# NORTH FORK NOLIN RIVER
# MCDOUGAL AND CASTLEMAN CREEK
# WATERSHED MANAGEMENT PLAN

HODGENVILLE, LARUE COUNTY, KENTUCKY

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# EXECUTIVE SUMMARY

## 1. INTRODUCTION

The McDougal & Castleman Creek Watershed Management Plan (MCCWMP) began as an initiative by the LaRue County Fiscal Court. The LaRue County Fiscal Court hired Palmer Engineering to write the watershed plan. The objectives of the MCCWMP are to provide direction to the community regarding review of existing data; prioritize projects within the McDougal & Castleman Creek Watershed (MCCW); and produce a plan for the community that can lead to measurable results to improve water quality, watershed conditions, and enhance future funding opportunities for projects within the watershed. This project is funded in part by a grant from the US Environmental Protection Agency under Section 319(h) of the Clean Water Act through the Kentucky Division of Water (KDOW).

## 2. McDOUGAL and CASTLEMAN CREEK WATERSHEDS (MCCW)

This plan covers two separate United States Geological Survey (USGS) Hydrologic Unit Code 12 watersheds; McDougal Creek – North Fork Nolin River (HUC #051100010905) and Castleman Creek – North Fork Nolin River (HUC #051100010904). These two watersheds are centered in LaRue County and contain the City of Hodgenville, Salem Lake, and McDougal Lake. These watersheds were prioritized for planning because they are all included in Zone I, Zone II, or Zone III of the Kentucky Division of Water (KDOW) Source Water Assessment and Protection Program (SWAPP), indicating these are significant water sources for public drinking water supplies. As a part of the KDOW SWAPP, a significant amount of water quality data has already been collected for these watersheds and has been utilized by the LaRue County Fiscal Court for plan preparation. The results from the KDOW sampling led to listings of McDougal Creek, Castleman Creek, North Fork Nolin River (NFNR), and Salem Lake as impaired in the 303(d) list on the 2022 Integrated Report.

## 3. MONITORING

Kentucky Division of Water collected data in MCCW as part of the 2018 & 2019 Total Maximum Daily Load (TMDL) Monitoring in North Fork Nolin River. This study included field and lab water quality data, *E. coli* measurements, and habitat and biology assessments. Each site was tested for the critical parameters listed in Table 9 in the following report. Phase I monitoring, in 2018, sampled 13 locations throughout the watershed in an effort to confirm pollutant levels and probable sources of pollutants within the main stem and larger tributaries of NFNR. Phase II sampling in 2019 included eight locations; four of these locations were repeated from Phase I, and four were newly identified for Phase II. Phase II focused on characterizing the conditions above and below Nolynn Spring, Nolynn Spring proper, above the Wastewater Treatment Plant (WWTP) and above the Water Treatment Plant (WTP). This phase also included an attempt to capture water quality conditions in North Fork Nolin main stem above and below where it sinks and loses flow to the spring drainage area.

## 4. ANALYSIS

To evaluate the nature and level of the pollutant concentrations within MCCW, it was necessary to compare the monitoring results with a set of water quality benchmarks. The water quality benchmarks used for MCCW were a combination of documented legal limits and recommended benchmarks from

KDOW. The water quality benchmarks are listed in Table 13 in the following report. The critical parameters were collected and then compared with these water quality benchmarks to determine exceedances. Table 16 provides a combined summary of the results from both phases. Pollutant loads and target loads based on water quality benchmarks were calculated for *E. coli*, Nitrate & Nitrite, Total Phosphorus, and Total Suspended Solids (TSS). When pollutant loads exceeded target loads, target reductions were calculated and compared. All assessed subwatersheds require *E. coli* load reductions to meet target loading. Four subwatersheds required nitrate & nitrite load reductions. Five subwatersheds required reductions to meet phosphorus benchmarks. Three subwatersheds require TSS reductions to meet benchmarks. *E. coli* is the most common pollutant throughout the watershed. Subwatersheds 17 and 18, at the northern tip of the Castleman Creek watershed, require the highest amount of reduction to meet benchmark levels.

# 5. BEST MANAGEMENT PRACTICES (BMPs)

To direct BMP selection, the project team, with the assistance of stakeholders, established goals and objectives for the MCCW. Based on the existing watershed data, sampling results, stakeholder input, and engineering judgment, the following four goals were prioritized as most important for MCCW:

1. Improve water quality for aquatic life support and safe recreational use.
2. Increase watershed awareness and education in the community.
3. Improve stormwater management to reduce flooding during large rain events.
4. Promote measures that protect the stream and riparian zone during future development and current practices in the watershed.

Goal selection provided a broad plan of action, but identified priorities that were not strictly measurable or tangible. Objectives were selected to assist in achieving the above identified goals. The project objectives were identified as:

1. Reduce human fecal inputs to aid in bacteria reduction to benchmark levels.
2. Reduce livestock fecal inputs to aid in bacteria reduction to benchmark levels.
3. Reduce fecal inputs from native wildlife to aid in bacteria reduction to benchmark levels.
4. Incorporate agricultural best management practices.
5. Expand riparian zone to filter runoff and provide habitat.
6. Stabilize stream bank to reduce erosion.
7. Inform the public of the water quality status of MC & CC watersheds.
8. Evaluation codes and ordinances for incorporation of water quality standards and issues.
9. Incorporate educational signage and inform the public of water quality issues.
10. Develop a stormwater management plan that identifies flood prone areas.
11. Reduce flooding by clearing waterways of obstructions such as large debris and beaver dams.
12. Reduce flooding by reducing or slowing storm water runoff.
13. Encourage the use of green infrastructure and low impact development.
14. Retrofit existing development to incorporate green infrastructure.
15. Provide resources for environmentally friendly agricultural practices.
16. Identify sink holes via dye tracing.
17. Provide resources for environmentally friendly waste disposal, including dead animals.
18. Promote water quality improvements to manmade infrastructure in the watershed.

A large number of the considered BMPs were recommended for implementation. The following list details the BMPs that were recommended:

A. Sanitary lateral line repair
B. Replace failing septic systems or eliminate straight pipes
C. Livestock alternate water source and shade
D. Livestock stream access control (exclusion fencing, stream crossing, etc.)
E. Livestock field rotation
F. Streamside filter strips
G. Public education on pet waste disposal
H. Public education on Ag Water Quality Plans and Nutrient Management Plans
I. Cover crops practices
J. No-till / reduced till practices
K. Heavy use area practices
L. Decommission abandoned manure lagoons
M. Riparian buffer development
N. Stream restoration / streambank stabilization
O. Public education on general water quality improvement practices
P. Review of planning, code & ordinance documents
Q. Installation of educational signage
R. Stormwater management plan / flood hazard mitigation plans
S. Beaver wildