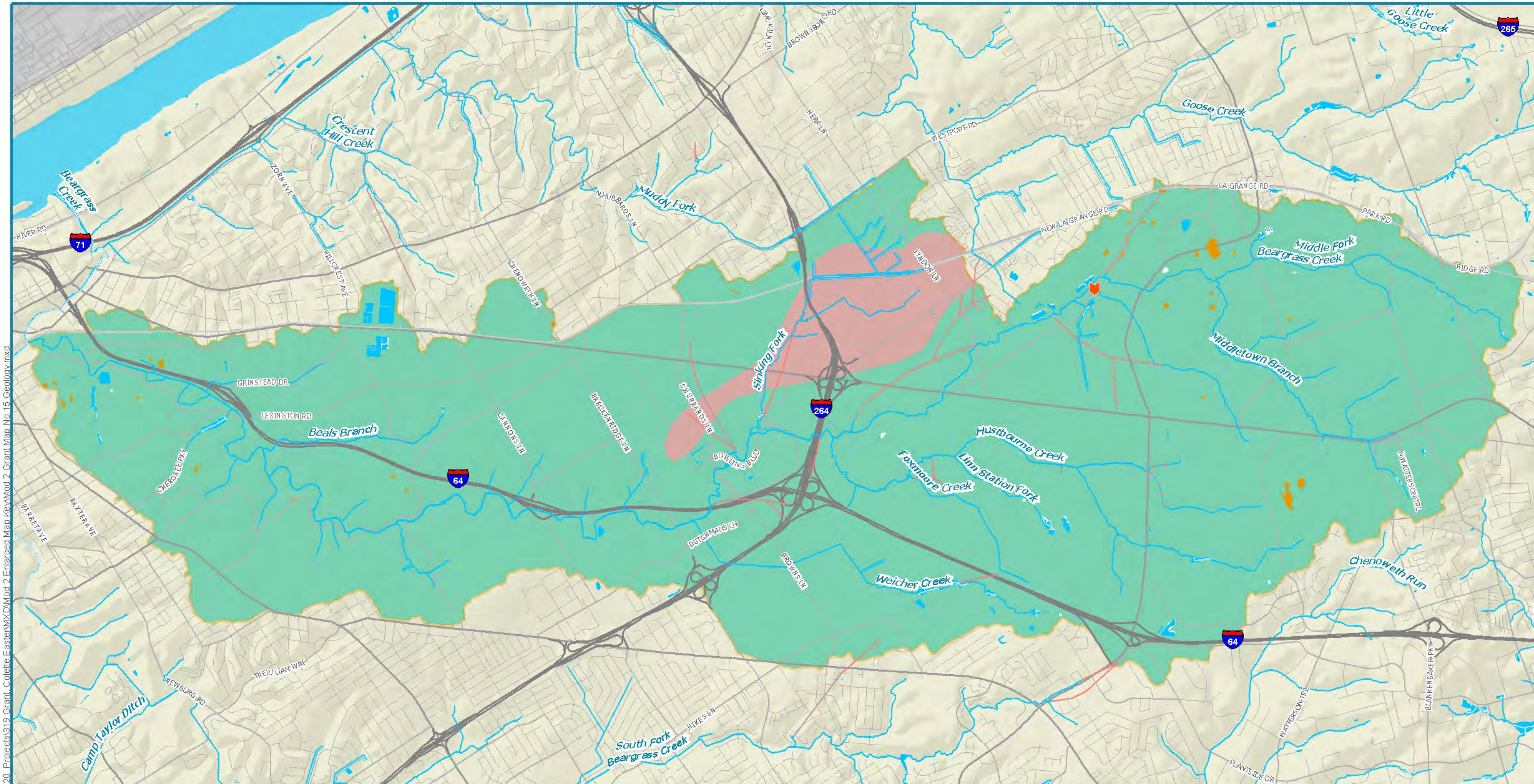
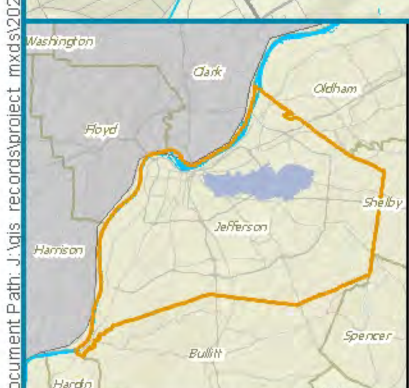
NOTE: See Table for additional detail regarding Monitoring Sites 1-10





Map Key

Watershed Boundary
Bodies of Water
Wetlands
Dams

Geology
Black Shale
Limestone
Sinkholes

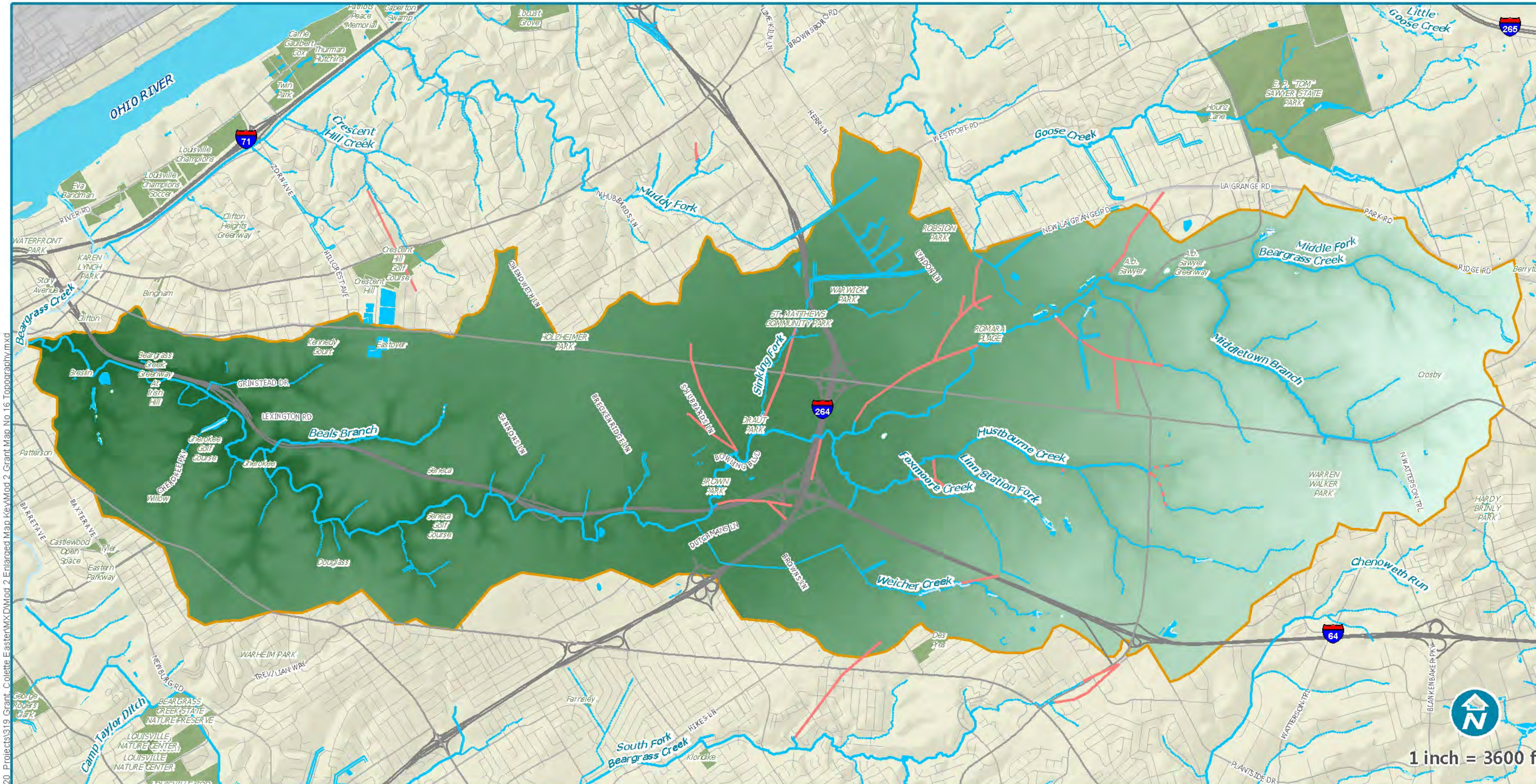
Stream/River, Perennial
Stream/River, Intermittent
Canal/Ditch
Underground Conduit

Pipeline
Artificial Path
Connector

Geology

Middle Fork Beargrass Creek
319(h) Grant

LOJIC msd



Map Key

Watershed Boundary	Stream/River, Perennial	Pipeline
Bodies of Water	Stream/River, Intermittent	Artificial Path
Wetlands	Canal/Ditch	Connector
	Underground Conduit	

749.2 Ft

405.0 Ft

Topography

Middle Fork Beargrass Creek
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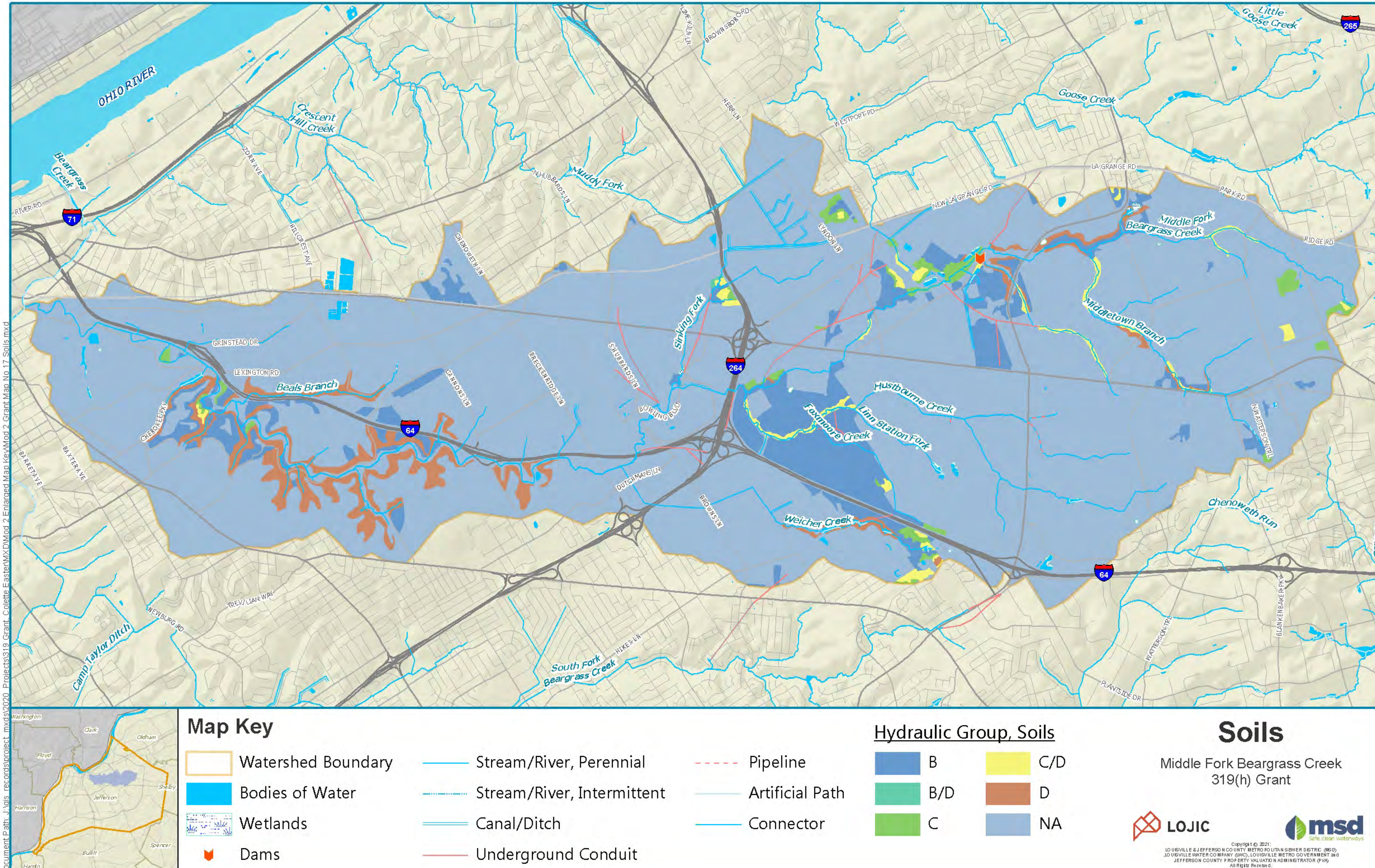
Safe, clean waterways


OHIO RIVER
Beargrass Creek
Crescent Hill Creek
Muddy Fork
Goose Creek
Little Goose Creek
Middle Fork Beargrass Creek
Middletown Branch
Sinking Fork
Beals Branch
Hustbourne Creek
Foxmoore Creek
Linn Station Fork
Weicher Creek
Chenoweth Run
South Fork Beargrass Creek
Camp Taylor Ditch
RIVER RD
ZORN AVE
N HUBBARDS LN
HILLCREST AVE
CHENOWETH LN
LYNDON LN
HERR LN
BROWNSBORO RD
WESTPORT RD
LA GRANGE RD
NEW LA GRANGE RD
PARK RD
RIDGE RD
GRINSTEAD DR
LEXINGTON RD
CHEROKEE PKY
GANNONS LN
BRECKENRIDGE LN
S HUBBARDS LN
BOWLING BLVD
DUTCHMANS LN
BROWNS LN
N WATTERSON TRL
BARRET AVE
BAXTER AVE
NEWBURG RD
TREVILIAN WAY
HIKES LN
WATTERSON TRL
BLANKENBAKER PKY
PLANTSIDE DR
71
64
264
265
Map Key
Watershed Boundary
Bodies of Water
Wetlands
Dams
Stream/River, Perennial
Stream/River, Intermittent
Canal/Ditch
Underground Conduit
Pipeline
Artificial Path
Connector
Hydraulic Group, Soils
B
B/D
C
C/D
D
NA
Soils
Middle Fork Beargrass Creek
319(h) Grant
LOJIC
msd
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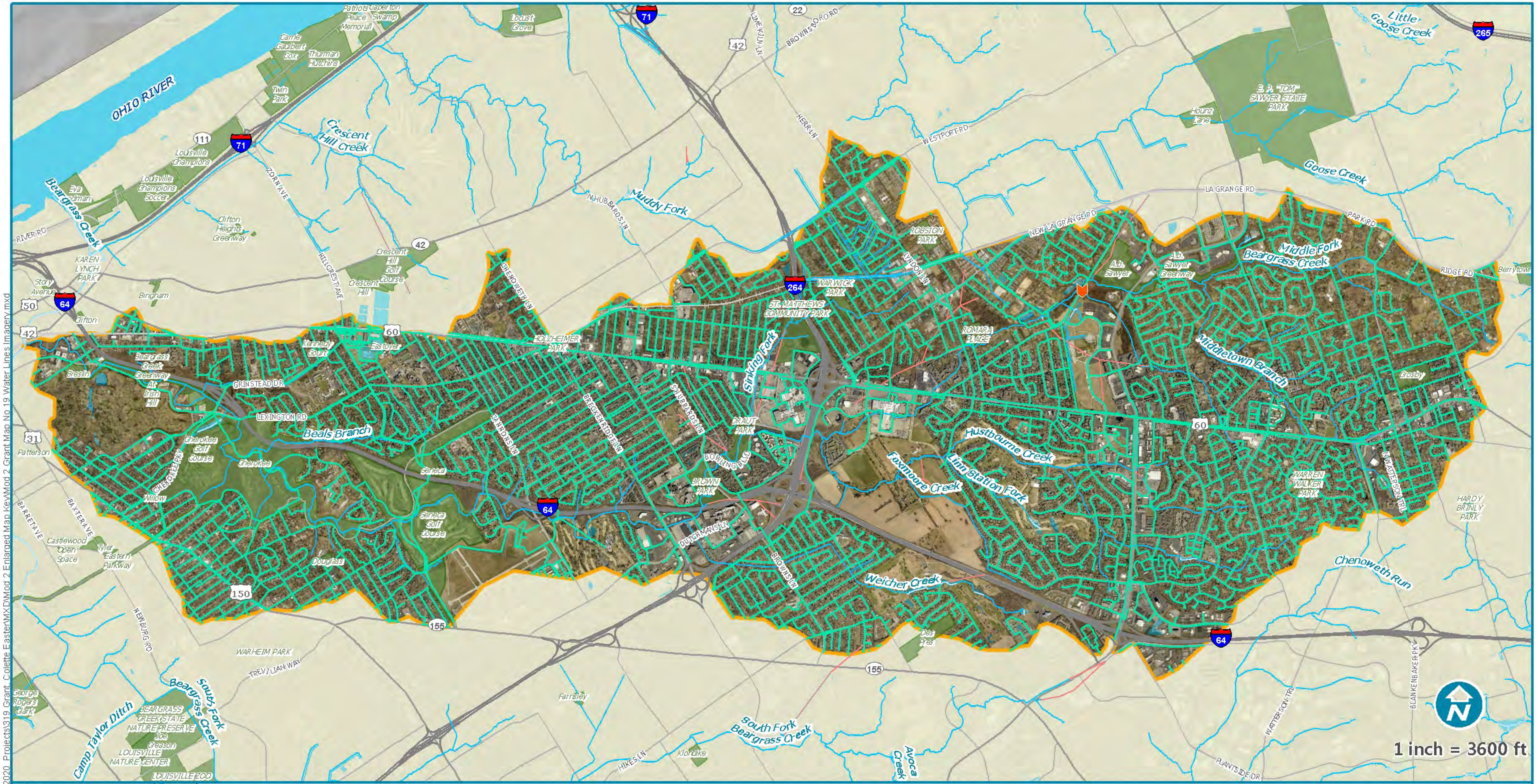

Map Key

Watershed Boundary	Wetlands
Parks	Dams
Bodies of Water	LWC Water Mains
Stream/River, Perennial	Pipeline
Stream/River, Intermittent	Artificial Path
Canal/Ditch	Connector
Underground Conduit	

Water Lines

Middle Fork Beargrass Creek
319(h) Grant

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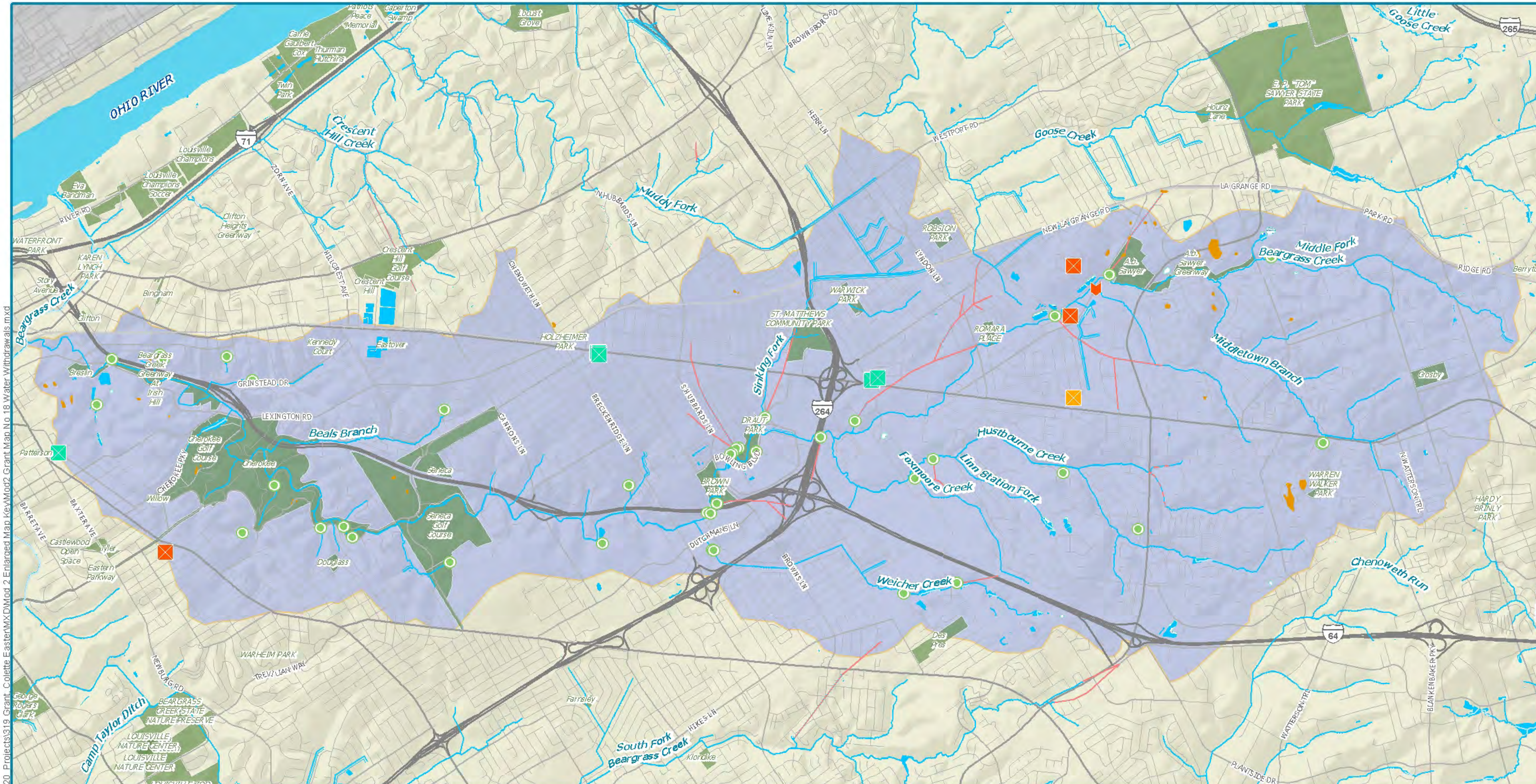

Map Key

Watershed Boundary	Stream/River, Perennial
Sinkholes	Stream/River, Intermittent
Bodies of Water	Canal/Ditch
Wetlands	Underground Conduit
Pipeline	Agriculture Wells
Artificial Path	Domestic Wells
Connector	Remediation Wells
Dams	Groundwater Springs

Water Withdrawal

Middle Fork Beargrass Creek
319(h) Grant

LOJIC msd

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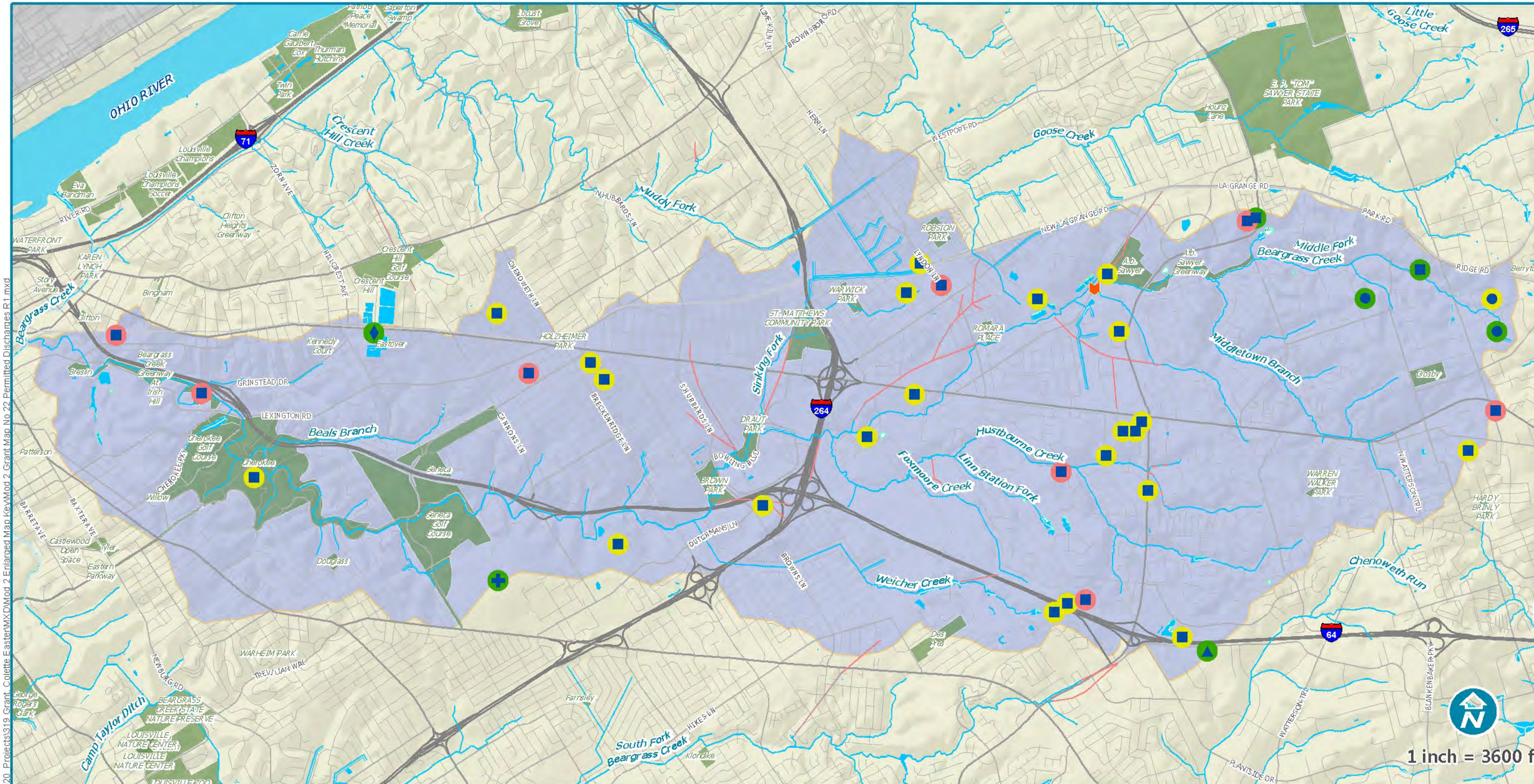


Document Path: J:\gis_records\project_mxds\2020_Projects\319_Grant_Colette_Eastern\MXD\Mod 2 Enlarged Map Key\Mod 2 Grant Map No 22 Permitted Discharges R1.mxd

Map Key

KDPES Permitted Discharge, Type

- ▲ KYR00s SW Industrial GP
- ■ KYR10s SW Const GP
- ♦ Minor DW Backwash
- ● Minor Home Unit
- ✚ SW Industrial-IP
- Dams

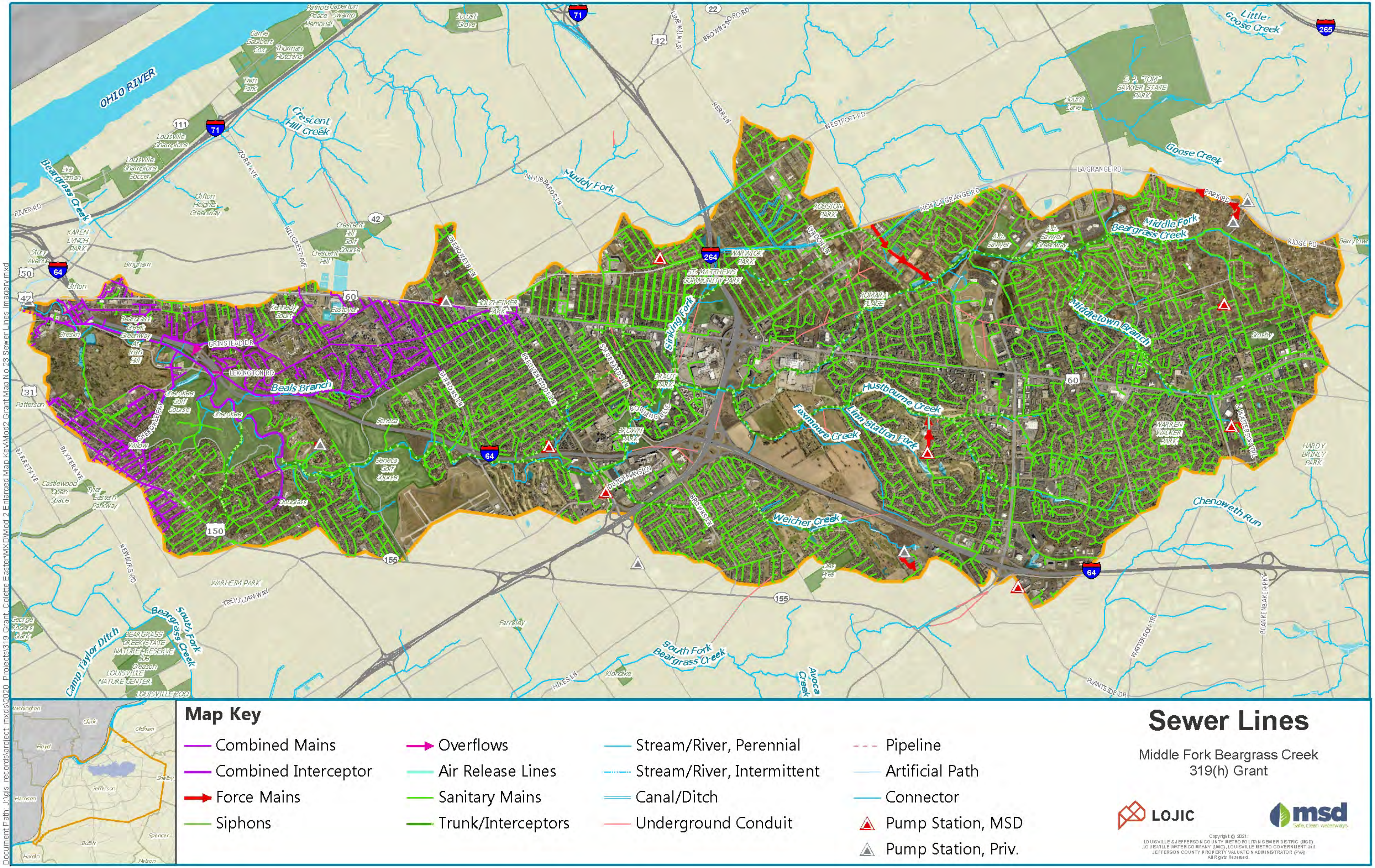
KPDES Permitted Discharge, Status

- Admin Continued
- Effective
- Expired

Permitted Discharges

Middle Fork Beargrass Creek
319(h) Grant

LOJIC msd



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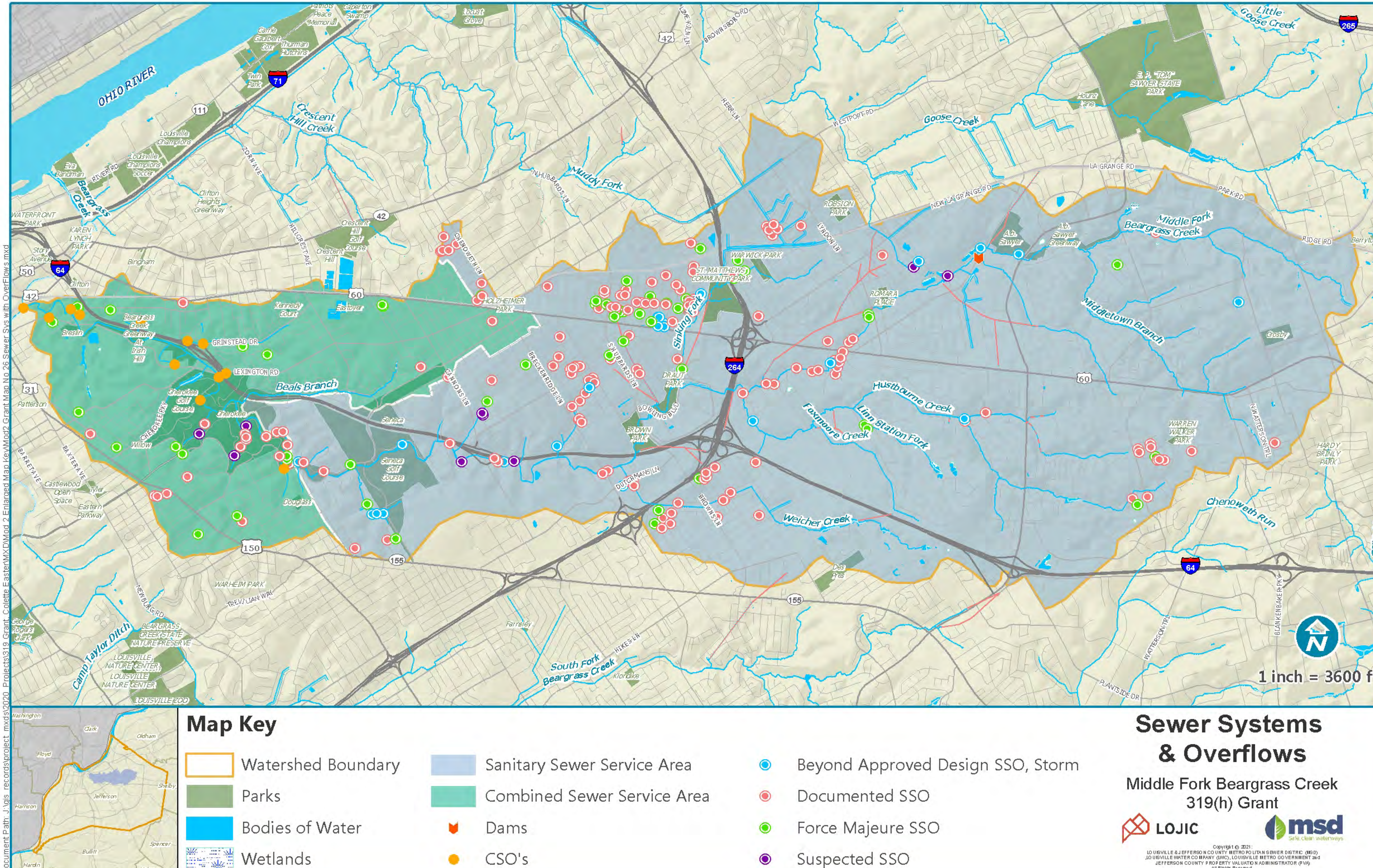
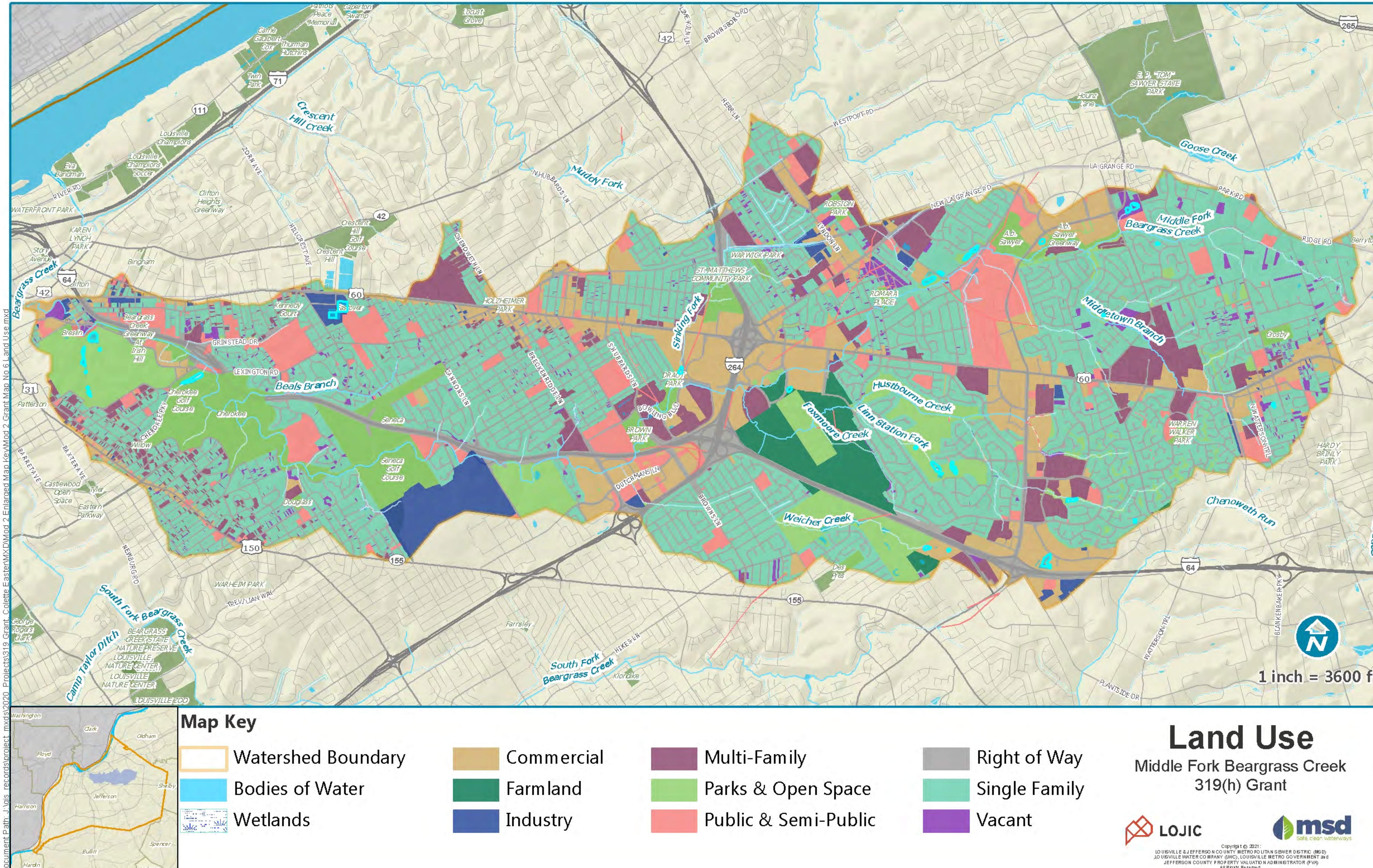

OHIO RIVER
Crescent Hill Creek
Muddy Fork
Goose Creek
Little Goose Creek
Middle Fork Beargrass Creek
Middletown Branch
Sinking Fork
Beals Branch
Hustbourne Creek
Foxmoore Creek
Linn Station Fork
Weicher Creek
Chenoweth Run
South Fork Beargrass Creek
Camp Taylor Ditch
Beargrass Creek
1 inch = 3600 ft
Map Key
Watershed Boundary
Parks
Bodies of Water
Wetlands
Sanitary Sewer Service Area
Combined Sewer Service Area
Dams
CSO's
Beyond Approved Design SSO, Storm
Documented SSO
Force Majeure SSO
Suspected SSO
Sewer Systems & Overflows
Middle Fork Beargrass Creek
319(h) Grant
LOJIC
msd



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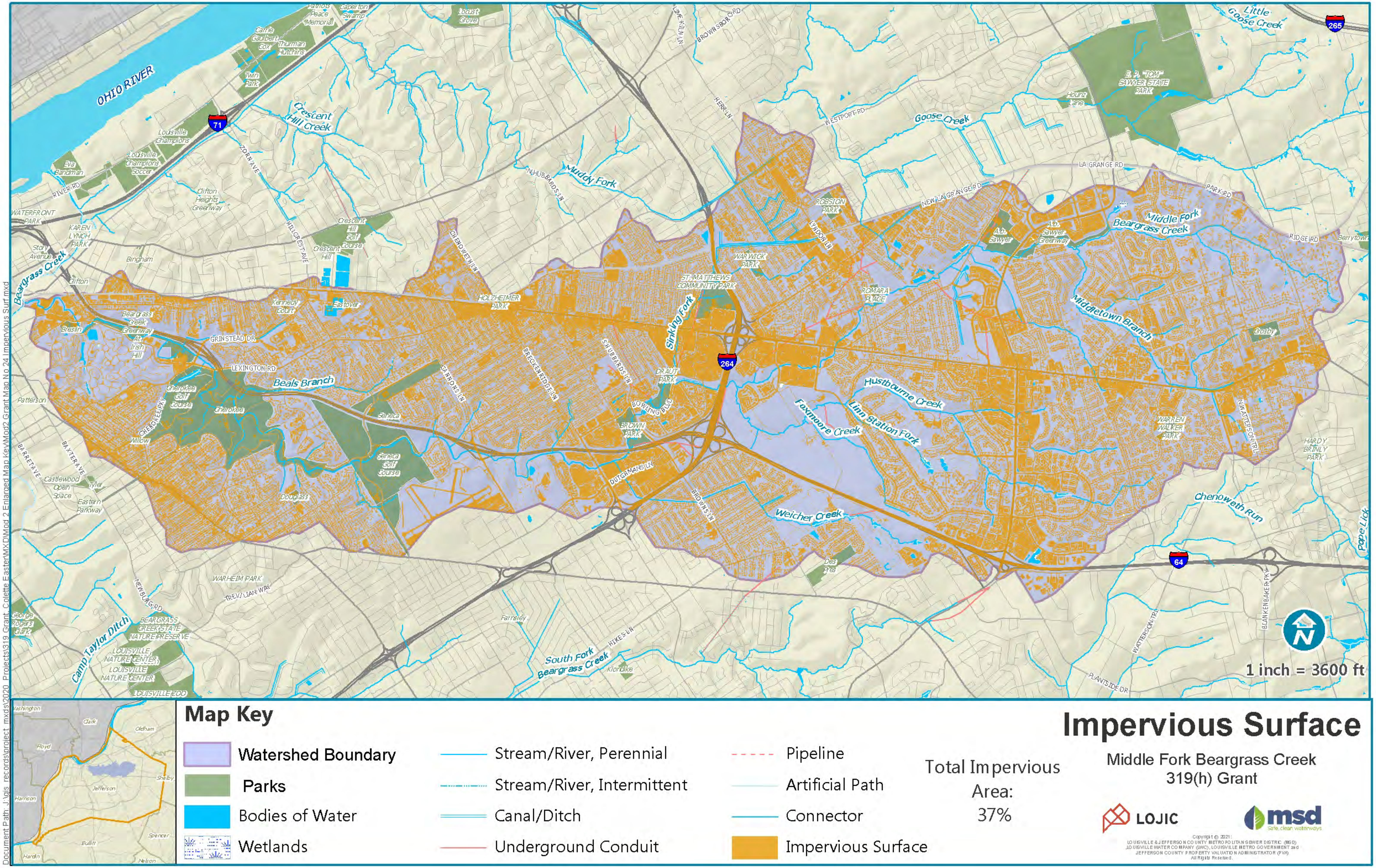

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APPENDIX 3.1 QAPP AND SOP

Quality Assurance Project Plan (QAPP)
MSD 319(h) Monitoring for the Middle Fork of Beargrass Creek Watershed Plan

Prepared By:

Stantec Consulting Services, Inc.
10509 Timberwood Circle, Suite 100
Louisville, KY 40223-5301
502-212-5000
and
Louisville and Jefferson County Metropolitan Sewer District
700 West Liberty Street
Louisville, KY 40201
502-540-6000

Prepared For: Kentucky Division of Water
Watershed Management Branch
Nonpoint Source Section
300 Sower Boulevard
Frankfort, KY 40601

Effective Date: 5/8/2020
Revision No.: 0.0
Revision Date: __________

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1.0 PROJECT MANAGEMENT

1.1 Title and Approval Sheet

Action By	Signature	Date
Sarah Goodin, Project Quality Assurance Manager Louisville MSD		05/14/2020
Colette Easter, Reviewed Project Manager Louisville MSD		05/14/2020
Lori Rafferty, Approved MS4 Program Manager Louisville MSD		05/19/2020
Daymond Talley, Reviewed Laboratory Manager Louisville MSD		05/28/2020
Perry Thomas, Reviewed Nonpoint Source Technical Advisor Watershed Management Branch, DOW		
Dale Booth, Approved NPS and Basin Team Supervisor Watershed Management Branch, DOW		
John Webb, Approved Manager Watershed Management Branch, DOW		
Caroline Chan, Approved Quality Assurance Coordinator Watershed Management Branch, DOW		
Mary Rockey, Approved Quality Assurance Officer Division of Water		
Paul Miller, Approved Director Division of Water		

Larry Taylor, Approved Quality Assurance Manager Department for Environmental Protection		

1.2 Revision History

Initial revision date is the first preparation of the document. Consecutive revisions should be listed first, with the older revisions listed last.

Date of Revision	Page(s)/Section(s) Revised	Revision Explanation	Person Responsible

1.3 Table of Contents

List of Figures

List of Tables

List of Appendices

Note: This Quality Assurance Project Plan (QAPP) was developed using the Quality Assurance Project Plan Template: Environmental Monitoring for a Watershed Plan provided by DOW personnel to MSD in March 2019.

1.4 Acronyms and Abbreviations

319(h) – Section 319(h) of the Clean Water Act (33 USC §1329)

BMP – Best Management Practice

COC – Chain of Custody (forms)

CSO- Combined Sewer Overflow

DOW- (Kentucky) Division of Water

DQI – Data Quality Indicators

DQO – Data Quality Objectives

E. coli – Escherichia coli

EPA – Environmental Protection Agency

FDCS – Field Data Capture Sheets

GA – Grant Advisor

GIS – Geographic Information System

DOW – Kentucky Division of Water

LIMS – Laboratory Information Management System

LOD – Limit of Detection

LOJIC – Louisville / Jefferson County Information Consortium

LOQ – Limit of Quantitation

LTMN – Long Term Monitoring Network

MDL – Method Detection Limit

MS4 – Municipal Separate Storm Sewer System

MSD – (Louisville and Jefferson County) Metropolitan Sewer District

NPS – Non-point source

NWIS – National Water Information System

QAPP – Quality Assurance Project Plan

QA – Quality Assurance

QC – Quality Control

RPD – Relative Percent Difference

RPPS – Resource Planning and Program Support

SOP – Standard Operating Procedure

SRWW – Salt River Watershed Watch

TA – Technical Advisor

TMDL – Total Maximum Daily Load

USGS – United States Geological Survey

WMB – Watershed Management Branch

WQTC – Water Quality Treatment Center

1.5 Distribution List

319(h) Grant Recipient Personnel		
Name	**Role**	**Organization ***
Lori Rafferty	Municipal Separate Storm Sewer System (MS4) Program Manager	MSD
Colette Easter	Project Manager	MSD
Dwight Mitchell	Field Team Manager	MSD
David Radke	Research Chemist	MSD
Daymond Talley	Laboratory Manager	MSD
Sarah Goodin	Project Quality Assurance Manager	MSD

These grant recipient members can be contacted at:

* Louisville and Jefferson County Metropolitan Sewer District (MSD)
700 W Liberty St
Louisville, KY 40203
502-540-6000

Kentucky Division of Water Personnel		
Name	**Role**	**Division/Branch/Section (1)**
Perry Thomas	Technical Advisor	DOW/WMB/NPS and Basin Team Section
Mike Reed	Grant Manager	DOW/Resource Planning and Program Support
Mary Rockey	Division Quality Assurance Officer	DOW
Dale Booth	NPS and Basin Team Supervisor	DOW/WMB/NPS and Basin Team Section
John Webb	WMB Manager	DOW/Watershed Management Branch
1. DOW: Division of Water WMB: Watershed Management Branch NPS: Non-point Source		

These DOW organization members can be contacted at:

Kentucky Division of Water (DOW)
300 Sower Blvd
Frankfort, KY 40601
502-564-3410

1.6 Project / Task Organization

DOW Project Technical Advisor (TA) – **Perry Thomas**: will oversee overall project operations. She communicates with MSD and is the liaison between the MSD and DOW personnel on project requirements and deliverables.

DOW NPS and Basin Team Supervisor – **Dale Booth**: may review the QAPP and will ensure the project Technical Advisor is assigned. She is ultimately responsible for overall project completion and preparing reports to DOW management and EPA.

DOW RPPS Grant Advisor (GA) – **Mike Reed**: will manage all grant operations. He will distribute required grant-related documents to the MSD and DOW.

DOW WMB Quality Assurance Coordinator – **Caroline Chan:** reviews and approves the QAPP and may make recommendations on project operations related to QA activities. She will be involved in reviewing data reports throughout the project.

DOW WMB Manager – **John Webb**: reviews and approves the QAPP.

DOW Quality Assurance Officer – **Mary Rockey**: reviews and approves the QAPP. She will provide technical input for QAPP development and will review data reports throughout the project.

MSD Grant Recipient Project Manager – **Colette Easter**: may write the QAPP or designate this role. She will be responsible for all communications between DOW and MSD. She will be responsible for project operations on the ground and reporting to DOW whenever this QAPP or the grant requires. She will be responsible for submitting progress and final reports and data to DOW.

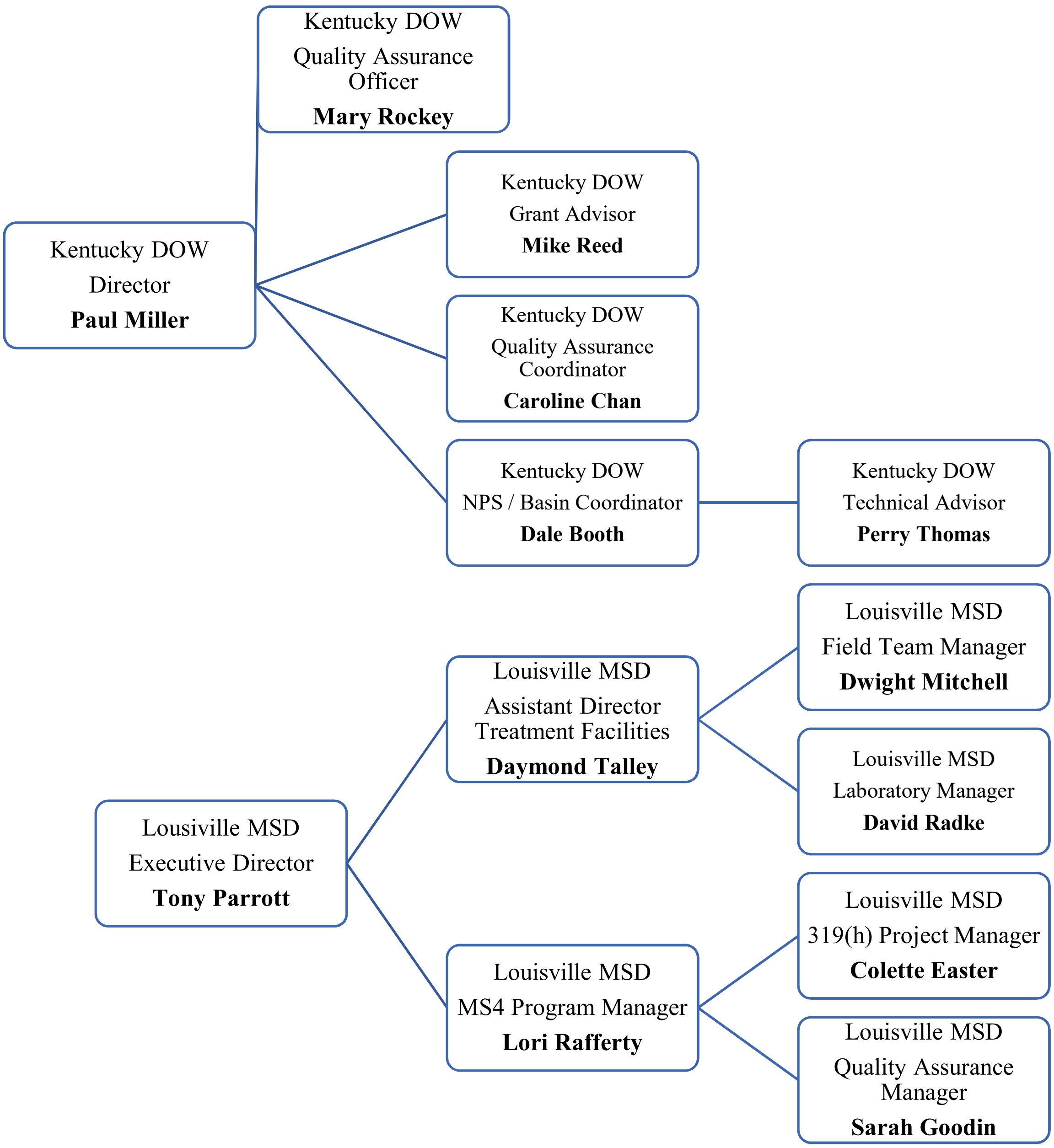
MSD Grant Recipient Project QA Manager – **Sarah Goodin**: will be separate from data collection for the project (if possible). She may be responsible for reviewing and implementing the QAPP and ensuring that all QA activities are followed throughout the project. She may conduct data analysis.

MSD Field Team Manager – **Dwight Mitchell**: is responsible for sample collection and ensuring that the field sample collection adheres to this QAPP.

MSD Morris Forman WQTC Laboratory Manager – **Daymond Talley:** oversees all aspects of laboratory operations including quality assurance, quality control, maintaining certifications, staffing, supplies and equipment, maintenance and operations, data management. This laboratory is certified by Kentucky Division of Water (DOW). The laboratory certification number is KY#08034.

MSD Morris Forman WQTC Laboratory Research Chemist – David Radke: is responsible for overseeing the water quality sample analysis performed at the MSD lab, data entry and QA/QC review and reporting for laboratory analysis.

Figure 1. Project Organizational Chart



1.7 Project Background and Overview

The Middle Fork of Beargrass Creek drains a 25.2 square mile watershed in Jefferson County, Kentucky (Figure 2). It includes approximately 61 linear miles of stream within the 14-digit Hydrologic Unit Code (HUC) 05140101250010. The Kentucky Division of Water (DOW) has identified water quality impairments in segments of Middle Fork Beargrass Creek (DOW, 2010a). The downstream segment (river mile 0.0 to 2.0) was listed as impaired because warm water aquatic habitat (fishable) and primary contact recreation (i.e., swimming) uses were not supported. The middle segment (river mile 2.0 to 2.9) and the upper segment (river mile 2.9 to 15.3) were listed as impaired because primary contact recreation uses (swimming) were not supported. Other designated uses were not assessed. In addition to these impairments, sedimentation and loss or lack of riparian habitat are also of concern.[1]

To address the recreational designated use impairments, DOW developed a Fecal Coliform Total Maximum Daily Load (TMDL) (DOW, 2011a). This TMDL included target reductions of fecal coliform bacteria needed to achieve the water quality standards. In addition, a proposed draft TMDL was developed for organic enrichment impairments (DOW, 2011b). Both of these TMDLs recommended development of a Watershed Based Plan as a non-regulatory strategy to support attaining the goals of the TMDL.

Per the most recent Integrated Report published in 2018, the downstream end of Middle Fork Beargrass Creek (River Mile 0.0 to 2.0) is listed as being impaired for Warm Water Aquatic Health. Warm Water Aquatic Health uses were listed as fully supported in the two (2) segments extending from River Mile 2.0 to 2.9 and 2.9 and 15.3. All three (3) of these segments were listed as having an approved or established TMDL with Primary Contact Recreation (swimming) uses not met due to elevated bacteria concentrations (KDOW, 2018).

The focus of this watershed plan is to work with project partners and watershed stakeholders to identify and reduce the sources of bacteria, focusing on urban runoff as a non-point source of bacteria. This watershed planning project does not directly address sources of oxygen-demanding substances. However, the Best Management Practices identified through this project as well as extensive efforts being implemented by the Louisville and Jefferson County Metropolitan Sewer District (MSD) to reduce the frequency and volume of combined sewer overflows and to eliminate sanitary sewer overflows are anticipated to result in reductions in oxygen-demanding substances. Other aspects of the watershed planning project not addressed through water quality monitoring will focus on habitat modification, and hydrologic modification. MSD will assess progress toward

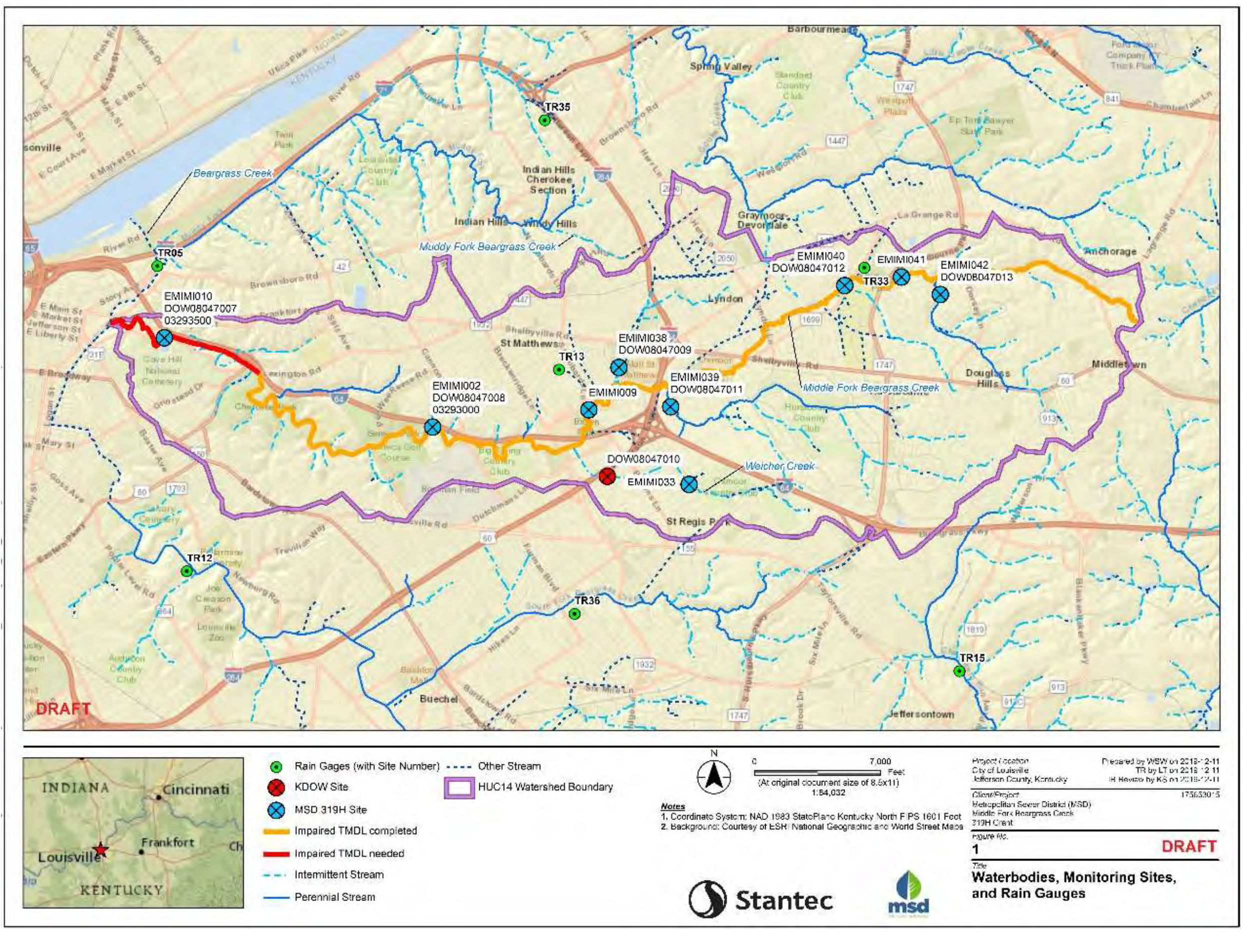
[1] Please see the Watershed Planning Guidebook, Watershed Basics, Part III: The Regulatory World for a more detailed description of designated uses and impairments (KDOW 2010b).

achieving the goals of watershed planning through the collection of water quality data at nine (9) locations within the watershed.

This Quality Assurance Project Plan (QAPP) was developed based on review of several guides and resources (EPA, 2002; DOW, 2011c; USGS, 2006), and outlines the measures taken to ensure the collection of quality surface water monitoring data throughout the conductance of this project.

The watershed boundary, mapped and assessed waterbodies, Long Term Monitoring Network sites (3 sites), DOW 319(h) monitoring sites (7 sites), MSD 319(h) monitoring sites (9 sites), some of which are co-located and MSD rain gauges are shown on Figure 2. This figure also depicts the impairment status per the *2016 Integrated Report 303(d) List* (DOW, 2018).

Figure 2. Waterbodies, Monitoring Sites, and Rain Gauges (1)



1. Map depicts watershed boundary, mapped and assessed waterbodies, Long Term Monitoring Network sites (3 sites), DOW 319(h) monitoring sites (7 sites), MSD 319(h) monitoring sites (9 sites), impairment status per the 2016 Integrated Report 303(d) List (DOW, 2018).

Monitoring performed by MSD under the Municipal Separate Storm Sewer System (MS4) Permit (KPDES Permit # KYS000001) and this 319(h) project and DOW in the Middle Fork Beargrass Creek Watershed is described below.

MSD MS4 Program Monitoring: MSD's Long Term Monitoring Network (LTMN) activities in the Middle Fork Beargrass Creek include continuous monitoring for stream discharge, gage height at three (3) sites, continuous monitoring for temperature, dissolved oxygen, pH, and specific conductance at two (2) sites. Monitoring activities at three (3) sites include: quarterly water quality, recreation season bacteria monitoring, and biological monitoring (every two years). Rain gauges continuously monitor precipitation at two (2) sites and NEXRAD radar data is also collected.

DOW 319(h) Monitoring: DOW completed monitoring at seven (7) locations in support of the Middle Fork Beargrass Creek Watershed-Based Plan between March 2019 and February 2020. Monitoring included *E. coli* bacteria, water chemistry, field observations, stream discharge, benthic macroinvertebrates, and habitat assessment. This monitoring will be reported in Chapter 3 of the Watershed-Based Plan.

MSD 319(h) Monitoring: The specific purpose of this monitoring is to collect additional *E. coli*, field parameters and flow data that more fully characterize bacteria concentrations and loadings as well as sources of bacteria pollution and watershed response to changes in season and flow. *Therefore, the E. coli and stream discharge data are considered to be the most critical parameters for this monitoring component of watershed-based plan development.*

Taken together, MS4 data, DOW 319(h) data and MSD 319(h) data will provide a stronger basis for identifying sources and tracking progress toward the ultimate goal of clean, safe waterways. This monitoring will be reported in Chapter 3 of the Watershed-Based Plan.

The MSD 319(h) Monitoring is the subject of this QAPP for nine (9) MSD locations (Figure 2). The types of samples, field activities, measurements/analyses collected, frequency and number of sites are summarized as in Table 1.

Table 1 – MSD 319(h) Monitoring Activities Overview

Monitoring Activity	Field Activities	Measurements/ Analyses Required	Frequency	# of Sites
E. coli bacteria	Grab sample	Standard Methods for the Examination of Water and Wastewater (SM9223B) 1997 MSD *E. Coli* Rev 6 090118 (or most recent update)	Monthly sampling event, plus 5 samples within 30 days for May or June	9

Monitoring Activity	Field Activities	Measurements/ Analyses Required	Frequency	# of Sites
Field Parameters	HydroTech Compact DS **(1)**	Dissolved oxygen, pH, specific conductance, water temperature, turbidity	Every sampling event	9
Stream discharge	Hach FH950 handheld flow meter & wading rod **(1,2)**	Stream discharge	Every sampling event	9

Notes:
1. At Middle Fork Beargrass Creek at Old Cannons Lane (03293000, EMIMI002) and Middle Fork Beargrass Creek at Lexington Road (03293500, EMIMI010), field parameters (i.e., dissolved oxygen, pH, specific conductance, water temperature) and stream discharge measurements will be supplemented with data from MSD/USGS sonde readings and USGS stream flow gages.
2. Hach FH950 is equipped with automatic depth sensor

The project schedule for the QAPP development, monitoring activities, data submittal, and report development are outlined in Table 2. The planned schedule for field quality control samples is provided in Appendix B.

Table 2 – MSD 319(h) Planned Project Schedule

Year	**2019**			**2020 (1)**												**2021**		
Month	**O**	**N**	**D**	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**J**	**F**	**M**
QAPP/ Planning	X	X	X	X														
Monitoring					X	X	X	X	X	X	X	X	X	X	X	X		
Data Analysis					X	X	X	X	X	X	X	X	X	X	X	X	X	
Final Report																		X

1. Monitoring includes field parameters, stream discharge and E. coli measurements once per month. In May or June, samples will be collected five (5) times in 30 days.

1.8 Data Quality Objectives (DQOs)

Data Quality Objectives are qualitative and quantitative statements that clarify the intended use of the data, define the type of data needed to support the watershed plan, and identify the conditions under which the data should be collected. Note that these data quality objectives are focused on MSD 319(h) monitoring.

State the Problem: According to 2016 DOW Integrated Report, segments of the Middle Fork Beargrass Creek did not meet the primary contact recreation (swimming) designated use and therefore were designated as impaired. The purpose of this monitoring is to collect additional data to better characterize bacteria concentrations and loadings throughout the watershed, including mainstem and tributaries and to characterize source areas (subwatersheds) that may be contributing to elevated bacteria on the mainstem of Middle Fork Beargrass Creek. In addition, accurate baseline conditions will be necessary in order to show improvements in water quality after the implementation of any prescribed Best Management Practices (BMPs). MSD's MS4 monitoring will supplement the 319(h) monitoring performed by DOW.

Identify the Goal of the Study: Existing monitoring data collected by MSD occurs on the mainstem of Middle Fork Beargrass Creek at three (3) downstream locations: Lexington Road, Cannons Lane and Browns Park. The goal of this study is to further characterize the sources of *E. coli* bacteria and impacts on basic water chemistry parameters of nonpoint sources of urban runoff throughout the Middle Fork Beargrass Creek watershed and to establish baseline conditions for showing measurable improvements. The monitoring will be performed in support development of a watershed plan for the Middle Fork of Beargrass Creek that focuses on measurable improvements in the watershed, including recreational designated use attainment.

Identify Information Inputs: Information inputs include 319(h) monitoring, GIS mapping and existing data from other projects that have an equivalent QA system in place as described below.

- **MSD 319(h) Monitoring:** bacteria monitoring data, field parameters (pH, temperature, dissolved oxygen, conductivity, turbidity, stream discharge). Quality assurance requirements for these measurements are included in this QAPP.

- **DOW 319(h) Monitoring:** *E. coli* bacteria, water chemistry, field parameters, stream discharge, benthic macroinvertebrates and aquatic habitat. This monitoring will be reported in Chapter 3 of the Watershed-Based Plan.

- **GIS Mapping:** data sources include data that has been reviewed and published by the Louisville and Jefferson County Information Consortium (LOJIC) (https://www.lojic.org/), KY GeoNet (http://kygeonet.ky.gov/) and monitoring site locations provided by DOW. These data sources are responsible for quality assurance and metadata associated with their GIS data.

- **Existing Data with QA System in Place:** Monitoring is conducted at three (3) LTMN sites in the Middle Fork Beargrass Creek as described below and a more detailed description of the LTMN program is provided in the *2017 Municipal Separate Storm Sewer System (MS4) Annual Report* (Louisville / Jefferson County Metropolitan Sewer District, 2017).

- **USGS Stream Flow:** USGS collects stream flow measurements every 5 to 15 minutes from two (2) gauges in the Middle Fork Beargrass Creek, station numbers 03293500 and 03293000. USGS performs a quality assurance review and publishes final flow data and stream statistics. Provisional and final data are available for download on the USGS National Water Information System (NWIS) website: http://waterdata.usgs.gov/ky/nwis.

- **MSD / USGS Continuous Monitoring:** Temperature, dissolved oxygen, pH, and specific conductance data are collected by MSD and USGS at two (2) cooperatively operated monitoring locations using probes called sondes in the Middle Fork Beargrass Creek. Provisional water quality data is sent via telemetry to USGS every 15 minutes. Up to 35,136 records per year were collected for each parameter at each station during the year. Using USGS procedures, sondes are cleaned, calibrated, and maintained on a regular basis by MSD staff, which is trained annually by USGS (USGS, 2006). USGS performs a quality assurance review, adjusts or deletes some records, and publishes final data to the NWIS website.

- **MSD Quarterly Monitoring**: Trained MSD staff collect quarterly water quality samples at three LTMN sites in the Middle Fork Beargrass Creek for parameters required in the MS4 Permit. Samples are analyzed at MSD's Laboratory and MSD reports results in MS4 Annual Reports.

- **MSD Bacteria Monitoring:** As required by the MS4 Permit, trained MSD staff collect five *E. coli* bacteria samples at three LTMN sites in the Middle Fork Beargrass Creek. Samples are analyzed at MSD's Laboratory and MSD reports results in MS4 Annual Reports.

- **MSD Biological Monitoring:** As required by the MS4 Permit, trained biologists collect biological community data at three LTMN sites in the Middle Fork Beargrass Creek. Biological monitoring includes fish communities, benthic macroinvertebrate communities, algal communities and aquatic habitat. MSD reports results in MS4 Annual Reports.

- **MSD Precipitation Monitoring:** As required by the MS4 Permit, MSD collects rainfall data at 46 sites in Jefferson County and surrounding counties, including at two (2) rain gauges in the Middle Fork Beargrass Creek. MSD also collects NEXRAD data.

Define the Boundaries of the Study: Monitoring sites located within the Middle Fork Beargrass Creek watershed were selected by MSD with consideration for DOW 319(h) monitoring sites (Figure 2). All are publicly accessible; landowner permission is not required. Samples will be collected from representative areas of the stream (thalweg) by MSD field staff during work hours.

Per the *Watershed Planning Guidebook for Kentucky Communities* (DOW, 2010b), two wet weather samples will be collected during the 12-month monitoring period. All other samples will be collected under ambient conditions occurring at the time of sampling.

Develop the Analytical Approach: Data analysis will be performed on final data (i.e., data quality reviews completed, results approved for use) per this QAPP. Results will be compared to the applicable water quality criteria (401 KAR 10:031). Criteria comparisons will be performed for *E. coli* criteria for May or June, when five (5) bacteria samples in 30 days have been collected, pH, dissolved oxygen, and water temperature. For months with fewer than five (5) *E. coli* samples, and for remaining parameters (i.e., specific conductance and stream discharge), medians or percentiles of data will be used to compare sites to each other and assess patterns at individual sites over time and to compare water quality under dry and wet conditions. Loads of *E. coli* bacteria, reported as colonies per day, will be calculated using final available concentration and flow data.

Specify Acceptance Criteria: Data will be reviewed per the Data Quality Indicators (DQIs) in Table 3 to ensure that sample data are within the expected range. and included in the results database as reported (qualified using data quality codes that indicate a data quality issue) or excluded from the analysis if sample contamination is reasonably suspected. Field parameter accuracy and resolution values are as reported by HydroTech Compact DS User Manual (HydroTech, undated). Acceptance criteria are provided in Tables 7 and 8, and data qualifier codes are provided in Table 11.

Table 3 – MSD 319(h) Data Quality Indicators and QC Requirements

Parameter (Units)	Method	Expected Range	Accuracy	Sensitivity (Resolution)	QC
Temperature (°C)	HydroTech Compact DS	0-35	0.01° C	0.10 ° C	As-needed maintenance per SOP
Specific Conductance (uS/cm)	HydroTech Compact DS	100-2,000	1% of reading	0.1 uS/cm	Calibration check within 24-hours of sampling, calibration and maintenance as-needed per SOP
pH (Std. units)	HydroTech Compact DS	4-10	0.2	0.01	Calibration check within 24-hours of sampling, calibration and maintenance as-needed per SOP

Parameter (Units)	Method	Expected Range	Accuracy	Sensitivity (Resolution)	QC
Dissolved Oxygen (mg/l)	HydroTech Compact DS	0-20	± 0.01 mg/L for 0–8 mg/L; ± 0.02 mg/L for greater than 8 mg/L	0.01 or 0.1 mg/L	Calibration check within 24-hours of sampling, calibration and maintenance as-needed per SOP
Turbidity (NTU)	HydroTech Compact DS	0-1,000	± 1% up to 100 NTU, ± 3% up to 100–400 NTU, ± 5% from 400–3000 NTU	0.1 NTU: 0–400 NTU, 1 NTU: >400 NTU	Calibration check within 24-hours of sampling, calibration and maintenance as-needed per SOP
Velocity (used to calculate discharge) (f/s)	Hach FH950 handheld flow meter & wading rod	0-5,000	0 to 10 ft/s: ±2% of reading 10 to 16 ft/s: ± 4% of reading	0.05 cfs	Calibration check within 24-hours of sampling, calibration and maintenance as-needed per SOP
E. coli (MPN/ 100 mL)	Grab sample	4 -240,000		4 MPN/100 mL	Field blanks and splits, laboratory blanks **(1)**
1. These project specific quality control measures are in addition to the extensive quality control measures and sterility checks employed by MSD's laboratory as required by DOW certification (MSD, 2019)					

The following DQIs apply to this MSD 319(h) sampling project. The purpose of the DQIs defined below is to ensure that the quality of the data collected is appropriate for its intended use in this watershed planning project. The planned schedule for field quality control sample collection is provided in Appendix B.

Table 4 – MSD 319(h) Data Quality Indicators

DQI	Definition	Project QC Samples
Precision **(1)**	Measure of agreement among repeated measurements of the same property under similar conditions. Usually expressed as a range, standard deviation, variance, percent difference in either absolute or relative terms.	*E. coli* - one split sample on each sample day (11%).

DQI	Definition	Project QC Samples
Accuracy	Measure of closeness of an individual measurement to a known or reference value. Expressed as percent recovery or percent bias.	All *E. coli* samples will be collected directly into sample bottles. All SOPs and QA/QC procedures will be followed throughout the sampling period.
Bias	Systematic or persistent distortion of a measurement process that results in errors in one direction.	Bias will be assessed one *E. coli* field blank, one method blank per sample event.
Representativeness	A qualitative measure of the degree to which data accurately and precisely represent a characteristic of a population parameter.	Bacteria samples and field parameter measurements will be collected using procedures described in the SOP, from representative thalweg areas with flowing water just above a riffle at the selected monitoring sites as described in the SOP. Stream discharge measurements will be collected from a representative location as described in Section 8.3.1.1 of the SOP.
Comparability	A qualitative term describing the degree to which different processes, methods or data agree or can be represented as similar. Expresses the measure of confidence that two data sets can contribute to a common analysis.	Comparability will be maintained by following the quality assurance procedures outlined in this QAPP and all relevant SOPs.
Completeness	An evaluation of the amount of data needed to be obtained from a measurement system. Expressed as a percentage of the number of measurements that should have been collected or were planned to be collected.	The target is to collect at least 90% of the monitoring data described in this plan (i.e., at least 130 out of 144 samples or measurements per parameter). Five (5) samples per 30 days will be collected in May or June 2020 to support comparison of E. coli data to primary contact recreation criteria (401 KAR 10:031)
Sensitivity	Capability of a method to discriminate between measurement responses representing different levels of the variable of interest. Terms used to describe sensitivity include MDL, LOD and LOQ.	Achieve MDL, LOD, LOQ targets for *E. coli* data per MSD's Laboratory SOP and QAPP. Sensitivity of E. coli (i.e., MDL, LOD and LOQ) are proportional to dilution needed to increase method

DQI	Definition	Project QC Samples
		sensitivity and minimize the number of "greater than" results.
1. Per In situ Water Quality Measurements and Meter Calibration for Lotic Waters DOWSOP03014 duplicate analysis is not appropriate for in situ measurements for lotic waters (KDOW, 2018a),		

1.9 Special Training Requirements

See Section 3 of *Technical Standard Operating Procedure for MSD 319(h) Monitoring for the Middle Fork Beargrass Creek Watershed-Based Plan* (Louisville / Jefferson County Metropolitan Sewer District, 2019).

1.10 Documentation and Records

Records management and progress data reports are described below.

1.10.1 Records Management

Critical records for this project include:

- Hach FH950 handheld flow meter and HydroTech Compact DS meter maintenance records are stored in bound notebooks at MSD's Central Maintenance Facility
- Hach FH950 handheld flow meter and HydroTech Compact DS meter calibration logs – originals are stored by MSD Field Staff Manager and scanned to MSD's network project folder
- Field Data Collection Sheets – originals stored by MSD Project Manager in paper files and scanned to the project file on MSD's network project folder
- Stream Discharge Excel Sheets – files downloaded from the Hach FH950 are transferred to Excel and used to calculate stream discharge per the SOP
- Chain of Custody Sheets – one copy delivered to MSD's laboratory and stored in laboratory paper files, one copy stored by MSD Project Manager in paper files and scanned to the project file on MSD's network project folder
- Site Photographs – digital files stored in the project file on MSD's network
- Laboratory Bench Sheets – used in the lab to record *E. coli* results
- Field parameters and stream discharge data are entered into MSD's Laboratory Information Management System (LIMS) by MSD Field Staff

- Laboratory data are entered into MSD's Laboratory Information Management System (LIMS) by Laboratory Technicians
- Monthly Monitoring Reports – digital files stored in the project file on MSD's network and submitted to DOW (See Section 4.5)

All project records will be maintained for three (3) years from the grant end date per DOW grant requirements (September 30, 2022 – September 29, 2025). File locations are described in Section 2.8 Data Management.

1.10.2 Monthly Monitoring Reports

As required by DOW, a progress data report and field and laboratory documentation will be submitted to DOW prior to the next sample event, generally within 30 days. The Monthly Monitoring Report will include all data collected during the event. The following sections describe specific elements of a progress data report that will be required after each sampling event.

<u>Field Documentation</u>
Field documentation will include copies or scans of calibration records, Field Data Collection Sheets, Chain of Custody sheets and site photographs. Photos will be retained and submitted so that the original date and location is recorded.

<u>Laboratory Documentation</u>
Sample results from the MSD Morris Forman WQTC Lab will be included in both report format (copies of lab reports) and electronic data (in Excel or another electronic spreadsheet) format. Lab reports will include data qualifiers and a narrative explanation of qualifiers (lab flags). If data problems are reported that may affect the usability of the data, quality control sample results may be requested. The MSD Morris Forman WQTC Laboratory is certified for wastewater analysis under the Kentucky Laboratory Wastewater Certification Program (KY#08034); these documents can be provided upon request.

2.0 DATA ACQUISITION

2.1 Sampling Design

Sampling will occur monthly, as described in Table 1. Sampling will be conducted during the third week of each month, between Monday and Thursday, and samples will be delivered to the laboratory before 1:00 pm on the day of sampling to allow time for laboratory analysis of samples. Monitoring sites are described in Table 5 and shown on Figure 2. The rationale for monitoring sites is provided in Table 6.

Table 5 - MSD and DOW 319(h) Monitoring Site Locations

Station ID (DOW, MSD, USGS)	Waterbody	Location	River Mile	Drainage Area (mi^2)	Latitude	Longitude
DOW08047007 EMIMI010 03293500	Middle Fork Beargrass Creek **(1,2)**	Lexington Road	0.9	24.8	38.250276	-85.716868
DOW08047008 EMIMI002 03293000	Middle Fork Beargrass Creek **(1,2)**	Old Cannons Lane	5.4	18.7	38.23729	-85.66468
EMIMI009	Middle Fork Beargrass Creek **(2,3)**	Browns Lane	7.97	15.2	38.2403	-85.6345
DOW08047010	Weicher Creek **(4,5)**	Above Blossom-wood Drive	0.55	1.3	38.23016	-85.63071
EMIMI033	Weicher Creek	Lincoln Road	1.56	0.57	38.22902	-85.61491
DOW08047009 EMIMI038	Middle Fork Beargrass Creek UT 8.45 (Sinking Fork) **(4)**	Below Bowling Boulevard	0.3	2.6	38.24683	-85.62881
DOW08047011 EMIMI039	Middle Fork Beargrass Creek UT 9.1	Off Steeplecrest Circle	0.2	3.9	38.24093	-85.61867
DOW08047012 EMIMI040	Middle Fork Beargrass Creek	Off Old Whipps Mill Road	11.7	5.0	38.25984	-85.58529
EMIMI041	Middle Fork Beargrass Creek **(3)**	Forest Bridge Road	12.38	4.07	38.26126	-85.57434
DOW08047013 EMIMI042	Middle Fork Beargrass Creek UT 12.8	Above Foxboro Road	0.2	2.2	38.25867	-85.56680

Notes:
1. USGS Gages record stream discharge; MSD/USGS sondes record pH, DO, temperature, conductivity on 15-minute intervals: 03293500, 03293000
2. MSD Long Term Monitoring Network sites: EMIMI010, EMIMI002, EMIMI009
3. This site sampled only by MSD, DOW did not sample this site
4. These sites were reversed in the grant application and are updated in this QAPP
5. MSD not monitoring this site for 319(h) monitoring; DOW monitored this site but it’s an intermittent tributary, so MSD discontinued this site

Table 6 - MSD 319(h) Monitoring Site Rationale

Station ID (DOW, MSD, USGS)	Waterbody	Location	Monitoring Rationale
DOW08047007 EMIMI010 03293500	Middle Fork Beargrass Creek	Lexington Road	Downstream end of watershed, add to LTMN and DOW 319(h) monitoring database
DOW08047008 EMIMI002 03293000	Middle Fork Beargrass Creek	Below Old Cannons Lane	Within Combined Sewer Overflow (CSO) area, add to LTMN and DOW 319(h) monitoring database
EMIMI009	Middle Fork Beargrass Creek	At Browns Lane	Upstream of CSO area, add to LTMN and DOW 319(h) monitoring database
DOW08047009 EMIMI038	Middle Fork Beargrass Creek UT 8.45 (Sinking Fork)	Below Bowling Boulevard	Commercial area
EMIMI033	Weicher Creek	Lincoln Road	Downstream of golf course
DOW08047011 EMIMI039	Middle Fork Beargrass Creek UT 9.1	Off Steeplecrest Circle	Suburban area
DOW08047012 EMIMI040	Middle Fork Beargrass Creek	Off Old Whipps Mill Road	Downstream of flood control dam and large wetland upstream of dam
EMIMI041	Middle Fork Beargrass Creek	Forest Bridge Road	Upstream of Old Whipps Mill Road dam
DOW08047013 EMIMI042	Middle Fork Beargrass Creek UT 12.8	Above Foxboro Road	Upstream end of watershed, characterize suburban area

Equipment and supplies, step-by-step procedures, and instrument or method calibration and standardization are documented Sections 6, 7, and 8 of the *Technical Standard Operating Procedure MSD 319(h) Monitoring for Middle Fork Beargrass Creek Watershed-Based Plan*, which is included as Appendix A.

Monitoring activities are described in Table 1 and field QC samples are described in Table 4.

2.2 Sampling Procedures and Requirements

Sampling procedures are described in the *Technical Standard Operating Procedure for MSD 319(h) Monitoring for the Middle Fork Beargrass Creek Watershed-Based Plan*, which is included as Appendix A.

2.3 Sample Handling and Custody Requirements

Sampling procedures are described in the *Technical Standard Operating Procedure for MSD 319(h) Monitoring for the Middle Fork Beargrass Creek Watershed-Based Plan*, which is included as Appendix A.

2.4 Analytical Methods Requirements

The *E. coli* analysis will be performed by MSD's laboratory using IDEXX Colilert based on *Standard Methods for the Examination of Water and Wastewater, 23rd. Edition,* 9223B Enzyme Substrate Coliform Test (Water Environment Federation, 2017b). This method is included in *U.S. Code of Federal Regulations: 40 CFR Part 136.4* (US CFR, 2012). The laboratory method is described in MSD's *Laboratory Standard Operating Procedure: E. coli, Rev 6 090118* (Louisville / Jefferson County Metropolitan Sewer District, 2018), or the most recent update. The laboratory is certified by the Kentucky Division of Water (KY#08034).

2.5 Quality Control Requirements

Quality control requirements for field sampling and field measurement instrumentation are shown on Tables 7 and 8. All documentation of calibration checks and calibrations will be retained in the project file and submitted to DOW with the event report after each sampling event. If measurement performance criteria are not met per these tables, corrective action will be taken promptly to address the problem. Every effort will be made to address QA/QC issues prior to the next sample event.

Table 7 – MSD 319(h) Field Sampling Quality Control Requirements

Requirement	Frequency	Corrective Action	Persons Responsible for Corrective Action	Data Quality Indicator	Measurement Performance Criteria
E. coli Field Splits (1)	1 field split each sample day (11%)	▪ Censor or qualify data as necessary ▪ Review sample collection procedures	Project Manager and QA Manager	Precision	The acceptable range of deviation between sample results will be determined by the precision criteria set using the procedures in SM 9020B, Section 8b (See SOP Appendices)

Requirement	Frequency	Corrective Action	Persons Responsible for Corrective Action	Data Quality Indicator	Measurement Performance Criteria
E. coli Field Blanks (2)	1 field blank each sample day (11%)	▪ Censor or qualify data as necessary ▪ Review sample collection and storage procedures	Project Manager and QA Manager	Accuracy or Bias, Contamination	Result is < 1 MPN/100ml

1. Field Split – single sample collected by field team. The lab will split into two samples and analyze separately in the lab. Used to estimate subsampling and laboratory analysis precision.
2. Field Blank – de-ionized water from the carboy or other container which is treated as a sample. Used to identify errors or contamination in sample collection and analysis.

Table 8 – MSD 319(h) Field Measurement/Analysis Quality Control Requirements

Requirement	Frequency	Corrective Action	Persons Responsible for Corrective Action	Data Quality Indicator	Measurement Performance Criteria
Calibration of HydroTech Compact DS Field Meter	Calibration check within 24-hours of sampling, calibration and maintenance as-needed per SOP	Re-calibrate to within allowable specifications	Field Manager, Project QA Manager, Project Manager	Accuracy	Must meet or exceed instrument accuracy specifications
Calibration of Hach FH950 Flow Meter	Calibration check within 24-hours of sampling, calibration and maintenance as-needed per SOP	Send to manufacturer for factory calibration	Field Manager, Project QA Manager, Project Manager	Accuracy	Must meet or exceed instrument accuracy specifications

Because *E. coli* varies widely within streams, field duplicates are representative of variability of bacteria in the stream as well as variability in the sample procedure. Therefore, field splits will be used to assess the variability of the sample procedure, using methods applied by DOW for their monitoring in Middle Fork Beargrass Creek. Field splits will be collected into one sterile bottle in the field and split into two samples in the laboratory. Each sample will be analyzed separately by the laboratory. The precision criterion will be calculated using methods described in *Standard*

Methods for the Examination of Water and Wastewater, 23rd. Edition: 9020 Quality Assurance/Quality Control (Water Environment Federation, 2017a).

2.6 Testing, Calibration and Maintenance Requirements for Equipment and Supplies

2.6.1 Instrument Testing and Calibration

Instrument testing and calibration procedures are described in the *Technical Standard Operating Procedure for MSD 319(h) Monitoring for the Middle Fork Beargrass Creek Watershed-Based Plan*, which is included as Appendix A.

Table 9 – MSD 319(h) Instrumentation and Required Checks

Instrument	Calibration	Maintenance
Hach FH950 Flow Meter	Velocity calibration check, calibrate as needed prior to each trip	As needed and per manufacturer's instructions
HydroTech Compact DS Field Meter	Calibration check, calibrate as needed prior to each trip	As needed and per manufacturer's instructions

2.6.2 Supplies and Consumables

The MSD Field Supervisor is responsible for ordering supplies and consumables including calibration solutions, pH buffers and sterile sample bottles. A sterility certificate accompanies the bottles and the field blank collected during each sample serves as an additional check of bottle sterility. The Field Supervisor oversees inspection of supplies and consumables to ensure that reagents are appropriate for the meters, not expired, containers are intact, and batteries are in working order. To ensure that adequate supplies and consumables are available to meet project needs, the MSD Field Supervisor will order supplies and consumables prior to expiration dates and / or when supplies are depleted.

The MSD Laboratory's Research Chemist is responsible for ordering all supplies and consumables related to *E. coli* analysis, inspection of these supplies and consumables, performing required sterility checks and ensuring an adequate supply of de-ionized water is available for field blanks and laboratory use.

Equipment and supplies are described in the *Technical Standard Operating Procedure for MSD 319(h) Monitoring for the Middle Fork Beargrass Creek Watershed-Based Plan*, which is included as Appendix A. Table 10 defines the acceptance criteria for supplies and consumables.

Table 10 – MSD 319(h) Supplies and Consumables

Supply Item	Acquired By	Acceptance Criteria
Sample Bottles	MSD Morris Forman WQTC Lab	Free from defects, residues, and flaws. Laboratory blanks (1 per 10 samples, 10%) serve as the check to ensure sample bottles are sterile. Bottle sterility certificates are on file at MSD and available upon request
Calibration Solutions	MSD Field Supervisor	Solution documented when received, when opened, and used prior to expiration. The expiration of calibration solutions may be different from the date printed on the label. It is the date printed on the label OR 1-6 months (depending on the type of solution) after the container was opened, whichever comes first.

2.7 Data Acquisition Requirements for Non-direct Measurements

Non-direct measurements include monitoring data that is relevant to the development of the Middle Fork Beargrass Creek Watershed-Based Plan, but the collection of this data is not included in this QAPP. The following monitoring efforts are considered non-direct measurements.

- **MSD LTMN Monitoring:** Water quality monitoring data are collected at three sites that are also being monitored for this 319(h) monitoring project. MSD has prepared a QAPP for MSD 319(h) Monitoring Programs that describes quality assurance.
- **MSD Rain Gauge Network:** Rain gauge data are collected at two (2) gauges in the Middle Fork Beargrass Creek watershed.
- **USGS Stream Gaging:** USGS has developed extensive quality assurance documentation for the national stream gaging program and for the Ohio-Kentucky-Indiana Water Science Center (Griffin, M., 2006). Stream gaging data will be used to evaluate stream flow patterns at the two gaged sites in this watershed.
- **DOW 319(h) Monitoring:** DOW collected monitoring data at 7 sites in the Middle Fork Beargrass Creek Watershed. DOW has stated that they will use this data to assess designated use attainment to support development of the Middle Fork Beargrass Creek Watershed-Based Plan
- **Salt River Watershed Watch Monitoring:** The Salt River Watershed Watch (SRWW) uses statewide protocols to train and equip volunteer monitors to test waterbodies of

interest to them, including sites in the Middle Fork Beargrass Creek. SRWW have collected bacteria data using a certified laboratory and field parameters using Hach and LaMotte test kits three (3) times per year. Some SRWW data extends back to 1999. This volunteer monitoring group does not have an approved QAPP, therefore, SRWW's data will be summarized in the Chapter 2 of the Watershed-Based Plan and used to evaluate reaches that may not be sampled by agency monitoring. If issues are identified, additional sites may be considered for future agency sampling efforts. SRWW data is not of sufficient quality to inform Best Management Practice (BMP) selection decisions.

2.8 Data Management

All project records will be maintained for three (3) years per KDOW grant requirements. All raw data and laboratory reports will be electronically stored and submitted to DOW. The MSD Project Manager is responsible for maintaining project documentation and records for a minimum of three years from the grant end date (September 30, 2022 – September 29, 2025).

Monitoring records will be in paper and digital format or digital format only (i.e., site photographs) and include, but are not limited to:

- QAPP, SOP and appendices
- Meter maintenance and calibration records
- Field data sheets
- Stream discharge Excel files
- Chain of custody sheets
- Site photographs (digital only)
- Monitoring data housed in MSD's Laboratory Information Management System
- Monthly Monitoring event reports

Paper records will be maintained by the MSD Project Manager. Digital files will be stored in the project directory on MSD's network.

Specific digital file locations are listed below:

- W:\DATA\MS4\Grants\319 Watershed\Middle Fork Beargrass
- Laboratory data will be stored in MSD's Laboratory Information Management System (LIMS).
- Laboratory SOPs: L:\\sfile201\vol1\mfwtp\data\lab

3.0 ASSESSMENTS

Project assessments are designed to determine whether the QAPP is being implemented as approved, and ultimately to ensure that the information will be usable for the intended purpose.

3.1 Technical Assessments

Monthly monitoring reports submitted after each sampling event will also serve as technical assessments, and DOW follow-up may occur if issues are found.

3.2 Audits of Data Quality

E. coli and field data will be reviewed when collected in field and when received in office for completeness and accuracy according to SOPs and laboratory standards.

Data quality will be assessed after each sampling event for completeness and range of acceptability of QC samples.

4.0 REVIEW, EVALUATION AND REPORTING REQUIREMENTS

This section describes initial data review, validation and verification methods, evaluation of data usability, and reconciliation with project requirements in Sections 4.1 to 4.4. Products from this section are reports to management which are described in Section 4.5.

4.1 Initial Data Review

MSD field staff will check Field Collection Data Sheets for completeness and accuracy prior to leaving the site. The MSD Quality Assurance Manager will review each Field Collection Data Sheets after each sample event.

MSD field staff will check COCs for completion and accuracy prior to leaving the site, including site ID, date, time, sampler initials, sample location number, parameters to be analyzed, and preservative. MSD's Research Chemist and Quality Assurance Manager will review the COCs after each sample event.

The MSD Research Chemist will oversee QA/QC reviews of raw laboratory data, including assigning data flags as needed. Flagged data (Table 11) will be assessed for usability according to project objectives. If flagged data are not within the expected ranges shown on Table 3, it could be rejected and not be used in water quality assessments.
The MSD Quality Assurance Manager will review stream flow spreadsheets and calculations of stream discharge.

The MSD Quality Assurance Manager will compare all (100%) records (i.e., Field Data Collection Sheets, COCs, stream flow spreadsheets) to records entered into the Laboratory Information Management System. Any discrepancies will be rectified with assistance from the MSD Field

Supervisor and MSD Research Chemist. Final values reflecting the culmination of quality assurance checks will be reported in the Monthly Monitoring Reports.

Deviation from the QAPP and or SOP will be described in the Monthly Monitoring Report and reviewed for applicability to each step in the project. The entire project team may be involved in this review and will therefore be informed of each step. If issues arise that need additional review, laboratory staff may be asked for clarification, before informing management of critical elements that may need to be addressed at a higher level.

The MSD Project Manager and/or QA Manager will be responsible for reviewing all (i.e., 100%) of project data initially, with a secondary review conducted by DOW staff. The reviews will determine if the data results provide enough information for making project decisions. The Monthly Monitoring Report will discuss all corrective actions taken with regard to oversight functions.

4.2 Validation and Verification Methods

The following data reviews for *E. coli* sampling and field data collection as well as laboratory analysis will be performed to ensure that the data collected throughout the project meet or surpass the data quality objectives defined in Section 1.8. Methods for validation will be according to the following items:

Field

QAPP Objectives

- Samples collected from correct site
- Timing of sample collection appropriate (stream was flowing, SOP conditions met, etc.)
- QC samples completed for each parameter and appropriate statistics calculated
- Deviations from sampling plan explained

Documentation

- Calibration sheets and maintenance logbooks complete and accurate
- Field data sheets complete and accurate
- Site photograph files labeled and filed correctly
- COCs complete and accurate
- Collection, preparation, and analysis techniques consistent with QAPP and SOPs
- Any missing data fields on field data sheets explained and qualified
- Secondary data referenced and qualified

Equipment

- Calibration standards traceable and not expired
- Calibration records traceable to instrument
- Maintenance and calibration records complete and acceptable in bound logbooks

Laboratory

QAPP Objectives

- Appropriate number of samples completed for each site
- Samples collected from correct site
- QC samples completed and appropriate statistics calculated

Sample Handling – Bacteriological

- Samples labeled with correct, unique identifier
- Samples labeled with date and time
- Samples preserved correctly
- Correct bottle and sample volume utilized
- Delivery hold time not exceeded – if so, explanation of why and final outcome
- Incubation times and temperatures were met

Documentation

- COCs complete and acceptable
- Sample login documentation complete and accurate
- Missing data fields explained and qualified
- Identification bench sheets completed and accurate

Sample Analysis

- Correct method and analysis performed by the MSD Morris Forman WQTC Lab
- Detection Limits identified and recorded as a value; ensured acceptable for all parameters
- All flagged data explained; description provided for acceptance/rejection criteria
- Data outliers confirmed and documented
- QC samples met performance and project specifications

Data Entry

- 100% of all field and laboratory data entered
- Data entry QA performed on 100% of all data entered
- Data entry QA documentation complete

Table 11 lists the data flags used by MSD's Laboratory for *E. coli* data.

Table 11 – MSD 319(h) Data Flags for *E. coli* Analyses

MSD Qualifier	Description
C	Analyte detected in associated method blank
H	Duplicate/Replicate precision outside control limits
Q	Samples held at incorrect temperature
R	Sample analyzed out of the established method hold time
W	Samples reported outside of quantifiable range
7	Samples not analyzed correctly as required by the method
8	Instrument Performance Check Sample did not meet the required range
9	Microbiological incubation period outside of required method limits
<	Less Than
>	Greater Than

4.3 Evaluation of Data Usability

The MSD Project Manager will oversee the review, verification and validation of monitoring data collected in this project. The review will be accomplished by comparing the data collection process to the requirements established in this Quality Assurance Project Plan and Standard Operating Procedures. Errors will be resolved as soon as possible to ensure that they do not become propagated in databases or other permanent records.

Any data collection that deviates from the procedures or does not meet the data quality indicators will be evaluated by the MSD Project Manager and QA Manager. If the deviations are considered to be minor, the data may be included with appropriate data flags (Table 11); otherwise the data will be excluded from the dataset that is used to develop the Watershed-Based Plan. If E. coli contamination is found in field or laboratory blanks, the data associated with the compromised samples will be excluded from further analysis.

The MSD Project Manager and QA Manager will evaluate data anomalies by comparing data from each event among all of the sites. For example, if stream flow decreases downstream, the intervening reach will be evaluated for the presence of karst and potential issues with the flow meter or data collection. Data anomalies in field meter readings and flow measurements may be identified by comparing the field data to provisional data available from sondes and flow gages. If *E. coli* is locally elevated, the upstream reach will be evaluated for potential bacteria sources and field QC efforts will be targeted at that site for the next sample event.

When data anomalies are identified, they will be discussed with the MSD Field Supervisor and field crew members that sampled the site(s) in question. The MSD Project Manager and QA Manager will work with the MSD Field Supervisor and field crews and MSD Laboratory personnel to address deviations from the QAPP and SOP prior to the next sample event and may shadow the field crew to observe the sample event.

4.4 Reconciliation with Project Requirements

The data will meet project objectives through collecting samples according to all SOPs, by analysis results meeting all reporting limits, and data meeting all QC requirements. Assessments for water quality reporting will be met by obtaining all raw data and lab reports, and correctly completing the field forms.

Any limitations in the data sets will be documented in the field notes, project files, and the final report. Data may be rejected by not meeting QC guidelines or by anomalies in the analysis process communicated through flags. The DOW Project Manager and DOW QA personnel will be responsible for reviewing data and will assist in making determinations about the usability of the data.

4.5 Reports to Management

Sampling Event Reports will be produced prior to the next monthly sample event under the direction of the MSD Project Manager. One monthly report will be produced for the month May or June 2020 during which five (5) E. coli samples will be collected within 30 days.

Monthly Monitoring Reports will be reviewed by the Field Manager and Lab Manager and made available to the MSD project team via MSD's network. Reports will include a narrative description of the sample event with attachments for COC, FDCS, Laboratory Bench Sheets, Water Quality Data Table and Flow Data. The reports will identify any significant quality assurance problems and recommended solutions.

Any aspects of the QAPP and SOP encompassing field and lab work that were not followed will be noted the Monthly Monitoring Report and reviewed for potential impacts on the project. This includes deviations from meter maintenance (documented in bound log books), calibration checks with calibration as needed within 24-hours of the sample event, field data, site photographs and laboratory sample collection in the field, laboratory analysis, accompanying documentation (i.e., calibration sheets, field data collection sheets, chain of custody forms) and data management The entire project team may be involved in this review and will therefore be informed of each step. If issues arise that need additional review, laboratory staff may be asked for clarification, before informing management of critical elements that may need to be addressed at a higher level.

The final report will document all findings and conclusions of the project. The report will be available for management review. The MSD Project Manager will prepare the final report, with assistance from the QA staff or field staff as needed.

The MSD Project Manager and/or QA Manager will be responsible for reviewing project data initially, with a secondary review conducted by DOW staff. The reviews will determine if the data results provide enough information for making project decisions. The final report will discuss all corrective actions taken with regard to oversight functions.

5.0 REFERENCES

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Appendix A.

Technical Standard Operating Procedure MSD 319(h) Monitoring for Middle Fork Beargrass Creek Watershed-Based Plan

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Technical Standard Operating Procedure for MSD 319(h) Monitoring for the

Middle Fork Beargrass Creek Watershed-Based Plan

Prepared by: Stantec Consulting Services and Louisville and Jefferson County Metropolitan Sewer District

Action By:	**Signature**	**Date**
Sarah Goodin, Louisville MSD Project Quality Assurance Manager	Sarah Goodin	05/14/2020
Dwight Mitchell, Louisville MSD Operations Field Supervisor	Dwight D Mitchell	5/28/2020
Daymond Talley, Louisville MSD Laboratory Manager		05/28/2020
David Radke, Louisville MSD Laboratory Research Chemist		5/21/2020
Colette Easter, Louisville MSD Middle Fork Beargrass Creek Grant Project Manager		05/14/2020
Lori Rafferty, Louisville MSD Floodplain and MS4 Program Manager		5/19/2020

Document Revision History

The most recent revision should be listed first, with consecutive revisions listed afterwards. The original document date should be last on the list.

Date of Revision	Page(s) Revised	Revision Explanation

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5. Hach FH950 Manual

Note: This Standard Operating Procedure (SOP) was developed using the Technical SOP Template Final 2018, downloaded from the Kentucky Division of Water's Quality Assurance Website (https://eec.ky.gov/Environmental-Protection/Water/QA/Pages/default.aspx)

1 Purpose/Scope

The purpose of this document is to describe the data collection procedures for monitoring that the Louisville and Jefferson County Metropolitan Sewer District (MSD) will perform in support of the 319(h) funded watershed planning project for Middle Fork Beargrass Creek.

This document and the procedures and standards included herein were developed after an extensive review of relevant material and resources relevant to surface water quality monitoring and quality assurance for sampling and data collection (DOW, 2009; DOW, 2011; DOW, 2018; DOW, 2019; Louisville / Jefferson County Metropolitan Sewer District, 2018) as well as manuals supplied with the HydroTech Compact DS5 field parameter meter and Hach HF950 hand held flow meter.

2 Definitions & Acronyms

Acronyms

BP	Barometric Pressure
COC	Chain of Custody
DO	Dissolved Oxygen
DOW	(Kentucky) Division of Water
E. coli	*Escherichia coli*
EDCA	Environmental Data Collection and Assessment
FDCS	Field Data Capture Sheet
LDO	Luminescent Dissolved Oxygen (probe)
LEW	Left Edge of Water (looking downstream)
LIMS	Laboratory Information Management System
MSD	(Louisville and Jefferson County) Metropolitan Sewer District
NTU	Nephelometric Turbidity Unit
PPE	Personal Protective Equipment
REW	Right Edge of Water (looking downstream)
QA / QC	Quality Assurance / Quality Control

QAPP	Quality Assurance Project Plan
SC	Specific Conductance
SOP	Standard Operating Procedure
U.S. EPA	United States Environmental Protection Agency
USGS	United States Geological Survey
<	Less than
>	Greater than

Definitions

Absolute barometric pressure - the actual atmospheric air pressure at a specific location that depends significantly upon the location altitude.

Conductivity – a measure of the ability of water to conduct electricity. The presence of dissolved salts and other chemicals increases conductivity of streams.

Dissolved Oxygen - a measure of how much oxygen is dissolved in the water

In-situ – in the original place.

Field Blank – de-ionized water from the carboy which is treated as a sample. Used to identify errors or contamination in sample collection and analysis.

Field Split – single sample collected by field team. The lab will split into two samples and analyze separately in the lab. Used to estimate subsampling and laboratory analysis precision.

pH - a scale used to specify how acidic or basic a water-based solution is. Acidic solutions such as vinegar have a lower pH, while basic solutions such as bleach have a higher pH. At room temperature, pure water is neither acidic nor basic and has a pH of 7.

Relative barometric pressure - the corrected barometric pressure calculated for the sea or zero feet of elevation, and usually used to refer atmospheric conditions.

Riffle – a rocky, shallow area in a stream, generally with faster flowing, more turbulent water.

Sonde - a devices that automatically transmits testing data for physical conditions, in this case, used for measuring several water quality parameters (i.e., pH, temperature, dissolved oxygen, specific conductance and turbidity)

Specific Conductance – a conductivity measurement made at or corrected to 25° C. Since water temperature affects the readings, reporting conductivity at 25° C allows data to be easily compared.

Stream discharge – the amount (volume) of water carried by a stream past a point per second, measured for this SOP in cubic feet per second. As a reference, one (1) cubic foot is about 7.5 gallons.

Tagline – a tape measure, usually with 1/10-foot increments, stretched across the stream used to locate the verticals during a discharge measurement.

Temperature - a physical property of water that quantitatively expresses hot and cold.

Thalweg – the deepest part of the stream channel, generally forming a deeper channel within the stream channel.

Vertical – a point along the cross- section of a stream where stream velocity is measured at a defined depth or depths.

3 Health & Safety Statement

3.1 Job Specific Training

Louisville MSD provides annual health and safety training to field technicians regarding safe work practices.

Supervisors, or designee, will observe employees performing the work previously demonstrated. If necessary, remedial instruction will be provided to correct training deficiencies prior to final release to perform unsupervised work.

Employees will be trained to use safe operating instructions prior to the use and operation of new equipment or processes.

Supervisors shall be responsible for reviewing safe work practices with employees before permitting new, non-routine, or specialized procedures to be performed.

The Kentucky Division of Water (DOW) will provide sample collection training to Louisville MSD field staff prior to initiating field work for this project. This training will include demonstration of job tasks using known safe work practices.

In case of emergency, MSD staff call 502-540-6182 and then their supervisor.

3.2 Human Health

Human health procedures are available in MSD Health and Safety Rule Book

3.3 Safety Equipment

The Personal Protective Equipment (PPE) to be used during this project are listed below. All personnel involved in field sampling for this project are required to adhere to Louisville MSD field safety standards.

- Reflective safety vest
- Personal floatation device (life jacket)
- Hard hat with chin strap
- Waders with non-slip boots
- Safety Cones
- Roof mounted flashers
- Hand sanitizer
- Safety harness
- First aid kit
- Bug spray

3.4 Safety Precautions

The buddy system should be implemented when conducting field work.

Monitoring may include field activities during all stages of the hydrologic cycle, including high discharge/flood stage conditions. Additional precautions should be taken during high flow events.

Work in streams can be dangerous due to a variety of factors including fast flow, water depth, temperature, and visibility. Prior to sampling, weather will be monitored to avoid potentially dangerous conditions. At no time will MSD employees enter streams with swift, high water or when the stream is at flood stage.

- **Water Temperature** - Hypothermia can quickly set in and overwhelm even the strongest of swimmers. Ensure that equipment appropriate for encountered stream temperatures is used during survey activities.
- **Current** - Even a slow current can have enough force to knock you off your feet. Do not attempt to cross streams that are swift and above the knee in depth.

- **Water Hazards** - Be very careful when walking in any stream. Rocky-bottom streams can be very slippery and may contain deep pools. If needed, use a walking stick or rod to help with stability and determine depths.

The best advice is to use common sense judgment when entering a waterway and avoid working in streams when flows are elevated. If depth is undetectable from the bank, use a pole or rod to feel for bottom depth before entering.

If high stream flow conditions make it unsafe to enter the stream, collect the water quality sample from the bank using the pole sampler or from a nearby bridge using the two-cup sampler. When working around fast flowing water, use of a personal floatation device (life jacket) is recommended. If samples are collected from the top of a culvert, use of a harness is required.

If it is not possible to sample safely, do not enter the stream. The team should try to sample from a nearby bridge, and if this is not safe, do not sample. Any team member can make this decision.

4 Interferences and Troubleshooting

Latex-free gloves should always be worn when collecting a sample. Immediately close all bottles after filling with the sample water and double check that the caps are completely secured on the sample bottles, and each bottle is placed in a clean Ziploc bag prior to storing in a cooler.

Samples should be collected from flowing water. If water is pooled, move upstream or downstream until an area with flowing water is found. If no nearby flowing water is found, do not sample and note the pooled or dry on the Chain of Custody (COC) form.

Store samples in a cooler on wet ice in a locked vehicle to ensure that they cannot be tampered with.

Completely fill out the COC form and keep it with the samples until they are delivered to the lab. The lab should only accept samples that are accompanied by a completed COC form.

5 Personnel Qualifications

All personnel involved in surface water quality sampling will meet at least the minimum qualifications for their job classification. In addition, all field staff will be trained in the proper collection and preservation techniques for water quality samples as well as meter maintenance, calibration and operation. Training will continue on-the-job through interaction with experienced field personnel and continued outside training when educational opportunities become available. In addition, training videos are available from the HydroTech website: http://www.hydrotechzs.com/videos/compact-training-videos.html

6 Equipment and Supplies

6.1 *E. coli* Bacteria Sampling Equipment and Supplies

- Labeled sterile *E. coli* sample bottles with sodium thiosulfate tablet. Sterile *E. coli* bottles are screw cap and tab seal with identification label (Appendix 1)
- COC Forms (one per site) See Appendix 2 Project Forms.
- Plastic carboy filled with de-ionized water for Field Blanks
- Cooler
- Wet ice
- Ziploc bags to store each sample in a separate bag
- Ziploc bag with wet ice (temporary cooler)
- Waterproof pen
- Double-cup sampler (modified for direct fill of *E. coli* bacteria bottles)
- Trash bags
- Latex-free gloves, extra large
- Elbow length gloves for cold water sampling
- Hand sanitizer
- Hatchet (to break ice)
- Camera
- Laminated sheets with site number (for site ID in photographs)

6.2 Compact DS Field Meter Readings Equipment and Supplies

- Field Data Capture Sheets (one per site) See Appendix 2. Project Forms
- HydroTech Compact DS Field Meter with probes for pH, temperature, dissolved oxygen [1], specific conductance [2], turbidity

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[1] MSD's dissolved oxygen probe has a Luminescent Dissolved Oxygen (LDO) sensor without a stirrer.
[2] MSD's specific conductance probe has a temperature compensation feature.

- pH buffers
- Conductivity calibration solutions
- Turbidity calibration solutions
- NX-10 tablet with stylus, zipper pouch and arm strap
- Detachable cable
- Protective plugs
- Backpack
- Paper towels
- Bucket sampler with rope, large enough to submerge the probes
- (8) AA batteries (optional backup power)
- Clean tap water for pre- and post-tap water check and storage
- Bucket for pre- and post-tap water check
- Probe storage cup and sensor guard
- HydroTech Meter Manual, LDO™ Dissolved Oxygen Calibration Transcript, Self-Cleaning Turbidity Two Point Calibration Video Transcript (Appendix 3)

6.3 Stream Flow Equipment and Supplies

- Hach FH950 handheld flow meter
    - Portable meter
    - Sensor height lock/release device
    - Top setting wading rod
    - Sensor cable
    - Adjustable mount for portable meter
    - Sensor assembly
    - Lanyard
    - Velcro strap

- Non-metallic bucket for meter calibration
- Potable tap water
- Flow meter user manual (Appendix 4)
- Tape measure with 1/10-foot increments (i.e., tagline)
- Stakes to secure the tape measure

7 Instrument Setup, Calibration and Standardization

7.1 HydroTech Compact DS Field Meter Setup

The following steps describe setting up the Compact DS field meter.

1. Remove all protective plugs and keep them in a safe place, they will be used again for moving and storage.
2. Connect the detachable cable to the Compact DS. The connectors are keyed for proper assembly. Align the bigger pin on the Compact DS male connector to the indicator dots on the female cable connector. Do not rotate the cable or force or twist the pins into the connectors to prevent damage to the connector pins. (Note, there will be resistance so firm pressure may be required to get the cord plugged into the Compact DS). See HydroTech Manual, Section 3.2 in Appendix 3.1.
3. Connect the other end of the detachable cable to the NX10. The NX10 is also the battery power for the Compact DS.
4. Start the communications program (Hydras 3 LT).
5. The software will automatically scan for Sondes (i.e., probes). All detected Sondes are displayed in the 'Connected Sondes' list in the Main window displayed below. If a Sonde is not found, reattach the data cable and press RE-SCAN FOR SONDES. Retry until the Sonde(s) are found.

7.2 Compact DS Calibration

The Compact DS will be maintained and calibrated in accordance with the manufacturer's recommendations in the Appendix 3. MSD will perform a calibration check on each of the probes within 24-hours of the sample event. If any of the calibration checks falls outside the acceptable range found on the calibration sheet, that probe will be calibrated.

Field technicians will record calibrations on calibration sheets (Appendix 2.1). Meter maintenance and the checks performed before and after the sampling event will be recorded in the bound meter maintenance logbooks. The logbooks are maintained by the MSD Field Supervisor and are available upon request.

On the morning of the sample event and after sampling is completed, pre- and post- tap water checks will be done in a bucket of clean tap water to check for meter drift. If the tap water check does not show anticipated readings, which could be an indication of an overnight calibration drift, the water in the bucket will be replaced and the meter will be checked again. If the readings still do not show expected results, both meters will be placed in the same bucket of water at the same time to compare readings. If the readings do not match, the meter with the erroneous readings will be re-calibrated prior to use in the field. Pre-and post- tap water checks will be recorded in the bound meter maintenance logbooks. ***Note*****:** Save the check water for the End of Day check.

The U.S. Environmental Protection Agency (U.S. EPA, 2007) recommends the following order for calibration of a field meters:

1) Specific Conductance
2) pH
3) Dissolved Oxygen
4) Turbidity

The temperature sensor is factory-set and does not require calibration.

7.3 Calibration Supplies

Per the project QAPP (Louisville / Jefferson County Metropolitan Sewer District, 2019), ensure that calibration standards are not expired, and sufficient volume is available to complete the calibration. The Field Staff will notify the MSD Field Manager who will order additional supplies as expiration date approaches or when standards run low.

- De-ionized water (for conductivity, pH and turbidity calibrations)
- Tap water (for dissolved oxygen calibration)
- Conductivity Standards Low, Medium and High Range concentrations
- pH standards

- Turbidity standards:. MSD may purchase premade standards or prepare standards for each field event by diluting a 4,000 NTU primary standard.
- Calibration Sheet (Appendix 2)

7.4 Specific Conductance Calibration Check and Calibration

7.4.1 Specific Conductance Calibration Check

1. Run a minimum of 3 calibration standards that bracket the desired analytical range. An example would be 250, 500 and 1000 µS/cm. Check the lot # and expiration date of each standard on the Calibration Sheet. These are pre-printed and will be updated by the MSD Project QA Manager when new calibration solutions are used.
2. If any are due to expire or are running low, notify the MSD Field Manager, who will place an order for new calibration solutions.
3. Record the temperature of each calibration standard on the Calibration Sheet.
4. Wipe SC chamber ***completely dry!*** Record what the sensor reads in air (this is the zero check).
5. Rinse sensor three(3) times with the lowest concentration standard (usually the **250 µS/cm** standard). Fill calibration cup with standard so that the SC chamber is submerged. Make sure there are no bubbles in the chamber. Record the sensor reading and time. Discard standard and rinse with de-ionized water three (3) times.
6. Rinse sensor three (3) times with the middle range concentration standard (usually the **500 µS/cm** standard). Fill calibration cup with standard so that the SC chamber is submerged. Make sure there are no bubbles in the chamber. Record the sensor reading and time. Discard standard and rinse with de-ionized water three (3) times.
7. Rinse sensor three (3) times with the highest concentration standard (usually the **1,000 µS/cm** standard). Fill calibration cup with standard so that the SC chamber is submerged. Make sure there are no bubbles in the chamber. Record the sensor reading and time.

   Note: If any of the readings from steps 1-4 differs by more than +/- 5 µS/cm or 3% (See Table 1), then move onto step 7. If it reads within the guidelines you are finished and can move on to the next parameter.

Table 1. Common Calibration Standards with 3% Differences

Standard	Minus 3%	Plus 3%
250 uS/cm	242.5	257.5
500 uS/cm	485	515
1,000 uS/cm	970	1,030

7.4.2 Specific Conductance One Point Calibration

1. You should still have high concentration standard (usually 1000 µS/cm) in your calibration cup from Step 6. Enter this value into HYDRAS and hit calibrate. You have now completed a one-point calibration.
2. Discard standard and rinse with de-ionized water three (3) times.

To ensure that the calibration was successful, complete the following steps:

3. Rinse with de-ionized and fill with the mid-range concentration (usually 500 µS/cm) standard, record this reading.
4. Rinse with de-ionized and fill with lowest concentration (usually 250 µS/cm) standard, record this reading.

TIP: If readings are still off or you see an asterisk next to the sensor reading, it may be necessary to perform a 2-point calibration.

7.4.3 Specific Conductance Two Point Calibration

1. Completely dry sensor of all water and enter 0 into the HYDRAS software and hit calibrate.
2. Next, rinse the sensor with the highest concentration (usually 1000 µS/cm) standard three (3) times. Fill calibration cup with the same standard and make sure there are not any bubbles in the SC chamber. Enter the highest concentration value into the HYDRAS software and hit calibrate. You have now completed a 2-point calibration.
3. If you are still having trouble call HydroTech Technical and Customer Service 512-846-2893 or through their website (http://www.hydrotechzs.com/) for Technical Assistance.

7.5 pH Calibration Check and Calibration

Calibration of pH focuses on pH 7 and pH 10 because this is the typical range for Jefferson County streams. Always use fresh standard and do not alter the standards in any way.

The calibration standards for pH are affected by temperature. To reduce the time for stabilization, keep all calibration standards and equipment stored at the same temperature before parameter calibration. Always allow sufficient time for thermal stabilization of standards. Refer to the table in Appendix 4-RICCA Temperature Dependence of pH for Reference Buffers to check pH calibration readings based on the temperature of the solution.

7.5.1 pH Calibration Check

1. Ensure the lot # and expiration date of each standard is reported correctly on the Calibration Sheet.
2. If any are due to expire or are running low, notify the MSD Field Manager, who will place an order for new calibration solutions.
3. Record the temperature of each pH buffer on the Calibration Sheet.
4. Rinse sensors with de-ionized water and pH 10 standard three (3) times each. Fill calibration cup with fresh standard within one (1) centimeter of the top of the cup. Place the probes into the sample cup and allow readings to stabilize. Record the sensor reading. Note that the pH of this buffer depends on its temperature. Refer to the Temperature Dependence table in Appendix 4 for the actual pH of the buffer at the current temperature.[3] Discard standard and rinse with de-ionized water three (3) times.
5. Rinse sensor three (3) times with pH 7 standard. Fill calibration cup with standard within one (1) centimeter of the top of the cup. Place the probes into the sample cup and allow readings to stabilize. Record the sensor reading. Note that the pH of this buffer depends on its temperature. Refer to the Temperature Dependence table in Appendix 4 for the actual pH of the buffer at the current temperature.
6. If the pH 10 OR pH 7 reading differs by more than +/- 0.2 units from the pH of the buffer at the current temperature, then move onto pH Calibration. If the sensor reads within the guidelines you are finished.

7.5.2 pH Calibration

1. The pH sensor should still be submerged in the pH 7 standard from step 6 above. In HYDRAS enter the temperature adjusted pH value and hit calibrate.

[3] Note that if a different vendor is used for pH buffers, the temperature dependence table in SOP Appendix 4 will be updated.

2. Rinse the sensor with de-ionized water and pH 10 standard three (3) times each. Fill the calibration cup with pH 10 standard. Enter the temperature adjusted pH value into HYDRAS and hit calibrate. You have now completed the 2-point calibration. Rinse sensors.

7.6 Dissolved Oxygen Calibration

This method uses air-saturated water to calibrate the sensor. The manufacturer does not recommend using water-saturated air to perform calibration.

The LDO sensor compensates for the temperature of the water. To perform an accurate calibration, it is important that the temperature of the water remain constant during the procedure. The easiest way to do this is to allow the water used for calibration to sit overnight in an open container until it equilibrates to room temperature. ***Important:*** If the temperature changes by more than 0.5 ^{o}C during calibration, dissolved oxygen measurements may be inaccurate, and the sensor will need to be recalibrated when the temperature of the water stabilizes. For this reason, the calibration should also not be done in direct sunlight.

The steps outlined below are based on a transcript of the DO sensor calibration video (Ott HydroMet, undated). The LDO sensor manual includes more information regarding maintenance and operation of this sensor and is included in Appendix 3.2. Note that the LDO manual includes a calibration in air, but the air-saturation water will be used for this project.

1. Stand the Compact DS so the sensors are pointed upwards with the storage cup attached.
2. Add about one (1) liter of room temperature de-Ionized water (or clean tap water with a conductivity of less than 500 micro-Siemens per centimeter) to a clean one-gallon jug. Shake the jug very vigorously for 40 seconds. Alternatively, running an air bubbler through the water for ten (10) minutes can be used to saturate the water with air.
3. Establish a connection to the sonde using Hydras3 LT and click the button labeled ‘Operate Sonde’. Wait for Hydras to initialize the sensors. Progress can be monitored on the bar at the bottom of the screen.
4. Fill the storage cup with the air-saturated water over the sensors to the bottom of the threads and place the storage cap on upside-down. Do not screw on the cap!
5. When the sonde is ready to operate click the ‘Calibration’ tab.
6. Select the ‘LDO (%Sat)’ tab. A picture of the LDO sensor should appear on the screen.

7. Wait for the current value and temperature readings to stabilize. If the cap was stored wet this should happen very quickly. A dry cap may take several minutes to stabilize.
8. Enter the current absolute barometric pressure (BP)[4] in mm/Hg in the box. BP readings may be obtained from MSD's HL4 Surveyor sonde with internal barometer which measures absolute BP, local weather reports or other sources. It is important to ensure that the readings are absolute BP which has been corrected for elevation. Relative BP (at sea level) is typically used in weather reports. As needed use the Actual BP tool on HydroTech's website to convert relative (sea level) BP readings to absolute BP readings:

   http://www.hydrotechzs.com/references/calculators.htm.
9. Click 'Calibrate'.
10. A "Calibration Successful" message will be displayed.

Verification

1. Click the red 'X' in the upper right corner and close the Calibration window. In the Connection window click the button labeled 'Terminal mode'
2. Using the Arrow keys, highlight 'Login' and press <Enter>.
3. Highlight 'Level 3' and press <Enter>.
4. Type the password and press <Enter>. The default is 'Hydrolab' and it is case sensitive.
5. Use the Arrow keys to highlight 'Setup' and press <Enter>.
6. Highlight 'Sensors' and press <Enter>.
7. Highlight 'LDO' and press <Enter>.
8. Highlight 'LDO % SAT' and press <Enter>.
9. Read the Scale Factor. A valid calibration will produce a Scale Factor between 0.5 and 1.5. Values outside of these parameters may indicate a problem with the sensor or electronics.
10. DO NOT type a new value for the Scale Factor. This will invalidate the calibration and

[4] Absolute barometric pressure is the actual atmospheric air pressure at a specific location that depends significantly upon the location altitude. Relative barometric pressure is the corrected barometric pressure calculated for at sea level or zero elevation, and usually used to refer atmospheric conditions.

cause the sensor to take incorrect readings!

11. Press <Esc> after you have verified the Scale Factor is acceptable.
12. Your LDO is now calibrated and ready to deploy.

Table 2. DO Calibration Responses

Response	Explanation
Cal Complete	Calibration is complete
Cal Fail, Offset High	Indicates the air calibration has failed due to an excessively high calculated gain value. Repeat the calibration
Cal Fail, Offset Low	Indicates the air calibration has failed due to too low of a calculated gain value. Repeat the calibration
Cal Fail, Unstable	Indicates the air calibration has failed because the readings did not stabilize during the maximum allowed calibration time interval. Repeat the calibration.

Record calibration status on Calibration Sheet.

For continued accuracy and repeatability, the manufacturer recommends replacing the sensor cap after one year of operation.

7.7 Turbidity Calibration Check and Calibration

The Self Clean Turbidity sensor uses scattered light to report the concentration of suspended particles in water, so it is important to clean the instrument as thoroughly as possible prior to calibration. Use a soft brush and mild soap to remove dirt and debris from all of the sensors and the inside of the storage cup. Rinse the storage cup and sensors until they are free of soap and dirt, then dry with lint free towels.

Calibration checks and calibrations can be performed in the calibration cup or in a stirred vessel. The stirred vessel is preferred for high turbidity standards because the standard can settle and cause low readings for the standards. Shaking the standards will produce bubbles which cause high readings for the standards.

Some helpful techniques for calibrating turbidity include gently rocking the bottle of standard back and forth about 30 times, then rinse the calibration cup with the standard. Pouring the standard slowly and gently into the calibration cup will help to avoid bubbles.

Run a minimum of 3 calibration standards that bracket the desired analytical range. The following can be used as a guide for determining calibration ranges based on expected stream flows:

- Low or Normal Flows: 0 NTU; <=100 NTU
- High Flows:<100 NTU

7.7.1 Turbidity Calibration Check

1. In the Hydras 3LT software on the NX10, click on the Calibration Tab and select Turbidity NTU.
2. Rinse the sensor and the calibration cup with turbidity-free water[5] several times and dry with a lint-free cloth or compressed air. Any residue or fluids left behind will affect the calibration accuracy.
3. Rinse and thoroughly dry the sensor end of the turbidity probe.
4. Read the turbidity of the 0 NTU standard (i.e., deionized water) and record on the Calibration Sheet (Appendix 2)
5. Fill the cup with predetermined turbidity standard to check for the 0 NTU, low, normal and high flow concentrations. To prevent excess air bubbles, slowly pour the standard down the interior side of the cup.
6. Wait at least 30 seconds for the turbidity values to stabilize.
7. Read the turbidity of the standard and record on the Calibration Sheet (Appendix 2). Repeat Steps 5 and 6 with the middle and high range calibration standards.
8. If the values are not within the accepted ranges shown on the Calibration Sheet, rinse the sensor and repeat the measurements.
9. Turbidity sensor maintenance is required when any of the optical surfaces have a visible coating, or when the zero check reads >0.9 NTU.

[5] Turbidity-free water can be prepared by running distilled water through a 0.2-micron filter.

7.7.2 Turbidity Calibration

Follow the steps below if calibration is required because the values are not within accepted ranges shown on the Calibration sheet. The steps outlined below are based on a transcript of the turbidity sensor calibration video (Ott HydroMet, undated). The turbidity sensor instruction sheet includes more information regarding maintenance and operation of this sensor and is included in Appendix 3.3.

1. In the Hydras 3 LT program, click the 'Operate Sonde' button. Wait for the sensors to initialize (less than one minute).
2. Zero Point Calibration – With the sensors pointed upwards, fill the storage cup approximately 75% with De-ionized Water or <0.1 NTU standard and screw the storage cap on tightly. Slowly turn the sonde over so the sensors point downwards.
3. In Hydras 3 LT, click on the 'Calibration' tab, then click on the 'Turbidity [rev]' tab. You should see a picture of the Self-Cleaning Turbidity sensor. Verify that the value in the box is '1' and click the 'Calibrate' button. The wiper should make one complete revolution, removing any air bubbles from the optics.
4. Click the 'OK' button in the "Calibration Successful" window.
5. Now click on the 'Turbidity [NTU]' tab. There are two boxes on this page.
6. In the box labeled 'Turbidity [Point]' enter a '1'.
7. In the box labeled 'Turbidity [NTU]' enter a value of 0.3 to 0.6 depending on the cleanliness of the sensors.
8. When the readings at the top of the page are stable, click 'Calibrate'.
9. Click the 'OK' button in the "Calibration Successful" window.
10. The highest calibration point should be a value higher than the highest value anticipated at the deployment site. The standard factory high point is 100 NTU. Note that different standards may be used for elevated flow samples.
11. Pour the de-ionized water out of the storage cup and dry the sensors again.
12. Gently swirl or invert the bottle of the high range calibration standard for two to three minutes to mix the suspension.
13. DO NOT shake the bottle of calibration standard! This will suspend air bubbles in the solution and change the turbidity of the standard.

14. Pour the calibration standard into the storage cup until it is about 25% filled. Screw the cap on tightly and shake the sonde. Remove the cap and pour the solution out.
15. Gently pour calibration standard into the storage cup again, this time filling the cup to 75%. Screw the cap on and gently turn the sonde over so the sensors are pointing downward. The end of the Self-Cleaning Turbidity sensor should be fully submerged.
16. Again, in Hydras 3 LT, click on the 'Calibration' tab, then click on the 'Turbidity [rev]' tab. Verify that the value in the box is '1' and click the 'Calibrate' button. The wiper should make one complete revolution, removing any air bubbles from the optics.
17. Click the 'OK' button in the "Calibration Successful" window.
18. Now click on the 'Turbidity [NTU]' tab.
19. In the box labeled 'Turbidity [Point]' enter a '2'.
20. In the box labeled 'Turbidity [NTU]' enter the high range value (Ex '100').
21. When the readings at the top of the page are stable, click 'Calibrate'.
22. Click the 'OK' button in the "Calibration Successful" window.
23. The Self-Cleaning Turbidity sensor is now calibrated. Perform a check with the low and mid-range turbidity standards as in section 7.7.1.
24. After all the calibrations are complete, fill the storage cup with one inch of clean tap water. This will prevent the sensors from dehydrating.
25. If the meter is going to be used for sampling on the same day as calibration, leave the equipment as is. If not, turn off the NX10 and detach the cable from both the NX10 and the sonde. The NX10 goes on the charger and the probe is to be placed in a temperature regulated room for overnight storage.

7.8 Flow Meter Calibration and Standardization

The flow meter will be maintained and calibrated in accordance with the manufacturer's recommendations contained in the manual (Appendix 5). Maintenance will be documented in bound logbooks, maintained by the MSD Field Manager. Logbooks are available upon request. Calibration will be recorded on the Calibration Sheet.

Flow meter calibration will take place on the morning of sampling, before its use at the first monitoring location. Each flow meter to be used for sampling must be calibrated. The calibration will take place according to the following steps:

1. Fill a bucket with tap water. The bucket must be non-metallic and at least eight (8) inches (20.32 cm). The water depth must be at least six (6) inches (15.24 cm).
2. Got to *Main Menu* on the Hach handheld device, select *Setup*, and then *Velocity Calibration*.
3. Put the sensor in the center of the bucket so that it does not touch the sidewall or the bottom of the bucket.
4. Let the water become still.
5. Let the velocity reading stabilize.
6. Select Zero Velocity.

If there is moving water and the meter shows zero (0) velocity or if the water is moving in a positive direction and the flow meter shows negative flow; both circumstances are indicators that the meter has lost its calibration. The user will follow the above steps using water from the stream to recalibrate the meter. Record the calibration and recalibrations (if any) on the Calibration Sheet.

If the meter fails to achieve zero velocity in still water, contact the manufacturer. The meter may need repair.

8 Step-by-Step Field Sampling Procedure

Sampling will occur monthly, as described in Table 2 of the project QAPP. Sampling will be conducted during the third week of each month, between Monday and Thursday, and samples will be delivered to the laboratory **before 1:00 PM** (13:00) on the day of sampling to allow time for laboratory analysis of samples. If needed, samples can be delivered by 10 AM on Friday.

8.1 Sample Preparation

- Assemble Equipment and Supplies identified in **Section 6.**
- Ensure all bottles are labeled with Location Code and Site Name.
- Field Blank and Field Splits will be collected on a rotating schedule shown on **Table 3. Field Quality Control Sample Schedule**

Table 3. Field Quality Control Sample Schedule

Event	Site	Event	Site
1 – 2/2020	EMIMI010 – MFBGC @ Lexington Road	7 – 8/2020	EMIMI040 – MFBGC off Old Whipps Mill Road
2 – 3/2020	EMIMI002 – MFBGC Below Old Cannons Lane	8 – 9/2020	EMIMI041 – MFBGC at Forest Bridge Road
3 – 4/2020	EMIMI009 – MFBGC at Browns Lane	9 – 10/2020	EMIMI042 MFBGC UT above Foxboro Road
4 – 5/2020	EMIMI038 – Sinking Fork below Bowling Boulevard	10 – 11/2020	EMIMI010 – MFBGC @ Lexington Road
5 – 6/2020	EMIMI033 – Weicher Creek at Lincoln Road	11 – 12/2020	EMIMI002 – MFGBC Below Old Cannons Lane
6 – 7/2020	EMIMI039 – MFBGC UT off Steeplecrest Circle	12 – 1/2021	EMIMI009 – MFBGC at Browns Lane

Sampling locations are shown on Figure 1.

Figure 1. Monitoring Sites, and Rain Gauges

8.2 Arriving at the Site

- Team members will put on safety vests prior to arriving at the sampling site.
- Utilize other appropriate Personal Protective Equipment (PPE) including hard hat with chin strap, waders, life jackets, eye protection, disposable gloves and harnesses if the site hazards call for them.
- Park carefully and use the hazard flashers on the car as well as the roof mounted strobe flasher in your sampling kit and place safety cones as appropriate to the site. Follow all other safety requirements from MSD and / or outlined in this SOP.
- Prior to sample collection, establish an appropriate safety zone around the work area, especially related to traffic and walking hazards.

- Record the time of arrival and time of departure from the site, on the Field Data Capture Sheet(FDCS). The arrival time is the time that the team arrives at the site and the departure time is the time that the team leaves the site.
- Record the 24-hour and 48-hour rainfall from rain gauge TR-13: St. Matthews Elementary School using the MSD website: http://raingauge.louisvillemsd.org/ Use the arrival time recorded on the FDCS as the start time to review 24 & 48-hour rainfall.
- Assess the stream and decide if it is safe to sample. ***Follow the safety precautions in Section 3.4.***
- If it is possible to safely wade in the stream, follow the steps in ***Section 8.3, Sampling When Stream Flow is Normal.***
- If it is not possible to safely wade into the stream, do not collect stream flow measurements. Follow steps in ***Section 8.4 Sampling When Stream Flow is High***.
    - If it is safe to sample from the stream bank, use the pole sampler to collect the *E. coli* sample and bucket sampler to collect field parameters.
    - If the stream bank is unsafe, try to sample from a nearby bridge using the double-cup sampler for *E. coli* and bucket sampler for field parameters.
- Samples should be taken from flowing water; samples should not be collected if the stream is pooled or not flowing. Move a short distance up or downstream to find flowing water. If flowing water is not found, do not sample. Write POOLED or DRY on the COC form and FDCS, take site photos and go on to the next site.

8.3 Sampling When Stream Flow is Normal

If the stream is safe to sample in the stream and is flowing, collect data in this order:

- **Team Member 1:**
    - Stream flow measurement
- **Team Member 2:**
    - Site Photos
    - Field Parameters
    - *E. coli* bacteria

- Chain of Custody Form (COC)
- Field Data Capture Sheet (FDCS)

To the extent possible, *E. coli* samples, field parameters and flow measurements should be collected from flowing water just above (upstream) of a riffle. Pools should be avoided if possible because water may be too deep to sample safely and the stagnant water may affect results.

Important: The flow measurement should be collected *downstream* of the field parameter readings and *E. coli* samples. This set up avoids contaminating the meter readings and bacteria samples if sediment is disturbed when flow measurements are made.

8.3.1 Stream Flow Measurements

An overview of the stream flow measurement collection is provided in Section 8.3.1.1, the specific instructions for setting up the Hach FH950 meter are provided in Section 8.3.1.2 and meter operations to collect stream flow measurements are provided in Section 8.3.1.3.

8.3.1.1 Overview of Stream Flow Measurements

Stream flow will be measured only when it is safe to wade in the stream. Measuring the flow is done in four (4) steps, as described below, based on DOW Stream Discharge SOP (Kentucky DOW, 2010). Operation of the Hach FH950 Meter used by MSD follows these general steps (Hach, 2018).

Step 1. Select a Cross-Section: The following are ideal conditions for selecting the cross-section.

- The site lies within a straight reach of stream and flowlines are parallel to each other. Avoid sites directly below sharp bends.
- Flow is relatively uniform and free from eddies, slack water, and excessive turbulence.
- The streambed is free from large obstructions, such as boulders and aquatic vegetation.
- Water velocity is >0.5 ft/s (may not be possible during low flow).
- Water depth >0.5 ft is preferred, but a minimum depth of >0.1 ft is required per DOW SOP (Kentucky DOW, 2010).
- The flow is perpendicular to the tagline at all points.

Prior to starting the flow measurements**,** it may be necessary to move rocks, logs, algae mats, rooted aquatic vegetation or other debris to meet as many of the cross-section conditions as possible.

> **Important:** Do not move rocks, logs, or other obstructions ***during the measurement process*** as this may cause the stream flow to change in an area of the stream where velocity has already been measured. Once the process of measuring velocity has begun, the stream should not be altered further.

Step 2. Setting the Tagline and Vertical Spacing: Set up a tagline by stretching a tape measure across the stream so that it is tight and perpendicular to the stream flow. The tagline should be at the cross-section to be measured and must not touch the water surface.

Identify the starting edge as either left edge of water (LEW) or right edge of water (REW) when ***facing downstream***. Determine the approximate width of the stream.

Discharge measurements are taken at several verticals, defined as a point along the cross-section where water velocity is measured at a defined depth (or depths). If the width of the stream flow is:

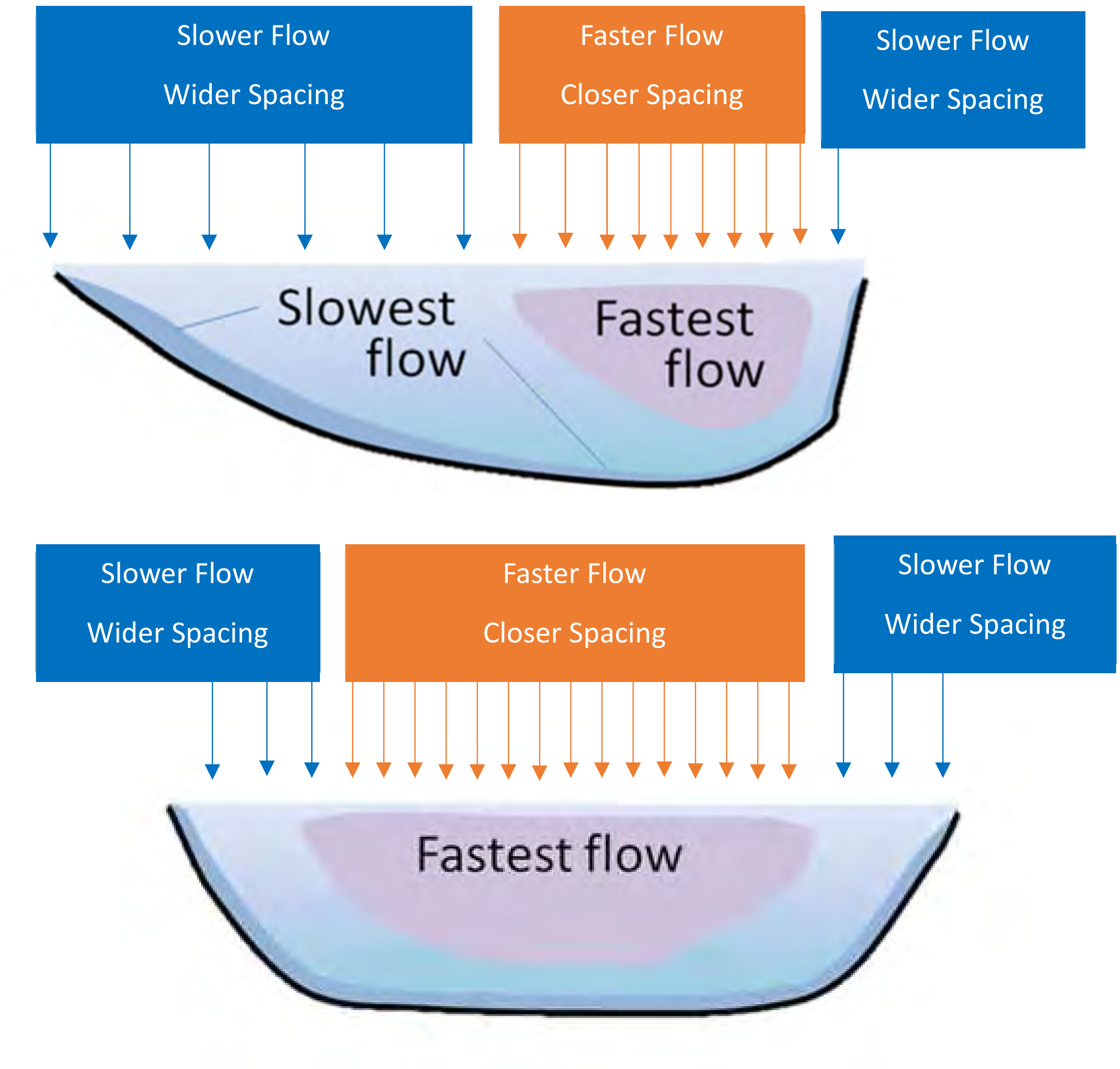
- <2.2 feet: collect velocity measurements at 1 to 12 verticals
- 2.2 to 20 feet: collect velocity measurements at 12 to 20 verticals
- >20 feet: collect velocity measurements at 20-30 verticals

The stream flow measurements are NOT collected uniformly across the stream (e.g., every (2) feet). This is because the flow of the stream varies across the stream and the discharge of each vertical should not exceed 10% of the total stream discharge. For example, if the width of the stream is 18 feet wide the verticals may be placed accordingly:

- Farther apart (i.e. 1 foot to 2 feet) where the stream is shallow and / or flowing slower compared to other sections of the cross-section profile
- Closer together (i.e. 0.8 feet or 1 foot) where stream is slightly deeper and / or flowing faster
- Very close together (i.e. 0.2 to 0.4 feet) where stream depth is the deepest and / or flowing the highest, typically near the thalweg

The spacing mentioned in the example above relates to a stream with varying depth and flow. If depth and flow is uniform across the cross-section it is likely that less variation in verticals is needed. The concept of using stream flow to adjust vertical spacing is shown in Figure 2.

Figure 2. Spacing Verticals based on Stream Flow



Note: Per the DOW SOP (DOW, 2010) verticals should not be less than 0.2 feet apart. Because of the minimum vertical spacing requirement, small streams with a flowing width of less than 2.2 feet will have less than 12 verticals and can have as few as one vertical during very low stream flow.

Initial readings should be at least 0.2 feet apart. Vertical spacing less than 0.2 feet is acceptable if needed to ensure that all sections account for less than 10% of the total flow.

Note: The vertical spacing in the Hach FH950 User's Manual are less stringent (i.e., fewer verticals per stream width) than DOW requirements. DOW requirements are used in this project (DOW, 2010).

Step 3. Measuring Depth: A standard top-setting wading rod should be used to correct for depth when using flow meters. The flow meter probe and depth sensor (pressure transducer) must be mounted according to the user manual to achieve accurate measurements. Ensure the probe is adjusted to bottom of the wading rod. The Hach FH950 will display the depth reading from the sensor. The user should perform a check on the depth displayed versus the marks on the wading rod. If the readings between the Hach device and wading rod are off by more than 0.05 feet, the user should ensure the sensor is set to the bottom of the rod or confirm the wading rod is in an upright/vertical position. If neither action closes the difference of the depth reading, the user should lift the sensor out of the water to auto zero depth. The instrument does an air calibration when the sensor is removed from the water and is in the air. As explained in Section 8.3.1.2, this function needs to be turned on in the setup window. The wading rod is marked in 0.10-foot increments. It is appropriate to further estimate depth to the 0.02-foot or 0.05-foot increment level, despite the wading rod not being marked to this level. It is advisable to permanently mark these increments on the wading rod to increase the accuracy of depth measurements.

Step 4. Measuring Velocity: The number of measurements taken at each vertical is dependent upon the depth of the stream. Follow these guidelines when determining the number of measurements to make:

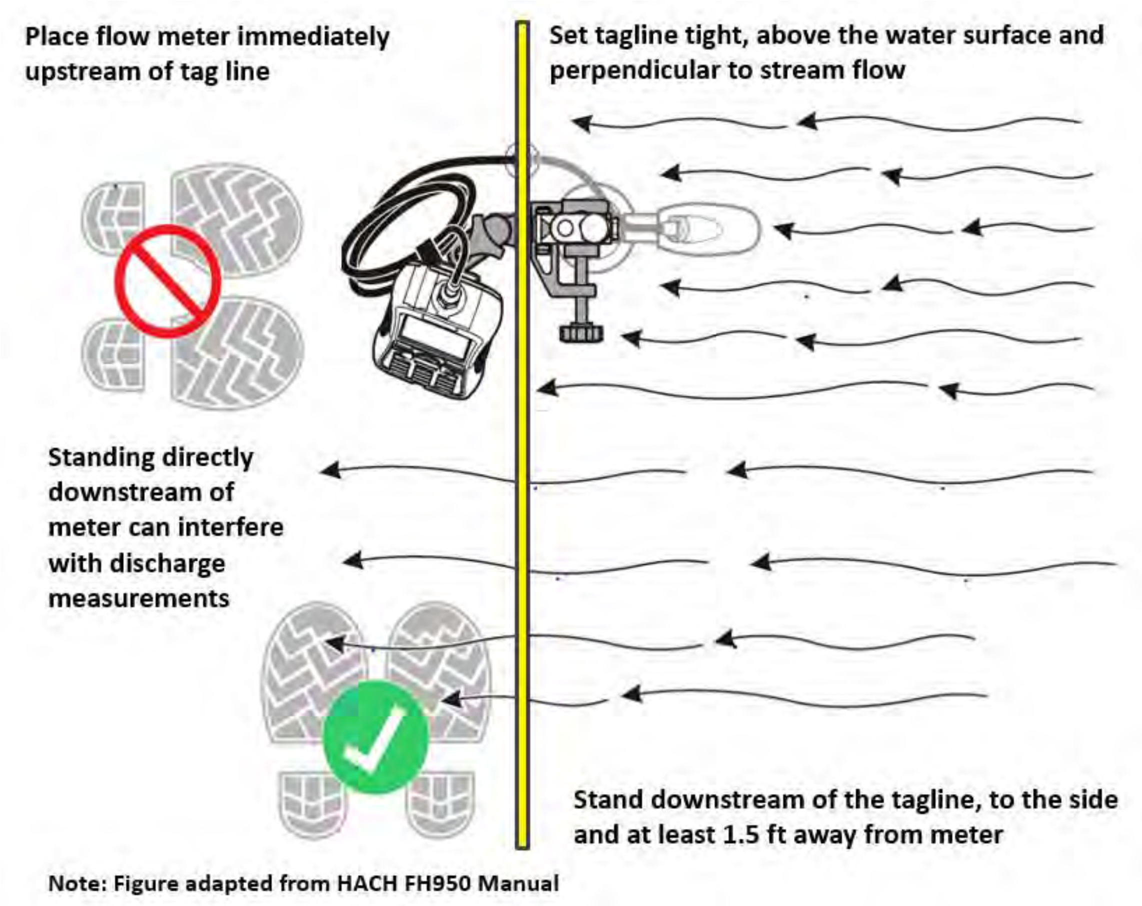
> **Stream Depths ≤ 2.5 feet:** When stream depth is ≤ 2.5 feet, velocity is measured at 0.6 times the total water depth, measured from the water surface. A standard top-setting wading rod will automatically adjust the probe to the 0.4 times the total water depth up from the streambed.
>
> **Stream Depths ≥ 2.5 feet:** When stream depth is ≥ 2.5 feet, velocity is measured at 0.2 and 0.8 of the total depth below the water's surface at each vertical, referred to as the two-point method. For example, if the stream depth is three (3) feet, one should take a velocity measurement at 0.6 feet and another at 2.4 feet up from the streambed. An average of these two readings will be used as the average velocity for the vertical.

A standard top-setting wading rod can be adapted to this method by following these instructions:

- To set the rod at the 0.2-depth, position the setting rod at half the water depth.
- To set the rod at the 0.8-depth, position the setting rod at twice the water depth.

The wading rod should be placed just upstream of the tagline, held perpendicular to the water's surface and parallel to the stream flow. As shown on Figure 3, the individual making the measurements should stand at least 1.5 feet away and to the left or right of the wading rod. This positioning helps to keep the meter close to the tagline.

Figure 3. Correct Standing Position during Velocity Measurements



Record the location of the starting edge in the meter as LEW or REW looking downstream. If the starting edge has a water depth, record this. No velocity measurements should be made at the starting or ending edges.

Facing upstream, place the wading rod behind the tape measure at the first vertical and record the location and stream depth. Velocity readings should be averaged over a time period of 25 to 45 seconds, depending on in-stream conditions. Typically, 25 seconds is sufficient, but 45 seconds should be used if the water is turbulent.

Once the stream velocity has been measured and recorded at the first vertical, continue measuring water velocity at each vertical, making sure that the appropriate number of measurements are being taken based on water depth (0.6-depth method vs. two-point method). Continue until you have reached the end of the cross-section. Record the location and depth of the ending edge.

The meter will calculate stream discharge once the ending edge has been reached. Flow calculation will be done using the ***Mid-Section Method*** to calculate stream discharge; this method has been shown to be more accurate than the Mean-Section Method. Record the final calculated discharge on the COC form.

8.3.1.2 Using the Hach FH950 - Main Menu and Initial Set Up

- On the Main Menu, select PROFILER
- Select STREAM (not conduit)
- In SET UP, the following options can be accessed
  - Velocity Calibration – use to calibrate the meter
  - Filter Parameters – set to Fixed Period Averaging, 25 seconds for stable flow, 45 seconds for turbulent flow
  - Wet Dry Threshold – use default of 5
  - Auto Zero Depth – set to ON – the instrument will do an automatic air calibration when the sensor is removed from the water
  - EMI – use default
  - Clock – set date and time in 24-hour format. Daylight savings time is not supported. Manually adjust the meter clock to the current time (i.e., standard time or Eastern Daylight Savings Time), as appropriate.
  - USB – use Mass Storage default
  - Language – English

- Units – use English (cubic feet per second, cfs)
- Beeper – use default ON, the meter makes an audible tone when the sensor is at the correct depth for applicable profile methods. The meter also makes an audible tone when an inactive button is pushed in any menu. This feature is available only with the optional depth sensor.
- Flow Calculation – set to Mid-Section method (not Mean-Section Method)
- Station Entry – use default NON-FIXED
- Restore defaults – resets the meter to factory defaults

8.3.1.3 Stream Flow Measurements

1. In the Main Menu, select PROFILER.
2. Enter the Operator Name.
3. Select Setup > Maximum Depth > Automatic. (MSD's meter is equipped with an automatic depth sensor)
   - Put the sensor at the lowest position on the wading rod.
   - Enter the measured distance from the ground to the bottom of the sensor. This is the minimum depth that the sensor can read.
4. Select **Top** for the measurement reference then push OK
5. In Setup>Filter Parameters>Main Filter, set the Fixed Period Averaging to 25 seconds. Adjust to 45 seconds if flow is turbulent
6. In the Profiler menu, select Stream
7. Enter a name for the stream (MFBGC LOCODE) (Max is 11 characters).
8. The menu may ask for a stage reference to be entered, if so, skip this step.[6]
9. In the Station Menu, select Edge/Obstruction and select one of the options:
   - LEFT – select if the station is at the LEW (facing downstream) or an obstruction.

[6] The stage reference is a tape down from a bridge / culvert to the water surface. It is used to get a reference point to relate water surface to stream discharge for developing a rating curve. Most of the 319(h) sites do not have a bridge / culvert to get this measurement from and it's not required by DOW SOP.

- RIGHT - Use this option if the station is at the REW (facing downstream) or an obstruction.
- OPEN WATER - Use this option to configure the edge as an open water environment (default).

10. Select DISTANCE TO VERTICAL and enter the value from the tagline.
11. Select SET DEPTH. In Automatic mode, push OK to set the maximum flow depth at the value shown. Ensure that the sensor is at the bottom of the wading rod (as low as possible, until it touches the disk at the bottom of the rod), and that the sensor is out of the water if the depth at the edge is zero. If there is a depth at the edge, place the sensor in the water as close as possible to the edge and to the full depth of the water.

    Note: If Left or Right Edge of Water was selected in Step 9 and a depth is assigned, enter an edge factor for the vertical. Select a factor from the list or User-defined. For User-defined values, enter a roughness factor between 0.50 (very rough) and 1.00 (smooth). The roughness factor is relevant only for right angled cross sections. It is used as a factor in the calculation of the discharge proportion of edge areas. For example:

    - Smooth edge with no vegetation (e.g., concrete, steel, cement)— 0.8 to 0.9
    - Brick sides with vegetation— 0.7
    - Rough walls with heavy vegetation—0.6 to 0.5

12. Select MEASURE VELOCITY. Select the number of points on the vertical to collect. Per DOW Stream Discharge SOP, the following points on the vertical should be collected based on stream depth (DOW, 2010).
    - If depth is < 2.5 feet, select 1
    - If depth is $\geq$ 2.5 feet, select 2

Reminder: Stand at least 1.5 feet away from the meter to the left or right as shown in **Figure 3.**

13. Select a measurement point from the list. Obey the instrument prompts and adjust the sensor to the correct depth. If the sensor has a depth option, adjust the sensor depth until the depth box is green. This means the sensor is in at the correct position.

Note: Red indicates more adjustment is necessary. Yellow indicates the depth is close to the correct depth.

14. Select CAPTURE to start the measurement process. DOW Stream Discharge SOP requires collecting measurements for 25 seconds for most measurements and 45 seconds for turbulent flow (DOW, 2010).
15. If necessary, the setup can be changed, and the measurement can be repeated. When the measurement is complete, push OK to store the data.
16. If necessary, repeat steps 13–16 for the other measurement point on the vertical.
17. When all measurements for the station are complete, select Main or Verify. Push OK to return to the list of measurement points.
    - MAIN – Returns to the station menu
    - VERIFY - Shows the average velocity reading for the station based on the measurement method
18. Select NEXT to go to the next station.
19. Repeat steps 10–19 for the remaining stations.
20. When all measurements for all stations in the profile are complete, select Channel Summary to view the results.
    - **Note**: The Hach FH950 flow meter will show a visual bar chart of the stream profile measurements when the cross-section is completed. Sections that are calculated to be < 5% of total stream flow will appear as green bars, sections calculated to be between 5% and 10% of the total stream flow will appear as yellow/orange bars, sections calculated to be > 10% of total stream flow will appear as red bars. Sections with > 10% calculated flows will have to be subdivided with additional measurement points before saving the results or leaving the site.
21. If any sections are determined to be > 10% of total cross-sectional flow, insert additional flow measurements at the correct cross-section locations according to the following procedure:

Insert or delete a station

Prev, Next, Ins and **Del** options show at the bottom of the display in the Station screen. **Prev** and **Next** are used to navigate to a previous or subsequent station.

Ins and **Del** are used to insert or delete a station.

For example, after measurements have been done at 10 stations, a user may wish to insert a new station between stations 3 and 4. The steps below describe how to do this. These steps can be applied in similar situations.

- Select **Prev** and push **OK** until the display shows the information for Station 3.
- Select **Ins** and push **OK**.

  The instrument adds a new station named Station 4. Subsequent stations are automatically given new sequential numbers.
- To delete the current station (when in non-fixed mode), select **Del** and push **OK**.

Troubleshooting the Hach FH950 Meter

The meter and sensor contain no user-serviceable parts. For the errors and messages listed, try the corrective action. If the problem does not go away or a problem occurs that is not in the list, contact the manufacturer.

Table 4. Hach FH950 Flow Meter Troubleshooting

Message or problem	Solution
Sensor is not connected	Connect a sensor and try the action again.
Value is out of range	Change the measurement parameters or put in a different value, then try the action again.
Sensor data is known to be not correct or not accurate	Clean the sensor and test.
Sensor is not recognized	Check the sensor connection. Make sure that the lock nut on the connection port is tight (finger-
Display is dim or is not visible	Push a key on the keypad.
Data is not available or access to the data is not	Make sure that the USB option (Main Menu) is set to Mass Storage.

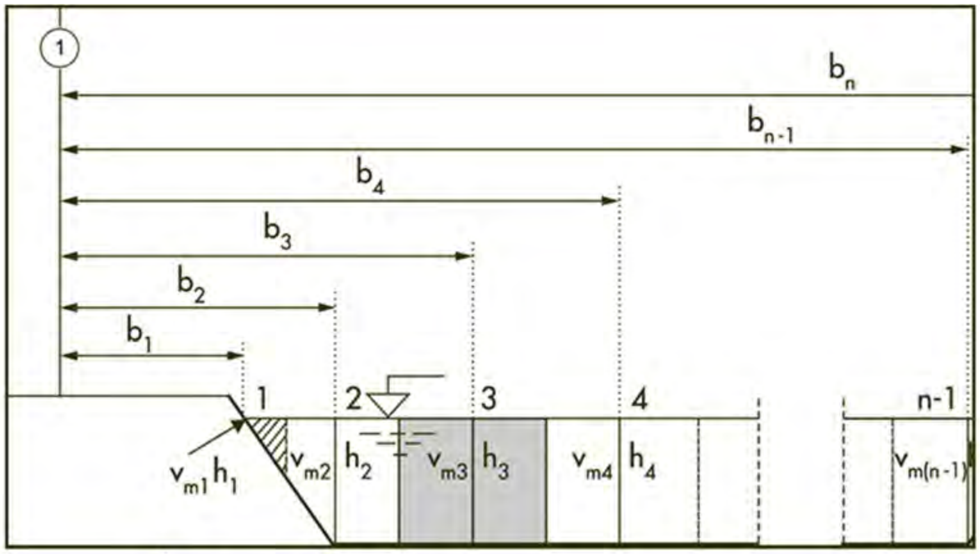
Message or problem	Solution
Meter is unresponsive	Push and hold the power button for at least three (3) seconds. This de- energizes the meter. Energize the meter again. ***Note:*** *Do not use this method to power off while in normal operation or if the file access icon is visible in the display.*

22. Calculate Discharge and Record on FDCS

The user can select the Mean-section or the Mid-Section Method for flow calculations. Per the Hach FH950 User Manual for the flow meter, the Mid-Section Method gives more exact results compared to the Mean- section method. The Mid-Section method will be used for this project.

The Mid-Section Method divides the cross-section into individual flow segments. With the Mid- Section Method, the segments are defined by half of the distance to neighbor verticals in each case. For this reason, the first and last verticals should be as near to the edges as possible (i.e., LEW, REW). Boundary conditions dictate the proximity of the first and last vertical to the edge of water. Figure 4 shows the definitions and equation for the Mid-Section Method.

Figure 4. Mid-Section Method for Discharge Calculation



$$q_3 = V_{m3} \times \left(\frac{(b_3 - b_2) + (b_4 - b_3)}{2} \right) \times h_3$$

Where:

m = station number

n = total number of stations V = velocity at vertical

b = distance to vertical from bank h = depth at vertical

q = flow at vertical

23. Download Data and Delete from Hach FH950 Meter

A good practice is to download after two (2) sites have been completed if time allows in the field. This will ensure that not all data is lost if the device was accidently damaged and data cannot be recovered. The FH950 Manual can hold up to 10 profiles with 32 stations per profile.

The meter directory is Read Only. In Windows, the meter operates as a mass storage device or removable hard drive.

Download Data

- Set the meter to USB Mass Storage mode.

- To edit the data in a file, drag and drop the file to a laptop or PC. File names are limited to eight characters. Use the MSD LOCODE for the file name.
- Data files are kept in the tab separated variable (.TSV) format. To see files in Microsoft® Excel, double or right-click a file and open the file with Excel.
- Open the Excel file on the laptop to ensure that the data downloaded correctly.
- Resave the Excel file with the MSD LOCODE and date. (Example: EMIMI010_2020-03-18)

Delete data files

To delete Profiler files:

- Go to Main Menu > Profiler > Files.
- Select Delete All or use the UP or DOWN arrow to select a file in the list.
- Push OK once to delete the files, then one more time to return to the previous screen.

8.3.2 Site Photos

Take the first picture at each site of the laminated Site ID sheet, then take at least three site photos: looking upstream, looking downstream, and across the tagline location (take the tagline photo with both banks visible).

Take other site photos to document unusual conditions or changes since the previous sample event.

8.3.3 Field Parameters Water Quality Meter

- Unscrew the storage cup on the sonde and replace it with the sensor guard.
- Unwind the cable and place the Compact DS in the stream upstream of the tag line used for stream discharge measurements.
- Try to place the probes near the center of flow to avoid ponded or stagnant water. At least three (3) inches of flow depth is necessary for full immersion of the meter.
- There is no specified orientation for the Compact DS meter (parallel or perpendicular to the stream flow), though the team member will ensure the probes are not obstructed by

debris or the streambed. The team member will also ensure that nothing is inside the sensor guard or that no algae/aquatic plants are touching any of the probes during stabilization prior to taking final reading as this will cause the meter to read incorrectly.

- Return to the stream bank and power up the NX10 from sleep mode. Use your finger or stylus to select and open the Hydrolink Terminal program. A dialog box will pop up. Hit ok. Readings should almost immediately start and update every second across the screen. Place the meter the plastic bag to keep the case clean and step away to allow the probes to stabilize. Do not enter the stream around or upstream of the sonde until the readings have been collected.
- Allow the meter to stabilize for three (3) to five (5) minutes and ensure that any sediment disturbed when placing meters in the stream has settled before taking readings. The team member will stand downstream of the field meter if it is necessary to enter the stream to collect the reading.
- If parameter readings are still fluctuating after the meter has been in the stream for five (5) minutes or more try these steps:
    - Move probes to a different location in stream
    - Examine probes for acceptable operating condition
    - Gently swirl the probes in low flow conditions[7]
    - Suspend the probes vertically in water column
- Per 401 KAR 10:031 section 4(e)2 , measurements should be collected at mid-depth at sites < 10 feet deep and at representative depths at sites that are > 10 feet deep. Readings for this project will be collected at mid-depth.
- If the stream depth is too shallow, collect stream water into a bucket that has been rinsed three (3) times with stream water. Move the bucket to a location that is shaded from direct sunlight and strong breezes. Immediately, gently swirl the probes in the bucket until the reading stabilizes. ***Do not allow the probe guard to touch the bottom or sides of the bucket.*** Then record the reading on the FDCS as described below.
- After allowing the probe to stabilize and without removing the meter from the water,

[7] MSD's field meter does not have a stirrer. Gentle swirling is used to collect measurements during low flow conditions, either in the stream or in a bucket.

note the times the measurements were captured from the Hydrolab program. Then record the time along with the following on the FDCS:

- ***Temperature:*** Record water temperature in ^{o}C on the FDCS.
- ***pH:*** Record pH on the FDCS.
- ***Dissolved Oxygen (DO):*** Record DO in mg/L on the FDCS.
- ***Specific Conductance:*** Record specific conductance in µS/cm on the FDCS.
- ***Turbidity:*** . Record turbidity in NTU on the FDCS.

- After measurements have been taken, exit out of the program and remove the sonde from the stream. Take a paper towel and wiped down the sonde and cord but not the probes.
- Replace the sensor guard with the storage cup that should contain tap water, not DI water. Wind up the cord and place the NX10 and the sonde into the backpack provided.
- Check the Field Parameters section on the FDCS to ensure all data has been collected and recorded.
- If unable to collect data for one or more parameters, write Not Sampled on the FDCS and provide comments to explain why.

8.3.4 *E. coli* Bacteria

- Fill out the date, time, and initials of one or both of the sampling personnel on each bottle label using waterproof ink pen (i.e., Sharpie). Military format should be used for the time (for example, if a sample is collected at 5:15 PM, the time should be shown as 17:15).
- The team member collecting the sample puts on latex-free gloves.
- The sampler should enter the ***upstream*** of the work areas for field parameters and stream discharge measurements.
- Face upstream and approach the site from downstream ensuring no disturbed streambed sediments contaminate the sample.
- Do not pre-rinse sample bottle prior to use.
- The sample should be collected from the center of flow (this may or may not be the center of the stream).

- Open the sample bottle and pour the sodium thiosulfate tablet on the lid of the bottle; without touching the tablet.
- To collect a subsurface sample, scoop water from beneath the surface of the stream in one (1) swift motion to fill the bottle at least to 100 mL line; do not pour off excess water
- If adequate volume is not obtained on first effort, do not re-dip the bottle in the water to get the volume over the 100ml mark or reuse the bottle. Use a new, un-contaminated bottle and repeat the procedure.
- Close and secure the sample bottle lid immediately, ensuring that the non-contaminated sodium thiosulfate tablet is returned to the bottle.

  Note: The sodium thiosulfate tablet is not absolutely necessary for stream samples. However, in order to maintain consistency, the tablet should be included if possible, using the above method. If for some reason the tablet is dropped or otherwise not included, note this in the Field Data Capture Sheet and the Chain of Custody form.
- On the COC form, record the date/ time in the Grab Sample columns, Sample Volume (100 ml), Sample Matrix and check the box for *E. coli* analysis.
- Add Samplers name in the bottom right corner of the COC
- Within 15-minutes, place the sample in a clean Ziploc bag and place the sealed bag in the cooler containing wet ice. If it is not possible to place the sample in the cooler within this timeframe, use a gallon Ziploc bag containing wet ice as a temporary cooler until you return to the vehicle.
- Dispose of the gloves and sanitize your hands.
- Lock the cooler in the vehicle and prepare to go to the next site.

8.3.5 Field Data Capture Sheet

Complete the field observations section of the Field Data Capture Sheet(FDCS) and check the form to ensure all fields are completed. As needed, write Not Sampled for any field parameters, *E. coli* or stream flow samples/measurements that were not collected and add the reasons in the comment section.

8.4 Step-by-Step Procedures for Sampling Under Difficult Conditions

- ***During high flow events, do not wade into the stream to collect stream discharge measurements!***
- ***If the stream is icy, you may use the hatchet to break a hole in the ice near the stream bank to collect field parameter readings and* E. coli *samples. Do not attempt to collect stream discharge measurements from an icy stream.***
- Decide if it is safe to sample from the stream bank or nearby bridge.

8.4.1 High Flow Field Parameter Readings

- Rinse the bucket sampler three (3) times with water from the stream, ensuring that the entire inside of the bucket has been in contact with water from this site
- Collect a bucket of water and place it out of direct sunlight and strong breezes before and during temperature measurement
- Hold the meter housing to immediately suspend the field meter probes in the water; avoid touching the bottom of the bucket with the meter probes
- Allow the meter to stabilize
- Fill in the Field Parameters section on the FDCS
- Empty the bucket and rinse out any sediment before leaving the site

8.4.2 High Flow Sample Collection for *E. coli*

- Fill out the date, time, and initials of one or both of the sampling personnel on each bottle label using waterproof ink pen (i.e., Sharpie). Military format should be used for the time (for example, if a sample is collected at 5:15 PM, the time should be shown as 17:15).
- Put on latex-free gloves.
- Lower the sampling device into the stream flow to rinse the sampler.
- Insert a clean bottle into *the E. coli* bottle holder on the double-cup sampler and make sure the top of the bottle extends above the top of the double-cup sampler.
- Remove the sample bottle cap.
- Then, lower the sampling device into the flow and collect the sample from below the surface (i.e., subsurface) of the stream.

- Raise the sampler from the stream, cap the sample bottle and remove it from the double-cup sampler.
- Within 15-minutes, place the sample in a clean Ziploc bag and place the sealed bag in the cooler containing wet ice. If it is not possible to place the sample in the cooler within this timeframe, use a gallon Ziploc bag containing wet ice as a temporary cooler until you return to the vehicle.
- On the COC form, record the date/ time in the Grab Sample columns, Sample Volume (100 ml), Sample Matrix and check the box for E. coli analysis. On the FDCS, circle the correct method used to collect the sample.
- Dispose of the gloves and sanitize your hands.
- Lock the cooler in the vehicle and prepare to go to the next site.

8.5 Field Quality Control Samples

Field quality control (QC) samples for this project include Field Splits and Field Blanks. One Field Split and one Field Blank will be collected on each sample day. The sites where field QC samples are collected are based on a rotating schedule shown in Table 3. Field Quality Control Sample Schedule.

8.5.1 Field Split Sample

- Label the sample bottle as Field Split sample, add field team initials, date and time of sample collection. [8]
- Collect the *E. coli* sample as described in Section 8.3.4 for normal flow conditions or Section 8.4.2 for high flow conditions.
- Within 15-minutes, place the sample in a clean Ziploc bag and place the sealed bag in the cooler containing wet ice. If it is not possible to place the sample in the cooler within this timeframe, use a gallon Ziploc bag containing wet ice as a temporary cooler until you return to the vehicle.

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[8] The Field Split sample is different from a field duplicate. Field duplicates are collected into two (2) bottles and analyzed separately in the lab. The Field Split sample is collected into one (1) bottle and the lab will extract two (2) 1 mL subsamples and two (2) 25-ml subsamples to analyze separately. Since subsamples total 52 ml, the standard 120 ml bacteria bottle is used for sample collection. DOW used the Field Split sample for bacteria in their 319(h) sampling of Middle Fork Beargrass Creek (DOW, 2019).

- Record the sample on a Chain of Custody Form.
- The lab will split this sample into two samples analyzed separately. Results will be used to check accuracy of subsampling and analysis in the lab.

8.5.2 Field Blank Sample

- Label the sample bottle as Field Blank sample, add field team initials, date and time of sample collection.
- At the MSD vehicle, collect the field blank by pouring the de-ionized water from the carboy (located inside MSD vehicle) into the labeled sample bottle.
- Within 15-minutes, place the sample in a clean Ziploc bag and place the sealed bag in the cooler containing wet ice. If it is not possible to place the sample in the cooler within this timeframe, use a gallon Ziploc bag containing wet ice as a temporary cooler until you return to the vehicle.
- Record the sample on a Chain of Custody Form.
- The lab will analyze this sample to check that samples are not contaminated with *E. coli* during handling in the field.

8.6 Wrapping Up at a Site

- Return to the vehicle and place the sample and blank (if any) in the cooler with wet ice for storage, adding fresh ice as needed to ensure samples are kept cold (above freezing and less than 4 ^{o}C).
- The sample bottles should be kept upright in the cooler and the vehicle should be kept locked.
- If sampling device was used, place the sampling device in a clean plastic bag.
- Place all equipment and trash back in the vehicle.
- Remove/dispose of gloves and sanitize your hands.
- Check COC forms to ensure they are completed correctly. The date/times/initials on the COC form and sample bottles must match!
- Check the FDCS for any blank fields and/or add comments to ensure they are completely filled out and that site photos were taken.

- As needed, write Not Sampled for any field parameters or flow measurements that were not collected and provide a brief explanation in the comments section provided on the FDCS.

8.7 Wrapping Up for the Day

- The lab must analyze the samples within eight (8) hours to meet the maximum holding time.
- Samples will be delivered to the MSD lab ***no later than 1:00 PM*** (13:00) on the day of sampling.
- Samples will be analyzed using MSD SOP (*E. coli* Rev 6 090118) or most recent update. MSD's lab is certified by DOW as KY#08034.
- At the end of the sampling day, take a second reading of the check water to check for drift. (Note that temperature may be subject to change).
- Download stream flow measurements from the flow meter, see Section 8.7.1.
- Download site photos to the project directory, labeled by site and date.
- The lab will make a copy of the COC form to retain with the sample. Laboratory copies of the COC forms are stored at the Laboratory
- The Field Team will scan the copies of COC Forms and original FDCS to the project directory. The Field Supervisor will then notify the QA Officer once these forms are available for review.
- The Field Team will enter field parameters from the FDCS into Laboratory Information Management System (LIMS) by the end of the week. If no data was collected for a parameter, enter "Not Sampled".
- The Laboratory Technicians will enter *E. coli* results into LIMS
- Upon returning to the office, a final meter check will be performed in the same bucket of water used in the morning check. This will be recorded in the maintenance log.
- Clean, organize and restock field equipment.
  a. Disconnect the detachable cable from the Compact DS and IMEDIATELY place the protective plug cover over the now exposed pins.
  b. Discard the tap water in the sampling cap that was used in the field and replace it

with fresh tap water for long term storage.

c. Turn off the NX10 completely and detach the cable. Wrap the cable and place it with the probe. Place the NX10 on the charging cable.

- Clean and store meters according to manufacturer's instructions.
- Recharge meters according to manufacturer's instructions.
- As needed, update meter software according to manufacturer's instructions.

8.7.1 Downloading Stream Flow Measurements

The meter directory is Read Only. In Windows, the meter operates as a mass storage device or removable hard drive.

1. Set the meter to USB Mass Storage mode.
2. To edit the data in a file, drag and drop the file to a laptop or PC. File names are limited to eight characters.
3. Data files are kept in the tab separated variable (.TSV) format. To see files in Microsoft® Excel, double or right-click a file and open the file with Excel. Real time files are stored in a directory called RT. Stream and conduit profile files are stored in a directory called P.
4. Save files to MSD Directory labeled by sample date.
5. The Field Team will convert flow data from cubic feet per second (CFS) to cubic feet per minute (CFM) as follows: CFS * 60 = CFM then enter data into LIMS.

Delete data files

- Go to Main Menu > Profiler > Files.
- Select Delete All or use the UP or DOWN arrow to select a file in the list.
- Push OK once to delete the files, then one more time to return to the previous screen.

9 Data and Records Management

MSD's Field Technicians, overseen by the Field Team Manager, will enter field parameters and stream discharge data from the FDCS into MSD's Laboratory Information Management System (LIMS). Missing data due to no data collected for field parameters or flow will be documented in LIMS as Not Sampled.

MSD's Laboratory Technicians, overseen by the Laboratory Manager will enter data from the COC and laboratory results into MSD's Laboratory Information Management System (LIMS). Missing data due to no *E. coli* sample collected will be documented in LIMS as "Not Sampled". MSD's Research Chemist will review COC forms, bench sheets and check data entry into LIMS.

The Project Quality Assurance Manager will conduct quality assurance review to document accurate data entry from the FDCS forms. The Project Quality Assurance Manager will work with MSD's Field Team Manager and Laboratory Manager to address quality assurance and / or quality control issues associated with the sampling event.

A Monthly Sampling Event Report will be completed after each sampling run and distributed to the MSD project team and DOW project staff prior to the next sample event, generally within 30 days. MSD's Project Quality Assurance Manager will review 100% of field data, including field parameters, flow data, and laboratory data will be reviewed for quality after each sampling event and included in this report. The Monthly Sampling Report will include:

- Narrative description of event, including any deviations from the QAPP and SOP and corrective actions to be taken before the next sample event
- Chain of Custody Sheets
- Field Data Capture Sheet
- Flow spreadsheets
- Laboratory Bench Sheets
- LIMS Data in Excel Format

See the project QAPP for further information on project Data and Records Management.

10 Quality Control

See QAPP Section 2.5.

11 References

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U.S. Environmental Protection Agency (EPA), 2007. *In* situ Water Quality Monitoring Operating Procedure. United States Department of the Interior, Science and Ecosystem Support Division, Ecological Assessment Branch, Region 4. Atlanta, GA.

Appendices

1. Sample Bottle Label
2. Project Forms
    - 2.1. Calibration Sheet
    - 2.2. Field Data Collection Sheet
    - 2.3. Chain of Custody Form
    - 2.4 Photo Log Template
3. HydroTech Compact DS
    - 3.1. HydroTech Compact DS5 Manual
    - 3.2. LDO™ Dissolved Oxygen Sensor User Manual
    - 3.3 Self-cleaning Turbidity Sensor Instruction Sheet
4. Temperature Dependence of pH for RICCA Reference Buffers
5. Hach FH950 Manual

Appendix B: MSD 319(h) Field Quality Control Sample Schedule

Event	Site	Event	Site
1 – 2/2020	EMIMI010 – MFBGC @ Lexington Road	7 – 8/2020	EMIMI040 – MFBGC off Old Whipps Mill Road
2 – 3/2020	EMIMI002 – MFBGC Below Old Cannons Lane	8 – 9/2020	EMIMI041 – MFBGC at Forest Bridge Road
3 – 4/2020	EMIMI009 – MFBGC at Browns Lane	9 – 10/2020	EMIMI042 MFBGC UT above Foxboro Road
4 – 5/2020	EMIMI038 – Sinking Fork below Bowling Boulevard	10 – 11/2020	EMIMI010 – MFBGC @ Lexington Road
5 – 6/2020	EMIMI033 – Weicher Creek at Lincoln Road	11 – 12/2020	EMIMI002 – MFGBC Below Old Cannons Lane
6 – 7/2020	EMIMI039 – MFBGC UT off Steeplecrest Circle	12 – 1/2021	EMIMI009 – MFBGC at Browns Lane

APPENDIX 3.2 DOW WATER QUALITY MONITORING RESULTS

1 INTRODUCTION

The objective of the water quality monitoring was to provide sufficient temporal and geographic data to evaluate the sources and loadings of water quality parameters.

This appendix focuses on the data collection and quality assurance review of data collected by DOW in support of watershed plan development. The Data analysis is presented in Chapter 4. Analyzing Results.

2 MONITORING METHODS

2.1 Monitoring Locations

DOW selected seven monitoring locations that included two of MSD's LTMN locations and five locations in the upper part of the watershed and on tributaries. DOW monitoring locations are shown on Table 1 and in Appendix 2.1.

Table 1 DOW Monitoring Locations

Site ID	Station ID	Waterbody	Location	River Mile	Drainage Area (mi^2)	Latitude	Longitude
1	DOW08047007	Middle Fork Beargrass Creek	Lexington Road **(1)**	0.9	24.8	38.250276	-85.716868
2	DOW08047008	Middle Fork Beargrass Creek	Old Cannons Lane **(1)**	5.4	18.7	38.23729	-85.66468
4	DOW08047010	Weicher Creek	Above Blossomwood Drive	0.55	1.3	38.23016	-85.63071
6	DOW08047009	Middle Fork Beargrass Creek Tributary 8.45 (Sinking Fork)	Below Bowling Boulevard	0.3	2.6	38.24683	-85.62881
7	DOW08047011	Middle Fork Beargrass Creek Tributary 9.1	Off Steeplecrest Circle	0.2	3.9	38.24093	-85.61867
8	DOW08047012	Middle Fork Beargrass Creek	Off Old Whipps Mill Road	11.7	5	38.25984	-85.58529
10	DOW08047013	Middle Fork Beargrass Creek Tributary 12.8	Above Foxboro Road	0.2	2.2	38.25867	-85.5668

Notes:

1. MSD monitors this location as part of the LTMN

2.2 Sampling Schedule

DOW collected monitoring data between March 21, 2019 and February 18, 2020. In general, seven site visits occurred monthly for collection of field measurements and observations and water chemistry samples. *E. coli* bacteria and field measurements and observations were collected during the May 1 to October 31 recreation season, including five times per month between May 9 and June 6, 2019, then monthly during July to October. Benthic macroinvertebrate communities, habitat, and water chemistry were collected concurrently once at each site between March and July 2019. In general, sampling was conducted as planned. However, dry or pooled stream conditions precluded sampling at three monitoring sites between May and October, affecting water chemistry, *E. coli* bacteria and field measurements and observations: DOW08047009 - Middle Fork Beargrass Creek Tributary 8.45 (Sinking Fork) Below Bowling Boulevard and DOW08047011 - Middle Fork Beargrass Creek Tributary 9.1 Off Steeplecrest Circle. The number of site visits per month is shown on Table 2. Note that it was not possible to collect all of the planned samples and field measurements due to dry or pooled stream conditions. Specific information regarding the effects of dry and pooled stream conditions on sampling schedule is presented in Sections 4 through 7.

Table 2 Number of Sample Events per Month at Seven DOW Sites

Monitoring Type	2019										2020	
	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb
Water Chemistry **(1)**	8	7	9	8	6	6	4	5	6	7	7	7
E. coli Bacteria **(2)**			28	7	7	7	7	7				
Field Measurements & Observations **(3)**	7	7	28	7	7	7	7	6	6	7	7	7
Macroinvertebrates Habitat Assessment **(4)**	2		2	1	2							

Notes:

1. Water chemistry collected approximately monthly and also concurrently with macroinvertebrate & habitat assessments
2. *E. coli* bacteria collected five (5) times in 30 days between May 9, 2019 and June 6, 2019
3. Field measurements and observations collected concurrently with most water chemistry and E. coli sample events
4. Macroinvertebrates, habitat assessments performed once at each site, concurrent water chemistry data collected

Wet and Dry Sample Conditions: The Watershed Planning Guidebook states that two wet and two dry samples must be collected, defined as follows: A wet weather event is defined as a seven-day antecedent dry period (in which no more than 0.1 inch of precipitation occurs) followed by visible run-off conditions, such as sheet flow on impervious surfaces and visible surface flow in ephemeral channels. A dry weather event is defined as following a seven-day dry period, in which no more than 0.1 inch of precipitation occurs.

The sampling data from DOW were classified as wet or dry sampling events based on the rainfall patterns prior to and during the sampling dates. Wet weather sampling demonstrates pollutants that have accumulated across the watershed and are being flushed into the waterways via stormwater runoff, while dry weather sampling events demonstrate the existing pollutants in the waterways and may indicate leaks or illicit discharges somewhere in the watershed.

For the purposes of this analysis, rain data for the prior seven days up to the day of sampling were pulled from two MSD Rain Gauges: TR13 St. Matthews Elementary School and TR33 AB Sawyer Park. Rainfall patterns across Jefferson County vary in distribution and intensity. While these gages are geographically within and near the watershed, rainfall totals in the headwaters of the watershed may be different from the recorded totals at the gages located lower in the watershed. The total rain amounts were recorded on the sampling date, 0-24 hours prior to the sampling, 24-48 hours prior, and the total seven days prior to sampling.

Events with greater than 0.1 inches of rain recorded in the prior 24 hours were classified as wet events. **Error! Reference source not found.** Table 3 summarizes each sampling event's rain totals and classification, as well as notes regarding antecedent conditions and rainfall patterns.

Table 3 Rainfall Records on and Prior to Sampling Days

Sampling Date	Sampling Start Time	Wet vs Dry	TOTAL RAINFALL (in)				Notes
			On sample date	0-24 hours Prior to Sample Time	24-48 hours Prior to Sample Time	Total 7 days prior to sample date	
3/21/2019	9:45AM	Dry	0.06	0	0	1.05	.99" of rain on March 14
3/28/2019	9:40AM	Dry	0	0	0	0.46	
4/24/2019	10:15AM	Dry	0	0	0	2.555	Majority of rain occurred April 19-20, some sites had not returned to base flow before sampling
5/9/2019	9:45AM	Dry	0.02	0	0	1.735	1.4" of rain on May 2-3
5/16/2019	10:20AM	Dry	0	0	0	0.3	0.51" of rain on May 16 not included in total, occurred after sampling time
5/23/2019	10:15AM	Dry	0.035	0	0	0.95	0.1" of rain on May 23 not included in total, occurred after sampling time
5/30/2019	10:20AM	Wet	0.3	0.815	0.24	2.215	
6/4/2019	9:30AM	Dry	0	0	0	1.305	1.3" of rain on May 29-30
6/6/2019	9:50AM	Wet	0	0.65	0.04	0.925	Rain on June 6 not included in total, occurred after sampling time
7/10/2019	9:45AM	Dry	0.04	0	0	2.01	1.97" of rain on July 3-4
7/16/2019	9:35AM	Dry	0	0	0	0.1	Rain on July 16 not included in total, occurred after sampling time
8/22/2019	10:00AM	Wet	0.915	0	0.07	1.07	
9/17/2019	10:15AM	Dry	0	0.04	0	0.04	
10/23/2019	8:40AM	Dry	0	0	0.02	0.245	

Sampling Date	Sampling Start Time	Wet vs Dry	TOTAL RAINFALL (in)				Notes
			On sample date	0-24 hours Prior to Sample Time	24-48 hours Prior to Sample Time	Total 7 days prior to sample date	
11/12/2019	9:00AM	Dry	0	0.11	0	0.845	TR13 recorded 0.13" rain on November 11 and TR13 recorded 0.09", the average was rounded to 0.1" and event classified as dry
12/4/2019	10:10AM	Dry	0	0	0.03	2.34	1.885" of rain on November 30; 0.415" of rain on November 27
1/16/2020	10:00AM	Dry	0	0	0	1.685	1.075" of rain on January 11; 0.61" of rain on January 10
2/18/2020	10:00AM	Wet	0.295	0	0	1.585	

2.3 Sample Collection and Analysis

DOW field teams performed sample collection activities as described in Water Quality Monitoring Quality Assurance Project Plan, Revision 2.0 (DOW, 2019), 2019 Success Monitoring Program Study Phase 1 Watershed Plan Monitoring in Middle Fork Beargrass Creek (DOW, 2019a) and accompanying Standard Operating Procedures. DOW sample collection included *E. coli* bacteria and water chemistry samples, field measurements including pH, water temperature, dissolved oxygen, dissolved oxygen percent saturation, conductivity and stream discharge, and field observations.

Analysis for DOW water quality and *E. coli* samples was performed by Department for Environmental Protection Laboratory in Frankfort, Kentucky using analytical methods specified in the DOW QAPP (DOW, 2019). This laboratory was certified to perform the analysis included in this appendix. DOW provided laboratory analytical reports, scans of field data sheets and data in Excel format to MSD for incorporation into the Middle Fork Beargrass Creek Watershed Plan.

2.4 Benthic Macroinvertebrate Communities and Aquatic Habitat Assessments

Benthic macroinvertebrates and aquatic habitat assessments were completed in the spring and summer months of 2019. DOW biologists identified benthic macroinvertebrates to the species level and these data were used to calculate the Macroinvertebrate Index of Biological Integrity (MIBI). MIBI scores were used to assign the narrative rating of Good, Fair, or Poor for headwater and wadeable sites in the Bluegrass Physiographic Province based on DOW protocols.

USEPA's Rapid Bioassessment Protocol (RBP) was used to assess the quality of aquatic habitat using DOW protocols. RBP scores were used to assign a narrative rating of Good, Fair, Poor for headwater and wadeable sites in the Bluegrass Physiographic Province based on DOW protocols and SOP. Stream habitat was evaluated using the high gradient RBP assessment form. High gradient indicates streams have velocities greater than 0.5 ft/second and riffle habitat. Representative upstream and downstream photographs were collected at each site and are provided in Chapter 4. Headwater and wadeable streams are included in this study and were analyzed accordingly (Table 4).

Table 4 Wadeable and Headwater Sampling Stations

Station	Watershed Area (sq mi)	Scoring Type	Sample Period
DOW08047007	24.8	Wadeable	July 10, 2019
DOW08047008	18.7	Wadeable	July 16, 2019
DOW08047009	15.2	Wadeable	May 23, 2019
DOW08047010	1.3	Headwater	March 21, 2019
DOW08047011	3.9	Headwater	May 23, 2019
DOW08047012	5	Wadeable	June 4, 2019
DOW08047013	2.2	Headwater	March 21, 2019

Note that DOW collected and reviewed the data and then provided it to MSD in PDF and excel formats. MSD prepared the monitoring report to support development of this plan. Note that this report does not include data analysis such as comparison to water quality criteria, non-regulatory benchmarks, or estimates of pollutant loads. These analysis are provided in Chapter 4. Analyzing Results.

3 QUALITY ASSURANCE OVERVIEW

The quality assurance review focused on comparing quality assurance sample results to data quality objectives included in the DOW QAPP (DOW, 2019) as summarized on Table 5.

Table 5 DOW Data Quality Objectives

Data Quality Measure	Definition (1)	Measurement (2)
Completeness	The amount of valid data needed so that the data may be used for its intended purpose	**(3)**
Representativeness and Comparability	All project activities will follow DOW SOPs to ensure representativeness and comparability with past and future data.	Documentation of adherence to SOPs
Precision	The measure of agreement among repeated measurements of the same property under identical or substantially similar conditions.	Field duplicates and for *E. coli*, field splits of at least 10% of sample distributed across the project
Accuracy	A measure of the overall agreement of a measurement to a known value. Measured by “spiking” a sample with a known concentration of specific analytes.	Percent recovery of laboratory spikes between 90 to 110%
Bias	The systematic or persistent distortion of a measurement process that causes error in one direction.	Field blanks (water quality – 10% of samples distributed across project), (E. coli – one per sample day) Equipment rinsate blanks (ortho-phosphorus – one per sample day), laboratory method blanks

Data Quality Measure	Definition (1)	Measurement (2)
Sensitivity	The capability of a method or instrument to discriminate between measurement responses representing different levels of the variable of interest.	Comparison of published detection limits for the analysis to actual detection limits achieved in the laboratory

Notes:

1. Definitions from DOW QAPP, Section 1.3.2 Performance and Acceptance Criteria (DOW, 2019)
2. Measurements from DOW 2019 Success Monitoring Program Study Phase 1 Watershed Plan Monitoring in Middle Fork Beargrass Creek, Table 3 (DOW, 2019a)
3. For the purpose of watershed plan development, completeness will be assessed by comparing the collected data to the monitoring requirements of the Watershed Planning Guidebook for Kentucky Communities, 1st Edition (KWA and DOW, 2010)

Field quality control samples included field duplicates, field splits, field blanks, and equipment rinsate blanks. In addition, a method blank is analyzed in the laboratory as one type of laboratory quality control sample. A description of these quality control samples is included on Table 6.

Table 6 Types of Quality Control Samples

Sample Type	Description (1)	Purpose
Field Duplicate	A sample taken from the same location as the ‘regular grab’ sample, at the same time. The sample is used to assess variability of environmental conditions at sampling sites.	Evaluate precision (i.e., reproducibility) of water quality samples and measurements
Field Split	A sample that is collected by initially collecting twice as much volume as is normally collected and then thoroughly mixed and split in the lab into two sets of containers. This type of sample is used to assess analysis variability.	Evaluate precision (i.e., reproducibility) of *E. coli* analysis
Field Blank	A sample that is prepared in the field using de-ionized or certified ultrapure water. The water is poured into appropriate sample containers at specific locations during a sampling event. The sample is used to assess potential contamination from the environment, not associated with the source being sampled.	Evaluate potential contamination (i.e., bias) of water quality and *E. coli* samples
Equipment Rinsate Blank	A sample used to assess the possible contamination level of equipment that is field cleaned and re-used on-site. The sample is taken by rinsing field cleaned equipment with de-ionized water and collecting the rinse water to be submitted for analyses of all constituents that are normally collected using that piece of equipment.	Evaluate potential sampling equipment contamination (i.e., bias) used for ortho-phosphorus filtration equipment
Method Blank **(2)**	Laboratory pure water that is treated exactly as a sample including exposure to glassware, equipment, solvents, reagents, internal standards, and surrogates that are used with other samples.	Evaluate potential contamination in the laboratory.

Note:

1. DOW (2011). Sampling Surface Water Quality in Lotic Systems, Revision 2. DOWSOP03015
2. MSD (2019). Quality Assurance Plan, Effective Date: 10/14/2019

Data flags are assigned by the lab to provide additional information about field collection and sample analyses performed in the laboratory as part of routine laboratory data management. Data flags B. Analyte in Method Blank and K. Analyte in Trip or Field Blank are used to evaluate potential bias in the sample results caused by contamination in the field or laboratory. DOW recommended that data associated with flags H. Exceeded Prep Hold Time, P. Improper Preservative and T. Exceeded Holding Time be excluded from further analysis. One or more data qualifiers may be assigned when sample concentrations are near the lower limits of the analytical range (i.e., low concentrations). It is important to note that data flags provide additional information about analytical results and their presence does not indicate "bad" data. Data flags that were assigned to the DOW data and potential data implications are shown on

Table 7.

Table 7 Data Flags and Potential Data Implications

Flag	Flag Description	Potential Data Implications
B	Analyte in Method Blank	Blank sample may have been inadvertently contaminated in the lab and the source of the contamination may also have affected samples, increasing the resulting concentration (i.e., bias). Blank concentrations may be subtracted from detected sample concentrations analyzed in the same batch.
D	Analyzed at a Higher Dilution	DOW applied this flag to *E. coli* bacteria note samples analyzed at 1:10 dilution. No adjustment to sample results.
J	Estimated Value	This qualifier is typically assigned to values outside the upper or lower range of the analytical method. For results reported as greater than the maximum detectable value, the reported numeric result may be used in subsequent analysis. For results reported as less than the minimum reporting limit, the reported numeric result may be multiplied by 0.5, and that adjusted value is used for subsequent results
K	Analyte in Trip or Field Blank **(1)**	Blank concentrations may be subtracted from detected sample concentrations collected on that day.
M	Matrix Spike Limits Exceeded	No change to sample results
O	Lab Fortified Blank Limits Exceeded	No change to sample results
Q	QC Limits Exceeded	No change to sample results
T	Exceeded Holding Time	Some samples, notably *E. coli* bacteria, must be analyzed within a specified time between collection and analysis in order to ensure a valid sample. DOW recommended results with this data flag be excluded from further analysis.
U	Analyte Not Detected	For results reported as less than the minimum reporting limit, the reported numeric result may be multiplied by 0.5, and that adjusted value is used for subsequent results
V	Calibration Verification Limits Exceeded	No change to sample results

Flag	Flag Description	Potential Data Implications
X	See Case Narrative	May or may not affect sample results, depending upon the case narrative provided by the lab
Z	Sample Preserved by Freezing	No change to sample results, except if applied to bacteria sample (which did not occur in this dataset).
Notes: 1. Data flag K was not assigned by DOW; however, several field blanks had detected concentrations		

4 E. COLI MONITORING AND DATA QUALITY REVIEW

The Watershed Planning Guidebook specifies monthly *E. coli* sample collection at the selected watershed monitoring sites over one year and collection of five samples in 30 days during May or June. (KWA and DOW, 2010) The DOW sampling schedule focused on the May 1 to October 31 recreation season, with five samples in 30 days collected in May 2019. MSD's sampling extends from March 2020 to February 2021. Taken together, the DOW and MSD monitoring efforts exceed the Guidebook monitoring requirements for *E. coli* bacteria.

DOW collected *E. coli* bacteria samples using methods described in the Standard Operating Procedure (SOP) Sampling Surface Water Quality in Lotic Systems, Revision 2, DOWSOP03015 (DOW, 2011). Sample bottles were filled directly from the subsurface of the stream to minimize sample handling and stored on ice. Five samples in 30 days were collected between May 9 and June 6, 2019. The *E. coli* sample collection schedule is shown on

Table 8.

Table 8 DOW E. coli Sample Collection Schedule (2019)

DOW Monitoring Sites	May				Jun	Jul	Aug	Sept	Oct	# Samples
	9	16	23	30	6	16	22	17	23	
DOW08047007 Middle Fork Beargrass Creek at Lexington Road	1	1	1	1	1	1	1	1	1	9
DOW08047008 Middle Fork Beargrass Creek at Old Cannons Lane	1	1	1	1	1	1	1	1	1	9
DOW08047009 Sinking Fork at Bowling Blvd	1	1	1	1	1	1	1	X	1	8
DOW08047010 Weicher Creek at Blossomwood Drive	1	X	X	1	1	X	X	X	X	3
DOW08047011 Middle Fork Beargrass Creek Tributary at Steeplecrest Circle	1	1	1	1	1	X	1	X	X	6
DOW08047012 Middle Fork Beargrass Creek at Old Whipps Mill Road	1	1	1	1	1	1	1	1	1	9
DOW08047013 Middle Fork Beargrass Creek Tributary at Foxboro Road	1	1	1	1	1	1	1	1	1	9
Total										**53**

Samples were transported to the Department for Environmental Protection Laboratory for analysis using procedures described in SOP Enzyme Substrate Test for the Detection Total Coliforms and Escherichia coli, Revision 2, DOWSOP03025 (DOW, 2018). Results were reported as Most Probable Number per 100 milliliters (MPN/100 mL). As a reference, 100 mL is approximately 3.2 ounces. The detection range for this method is <1 MPN/100 mL to 2,419 MPN/100 mL for undiluted samples. 20 samples were diluted 1:10 with sterile water in the laboratory and were assigned a data flag of D. Analyzed at a Higher Dilution. The detection range for samples at this dilution is <10 MPN/100 mL to 24,196 MPN/100 mL. A total of 63 samples were planned (i.e., nine samples at seven sites). Of these, 53 samples (84%) were collected. It was not possible to collect 10 of the samples due to dry or pooled stream conditions.

The data quality review included evaluation of results from analysis of quality control samples and data flags. Quality control samples collected for *E. coli* bacteria included field blanks and field splits. Per the 2019 Success Monitoring Program Study Phase 1 Watershed Plan Monitoring in Middle Fork Beargrass Creek one field blank was collected on each sample day. All nine samples were reported as less than the detection limit of 1 MPN/100 mL, indicating that the reported results were not biased by contamination during sample collection and analysis. Data flag D was assigned to the 20 samples analyzed at 1:10 dilution; no other data flags were assigned by the laboratory.

Nine *E. coli* field splits[1] were collected over the duration of the study and used to assess precision (i.e., reproducibility) of the analysis. Field split results were analyzed using a statistical method published by Standard Methods (Eaton, et. al., 1998) as recommended by DOW. Because the absolute difference was less than the calculated performance criteria, the field duplicates met the precision target. The precision analysis is shown on

Table 9.

Table 9 E. coli Field Split Precision Analysis

Monitoring Site	Sample Date	Field Split 1 (MPN/100 mL)	Field Split 2 (MPN/100 mL)	Log (Split 1)	Log (Split 2)	Absolute Difference
DOW08047007 Middle Fork Beargrass Creek at Lexington Road	5/16/2019	81	108	1.91	2.03	0.12
DOW08047007 Middle Fork Beargrass Creek at Lexington Road	5/30/2019	4,106	4,884	3.61	3.69	0.08
DOW08047007 Middle Fork Beargrass Creek at Lexington Road	9/17/2019	122	102	2.09	2.01	0.08
DOW08047008 Middle Fork Beargrass Creek at Old Cannons Lane	5/9/2019	548	411	2.74	2.61	0.12
DOW08047011 Middle Fork Beargrass Creek Tributary at Steeplecrest Circle	5/23/2019	>2,419	>2,419	3.38	3.38	0.00

[1] One *E. coli* sample was identified as a field duplicate collected from mid-depth, rather than subsurface (Lab sample ID FF19403). This sample was treated as a field split collected from subsurface.

Monitoring Site	Sample Date	Field Split 1 (MPN/100 mL)	Field Split 2 (MPN/100 mL)	Log (Split 1)	Log (Split 2)	Absolute Difference
DOW08047011 Middle Fork Beargrass Creek Tributary at Steeplecrest Circle	6/6/2019	3873	5794	3.59	3.76	0.17
DOW08047012 Middle Fork Beargrass Creek at Old Whipps Mill Road	7/16/2019	158	158	2.20	2.20	0.00
DOW08047012 Middle Fork Beargrass Creek at Old Whipps Mill Road	10/23/2019	285	194	2.45	2.29	0.17
DOW08047013 Middle Fork Beargrass Creek Tributary at Foxboro Road	8/22/2019	>2,419	>2,419	3.38	3.38	0.00
Average						**0.08**
Performance Criteria: Less than (3.27 * Average)						**0.27**

Summary: DOW sample and collection analysis was consistent with the DOW QAPP (DOW, 2019). The Watershed Planning Guidebook bacteria monitoring requirements (KWA and DOW, 2010) specify monthly bacteria monitoring for one year, with five samples in 30 days collected in either May or June. The DOW *E. coli* data was collected during the recreation season of May 1 to October 31, with five samples collected in 30 days between May 9 and June 6, 2019, for a total of nine sample events. MSD *E. coli* data was collected monthly from February 2019 to January 2020, so the two sampling efforts exceed the bacteria monitoring requirements of the Guidebook. The *E. coli* data collected by DOW and MSD will be integrated for the data analysis performed in Chapter 4. Analyzing Results, providing approximately two years of *E. coli* record for this watershed.

DOW planned a total of 63 samples (i.e., nine samples at seven sites). Of these, 53 samples (84%) were collected. It was not possible to collect 10 of the samples due to dry or pooled stream conditions. One field blank was collected on each sample day. All nine samples were reported as less than the detection limit of 1 MPN/100 mL, indicating that the reported results were not biased by contamination during sample collection and analysis. Nine E. coli field splits[2] were collected over the duration of the study and used to assess precision (i.e., reproducibility) of the analysis. Because the absolute difference was less than the calculated performance criteria, the field duplicates met the precision target.

5 WATER CHEMISTRY MONITORING AND DATA QUALITY REVIEW

The Guidebook specifies monthly water chemistry sample collection at the selected watershed monitoring sites over one year (KWA and DOW, 2010). DOW collected water chemistry samples using methods described in the Standard Operating Procedure (SOP) Sampling Surface Water Quality in Lotic Systems, Revision 2, DOWSOP03015 (DOW, 2011). Sample bottles were filled directly from the mid-depth of the stream to minimize sample handling, preserved as necessary and stored on ice in

[2] DOW collected eight (8) field splits and one (1) field duplicate. These results were combined to evaluate precision of the analysis.

the field. The DOW water chemistry sampling occurred between March 28, 2019 to February 18, 2020 as shown on

Table 10.

Table 10 Monthly Water Chemistry Sampling Schedule

Monitoring Location	2019										2020		Total
	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	
	28	24	30	6	16	22	17	23	12	4	16	18	
DOW08047007 Middle Fork Beargrass Creek at Lexington Road	1	1	1	1	1	1	1	1	1	1	1	1	12
DOW08047008 Middle Fork Beargrass Creek at Old Cannons Lane	1	1	1	1	1	1	1	1	1	1	1	1	12
DOW08047009 Sinking Fork at Bowling Blvd	1	1	1	1	1	1	X	1	1	1	1	1	11
DOW08047010 Weicher Creek at Blossomwood Drive	X	1	1	1	X	X	X	X	X	1	1	1	6
DOW08047011 Middle Fork Beargrass Creek Tributary at Steeplecrest Circle	1	1	1	1	X	1	X	X	1	1	1	1	9
DOW08047012 Middle Fork Beargrass Creek at Old Whipps Mill Road	1	1	1	1	1	1	1	1	1	1	1	1	12
DOW08047013 Middle Fork Beargrass Creek Tributary at Foxboro Road	1	1	1	1	1	1	1	1	1	1	1	1	12
Total # of Monthly Water Chemistry Sampling Events													**74**

In addition, DOW collected water chemistry samples concurrently with benthic macroinvertebrate communities and habitat assessments on the dates shown on Table 11.

Table 11 Water Chemistry Samples Collected with Benthic Macroinvertebrate Communities

Monitoring Location	Date
DOW08047007 Middle Fork Beargrass Creek at Lexington Road	July 10, 2019

Monitoring Location	Date
DOW08047008 Middle Fork Beargrass Creek at Old Cannons Lane	July 23, 2019
DOW08047009 Sinking Fork at Bowling Blvd	May 23, 2019
DOW08047010 Weicher Creek at Blossomwood Drive	March 21, 2019
DOW08047011 Middle Fork Beargrass Creek Tributary at Steeplecrest Circle	May 23, 2019
DOW08047012 Middle Fork Beargrass Creek at Old Whipps Mill Road	June 4, 2019
DOW08047013 Middle Fork Beargrass Creek Tributary at Foxboro Road	March 21, 2019
Total # of Concurrent Water Chemistry and Macroinvertebrate Sampling Events	**7**

DOW planned 91 water chemistry sampling events, including 84 monthly events and one concurrent collection with benthic macroinvertebrate communities at seven sites. A total of 81 of 91 (89%) planned water chemistry sampling events were completed. It was not possible to collect samples for the remaining ten events due to pooled or dry stream conditions.

Water chemistry samples were transported to the Department for Environmental Protection Laboratory in Frankfort, Kentucky for analysis for the parameters shown on Table 11.

Table 12 Water Chemistry Parameters Analyzed by DOW

Parameter Type	Water Chemistry Parameters (1)
Bulk	**biochemical oxygen demand**, bromide, chloride, fluoride, nitrate, nitrite, sulfate, turbidity, total dissolved solids
Nutrients	**ammonia (as N), nitrate+nitrite (as N)**, **total Kjeldahl nitrogen**, total organic carbon, **total phosphorus, ortho-phosphorus (field filtered)**
Sediment	**total suspended solids**
Alkalinity	acidity, alkalinity, alkalinity-carbonate, alkalinity-bicarbonate
Metals and Hardness	aluminum, antimony, arsenic, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, molybdenum, nickel, potassium, selenium, silver, sodium, thallium, vanadium, zinc, total hardness
Notes: 1. Parameters required by the Watershed Planning Guidebook for Kentucky Communities, 1st Edition (KWA and DOW, 2010) are shown in bold.	

The laboratory analyzed the samples using approved methods specified in the QAPP (DOW, 2019). Data provided to MSD for use in the watershed plan included scanned field sheets, site photographs, laboratory analysis reports in PDF format and water chemistry data in Excel format.

The water chemistry data quality review included evaluation of results from analysis of quality control samples and data flags. The DOW recommended excluding results with data flags H. Exceeded Prep Hold Time, P. Improper Preservative, and T. Exceeded Holding Time. 13 results with data flag T were excluded from all subsequent quality control reviews and analyses; data flags H and P did not occur in the dataset. Four acidity samples did not have reported values and were removed from the dataset. Orthophosphorus samples were analyzed by two different methods: EPA 300.0 Inorganic Anions by Ion Chromatography (Detection Limit 0.03 mg/L) and EPA 365.1 Phosphorus (all forms) by Semi-Automated Colorimetry (Detection Limit 0.01 mg/L).

Quality control samples collected for water chemistry included field blanks, equipment rinsate blanks (Orthophosphorus only), field duplicates and method blanks. Per the 2019 Success Monitoring Program Study Phase 1 Watershed Plan Monitoring in Middle Fork Beargrass Creek one of each type of field quality control sample was collected on each sample day.

Nine of 493 field blank results (1.8%) were detected in concentrations greater than the minimum detection limit, indicating a potential positive bias in samples associated with these blanks. A total of 16 equipment rinsate blanks were collected to identify potential contamination in filtering equipment used in the field for ortho-phosphorus samples. Concentrations of ortho-phosphorus were reported as less than the reporting limit for all but one of the samples indicating a potential positive bias in samples associated with these blanks.

Table 13 Water Chemistry Field Blank Detected Concentrations

Monitoring Location	Characteristic	Date	Detection Limit	Result	Units
DOW08047007 Middle Fork Beargrass Creek at Lexington Road	Phosphorus, Total (as P)	9/17/2019	0.01	0.04	mg/L
	Sulfate	9/17/2019	0.1	0.245	mg/L
	Sulfate	1/16/2020	0.1	0.244	mg/L
	Zinc	11/12/2019	2	10.5	µg/L
DOW08047008 Middle Fork Beargrass Creek at Old Cannons Lane	Sulfate	10/23/2019	0.1	0.235	mg/L
	Sulfate	12/4/2019	0.1	0.204	mg/L
	Zinc	10/23/2019	2	6.48	µg/L
DOW08047011 Middle Fork Beargrass Creek Tributary at Steeplecrest Circle	Aluminum	3/28/2019	2	6.03	µg/L
	Turbidity	6/6/2019	0.05	0.118	mg/L

Four samples and two field blanks collected had detectable concentrations of phosphorus as indicated by data flag B. Analyte in Method Blank indicating a potential positive bias in samples associated with these blanks. The concentration detected in the method blank was not reported in the DOW data.

Field duplicates were collected during each of the 12 sample events and used to assess precision (i.e., reproducibility) of the analysis. The field duplicate collection schedule is shown on

Table 14. There were twelve sets of field duplicate results per parameter, except for Orthophosphorus, which had 24 pairs of results. Orthophosphorus samples were analyzed by two different methods: EPA 300.0 Inorganic Anions by Ion Chromatography (Detection Limit 0.03 mg/L) and EPA 365.1 Phosphorus (all forms) by Semi-Automated Colorimetry (Detection Limit 0.01 mg/L). Field duplicate results from each method were analyzed separately.

Table 14 Water Chemistry Field Duplicate Collection Schedule

Monitoring Site	Date	Date	Date
DOW08047007 Middle Fork Beargrass Creek at Lexington Road	9/17/2019	12/4/2019	

Monitoring Site	Date	Date	Date
DOW08047008 Middle Fork Beargrass Creek at Old Cannons Lane	3/28/2019	6/6/2019	11/12/2019
DOW08047009 Sinking Fork at Bowling Blvd	2/18/2020		
DOW08047010 Weicher Creek at Blossomwood Drive	NA		
DOW08047011 Middle Fork Beargrass Creek Tributary at Steeplecrest Circle	5/30/2019		
DOW08047012 Middle Fork Beargrass Creek at Old Whipps Mill Road	4/24/2019	7/16/2019	10/23/2019
DOW08047013 Middle Fork Beargrass Creek Tributary at Foxboro Road	8/22/2019	1/16/2020	

Per the DOW QAPP Table 1.5 (DOW, 2019), the acceptance criteria shown on Table 15 were applied to water quality samples collected by DOW. Field duplicates and the concurrent routine samples were paired, and results were compared to detection limits, as indicated by “<” values in the dataset, and Limits of Quantitation (LOQ) specified in Table 2.2 of the DOW QAPP (DOW, 2019).

Table 15 Water Chemistry Acceptance Criteria

Sample Spread (1)	Acceptance Criterion
Both samples are ≥ 5x the LOQ	A relative percent difference (RPD) of 20%
1 of 2 samples is ≥ 5x the LOQ	An absolute difference ≤ to the 2x LOQ[(1)]
Both samples are < 5x the LOQ **(2)**	An absolute difference ≤ to the 2x LOQ[(1)]
Both samples are non-detect	Not Applicable – No Calculation Required

Notes

1. Excerpted from DOW QAPP Table 1.5 (DOW, 2019)
2. If both samples are less than 5x the LOQ and are also found to have an absolute difference of >2x the Limit of Quantitation (LOQ), these data will be investigated further. If sufficient additional indicators of QA issues are found, the samples will be considered to have failed this QA check. Corrective action will be implemented as appropriate and outlined in this QAPP. All corrective actions must be reported in the final data report.

The results of the precision review for parameters included in the Guidebook, 1st Edition (KWA and DOW, 2010) are presented on Table 16.

Table 16 Results of Precision Review for Guidebook Parameters

Characteristic	Analysis Method	LOQ (1)	Number of Paired Analyses	Number Meeting Acceptance Criteria
Ammonia (as N)	EPA 350.1 r2	0.05 mg/L	12	12
CBOD-5	SM20 5210 B	**(2)**	11	11

Characteristic	Analysis Method	LOQ (1)	Number of Paired Analyses	Number Meeting Acceptance Criteria
Nitrate & Nitrite (as N)	EPA 353.2 r2	0.02 mg/L	12	12
Nitrate (as N)	EPA 300.0 r2.1	0.02 mg/L	12	12
Nitrite (as N)	EPA 300.0 r2.1	0.02 mg/L	12	12
Nitrogen, Total Kjeldahl (as N)	EPA 351.2 r2	0.5 mg/L	12	12
Orthophosphate (as P)	EPA 300.0 r2.1	0.02 mg/L	12	12
Orthophosphate (as P)	EPA 365.1 r2	0.02 mg/L	11	11
Phosphorus, Total (as P)	EPA 365.4	0.02 mg/L	12	12
Solids, Total Suspended	SM20 2540 D	1.5 mg/L	12	10
Turbidity	EPA 180.1 r2	0.1 NTU	11	11
Total			**129**	**127**

Notes:

1. Limit of Quantification excerpted from DOW QAPP, Table 2.2 (DOW, 2019)
2. DOW QAPP, Table 2.2 did not include an LOQ CBOD-5. (DOW, 2019) However, CBOD-5 was detected in only one (1) of 12 paired duplicate samples.

Eight of twelve pairs of aluminum samples met the acceptance criteria. Relative percent difference between duplicate samples with aluminum concentrations above the detection limit ranged from 1.7% to 126.5%. Four values did not meet the relative percent difference acceptance criteria of 20%. For the remaining additional parameters analyzed by DOW, at least ten of twelve pairs of samples met the acceptance criteria. One lead sample collected from DOW08047007 Middle Fork Beargrass Creek at Lexington Road in December 2019 was slightly above the criteria for additional investigation shown in Table 13, Note 2. The Field Duplicate lead concentration was 1.11 micrograms per liter (ug/L) and the concurrent field sample lead concentration was 0.1 ug/L. With these few exceptions, the precision review indicates good reproducibility in the dataset.

Stream discharge was not measured on May 9 at any of the sites due to an impending thunderstorm. Stream discharge was not measured on May 30 in Middle Fork Beargrass Creek at Lexington Road (DOW08047007) and Old Cannons Lane (DOW08047008) due to safety issues from high water. Discharge data from USGS gages will be used at these sites.

The DOW monitoring included parameters that are required by the current Guidebook (KWA and DOW, 2010), plus 34 additional parameters. The DOW monitoring parameters are shown on Table 17, with parameters required by the Guidebook are shown in bold.

Table 17 DOW Monitoring Parameters

Parameter Type	Parameter(s) (1)
Bacteria	***E. coli* bacteria**
Bulk	**biochemical oxygen demand**, bromide, chloride, fluoride, nitrate, nitrite, sulfate, turbidity, total dissolved solids, total suspended solids

Parameter Type	Parameter(s) (1)
Nutrients	**ammonia (as N), nitrate-nitrite**, **total Kjeldahl nitrogen**, total organic carbon, **total phosphorus, ortho-phosphorus (field filtered)**
Sediment	**total suspended solids**
Alkalinity	acidity, alkalinity, alkalinity-carbonate, alkalinity-bicarbonate
Metals and Hardness	aluminum, antimony, arsenic, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, molybdenum, nickel, potassium, selenium, silver, sodium, thallium, vanadium, zinc, total hardness
Field Parameters	**turbidity, pH, dissolved oxygen, dissolved oxygen % saturation (calculated), conductivity, temperature**
Stream Flow	**stream discharge**
Biology & Habitat	**benthic macroinvertebrates, habitat assessment**
Notes: 1. Parameters required by the Guidebook are shown in bold.	

5.1 Riparian Assessment

The riparian assessment will be analyzed in Phase 2.

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APPENDIX 3.3 MSD WATER QUALITY MONITORING RESULTS

1 INTRODUCTION

The objective of the water quality monitoring was to provide sufficient temporal and geographic data to evaluate the sources and loadings of water quality parameters.

This appendix focuses on the data collection and quality assurance review of data collected by MSD in support of watershed plan development. Data analysis is presented in Chapter 4. Analyzing Results.

2 MONITORING METHODS

2.1 Monitoring Locations

MSD selected nine monitoring locations that included three of MSD's LTMN locations and seven locations selected to provide representative data in the upper part of the watershed and on tributaries. MSD monitoring locations are shown on Table 1 and Figure 1. Some of these sites were the same locations that DOW monitored for this plan.

Table 1 MSD Monitoring Locations

Site ID	Station ID	Waterbody	Location	River Mile	Drainage Area (mi^2)	Latitude	Longitude
1	EMIMI010	Middle Fork Beargrass Creek **(1)**	Lexington Road	0.9	24.8	38.250276	-85.716868
2	EMIMI002	Middle Fork Beargrass Creek **(1)**	Old Cannons Lane	5.4	18.7	38.23729	-85.66468
3	EMIMI009	Middle Fork Beargrass Creek **(1)**	Browns Lane	7.97	15.2	38.2403	-85.6345
5	EMIMI033	Weicher Creek	Lincoln Road	1.56	0.57	38.22902	-85.61491
6	EMIMI038	Middle Fork Beargrass Creek UT 8.45 (Sinking Fork)	Below Bowling Boulevard	0.3	2.6	38.24683	-85.62881
7	EMIMI039	Middle Fork Beargrass Creek UT 9.1	Off Steeplecrest Circle	0.2	3.9	38.24093	-85.61867
8	EMIMI040	Middle Fork Beargrass Creek	Off Old Whipps Mill Road	11.7	5.0	38.25984	-85.58529
9	EMIMI041	Middle Fork Beargrass Creek	Forest Bridge Road	12.38	4.07	38.26126	-85.57434

Site ID	Station ID	Waterbody	Location	River Mile	Drainage Area (mi^2)	Latitude	Longitude
10	EMIMI042	Middle Fork Beargrass Creek UT 12.8	Above Foxboro Road	0.2	2.2	38.25867	-85.56680

Notes:

1. MSD Long Term Monitoring Network sites: EMIMI010, EMIMI002, EMIMI009

2.2 Sampling Schedule

MSD collected monitoring data between March 11, 2020 and February 24, 2021. In general, nine site visits occurred monthly for collection of field measurements and observations and water chemistry samples. *E. coli* bacteria was collected during the May 1 to October 31 recreation season, including five times per month between May 27 and June 24, 2020. Field parameters, stream flow, and *E. coli* bacteria were collected concurrently once at each site between March 2020 and February 2021. In general, sampling was conducted as planned. However, dry or pooled stream conditions precluded sampling at three monitoring sites between April and September, affecting *E. coli* bacteria and field measurements and observations: EMIMI033 – Weicher Creek, EMIMI038 Middle Fork Beargrass Creek UT 8.45 (Sinking Fork), and EMIMI039 Middle Fork Beargrass Creek UT 9.1. During the March 11, 2020 sampling event, flow was not collected at two sites due to high volumes of flow causing a safety hazard to wade into the stream, EMIMI002 – Middle Fork Beargrass Creek at Old Cannons Lane and EMIMI010 – Middle Fork Beargrass Creek at Lexington Road. There was an equipment malfunction on June 3, 2020 and some field measurements were not collected at EMIMI041 – Middle Fork Beargrass Creek at Forest Bridge Road and EMIMI042 – Middle Fork Beargrass Creek UT 12.8 Above Foxboro Road. The number of site visits per month is shown on Table 2. Number of Sample Events per Month at Nine MSD Sites

Table 2 Number of Sample Events per Month at Nine MSD Sites

Monitoring Type	2020										2021	
	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb
E. coli Bacteria **(1)**	9	8	9	35	9	8	8	9	9	9	9	9
Field Measurements & Observations **(2)**	9	8	9	34	9	8	8	9	9	9	9	9

Notes:

1. *E. coli* bacteria collected five times in 30 days between May 27, 2020 and June 24, 2021
2. Field measurements and observations collected concurrently with most E. coli sample events

Wet and Dry Sample Conditions: The Guidebook states that two wet and two dry samples must be collected, defined as follows: A wet weather event is defined as a seven-day antecedent dry period (in which no more than 0.1 inch of precipitation occurs) followed by visible run-off conditions, such as sheet flow on impervious surfaces and visible surface flow in ephemeral channels. A dry weather event is defined as following a seven-day dry period, in which no more than 0.1 inch of precipitation occurs.

The sampling data from MSD were classified as wet or dry sampling events based on the rainfall patterns prior to and during the sampling dates. Wet weather sampling demonstrates pollutants that have accumulated across the watershed and are being flushed into the waterways via stormwater runoff, while dry weather sampling events demonstrate the existing pollutants in the waterways and may indicate leaks or illicit discharges somewhere in the watershed.

For the purposes of this analysis, rain data for the prior seven days up to the day of sampling were pulled from two MSD Rain Gauges: TR13 St. Matthews Elementary School and TR33 AB Sawyer Park. During June 2020, TR13 rain gauge was offline and two nearby gauges were used: TR05 Beargrass Creek and TR12 Nightingale PS. Rainfall patterns across Jefferson County vary in distribution and intensity. While these gages are geographically within and near the watershed, rainfall totals in the headwaters of the watershed may be different from the recorded totals at the gages located lower in the watershed. The total rain amounts were recorded on the sampling date, 0-24 hours prior to the sampling, 24-48 hours prior, and the total seven days prior to sampling.

Events with greater than 0.1 inches of rain recorded in the prior 24 hours were classified as wet events. Table 3 summarizes each sampling event's rain totals and classification, as well as notes regarding antecedent conditions and rainfall patterns.

Table 3 Rainfall Records On and Prior to Sampling Days

Sampling Date	Sampling Start Time	Wet vs Dry	TOTAL RAINFALL (in)				Notes
			On sample date	0-24 hours Prior to Sample Time	24-48 hours Prior to Sample Time	Total 7 days prior to sample date	
3/11/2020	9:22AM	Dry	0	0	0.45	0.45	Rain stopped by 9AM 3/10/2021
4/22/2020	8:41AM	Dry	0	0	0	0.595	Rain occurred evening of 4/17/2020
5/27/2020	7:28AM	Wet	0.215	0.135	0.015	1.125	Rain on sample day occurred at 4 AM
6/3/2020	10:42AM	Dry	0	0	0	0.257	Rain occurred 5/27-29/2020
6/10/2020	9:53AM	Dry	0	0.16	0	0.913	Rain during Day prior on gauge north of watershed, gauge inside watershed read zero and to the east read 0.05" Majority of rain occurred 6/4/2020
6/17/2020	9:46AM	Dry	0	0	0	0.077	Rain occurred 6/14/2020
6/24/2020	11:05AM	Wet	0	0.84	0.37	2.1	Rain ended at noon day prior to sampling
7/22/2020	8:42AM	Wet	0.645	0.12	0.09	0.875	Majority of rain on sample day after 5 PM, but 0.2 did occur early before 8 AM
8/19/2020	9:23AM	Dry	0.01	0.08	0	0.725	Majority of rain occurred 8/14/2020
9/16/2020	11:03AM	Dry	0	0	0	0.035	

Sampling Date	Sampling Start Time	Wet vs Dry	TOTAL RAINFALL (in)				Notes
			On sample date	0-24 hours Prior to Sample Time	24-48 hours Prior to Sample Time	Total 7 days prior to sample date	
10/21/2020	7:50AM	Wet	0.06	1.175	0.75	2.075	Majority of rain day prior occurred before 4 AM
11/18/2020	8:00AM	Dry	0	0	0	0.725	Rain occurred on 11/11/2020 and 11/15/2020
12/16/2020	8:19AM	Wet	0.305	0.01	0.025	0.505	Majority of rain on sample day occurred in the morning from 5-11 AM
1/20/2021	9:50AM	Dry	0	0	0.03	0.255	
2/24/2021	8:40AM	Dry	0	0	0.14	1.045	4-6 inches snow/ice melt caused elevated flow. Pollutant concentrations and loads not elevated.

2.3 Sample Collection and Analysis

MSD field teams performed MSD sample collection activities as described in Quality Assurance Project Plan MSD 319(h) Monitoring for the Middle Fork of Beargrass Creek Watershed Plan Version 1.0 and accompanying Standard Operating Procedures included in the References section of this document. MSD sample collection included *E. coli* bacteria and field measurements including pH, water temperature, dissolved oxygen, dissolved oxygen percent saturation, turbidity, conductivity and stream discharge, and field observations.

Field Quality Control Samples: Field quality control samples included field duplicates, field splits, field blanks, and equipment rinsate blanks. A description of the MSD field sampling quality control requirements is included on Table 4.

Table 4 MSD Field Sampling Quality Control Requirements

Requirement	Frequency	Corrective Action	Persons Responsible for Corrective Action	Data Quality Indicator	Measurement Performance Criteria
E. coli Field Splits (1)	1 field split each sample day (11%)	▪ Censor or qualify data as necessary ▪ Review sample collection procedures	Project Manager and QA Manager	Precision	The acceptable range of deviation between sample results will be determined by the precision criteria set using the procedures in SM 9020B, Section 8b (See SOP Appendices)

Requirement	Frequency	Corrective Action	Persons Responsible for Corrective Action	Data Quality Indicator	Measurement Performance Criteria
E. coli Field Blanks (2)	1 field blank each sample day (11%)	▪ Censor or qualify data as necessary ▪ Review sample collection and storage procedures	Project Manager and QA Manager	Accuracy or Bias, Contamination	Result is < 1 MPN/100ml

Notes:

1. Field Split – single sample collected by field team. The lab will split into two samples and analyze separately in the lab. Used to estimate subsampling and laboratory analysis precision.
2. Field Blank – de-ionized water from the carboy or other container which is treated as a sample. Used to identify errors or contamination in sample collection and analysis.

The types of samples, field activities, measurements/analyses collected, frequency and number of sites are summarized in Table 5.

Table 5 MSD 319(h) Monitoring Activities Overview

Monitoring Activity	Field Activities	Measurements/ Analyses Required	Frequency	# of Sites
E. coli bacteria	Grab sample	Standard Methods for the Examination of Water and Wastewater (SM9223B) 1997 MSD *E. Coli* Rev 6 090118 (or most recent update)	Monthly sampling event, plus 5 samples within 30 days for May or June	9
Field Parameters	HydroTech Compact DS **(1)**	Dissolved oxygen, pH, specific conductance, water temperature, turbidity	Every sampling event	9
Stream discharge	Hach FH950 handheld flow meter & wading rod **(1,2)**	Stream discharge	Every sampling event	9

Notes:

1. At Middle Fork Beargrass Creek at Old Cannons Lane (03293000, EMIMI002) and Middle Fork Beargrass Creek at Lexington Road (03293500, EMIMI010), field parameters (i.e., dissolved oxygen, pH, specific conductance, water temperature) and stream discharge measurements will be supplemented with data from MSD/USGS sonde readings and USGS stream flow gages.
2. Hach FH950 is equipped with automatic depth sensor

Data collection did not occur at the following sites due to pooled or no flow conditions. These conditions affected EMIMI033 – Weicher Creek, EMIMI038 Middle Fork Beargrass Creek UT 8.45 (Sinking Fork), and EMIMI039 Middle Fork Beargrass Creek UT 9.1. Due to the pooled or no flow conditions, one of five samples in 30 days were not collected at these sites. Monthly samples were unable to be collected as identified on the table.

Table 6 Samples Not Collected due to Dry or Pooled Stream Conditions

Station ID / Waterbody / Location	*E. coli* Bacteria	Field Measurements and Observations (1)
EMIMI033 Weicher Creek Lincoln Road	4/22/2020 6/17/2020 **(2)**	4/22/2020 6/17/2020
EMIMI038 Middle Fork Beargrass Creek UT 8.45 (Sinking Fork) Below Bowling Boulevard	6/17/2020 **(2)** 9/16/2020	6/17/2020 9/16/2020
EMIMI039 Middle Fork Beargrass Creek UT 9.1 Off Steeplecrest Circle	6/17/2020 **(2)** 8/19/2020	6/17/2020 8/19/2020

Notes:

1. Field Measurements and Observations were taken on dates listed. Data removed from analysis per QAPP.
2. These *E. coli* bacteria sampling dates were part of the five (5) samples in 30 days collected between May 27 and June 24, 2020.

3 QUALITY ASSURANCE OVERVIEW

The quality assurance review focused on comparing quality assurance sample results to data quality objectives included in the MSD QAPP (MSD, 2020) as summarized on Table 7 and Table 8.

Table 7 MSD 319(h) Data Quality Indicators and QC Requirements

Parameter (Units)	Method	Expected Range	Accuracy	Sensitivity (Resolution)	QC
Temperature (°C)	HydroTech Compact DS	0-35	0.01° C	0.10 ° C	As-needed maintenance per SOP
Specific Conductance (uS/cm)	HydroTech Compact DS	100-2,000	1% of reading	0.1 uS/cm	Calibration check within 24-hours of sampling, calibration and maintenance as-needed per SOP
pH (Std. units)	HydroTech Compact DS	4-10	0.2	0.01	Calibration check within 24-hours of sampling, calibration and maintenance as-needed per SOP

Parameter (Units)	Method	Expected Range	Accuracy	Sensitivity (Resolution)	QC
Dissolved Oxygen (mg/l)	HydroTech Compact DS	0-20	± 0.01 mg/L for 0–8 mg/L; ± 0.02 mg/L for greater than 8 mg/L	0.01 or 0.1 mg/L	Calibration check within 24-hours of sampling, calibration and maintenance as-needed per SOP
Turbidity (NTU)	HydroTech Compact DS	0-1,000	± 1% up to 100 NTU, ± 3% up to 100–400 NTU, ± 5% from 400–3000 NTU	0.1 NTU: 0–400 NTU, 1 NTU: >400 NTU	Calibration check within 24-hours of sampling, calibration and maintenance as-needed per SOP
Velocity (used to calculate discharge) (ft/s)	Hach FH950 handheld flow meter & wading rod	0-5,000	0 to 10 ft/s: ±2% of reading 10 to 16 ft/s: ± 4% of reading	0.05 cfs	Calibration check within 24-hours of sampling, calibration and maintenance as-needed per SOP
E. coli (MPN/ 100 mL)	Grab sample	4 -240,000		4 MPN/100 mL	Field blanks and splits, laboratory blanks **(1)**
Notes: 1. These project specific quality control measures are in addition to the extensive quality control measures and sterility checks employed by MSD's laboratory as required by DOW certification (MSD, 2019)					

Table 8 MSD 319(h) Data Quality Indicators

DQI	Definition	Project QC Samples
Precision **(1)**	Measure of agreement among repeated measurements of the same property under similar conditions. Usually expressed as a range, standard deviation, variance, percent difference in either absolute or relative terms.	*E. coli* - one split sample on each sample day (11%).
Accuracy	Measure of closeness of an individual measurement to a known or reference value. Expressed as percent recovery or percent bias.	All *E. coli* samples will be collected directly into sample bottles. All SOPs and QA/QC procedures will be followed throughout the sampling period.

DQI	Definition	Project QC Samples
Bias	Systematic or persistent distortion of a measurement process that results in errors in one direction.	Bias will be assessed one *E. coli* field blank, one method blank per sample event.
Representativeness	A qualitative measure of the degree to which data accurately and precisely represent a characteristic of a population parameter.	Bacteria samples and field parameter measurements will be collected using procedures described in the SOP, from representative thalweg areas with flowing water just above a riffle at the selected monitoring sites as described in the SOP. Stream discharge measurements will be collected from a representative location as described in Section 8.3.1.1 of the SOP.
Comparability	A qualitative term describing the degree to which different processes, methods or data agree or can be represented as similar. Expresses the measure of confidence that two data sets can contribute to a common analysis.	Comparability will be maintained by following the quality assurance procedures outlined in this QAPP and all relevant SOPs.
Completeness	An evaluation of the amount of data needed to be obtained from a measurement system. Expressed as a percentage of the number of measurements that should have been collected or were planned to be collected.	The target is to collect at least 90% of the monitoring data described in this plan (i.e., at least 130 out of 144 samples or measurements per parameter). Five (5) samples per 30 days will be collected in May or June 2020 to support comparison of E. coli data to primary contact recreation criteria (401 KAR 10:031)
Sensitivity	Capability of a method to discriminate between measurement responses representing different levels of the variable of interest. Terms used to describe sensitivity include MDL, LOD and LOQ.	Achieve MDL, LOD, LOQ targets for *E. coli* data per MSD's Laboratory SOP and QAPP. Sensitivity of E. coli (i.e., MDL, LOD and LOQ) are proportional to dilution needed to increase method sensitivity and minimize the number of "greater than" results.
Notes: 1. Per In situ Water Quality Measurements and Meter Calibration for Lotic Waters DOWSOP03014 duplicate analysis is not appropriate for in situ measurements for lotic waters (KDOW, 2018a).		

Data flags are assigned by the lab to provide additional information about field collection and sample analyses performed in the laboratory as part of routine laboratory data management. Data flags C Analyte in Method Blank is used to evaluate potential bias in the sample results caused by contamination in the field or laboratory. A few of the qualifiers may be used to exclude data from further analysis. One or more data qualifiers may be assigned when sample concentrations are near the lower limits of the analytical range (i.e., low concentrations). It is important to note that data flags provide additional information about analytical results, their presence does not indicate "bad" data. Data flags for *E. coli* analysis are shown on Table 9.

The MSD QA Manager oversaw the review, verification and validation of monitoring data collected in this project. The review was accomplished by comparing the data collection process to the requirements established in this Quality Assurance Project Plan and Standard Operating Procedures. Errors were resolved as soon as possible to ensure that they did not become propagated in databases or other permanent records.

Any data collection that deviated from the procedures or did not meet the data quality indicators were evaluated by the MSD Project Manager and QA Manager. If the deviation was considered to be minor, the data was included with appropriate data flags (Table 9); otherwise the data was excluded from the dataset that was used to develop the Watershed-Based Plan. If E. coli contamination was found in field or laboratory blanks, the data associated with the compromised samples would be excluded from further analysis. No E. coli contaminations were found.

Table 9 MSD Data Flags for *E. coli* Analyses

MSD Qualifier	Description
C	Analyte detected in associated method blank
H	Duplicate/Replicate precision outside control limits
Q	Samples held at incorrect temperature
R	Sample analyzed out of the established method hold time
W	Samples reported outside of quantifiable range
7	Samples not analyzed correctly as required by the method
8	Instrument Performance Check Sample did not meet the required range
9	Microbiological incubation period outside of required method limits
<	Less Than
>	Greater Than

A summary of the data collection and quality assurance review for *E. coli* bacteria is provided in the Section 4.

4 *E. COLI* MONITORING AND DATA QUALITY REVIEW

The Guidebook specifies monthly *E. coli* sample collection at the selected watershed monitoring sites over one year and collection of five samples in 30 days during May or June (KWA and DOW, 2010). The MSD sampling schedule included monthly sampling for one year as well as five samples in 30 days collected in May and June 2020. DOW's sampling schedule focused on the May 1 to October 31 recreation season in 2019, with five samples in 30 days collected in May and June 2019. Taken together, the DOW and MSD monitoring efforts exceed the Guidebook monitoring requirements for *E. coli* bacteria.

MSD collected *E. coli* bacteria samples using methods described in the Technical Standard Operating Procedure for MSD 319(h) Monitoring for Middle Fork Beargrass Creek Watershed-Based Plan. (MSD 2020) Sample bottles were filled directly from the subsurface of the stream to minimize sample handling and stored on ice. Five samples in 30 days were collected between May 27 and June 24, 2020. The *E. coli* sample collection schedule is shown on Table 10.

Table 10 MSD *E. coli* Sample Collection Schedule (2020-2021)

MSD Monitoring Sites	Mar	Apr	May	June				Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	# Samples
	11	22	27	3	10	17	24	22	19	16	21	18	16	20	24	
EMIMI010 MFBGC at Lexington Rd	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	15
EMIMI002 MFBGC at Old Cannons Ln	1	1	1	1	1	1	1	1	1	1	1	1	X	1	1	14
EMIMI009 MFBGC at Browns Ln	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	15
EMIMI038 Sinking Fork at Bowling Blvd	1	1	1	1	1	X	1	1	1	1	1	1	1	1	1	14
EMIMI033 Weicher Cr. at Lincoln Rd	1	X	1	1	1	X	1	1	1	1	1	1	1	1	1	13
EMIMI039 MFBGC UT 9.1 at Steeplecrest Cir	1	1	1	1	1	X	1	1	X	X	1	1	1	1	1	12
EMIMI040 MFBGC Off Old Whipps Mill Rd	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	15
EMIMI041 MFBGC at Forest Bridge Rd	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	15
EMIMI042 MFBGC UT 12.8 at Foxboro Rd	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	15
Total	9	8	9	9	9	6	9	9	8	8	9	9	**9**	**9**	**9**	**129**

Samples were transported to the MSD Laboratory for analysis using procedures described in MSD SOP Escherichia coli, Revision 6, 090118 (MSD, 2019). Results were reported as Most Probable Number per 100 milliliters (MPN/100 mL). As a reference, 100 mL is approximately 3.2 ounces. The detection range for this method is <1 MPN/100 mL to 2,419 MPN/100 mL for undiluted samples. A total of 135 samples were planned (i.e., 15 samples at nine sites). Of these, 129 samples (96%) were collected. It was not possible to collect six of the samples due to dry or pooled stream conditions.

The data quality review included evaluation of results from analysis of quality control samples and data flags. Quality control samples collected for *E. coli* bacteria included field blanks and field splits. Per the 2020 Quality Assurance Project Plan MSD 319(h) Monitoring for the Middle Fork of Beargrass Creek Watershed Plan one field blank was collected on each sample day. All fifteen samples were reported as less than the detection limit of 1 MPN/100 mL, indicating that the reported results were not biased by contamination during sample collection and analysis.

Seventeen *E. coli* field splits were collected over the duration of the study and used to assess precision (i.e., reproducibility) of the analysis. Field split results were analyzed using a statistical method published by Standard Methods (Eaton, et. al., 1998) as recommended by DOW. Because the absolute difference was less than the calculated performance criteria, the field duplicates met the precision target. The precision analysis is shown on Table 11.

Table 11 E. coli Field Split Precision Analysis

Monitoring Site	Sample Date	Field Split 1 (MPN/100mL)	Field Split 2 (MPN/100mL)	Log (split1)	Log (split2)	Absolute Difference
EMIMI010 MFBGC at Lexington Rd	11/18/2020	1350	1120	3.13	3.05	0.08
EMIMI010 MFBGC at Lexington Rd	10/21/2020	2660	2370	3.42	3.37	0.05
EMIMI002 MFBGC at Old Cannons Ln	12/16/2020	226	156	2.35	2.19	0.16
EMIMI002 MFBGC at Old Cannons Ln	3/11/2020	364	557	2.56	2.75	0.18
EMIMI009 MFBGC at Browns Ln	4/22/2020	182	105	2.26	2.02	0.24
EMIMI009 MFBGC at Browns Ln	1/20/2021	329	331	2.52	2.52	0.00
EMIMI009 MFBGC at Browns Ln	5/27/2020	2690	2460	3.43	3.39	0.04

Monitoring Site	Sample Date	Field Split 1 (MPN/100mL)	Field Split 2 (MPN/100mL)	Log (split1)	Log (split2)	Absolute Difference
EMIMI033 Weicher Creek	6/10/2020	443	440	2.65	2.64	0.00
EMIMI033 Weicher Creek	6/24/2020	920	880	2.96	2.94	0.02
EMIMI033 Weicher Creek	6/3/2020	11000	7420	4.04	3.87	0.17
EMIMI038 Sinking Fork	2/24/2021	618	830	2.79	2.92	0.13
EMIMI038 Sinking Fork	4/22/2020	2347	2030	3.37	3.31	0.06
EMIMI038 Sinking Fork	5/27/2020	13500	13800	4.13	4.14	0.01
EMIMI039 MFBGC UT 9.1 Off Steeplecrest Cir	7/22/2020	1560	1640	3.19	3.21	0.02
EMIMI040 MFBGC Off Old Whipps Mill Road	8/19/2020	525	592	2.72	2.77	0.05
EMIMI041 MFBGC at Forest Bridge Road	9/16/2020	133	145	2.12	2.16	0.04
EMIMI042 MFBGC UT 12.8 Above Foxboro Road	10/21/2020	1180	2120	3.07	3.33	0.25
Average						**0.10**
Performance Criteria: Less than (3.27*Average)						**0.32**

Summary: The *E. coli* data collected by MSD were consistent with the data requirements included in the DOW QAPP (DOW, 2019) and Guidebook for developing a watershed plan. The gap in *E. coli* data that affected four sites was caused by dry and pooled conditions, beyond the control of MSD. The *E. coli* data collected by DOW and MSD will be integrated for the data analysis performed in Chapter 4. Analyzing Results, providing approximately two years of *E. coli* record for this watershed.

4.1 Louisville MSD Monitoring Locations

MSD invested significant effort to develop the QAPP (MSD, 2020) and SOP (MSD, 2020a) using templates provided by DOW. These documents were approved by DOW on May 11, 2020. Development of these documents included two field visits with DOW to observe their water quality sample collections, training for MSD field technicians and extensive review by DOW. The QAPP and SOP outline MSD's quality assurance and quality control procedures that addressed safety, staff training, instrument calibration, maintenance and operation, sample collection procedures and collection of quality control instrument measurements and quality control samples. These documents were used to review the quality of MSD's data. MSD's QAPP and SOP are included in Appendix 3.2.

The purpose of the MSD 319(h) monitoring was to support the development of the Middle Fork Beargrass Creek Watershed-Based Plan, characterize water quality and stream flow at the selected sites and to supplement the water quality monitoring performed by DOW.

Water quality monitoring sites were selected to address monitoring needs more broadly across the watershed described in Section 3.3 and to build upon the data collected by DOW. MSD accompanied DOW to their monitoring sites and performed several site reconnaissance efforts to identify the final sampling locations. The rationale for MSD's monitoring locations is presented on Table 3.7 and is also included as Table 6 in MSD's Approved QAPP for 319(h) Monitoring for the Middle Fork Beargrass Creek Watershed Plan (MSD, 2020).

Table 12. MSD 319(h) Monitoring Site Rationale

Station ID (DOW, MSD, USGS)	Waterbody	Location	Monitoring Rationale
DOW08047007 EMIMI010 03293500	Middle Fork Beargrass Creek	Lexington Road	Downstream end of watershed, add to LTMN and DOW 319(h) monitoring database
DOW08047008 EMIMI002 03293000	Middle Fork Beargrass Creek	Below Old Cannons Lane	Within CSO area, add to LTMN and DOW 319(h) monitoring database
EMIMI009	Middle Fork Beargrass Creek	At Browns Lane	Upstream of CSO area, add to LTMN and DOW 319(h) monitoring database
DOW08047009 EMIMI038	Middle Fork Beargrass Creek UT 8.45 (Sinking Fork)	Below Bowling Boulevard	Commercial area
EMIMI033	Weicher Creek	Lincoln Road	Downstream of golf course
DOW08047011 EMIMI039	Middle Fork Beargrass Creek UT 9.1	Off Steeplecrest Circle	Suburban area
DOW08047012 EMIMI040	Middle Fork Beargrass Creek	Off Old Whipps Mill Road	Downstream of flood control dam and large wetland upstream of dam
EMIMI041	Middle Fork Beargrass Creek	Forest Bridge Road	Upstream of Old Whipps Mill Road dam
DOW08047013 EMIMI042	Middle Fork Beargrass Creek UT 12.8	Above Foxboro Road	Upstream end of watershed, characterize suburban area

Six sampling locations were sampled by both DOW and MSD; however, samples were collected during different periods and frequencies. MSD added two new monitoring locations at Browns Lane and Forest Bridge Road. DOW sampled Weicher Creek at Blossomwood Drive, however MSD sampled upstream at Lincoln Road (EMIMI033) which is downstream of the golf course. The Browns Lane location (EMIMI009) is one of MSD's LTMN sites and by adding it to the 319(h) project, the MSD LTMN data from this site can be used to support development of this watershed plan. The Forest Bridge Road location (EMIMI041) is located on the mainstem above the Whipps Mill dam where there are two holding ponds that have potential to overflow into the creek. The proposed MSD monitoring sites were mapped and provided to DOW for review and approval prior to establishing the location as a monitoring site.

The MSD monitoring parameters are presented on Table 3.8. MSD monitoring was conducted between March 2020 and February 2021. Sampling events on May 27, June 24, July 22, October 21, and December 16 were considered to be wet weather events.

Table 13. MSD Monitoring Parameters

Parameter Type	Parameter(s) (1)
Bacteria	*E. coli* bacteria
Field Parameters	Turbidity, pH, Dissolved Oxygen, Dissolved Oxygen % Saturation (calculated) Conductivity, Temperature
Stream Flow	Stream discharge
Notes: 1. Parameters required by the Guidebook are shown in bold.	

DOW water quality monitoring is presented in Appendix 3.2 DOW Water Quality Monitoring Report. Note that this report does not include data analysis such as comparison to water quality criteria, non-regulatory benchmarks, or estimates of pollutant loads. This analysis is provided in Chapter 4. Analyzing Results.

5 REFERENCES

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APPENDIX 4.1 TABLES AND FIGURES

Table 1 Percent of Benchmark Exceedances

Sampling Sites and Event Classifications	Parameters	*E.coli*	TSS	Turbidity	TN	SpCond	TP	Ammonia (as N)	UIA
	Sample Count	181	78	203	80	220	80	80	76
	Dry Sample Count	116	52	135	53	148	53	53	49
	Wet Sample Count	65	26	68	27	72	27	27	27
	Benchmark	240 CFU/100mL	12.9 mg/L	11.6 NTU	1.2 mg/L	521.8 µS/cm	0.2 mg/L	0.1 mg/L	0.05 mg/L
	Percent Exceeding Benchmark								
1	All	71%	31%	26%	85%	72%	0%	54%	0%
1	Dry	56%	11%	16%	78%	90%	0%	56%	0%
1	Wet	100%	75%	50%	100 %	33%	0%	50%	0%
2	All	71%	8%	4%	83%	67%	0%	0%	0%
2	Dry	63%	0%	0%	75%	90%	0%	0%	0%
2	Wet	88%	25%	13%	100 %	11%	0%	0%	0%
3	All	80%		0%		67%			
3	Dry	70%		0%		90%			
3	Wet	100%		0%		20%			
4	All	100%	0%	0%	71%	0%	0%	0%	0%
4	Dry	100%	0%	0%	100 %	0%	0%	0%	0%
4	Wet	100%	0%	0%	33%	0%	0%	0%	0%
5	All	62%		0%		31%			
5	Dry	38%		0%		25%			
5	Wet	100%		0%		40%			
6	All	81%	18%	8%	83%	78%	0%	0%	0%
6	Dry	69%	0%	0%	88%	100%	0%	0%	0%
6	Wet	100%	67%	25%	75%	33%	0%	0%	0%
7	All	67%	10%	0%	100 %	71%	0%	0%	0%

Parameters			*E.coli*	TSS	Turbidity	TN	SpCond	TP	Ammonia (as N)	UIA
		Dry	50%	0%	0%	100 %	93%	0%	0%	0%
		Wet	88%	25%	0%	100 %	33%	0%	0%	0%
	8	All	63%	33%	7%	85%	83%	0%	31%	0%
		Dry	50%	25%	5%	78%	100%	0%	33%	0%
		Wet	88%	50%	11%	100 %	44%	0%	25%	0%
	9	All	60%		7%		86%			
		Dry	40%		0%		100%			
		Wet	100%		20%		60%			
	10	All	79%	0%	0%	85%	65%	0%	0%	0%
		Dry	69%	0%	0%	78%	86%	0%	0%	0%
		Wet	100%	0%	0%	100 %	11%	0%	0%	0%

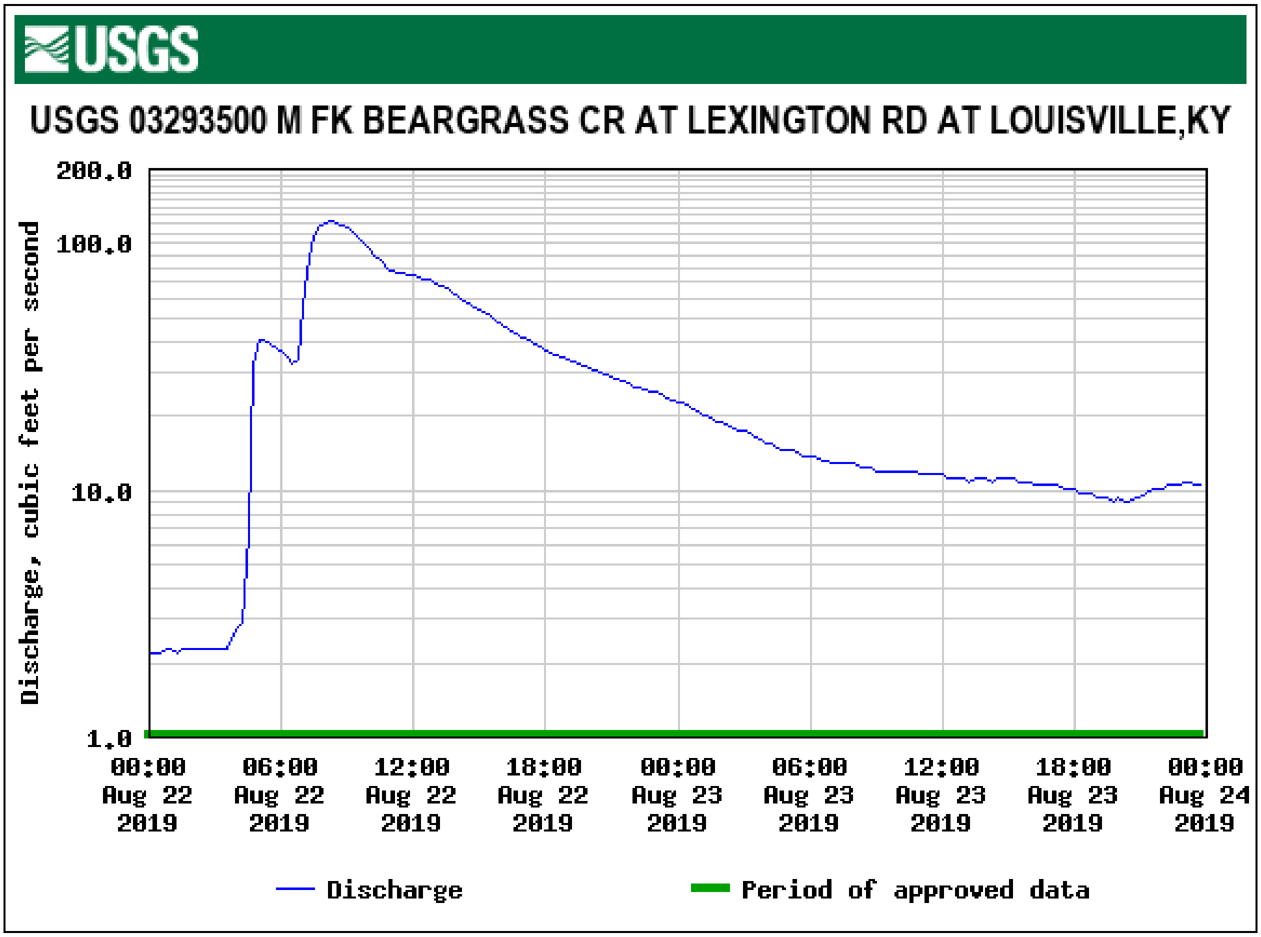


Figure 1 USGS Stream Gage at Lexington Road August 22, 2019 Wet Weather Event

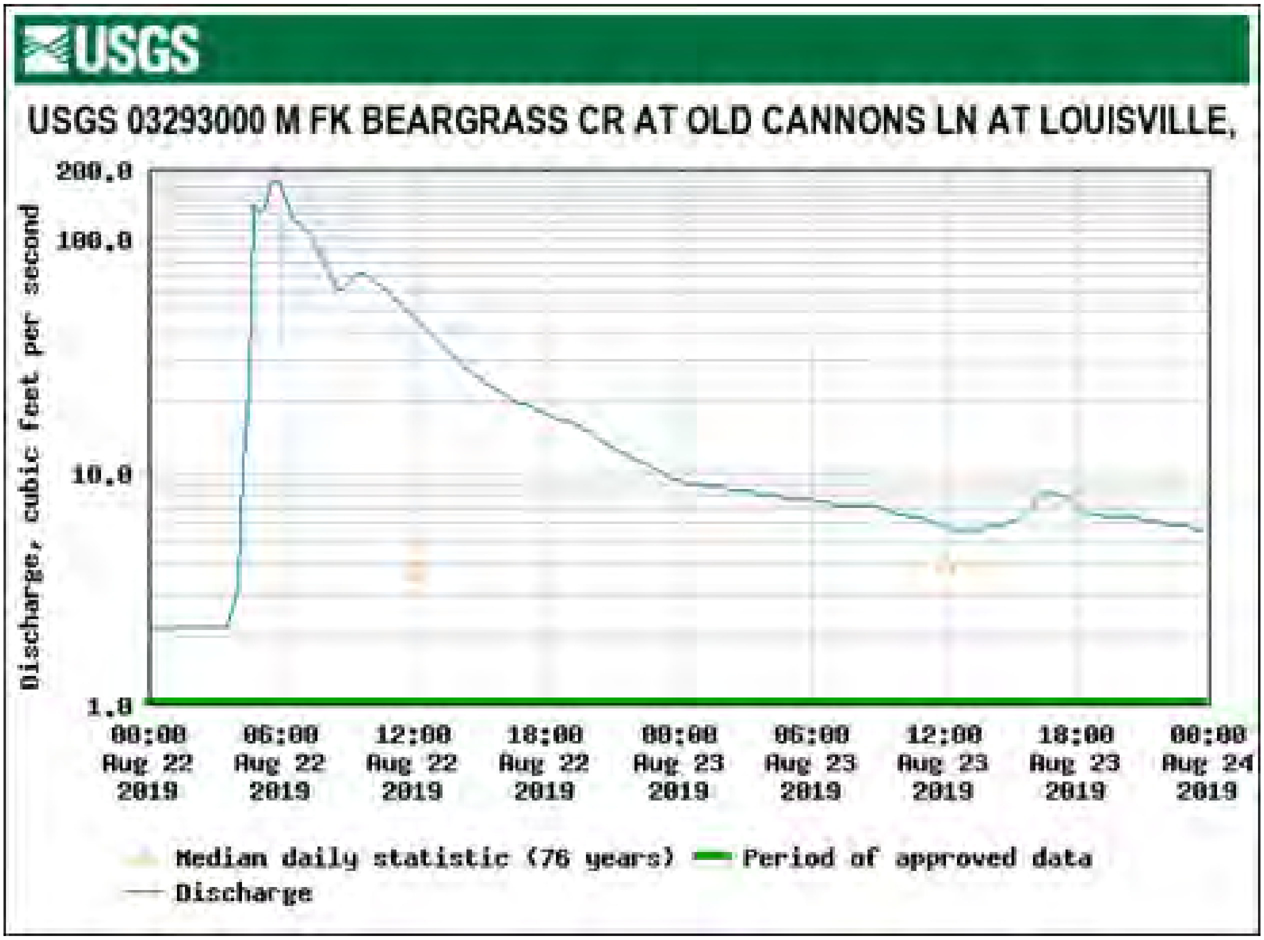


Figure 2 USGS Stream Gage at Old Cannons August 22, 2019 Wet Weather Event

Table 1 Station Visit Comments for Flow Not Measured

Site	Site Name	Station	Date	Station Visit Comments
1	Lexington Road	DOW08047007	5/9/2019	No flow measured because of impending thunderstorm.
2	Old Cannons Lane	DOW08047008	5/9/2019	No flow measured because of impending thunderstorm.
6	Sinking Fork	DOW08047009	5/9/2019	No flow measured because of impending thunderstorm.
4	Weicher Creek (DOW)	DOW08047010	5/9/2019	No flow measured because of impending thunderstorm.
7	Steeplecrest Circle	DOW08047011	5/9/2019	No flow measured because of impending thunderstorm.
8	Old Whipps Mill Road	DOW08047012	5/9/2019	No flow measured because of impending thunderstorm.
10	Foxboro Road	DOW08047013	5/9/2019	No flow measured because of impending thunderstorm.
4	Weicher Creek (DOW)	DOW08047010	5/16/2019	Dry conditions
4	Weicher Creek (DOW)	DOW08047010	5/23/2019	Stream dry. One small isolated pool at overpass.
1	Lexington Road	DOW08047007	5/30/2019	Flow not sampled, high water. USGS stream gauge 03293500 at this location.
2	Old Cannons Lane	DOW08047008	5/30/2019	Too deep, No flow sampled, see USGS gauge 03293000.
4	Weicher Creek (DOW)	DOW08047010	9/17/2019	No flow. Dry.
6	Sinking Fork	DOW08047009	9/17/2019	No flow. Pooled.
7	Steeplecrest Circle	DOW08047011	9/17/2019	Dry.
2	Old Cannons Lane	DOW08047008	2/18/2020	discharge not measured (Flowtracker malfunction)
4	Weicher Creek (DOW)	DOW08047010	2/18/2020	discharge not measured (Flowtracker malfunction)
6	Sinking Fork	DOW08047009	2/18/2020	discharge not measured (Flowtracker malfunction)
7	Steeplecrest Circle	DOW08047011	2/18/2020	discharge not measured (Flowtracker malfunction)
8	Old Whipps Mill Road	DOW08047012	2/18/2020	discharge not measured (Flowtracker malfunction)
10	Foxboro Road	DOW08047013	2/18/2020	discharge not measured (Flowtracker malfunction)
5	Weicher Creek (MSD)	EMIMI033	4/22/2020	No Flow Taken due to pooled conditions
9	Forest Bridge Road	EMIMI041	6/3/2020	flow not measured (Flowtracker malfunction)
5	Weicher Creek (MSD)	EMIMI033	6/17/2020	No Flow Taken due to dry or pooled conditions
6	Sinking Fork	EMIMI038	6/17/2020	No Flow Taken due to dry or pooled conditions
7	Steeplecrest Circle	EMIMI039	6/17/2020	No Flow Taken due to dry or pooled conditions

Site	Site Name	Station	Date	Station Visit Comments
7	Steeplecrest Circle	EMIMI039	8/19/2020	No Flow Taken due to dry or pooled conditions
6	Sinking Fork	EMIMI038	9/16/2020	No Flow Taken due to dry or pooled conditions

Table 3 Stream Flow Results

Recorded Flow (cfs)											
		Site ID and Location									
		1	2	3	4	5	6	7	8	9	10
Date	Event	Lexington Road	Old Cannons Lane	Browns Lane	Weicher Creek (DOW)	Weicher Creek (MSD)	Sinking Fork	Steeple-crest Circle	Old Whipps Mill Road	Forest Bridge Road	Foxboro Road
3/21/2019	Dry				1.2						2.0
3/28/2019	Dry	12.7	12.1				1.0	0.5	3.8		1.6
4/24/2019	Dry	55.1	33.4		2.8		3.8	5.7	12.7		5.8
5/9/2019	Dry	34.8	17.7		1.3		2.5	3.8	4.9		2.1
5/16/2019	Dry	9.5	10.1		0.0		0.7	0.2	4.0		1.4
5/23/2019	Dry	9.3	10.2		0.0		1.0	0.3	5.2		3.0
5/30/2019	Wet	71.4	41.4		1.2		27.0	32.9	27.0		8.5
6/6/2019	Wet	50.7	26.8		0.3		2.0	1.6	6.8		2.1
6/4/2019	Dry								2.2		
7/10/2019	Dry	11.9									
7/16/2019	Dry	4.7	5.1				0.0		0.5		0.6
8/22/2019	Wet	89.0	55.9				1.6	1.4	9.9		1.5
9/17/2019	Dry	1.3	1.1		0.0		0.0	0.0	0.5		0.3
10/23/2019	Dry	1.9	1.4				0.0		0.3		0.5
11/12/2019	Dry	11.6	8.6				0.6	0.8	2.9		1.6
12/4/2019	Dry	30.1	21.1		1.1		2.4	2.6	6.1		2.7
1/16/2020	Dry	29.7	25.3		0.3		2.4	2.3	7.0		2.9
2/18/2020	Wet	29.5	38.6		2.8		5.6	9.6	13.1		5.9
3/11/2020	Dry			15.7		0.7	1.4	2.6	6.3	7.3	3.2
4/22/2020	Dry	11.3	8.8	8.3			0.6	0.2	2.9	3.8	1.7
5/27/2020	Wet	24.2	31.5	14.7		0.6	1.2	2.0	5.8	5.6	3.1
6/3/2020	Dry	8.5	6.6	6.5		0.2	0.3	0.1	2.1	2.1	1.1
6/10/2020	Dry	7.8	5.3	5.6		0.0	0.2	0.1	1.6	2.0	1.0
6/17/2020	Dry	4.3	0.9	3.1					0.8	1.2	0.5

Recorded Flow (cfs)											
		Site ID and Location									
		1	2	3	4	5	6	7	8	9	10
Date	Event	Lexington Road	Old Cannons Lane	Browns Lane	Weicher Creek (DOW)	Weicher Creek (MSD)	Sinking Fork	Steeple-crest Circle	Old Whipps Mill Road	Forest Bridge Road	Foxboro Road
6/24/2020	Wet	20.4	14.6	13.7		0.3	2.1	1.2	3.6	2.7	1.5
7/22/2020	Wet	17.1	9.6	10.3		0.0	0.9	1.8	2.3	11.2	3.7
8/19/2020	Dry	5.7	3.6	4.5		0.0	0.1		1.0	1.5	0.5
9/16/2020	Dry	3.9	1.0	2.7		0.0			0.8	1.7	0.5
10/21/2020	Wet	38.5	19.1	19.2		0.5	1.8	1.8	4.3	3.6	1.7
11/18/2020	Dry	9.4	6.8	7.4		0.2	0.4	0.2	2.4	2.0	1.1
12/16/2020	Wet	7.2	7.0	9.1		0.5	0.2	0.1	3.2	5.0	6.1
1/20/2021	Dry	7.8	6.9	6.3		0.2	0.3	0.1	2.4	1.7	1.1
2/24/2021	Dry	44.7	28.1	27.1		1.4	2.6	4.4	9.4	8.9	3.7
Wet Events Average		38.7	27.2	13.4	1.4	0.4	4.7	5.8	8.4	5.6	3.8
Dry Events Average		15.0	10.7	8.7	0.8	0.4	1.1	1.5	3.6	3.2	1.8

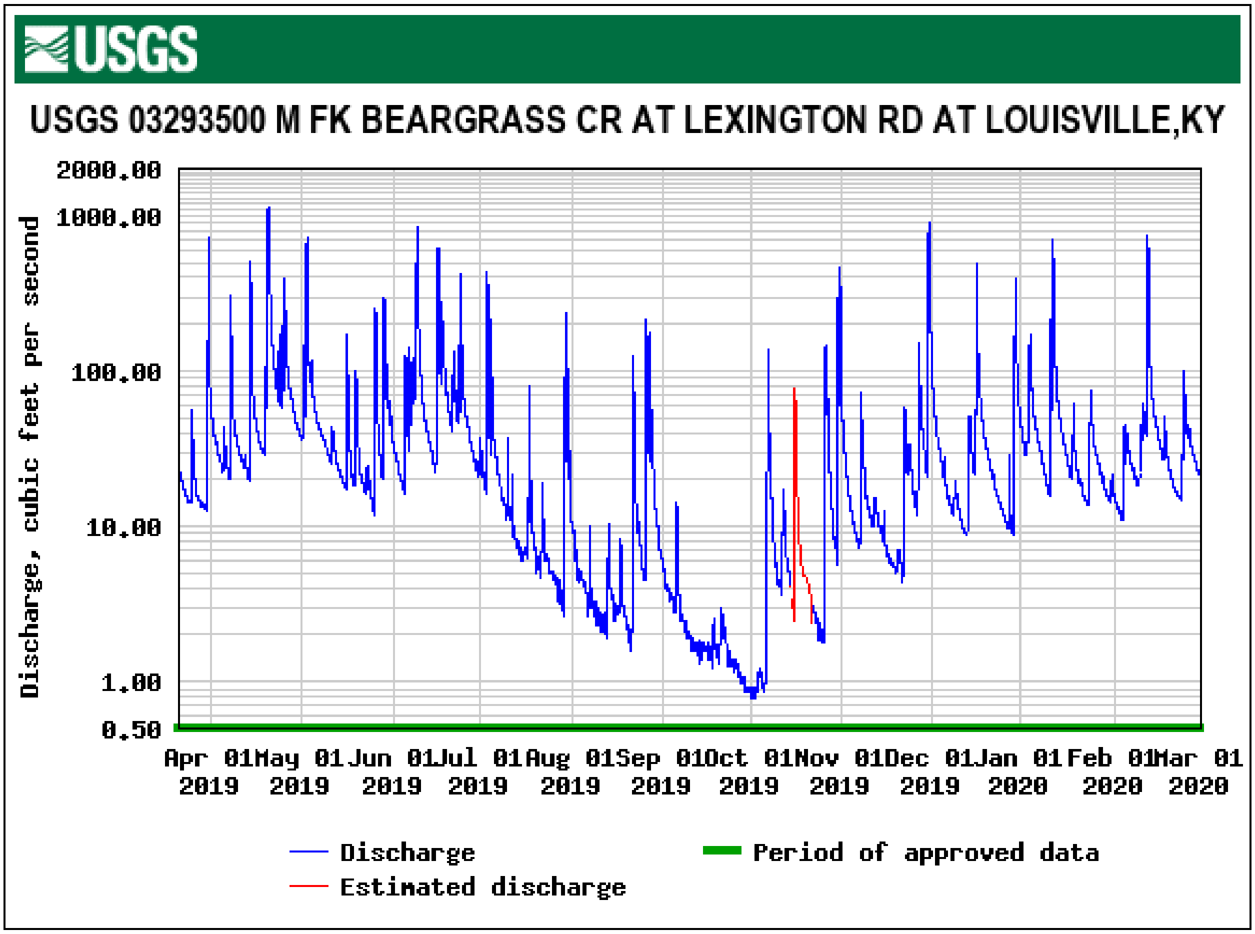


Figure 3 USGS Stream Gage Middle Fork Beargrass Creek at Lexington Road During Phase I Sampling

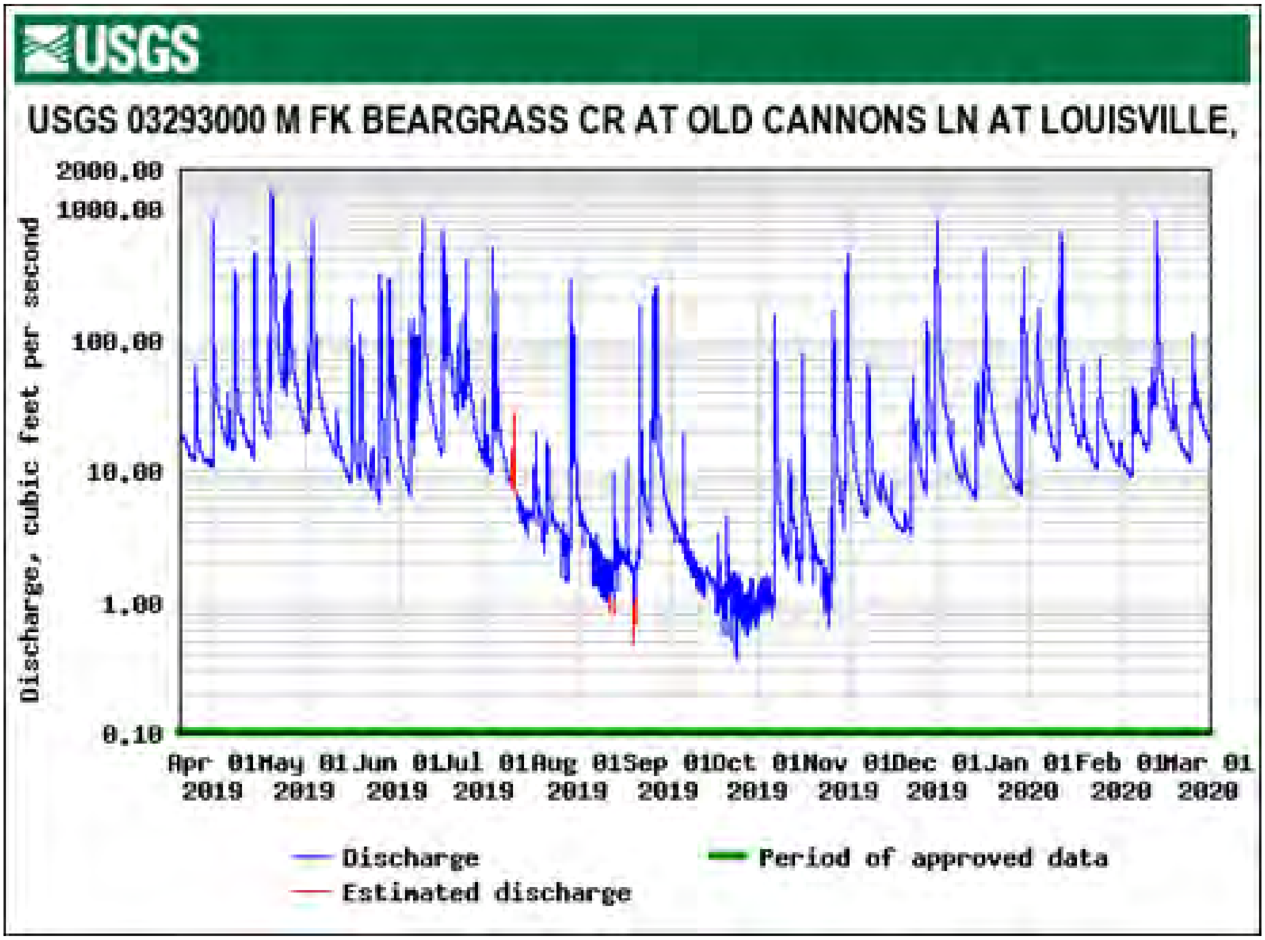


Figure 4 USGS Stream Gage at Middle Fork Beargrass Creek at Old Cannons Lane During Phase I Sampling

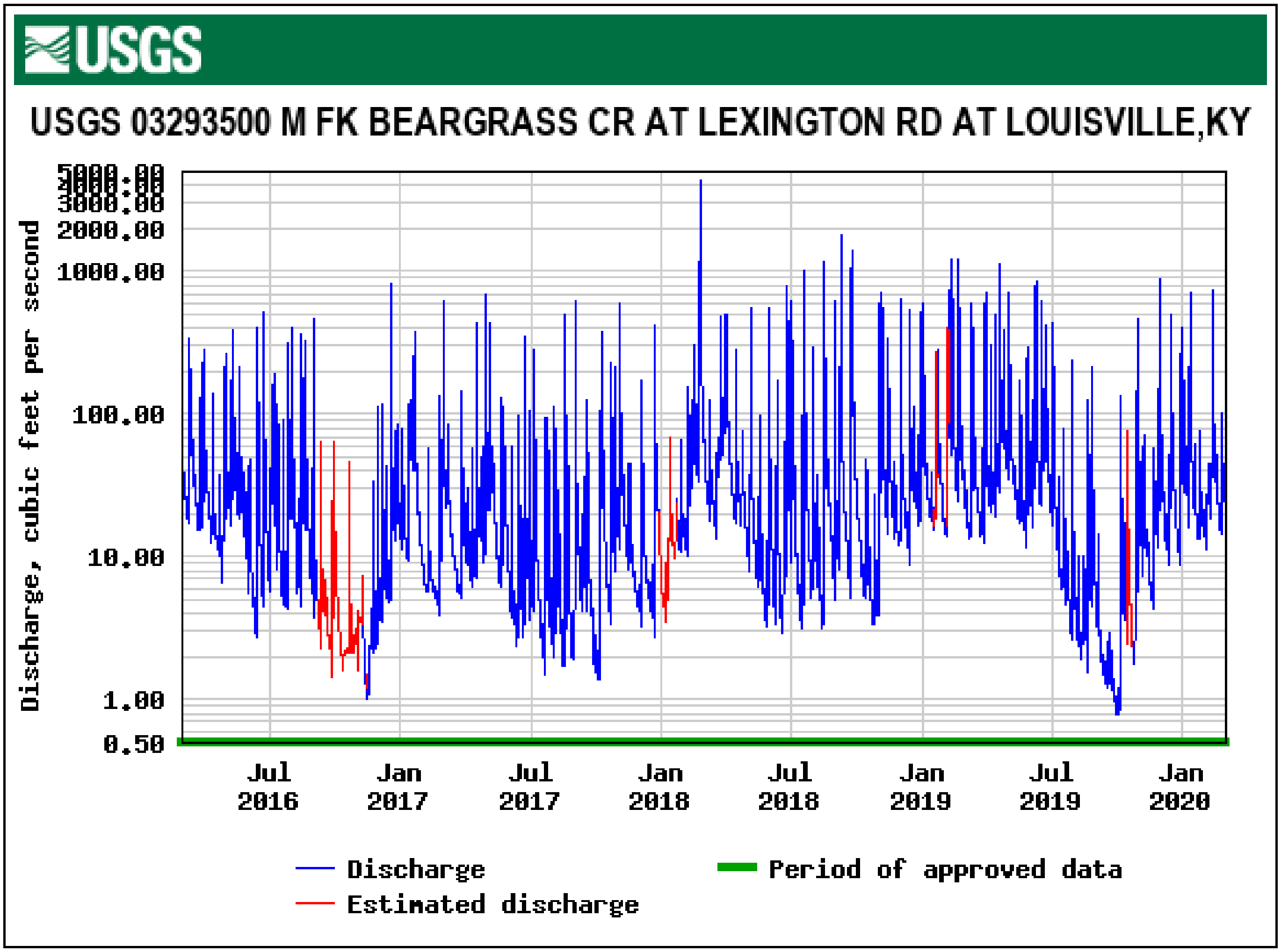


Figure 5 USGS Stream Gage Middle Fork Beargrass Creek at Lexington Road March 2016 to March 2020

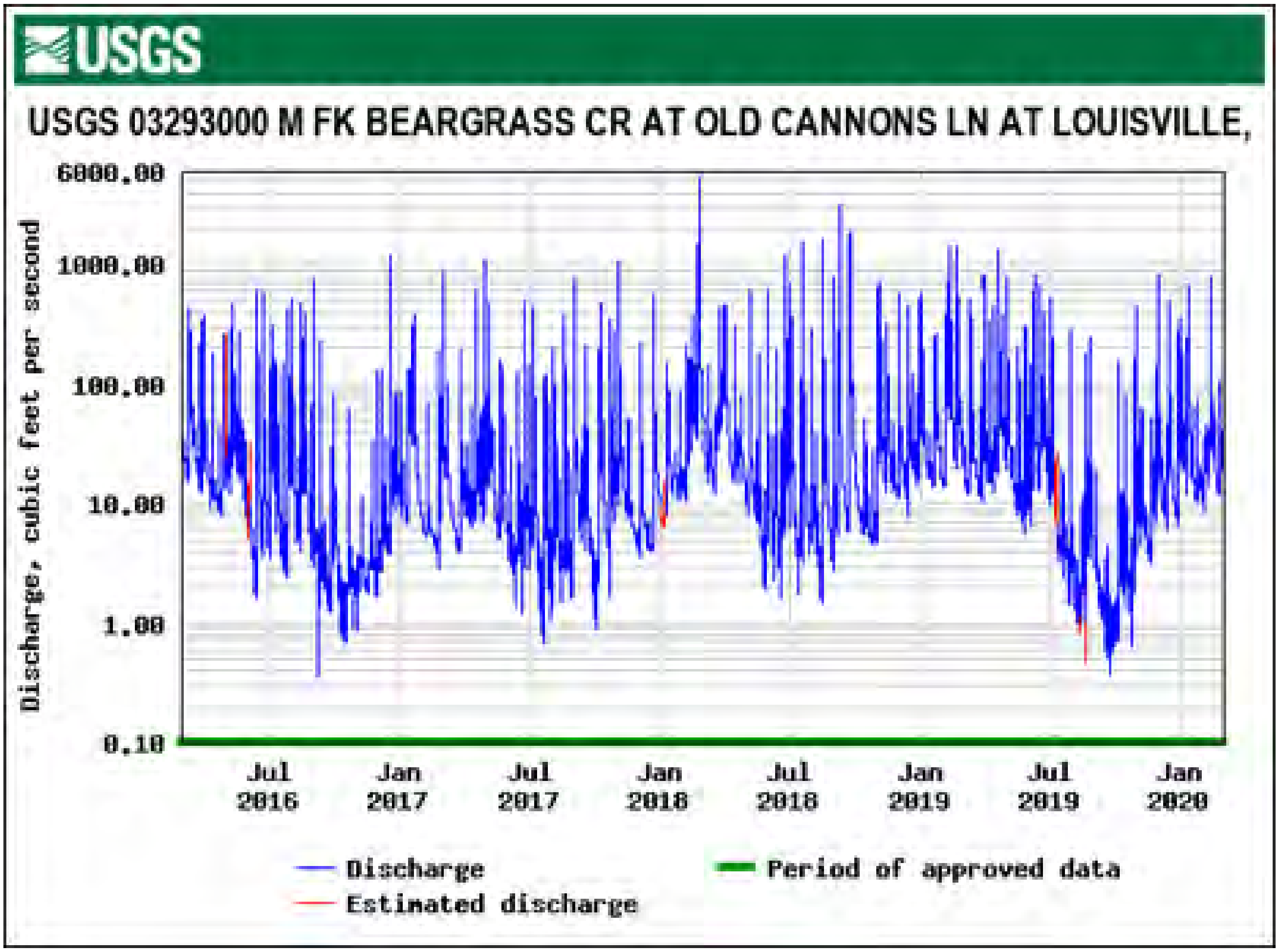


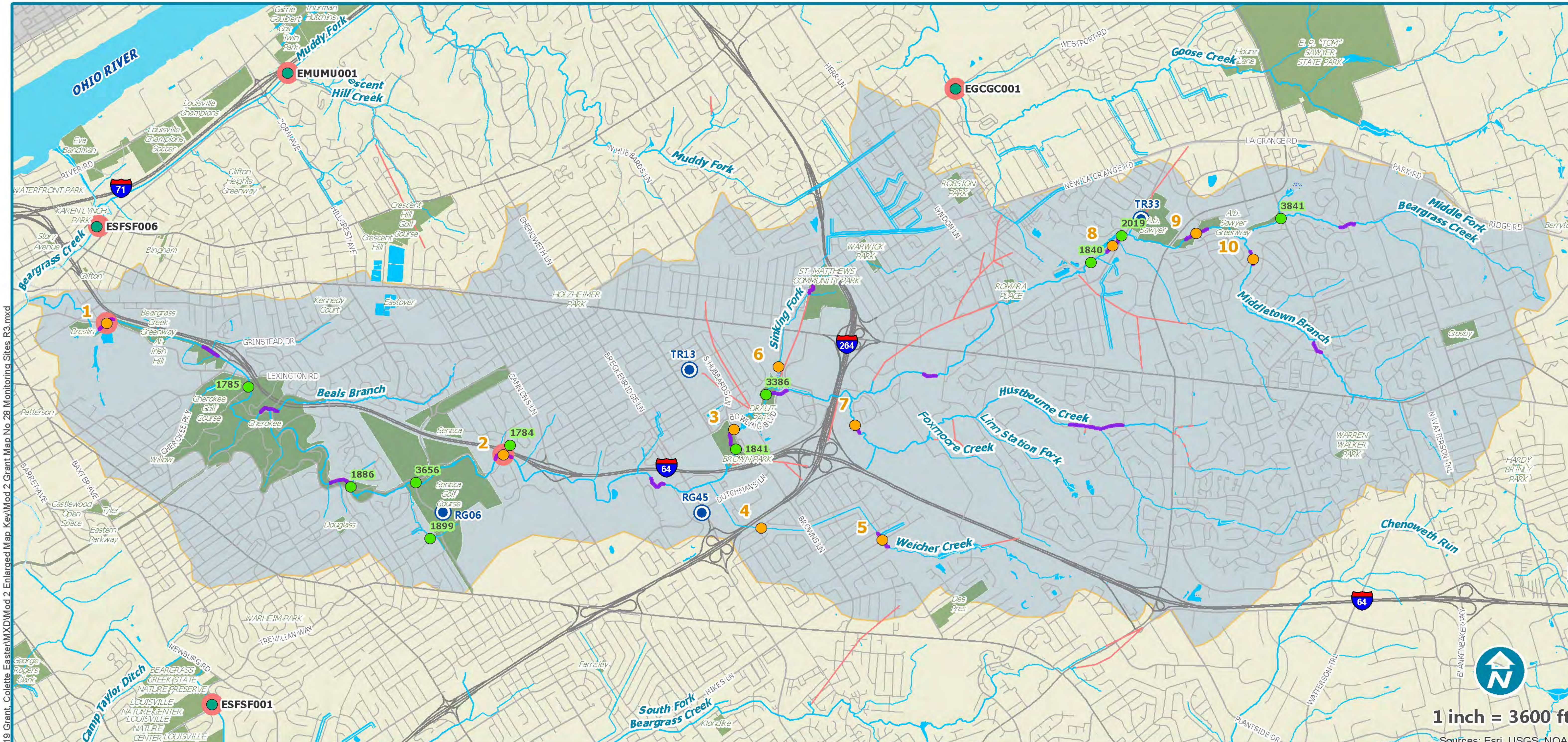
Figure 6 USGS Stream Gage at Middle Fork Beargrass Creek March 2016 to March 2020

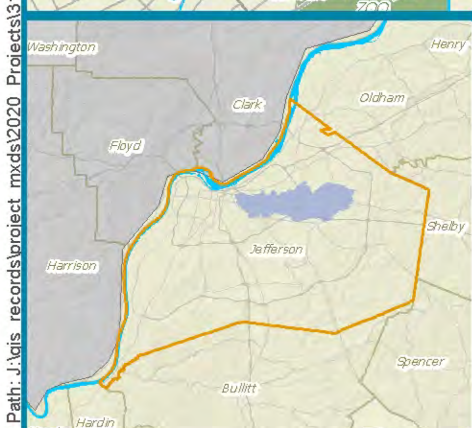
USGS Flow Data

Discharge data and other parameters collected at USGS gages can be accessed and viewed using the following steps.

- From usgs.gov website scroll down to Real-time Data section and click on Water header or Explore box
- Hover over the image on the left displaying the United States and all the current USGS gaging stations and click on the state of Kentucky
- This will bring user to the following website that you can type in directly: waterdata.usgs.gov/ky/nwis/rt
- On the USGS Current Water Data for Kentucky page click on the text that says Statewide Streamflow Table on the right.
- The default of this page is to group the gages by Major River Basin. For USGS sites in Jefferson County scroll down to Salt River Basin section. User can also change the grouping by County, click go to the right and scroll down to Jefferson County
- At this point a gage number can be selected to which real-time data can be viewed.
- The default on the graphs shown are the past 7 days. User can identify the past number of days to display or set a range to be shown on the graphs.
- The default on graphs shown are discharge and gage height. User can also check parameters such as Temperature, Specific Conductivity, Dissolved Oxygen and pH (if parameters are available at the USGS gaging station)
- Once a desired parameter is selected and date range selected, user should hit the GO box to the right side of the webpage.
- User can scroll down to the parameter/graph created and create a presentation-quality or stand-alone graph.

APPENDIX 4.2 CHAPTER 4 MAPS





Map Key

- Watershed Boundary
- Bodies of Water
- Wetlands
- Parks
- Stream Walk Sites
- Rain Gauges
- LTMN Only Site
- Combination Mon. Site
- SRWW Monitoring Site
- USGS Monitoring Sites
- Connector
- Stream/River, Perennial
- Stream/River, Intermittent
- Canal/Ditch
- Underground Conduit
- Pipeline
- Artificial Path

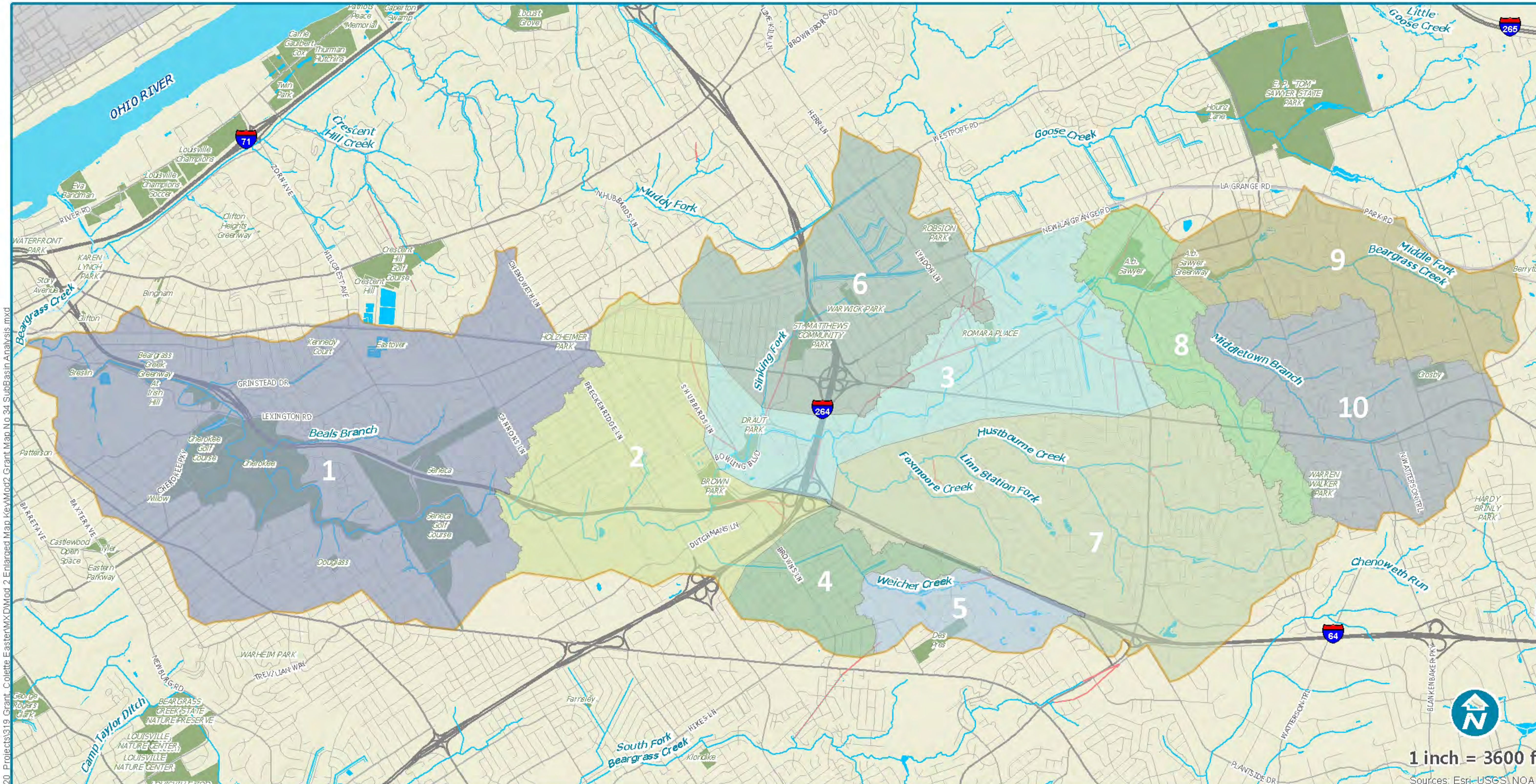
NOTE: See Table for additional detail regarding Monitoring Sites 1-10

Monitoring Sites

Middle Fork Beargrass Creek
319(h) Grant

LOJIC msd Safe, clean waterways

Document Path: J:\gis_records\project_mxds\2020_Projects\319 Grant, Colette Easter\MXD\Mod 2 Enlarged Map Key\Mod 2 Grant Map No 28 Monitoring Sites R3.mxd



Map Key

- Watershed Boundary
- Bodies of Water
- Wetlands
- Parks
- Stream/River, Perennial
- Stream/River, Intermittent
- Canal/Ditch
- Underground Conduit
- Pipeline
- Artificial Path
- Connector

Sub-Basin Analysis

Middle Fork Beargrass Creek
319(h) Grant

LOJIC msd

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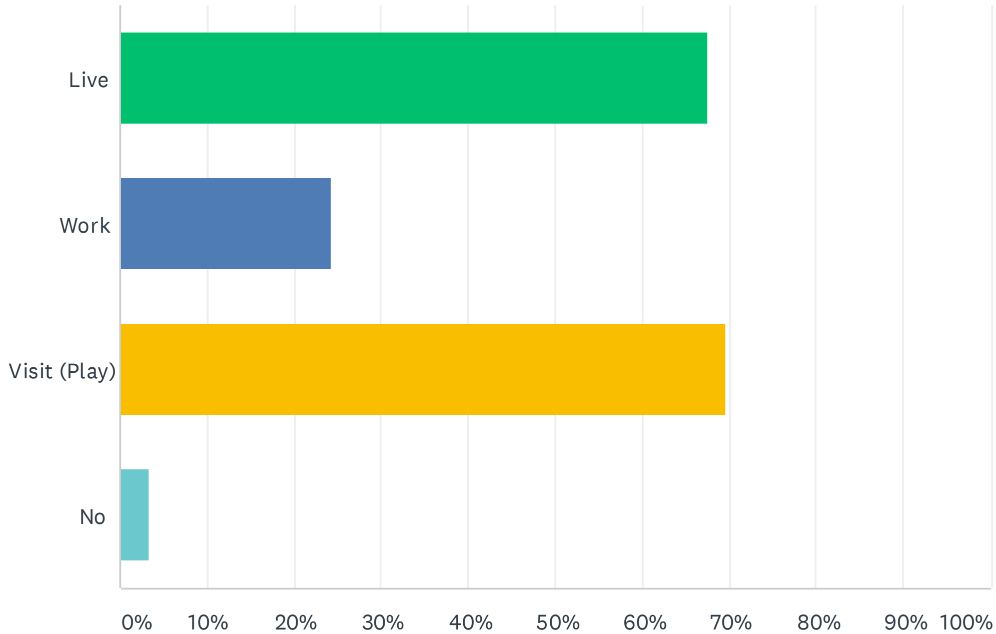
APPENDIX 6.1 COMMUNITY SURVEY RESULTS

Q1 Do you live, work, or visit the Middle Fork Beargrass Creek watershed?

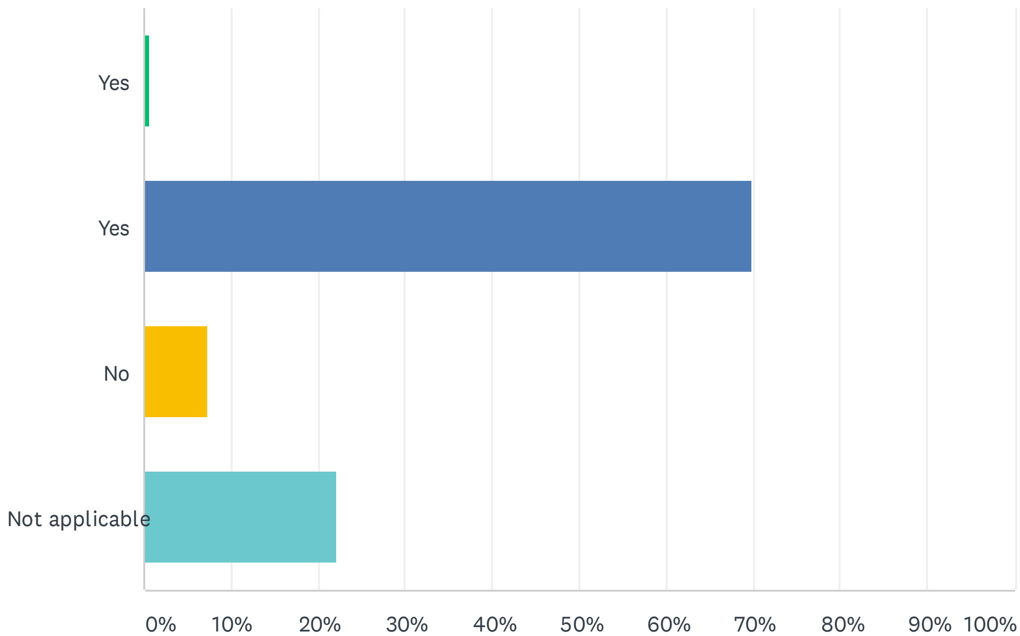
Answered: 148 Skipped: 2



ANSWER CHOICES	RESPONSES	
Live	67.57%	100
Work	24.32%	36
Visit (Play)	69.59%	103
No	3.38%	5
Total Respondents: 148		

Q2 If you live in the Middle Fork Beargrass Creek Watershed, do you know where the streams are in your neighborhood?

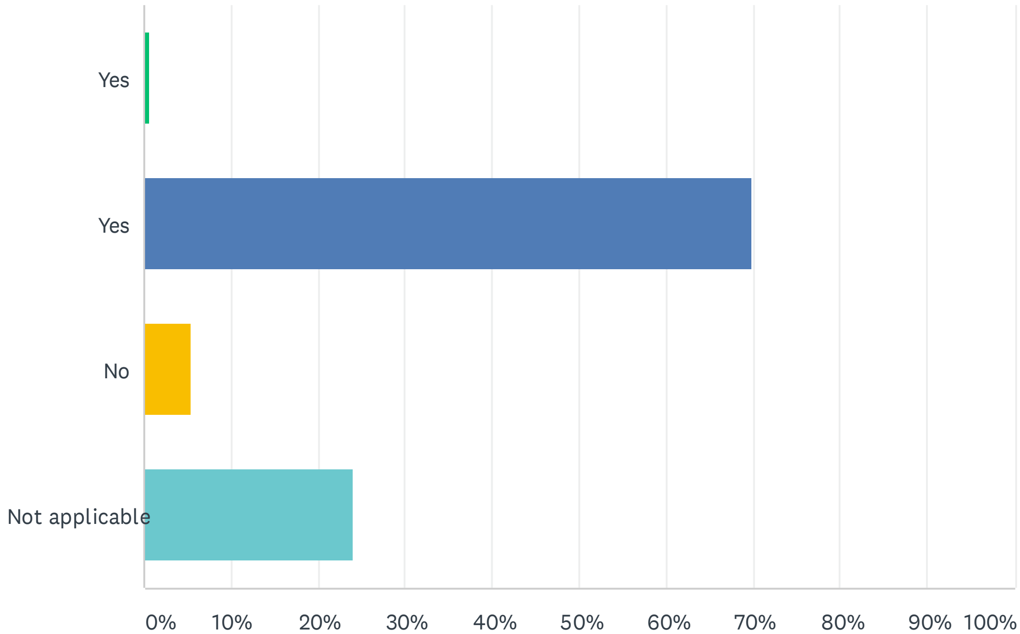
Answered: 149 Skipped: 1



ANSWER CHOICES	RESPONSES	
Yes	0.67%	1
Yes	69.80%	104
No	7.38%	11
Not applicable	22.15%	33
TOTAL		149

Q3 If you answered "yes" to #2, do you enjoy visiting the streams?

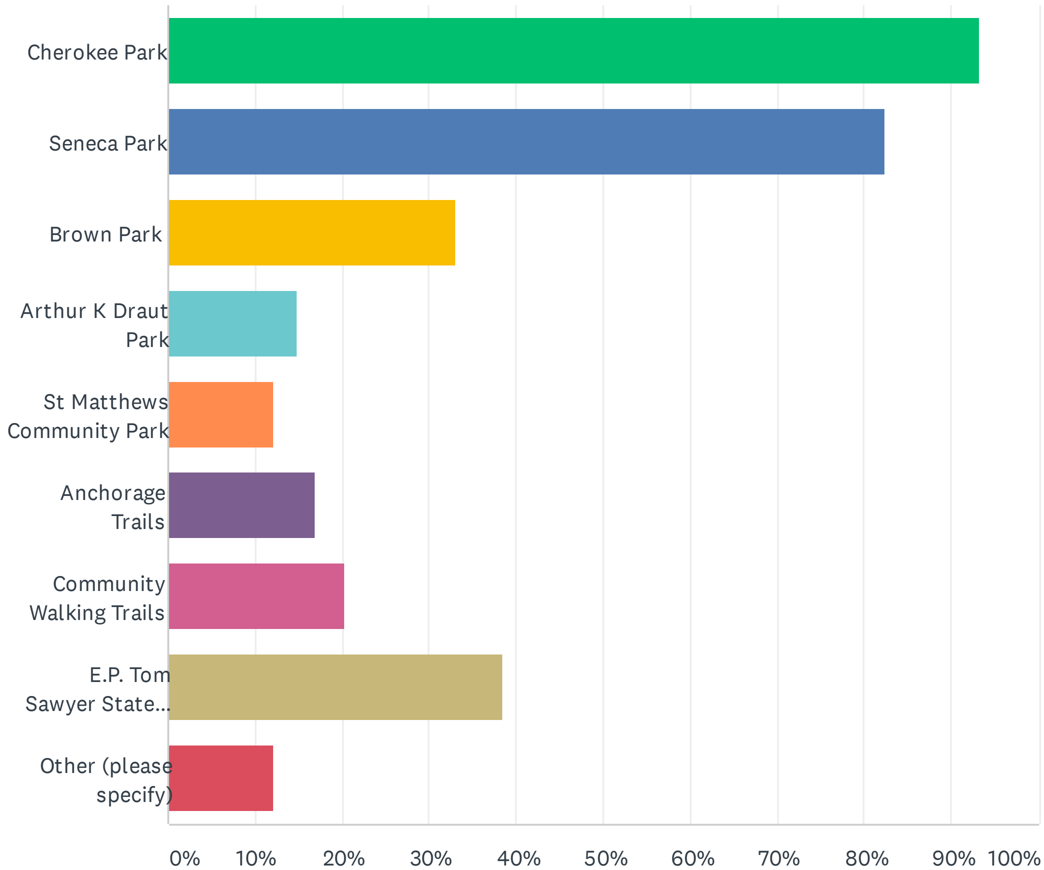
Answered: 149 Skipped: 1



ANSWER CHOICES	RESPONSES	
Yes	0.67%	1
Yes	69.80%	104
No	5.37%	8
Not applicable	24.16%	36
TOTAL		149

Q4 What parks do you visit in the watershed? (Check all that apply)

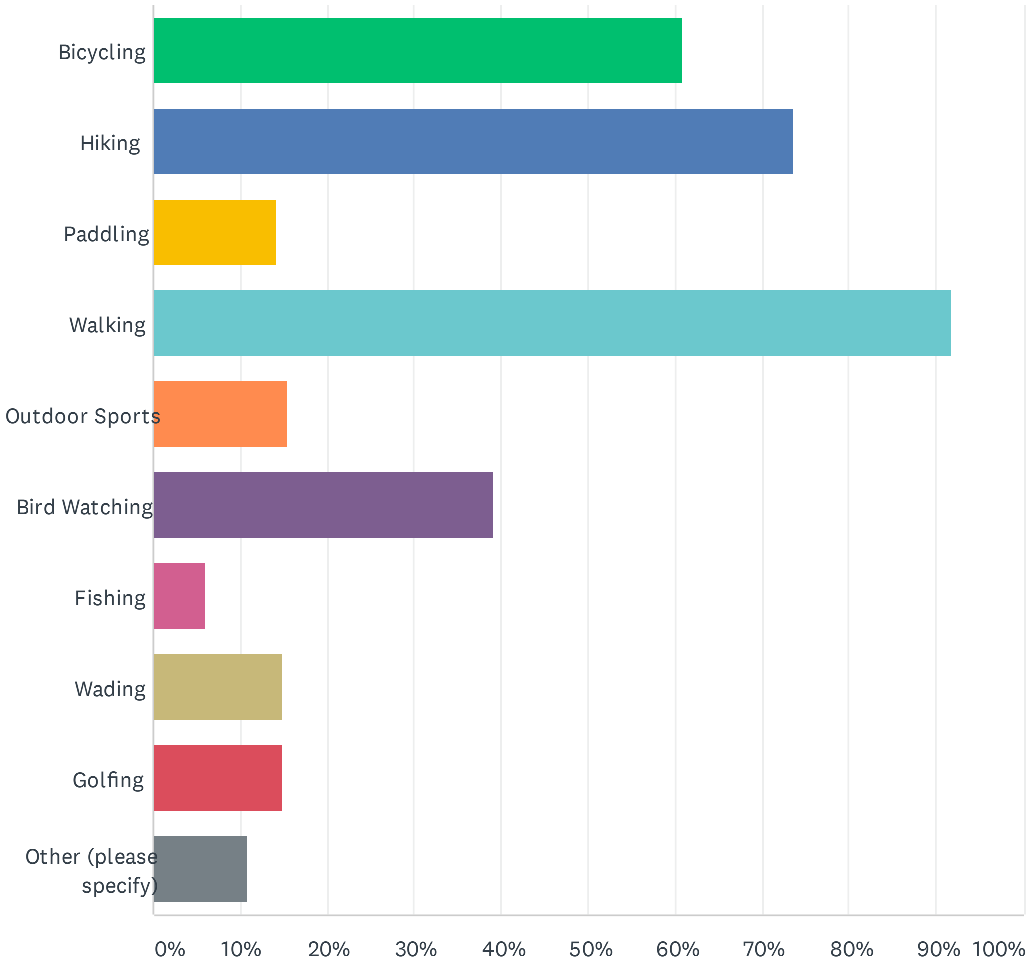
Answered: 148 Skipped: 2



ANSWER CHOICES	RESPONSES	
Cherokee Park	93.24%	138
Seneca Park	82.43%	122
Brown Park	33.11%	49
Arthur K Draut Park	14.86%	22
St Matthews Community Park	12.16%	18
Anchorage Trails	16.89%	25
Community Walking Trails	20.27%	30
E.P. Tom Sawyer State Park	38.51%	57
Other (please specify)	12.16%	18
Total Respondents: 148		

Q5 What activities do you like to do in the Middle Fork Beargrass Creek Watershed? (Check all that apply)

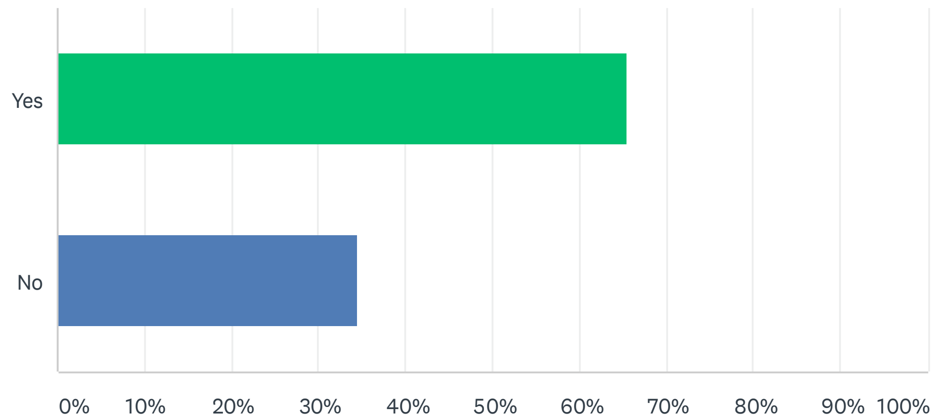
Answered: 148 Skipped: 2



ANSWER CHOICES	RESPONSES	
Bicycling	60.81%	90
Hiking	73.65%	109
Paddling	14.19%	21
Walking	91.89%	136
Outdoor Sports	15.54%	23
Bird Watching	39.19%	58
Fishing	6.08%	9
Wading	14.86%	22
Golfing	14.86%	22
Other (please specify)	10.81%	16
Total Respondents: 148		

Q6 Are you interested in participating in education and outreach opportunities related to Middle Fork Beargrass Creek?

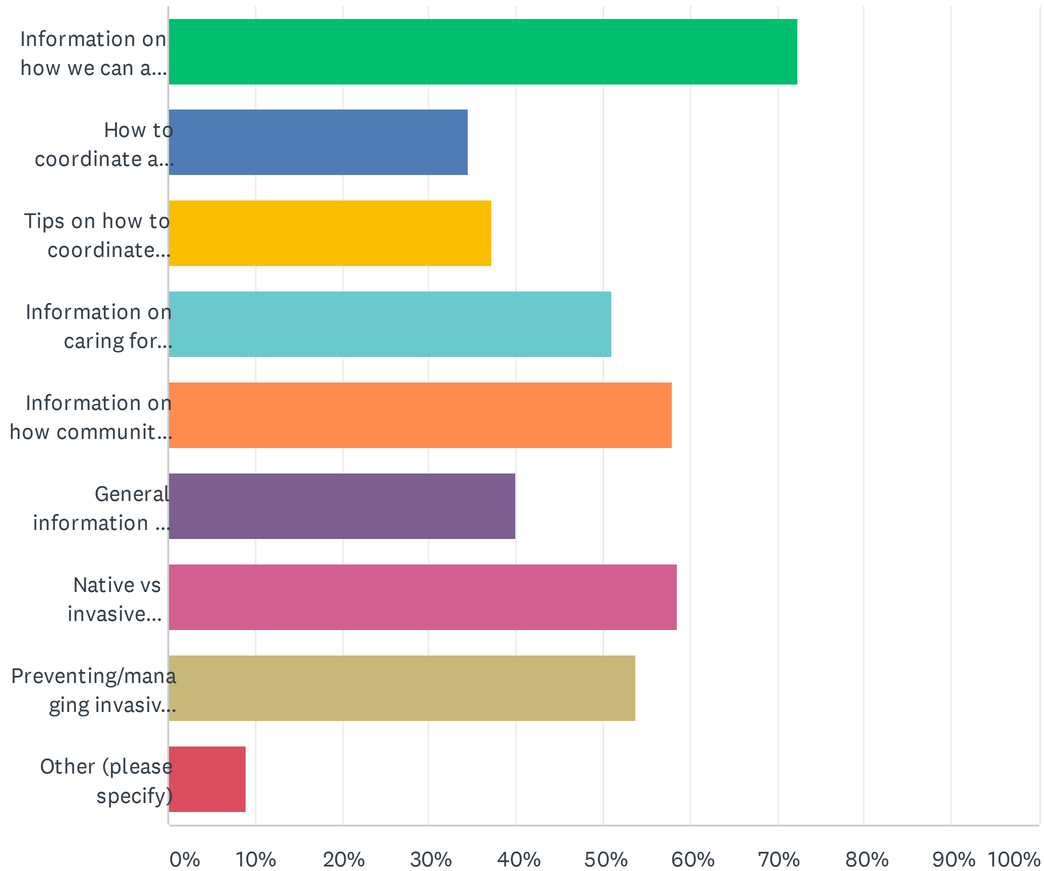
Answered: 148 Skipped: 2



ANSWER CHOICES	RESPONSES	
Yes	65.54%	97
No	34.46%	51
TOTAL		148

Q7 If there were information available to better care for streams in your backyard or neighborhood, what kind of information would you like to see? (Check all that apply)

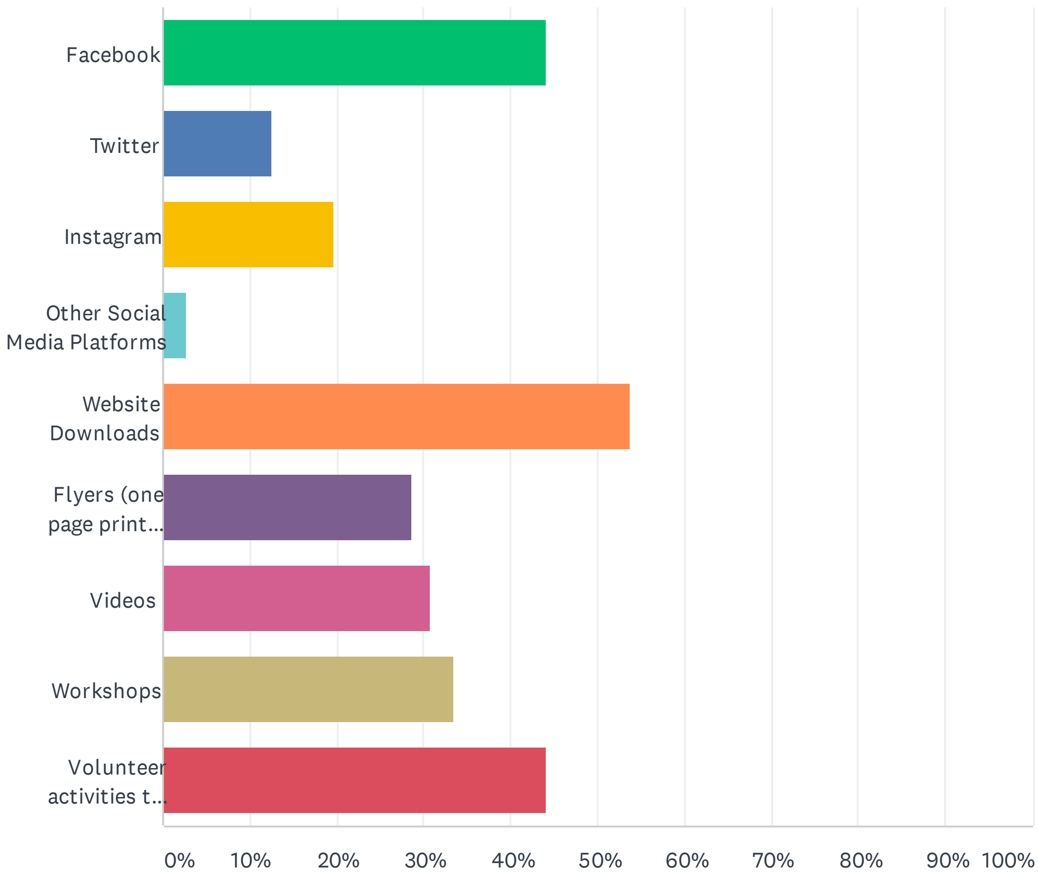
Answered: 145 Skipped: 5



ANSWER CHOICES	RESPONSES	
Information on how we can all improve water quality?	72.41%	105
How to coordinate a trash pick-up in your neighborhood?	34.48%	50
Tips on how to coordinate neighborhood water quality monitoring activities?	37.24%	54
Information on caring for riparian zones (vegetated areas along the stream)?	51.03%	74
Information on how communities can work together to increase habitat along waterway?	57.93%	84
General information on how to care for a stream in your backyard?	40.00%	58
Native vs invasive species identification?	58.62%	85
Preventing/managing invasive species?	53.79%	78
Other (please specify)	8.97%	13
Total Respondents: 145		

Q8 How would you like to receive education and outreach materials? (Check all that apply) Note: This is the last question in the Middle Fork Beargrass Creek Watershed survey. Thank you for your participation! Survey Monkey may invite you to complete another survey after you click “Done” below. You are under no obligation to do so.

Answered: 143 Skipped: 7



ANSWER CHOICES	RESPONSES	
Facebook	44.06%	63
Twitter	12.59%	18
Instagram	19.58%	28
Other Social Media Platforms	2.80%	4
Website Downloads	53.85%	77
Flyers (one page print outs)	28.67%	41
Videos	30.77%	44
Workshops	33.57%	48
Volunteer activities that include training	44.06%	63
Total Respondents: 143		

APPENDIX 6.2 BMP PLAN

Middle Fork Beargrass Creek Watershed Plan BMP Plan

BMP No.	BMP Description/Action Item	BMP Type/Pollutant Addressed	Additional Priority Goals and Objectives	Priority Action Items	Potential Responsible Party	Load Reduction*	Priority	Technical Assistance	Costs	Funding Mechanisms	Short Term 0-5 Years	Medium Term 5-10 Years	Long Term 10 + Years
1	Establish a Watershed Coordinator to implement watershed plan BMPs	General Watershed Health	Improve Water Quality	1. Apply for grant funding 2. Hire coordinator 3. Prioritize non-structural BMPs based on watershed needs and strengths	MSD	Not calculable	High	N/A	Estimated $75,000/year	319(h)	X		
2	Add watershed plan documents to project partner's websites	General Watershed Health	Involve Community Members	1. Upload watershed plan, watershed maps, and BMP plan to partner's website	MSD, KWA, BCA	Not calculable	Medium	N/A	Staff time	N/A	X		
3	Regulation, ordinance, and benchmark review and assessment: Review and assess local regulations and policies, as well as local ordinances that have the potential to impact water quality	General Watershed Health	Improve Water Quality	1. Evaluate existing regulations, ordinances, and benchmarks to understand potential water quality impacts 2. Develop recommendations for improvements/changes to regulations, ordinances, and benchmarks	MSD	Dependent on ordinance revisions	High	MSD, Project Partners	Staff time	MSD	X		
4	Create additional outreach for existing stream buffer requirements in Floodplain Ordinance	General Watershed Health	Improve Water Quality	1. Establish an outreach progam to educate homeowners about the benefits of stream buffers	MSD, Property owners	Not calculable	High	MSD	Staff time	MSD, 319(h)	X		
5	Adopt-a-storm drain program to promote nonpoint source awareness in the watershed	General Watershed Health	Involve Community Members	1. Utilize Watershed Coordinator to identify willing partners to develop and promote program 2. Leverage partnerships to develop an 3. Prioritize potential subwatersheds for program	MSD, Anchorage, St Matthews, Jefferstontown	Not calculable	Medium	MSD, Middle Fork Community Partners, Engineering Firms	Varies	MSD, Local, 319(h)	X		
6	Utilize public art and art education programs and activities to create energy around public awareness and activism to improve water quality	General Watershed Health	Involve Community Members	1. Leverage partnerships and relationship with Metro and other cities in the watershed 2. Citizen Lead Programs fostering arts and sciences with a water quality focus	MSD, Local environmental/ non-profit organizations, JCPS, Private Schools	Not calculable	Medium	MSD, Middle Fork Community Partners, Engineering Firms	Volunteer-donated costs	Art grants - External Agency Fund (Louisville Metro), MSD, 319(h), Environmental Education Grants	X		

Middle Fork Beargrass Creek Watershed Plan BMP Plan

BMP No.	BMP Description/Action Item	BMP Type/Pollutant Addressed	Additional Priority Goals and Objectives	Priority Action Items	Potential Responsible Party	Load Reduction*	Priority	Technical Assistance	Costs	Funding Mechanisms	Short Term 0-5 Years	Medium Term 5-10 Years	Long Term 10 + Years
7	Promote existing stormwater credit program	General Watershed Health	Involve Community Members	1. Distribute materials and promote existing stormwater credit program	MSD	Dependent on practice	High	MSD	$5,000-$25,000 per campaign	MSD	X		
8	Promote nonpoint source awareness in the watershed through education and outreach to schools	General Watershed Health	Involve Community Members	1. Partner with schools to develop curriculum for non-point source pollution and water quality 2. Present developed curriculum	KWA, JCSWCD, MSD, Parks, SRWW, Cities, JCPS, Private Schools, Home Schools	Not calculable	Medium	JCSWCD, JCPS, Curriculum Developers	$500 - $5,000 per curriculum	MSD, 319(h), Environmental Education Grants	X	X	
9	Outreach with Community Master Gardener and Community Gardener Groups to promote watershed health	General Watershed Health	Involve Community Members	1. Coordinate with Community Master Gardener and Community Gardener Groups to educate on watershed health and priorities.	JCSWCD, MSD	Not calculable	Medium	Master Gardeners	Volunteer and staff time	N/A	X	X	
10	Ongoing watershed planning and evaluation	General Watershed Health	Continuous Improvement	1. On a five year cycle the watershed plan will be reviewed and evaluated by steering committee 2. On a five year cycle action items specific to watershed needs and priorities will be developed 3. A complete update of the watershed plan will be completed when significant changes are identified	MSD, Watershed Coordinator, Steering Committee	Not calculable	High	KWA, BCA, Partners	$10,000-$50,000 per update	MSD, local	X	X	
11	Continue to implement the downspout disconnection program within the combined sewer system	General Watershed Health	Involve Community Members	1. Promote downspout disconnection program and explore ideas for similar programs	MSD, Property Owners	Dependent on project	High	MSD	$100/down-spout plus staff time	MSD	X	X	
12	Protect streams with conservation easements	General Watershed Health	Improve Water Quality	1. Identify areas where conservation easements are feasible	MSD, Jefferson County Environmental Trust	Dependent on project	Medium	MSD , Jefferson County Environmental Trust	Varies	Jefferson County Environmental Trust		X	

Middle Fork Beargrass Creek Watershed Plan BMP Plan

BMP No.	BMP Description/Action Item	BMP Type/Pollutant Addressed	Additional Priority Goals and Objectives	Priority Action Items	Potential Responsible Party	Load Reduction*	Priority	Technical Assistance	Costs	Funding Mechanisms	Short Term 0-5 Years	Medium Term 5-10 Years	Long Term 10 + Years
13	Implement a trash removal program focused on determing sources of trash in watershed	General Watershed Health	Improve Water Quality	1. Identify appropriate partner to conduct study 2. Develop program to catch trash that would otherwise end up in the waterways 3. Implement study to analyze trash collected in this process--then target the source 4. Develop multimedia outreach to address the key trash items found	Kentucky Waterways Alliance, Beargrass Creek Alliance, MSD, Metro Parks Landowner	Unknown	Medium	MSD, Universities, EPA	Varies	USACE, MSD, 319(h), 2-year EPA Grant		X	
14	Implement a car wash campaign to reduce pollution in waterways	General Watershed Health	Improve Water Quality	1. Education and outreach to general public	MSD, Cities	Unknown	Low	MSD	$5,000-$25,000 per campaign	MSD, Cities, 319(h)		X	
15	Continue implementation of chlorinated pools outreach program	Specific Conductance	Improve Water Quality	1. Review existing materials and promote and distribute	MSD, Board of Health, Cities	Unknown	Medium	MSD	Staff time	MSD, Cities, 319(h)	X		
16	Implement a salt management strategy with education and outreach component	Specific Conductance	Determine Current Conditions	1. Study other salt management strategies 2. Study salt usage and users in watershed 3. Draft materials	MSD, Louisville Metro, KYTC, Cities	Unknown	Medium	MSD, KYTC, Local Engineering Firms	Varies	Louisville Metro Public Works, MSD, Cities, 319(h)		X	
17	Street sweeping and catch basin cleaning	Sediment and Specific Conductance	Improve Water Quality	1. Work with cities in the watershed with street sweeping practices to understand frequency and perform cost benefit analysis for more frequent sweeping	MSD, Cities	Unknown	Low	KYTC	Varies	Louisville Metro Public Works, Cities	X		
18	Install green infrastructure, such as tree boxes, rain gardens, infiltration trenches	Sediment and Specific Conductance	Improve Water Quality	1. Identify potential project locations 2. Evaluate and design BMPs 3. Install BMPs	MSD, Louisville Metro, KYTC, Cities	Dependent on project	Medium	MSD, KYTC, Local Engineering Firms	Varies	MSD, Cities, 319(h)		X	
19	Increase education for EPSC	Sediment	Improve Water Quality	1. Expand education programs for EPSC	MSD	Not calculable	High	MSD, Engineering Firms	Staff time	MSD	X		

Middle Fork Beargrass Creek Watershed Plan BMP Plan

BMP No.	BMP Description/Action Item	BMP Type/Pollutant Addressed	Additional Priority Goals and Objectives	Priority Action Items	Potential Responsible Party	Load Reduction*	Priority	Technical Assistance	Costs	Funding Mechanisms	Short Term 0-5 Years	Medium Term 5-10 Years	Long Term 10 + Years
20	Encourage private land owners to establish and widen riparian buffers to stabilize banks with native trees and bushes	Sediment and Nutrients	Improve Water Quality	1. Provide grants or incentives for waterway bank stabilization	KWA, BCA, MSD, Property owners	Not calculable	High	MSD, Tree Nurseries, NRCS, Extension Office	$5,000 - $1,000,000 per project	USACE, MSD, 319(h), NRCS	X		
21	Design and install structural BMPs along the north side of Linn Station Road in Jeffersontown	Sediment and Nutrients	Improve Water Quality, Roadway Safety, Linear Flooding Impacts	1. Evaluate and design strucutral BMPs that address the drainage upstream of the degraded area 2. Install structural BMPs to capture and treat stormwater to address water quality and flooding concerns	Jeffersontown	Dependent on project	Medium	Engineering firms, MSD	Dependent on project	319(h), Jeffersontown	X	X	
22	Design and install structural BMPs along Valley View Road within the City of Anchorage	Sediment and Nutrients	Improve Water Quality, Roadway Safety, and Reduce Flooding	1. Evaluate and design strucutral BMPs that address the drainage upstream of the degraded area 2. Install structural BMPs to capture and treat stormwater to address water quality and flooding concerns	Anchorage	Dependent on project	Medium	Engineering Firms, MSD	Dependent on project	319(h), Anchorage	X	X	
23	Design and install structural BMPs along Woodland Drive	Sediment and Nutrients	Improve Water Quality, Roadway Safety, Linear Flooding Impacts	1. Evaluate and design strucutral BMPs that address the drainage upstream of the degraded area 2. Install structural BMPs to capture and treat stormwater to address water quality and flooding concerns	Anchorage	Dependent on project	Medium	Engineering Firms, MSD	Dependent on project	319(h), Anchorage	X	X	
24	Retrofit of detention basin at Osage Road and Cold Springs Road	Sediment and Nutrients	Improve Water Quality and Reduce Flooding	1. Evaluate and design a retrofit of the existing basin to current design standards to address the drainage upstream of the basin 2. Retrofit detention basin to a green basin to address water quality and volume control	Anchorage	Dependent on project	Medium	Engineering Firms, MSD	Dependent on project	319(h), Anchorage	X	X	

Middle Fork Beargrass Creek Watershed Plan BMP Plan

BMP No.	BMP Description/Action Item	BMP Type/Pollutant Addressed	Additional Priority Goals and Objectives	Priority Action Items	Potential Responsible Party	Load Reduction*	Priority	Technical Assistance	Costs	Funding Mechanisms	Short Term 0-5 Years	Medium Term 5-10 Years	Long Term 10 + Years
25	Design and implement structural BMPs along Bluegrass Parkway in Jeffersontown	Sediment and Nutrients	Improve Water Quality and Reduce Flooding	1. Evaluate and design strutural BMP to address sediment and water quality impacts due to flooding along Bluegrass Parkway 2. Install strutural BMPs to address water quality and flooding concerns	Jeffersontown	Dependent on project evaluation	Medium	Engineering Firms, MSD	Dependent on project	319(h), Jeffersontown	X	X	
26	Design and install structural BMPs at Blairwood Apartments	Sediment and Nutrients	Improve Water Quality, Increase Volume Storage, and Reduce Flooding	1. Evaluate and design structural BMPs that address the drainage upstream of site. Low lying area could potentially be used to create storage on site. 2. Install structural BMPs to capture and treat stormwater to address water quality and flooding concerns.	Hurstbourne, Landowner	Dependent of project	Medium	MSD, Engineering Firms	Dependent on project	319(h), Hurstbourne, MSD	X	X	
27	Retrofit impervious surfaces where feasible to utilize pervious pavers to decrease peak flows and associated pollutants	Sediment	Improve Water Quality	1. Identify locations and/or for potential pervious pavement projects 2. Install pervious pavers with long term maintenace agreements identifying responsible parties with an MOA	MSD and Watershed Partners	Dependent on Project	Medium	MSD, Engineering Firms	$10,000-$500,000 +/- per project	USACE, MSD, 319(h), Research funds		X	
28	Characterize subwatershed's erosion potential instream	Sediment and Nutrients	Determine Current Conditions	1. Determine nonpoint source pollution load potential 2. Select subwatersheds for further characterization 3. Utilize current methods and strategies to calculate load reduction potential within the system 4. Evaluate background and conduct a benchmarking study to specifically address instream sediment loading concerns	MSD, Cities, Metro Parks	Dependent of Project	Medium	Parks, KWA, BCA, NRCS, USACE, Extension Office, JCSWCD	$20,000 to $250,000 +/- per subwatershed	USACE, MSD, 319(h), Research funds		X	

Middle Fork Beargrass Creek Watershed Plan BMP Plan

BMP No.	BMP Description/Action Item	BMP Type/Pollutant Addressed	Additional Priority Goals and Objectives	Priority Action Items	Potential Responsible Party	Load Reduction*	Priority	Technical Assistance	Costs	Funding Mechanisms	Short Term 0-5 Years	Medium Term 5-10 Years	Long Term 10 + Years
29	Install infiltrative overbank streamside features (diversion/detention/ponding)	Sediment and Nutrients	Improve Water Quality	1. Identify priority areas to apply practice 2. Install overbank streamside features	MSD	Dependent on project	High	MSD, Engineering Firms	Dependent on project	USACE, MSD, 319(h)		X	
30	Implement stream restoration projects to prevent soil erosion and restore natural channel function	Sediment and Nutrients	Improve Water Quality	1. Identify potential project locations 2. Evaluate and design a stream 3. Construct stream restoration project	Conservation Landowners, MSD and Cities	0.02 lb./ft/yr. TN, 2.55 lb./ft/yr. TSS	High	KWA, BCA, NRCS, Extension Office	$25,000-$1,000,000 +/- per project	USACE, MSD, 319(h) , NRCS		X	
31	Evaluate and improve channels within the Hurstbourne Country Club property	Sediment and Nutrients	Improve Water Quality and Reduce Flooding	1. Evaluate existing channels 2. Use natural channel design to reduce 3. Install strutural BMPs according to evaluation and design with natural channel approach	Hurstbourne, Hurstbourne Country Club, MSD	Dependent on project	Medium	MSD, Engineering Firms	Dependent on project	319(h), Hurstbourne, Hurstbourne Country, Club, MSD		X	X
32	Create Stormwater Detention Features (regional, subregional, &/or pockets) to reduce peak flows and filter nutrients	Sediment and Nutrients	Improve Water Quality	1. Identify locations and partners for detention features 2. Design detention features 3. Construct detention features	MSD, Cities, Property Owners	~20% TN, ~60% TSS	Medium	MSD, Engineering Firms	$25,000 - $1,000,000+/- per project	MSD, Cities, 319(h)		X	X
33	Evaluate subwatersheds for the existing and potential constructed wetlands and enhance/construct wetlands	Sediment and Nutrients	Improve Water Quality	1. Identify locations of existing and potential wetlands and partners 2. Design constructed wetlands 3. Construct new wetlands and/or improve existing wetlands	MSD, Cities, Property Owners	25-55% TN, ~60% TSS	Medium	MSD, Engineering Firms	Low cost for location identification	MSD, Cities, 319(h)		X	X
34	Conduct tree planting events	Nutrients	Involve Community Members, Improve Water Quality	1. Identify potential locations for tree planting 2. Coordinate with community members on the location and planting plan 3. Plant trees and assign maintenance responsibilities	MSD, Property owners, Schools, KYTC	Not calculable	Medium	MSD, Louisville Metro	$5,000-$25,000 per campaign	MSD, Cities, 319(h), Trees Louisville, Louisville Grows	X		

Middle Fork Beargrass Creek Watershed Plan BMP Plan

BMP No.	BMP Description/Action Item	BMP Type/Pollutant Addressed	Additional Priority Goals and Objectives	Priority Action Items	Potential Responsible Party	Load Reduction*	Priority	Technical Assistance	Costs	Funding Mechanisms	Short Term 0-5 Years	Medium Term 5-10 Years	Long Term 10 + Years
35	Implement nutrient management program	Nutrients	Improve Water Quality	1. Establish partners for program 2. Determine target audience for program (e.g. golf courses, home owners, HOAs, commercial properties, etc.) 3. Implement program	MSD, SWCD	Dependent on practices	Medium	MSD, SWCD, Engineering Firms	$10,000-$25,000 per campaign	MSD, 319(h)	X		
36	Characterize subwatershed's bacteria load potential	Bacteria	Determine Current Conditions	1. Prioritize subwatersheds with high bacteria data 2. Correlate E. coli and fecal coliform data specific to MFBGC watershed 3. Identify projects and partners that reduce bacteria within prioritized subwatersheds	MSD	Unknown	High	MSD, Health Department	$50,000 to $250,000	MSD, 319(h)	X		
37	Conduct a "Pick up after your dog" campaign	Bacteria	Improve Water Quality	1. Partner with dog parks, parks, and cities 2. Create outreach campaign	MSD, Cities, Dog Parks	Unknown	Medium	MSD	$5,000-$25,000 per project	MSD, Cities, 319(h)	X		
38	Implement geese-control program	Bacteria	Improve Water Quality	1. Review geese population in watershed to determine extent of problem and establish specific control practices, including do not feed campaigns, anti-roost controls, etc.	MSD, KWA, BCA, Local Communities	Unknown	Medium	MSD, Ky Department of Fish and Wildlife	$10,000-$25,000 per campaign	MSD, Cities, 319 (h)	X		
39	Implement septic system outreach program such as EPA Septic SMART targeting areas with septic systems	Bacteria	Improve Water Quality	1. Identify areas with septic systems in the watershed 2. Work with landowners regarding maintenance 3. Work with local communities regarding transition to sewers 4. Education and outreach regarding septic systems	MSD, Health Department, Cities	Unknown	High	MSD, Health Department	$5,000-$25,000 per campaign, Varies for sewer projects	MSD, Cities, 319(h)	X	X	

Middle Fork Beargrass Creek Watershed Plan BMP Plan

BMP No.	BMP Description/Action Item	BMP Type/Pollutant Addressed	Additional Priority Goals and Objectives	Priority Action Items	Potential Responsible Party	Load Reduction*	Priority	Technical Assistance	Costs	Funding Mechanisms	Short Term 0-5 Years	Medium Term 5-10 Years	Long Term 10 + Years
40	Install pet waste stations, including bags and disposal	Bacteria	Improve Water Quality	1. Identify location for pet waste stations 2. Locate stations in parks and neighborhoods in watershed	Dog Parks, Metro Parks, City Parks	Unknown	Medium	MSD	$3,000 to $15,000 per station and annual maintenace costs	MSD, Cities, 319(h)		X	
41	Implement inflow and infiltration sanitary sewer projects and other IOAP Projects	Bacteria and Nutrients	Improve Water Quality	1. Construct projects in 2021 IOAP Modification including Middle Fork Relief Interceptor and Pump Station 2. Construct rehabilitation projects identified in 20-year Comprehensive Facility Plan 3. Identify other potential interceptor projects in the watershed	MSD	Unknown	Medium	MSD, Local Engineers	Based on project (See 2021 IOAP and 20-Year Comp. Fac. Plan)	MSD			X

APPENDIX 6.3 BMP WEB APPLICATION REPORT

Middle Fork Beargrass Creek BMP Web Application Report

In order to facilitate community engagement, MSD GIS created an ArcGIS Online web app that allowed users to see the physical boundaries of proposed projects, report problem areas, and express their support of specific projects. This web app was designed specifically for crowdsourcing projects and was accessible by web browser on both mobile devices and desktops. While community participation was modest, the concept was proven and some feedback was recorded. That feedback is outlined below.

Table 1 Proposed BMP Sites

Project Location	BMP	Vote Tally
Brown Park	Riparian Buffer	2
Arthur Draut Park	Stream Restoration	2
Cherokee Park	Pet Waste Management	4
I-64 & Grinstead Dr	Riparian Buffer	3
Middle Fork & South Fork Confluence	Brush Layering, Invasive Species Management	3
Home Depot Breckenridge Ln	Riparian Buffer, Fertilizer Management, Brush Layering, Mowing	2
Big Spring Country Club	Riparian Buffer, Fertilizer Management, Education, Brush Layering, Mowing	1
Oxmoor Country Club	Riparian Buffer, Fertilizer Management, Education, Brush Layering, Mowing	1
Hurstbourne Country Club	Riparian Buffer, Fertilizer Management, Education, Brush Layering, Mowing	3
TBD	Wwetlands, bioswales, bioretention, rain gardens, engineered storage	0

Table 2 Proposed Watershed Wide BMPs

Priorities	BMP	Vote Tally
Outreach	Stream In My Backyard Program	0
Outreach	Public Announcements (multi-media messaging)	0
Outreach	Community Trash Cleanups	1
Outreach	Pet and Wildlife Do’s and Don’ts	0
Outreach	Adopt a Storm Drain Program	0
Outreach	Inlet Painting	0
Outreach	Trash Trappers Collection Study	0
Outreach	Watershed Coordinator	1
Pollutants	Riparian Buffers	0
Pollutants	Stormwater Detention Features	1
Pollutants	Green Infrastructure	1
Flooding	Connect the Creek to Its Floodplains and Existing Wetlands	1
Flooding	Explore Flood Mitigation Funding Opportunities	0
Restoration	Stream Restoration	1
Restoration	Bank Stabilization	0
Restoration	Invasive Species Management	0
Roadways	Salt Management	0

Priorities	BMP	Vote Tally
Roadways	Roadside Infiltration Trenches	1
Roadways	Roadside Vegetative Buffers	1

Table 3 Proposed Stakeholder Projects (Crowdsourced Points)

All reported points located within Cherokee Park

Indicator Being Reported	BMP	Comments	ID #
Trash	Example	Example	1
Other	Bank Stabilization	Exposed high pressure gas line. Requires stream bank restoration.	2
Other	Bank Stabilization	Very steep stream bank, loss of riparian trees ongoing. Requires stream bank restoration and creation of secondary floodplain.	3
Other	Bank Stabilization	Stream bank restoration required. Loss of riparian trees.	4
Other	Bank Stabilization	Streambank restoration required.	5
Other	Bank Stabilization	Site of previous streambank restoration.	6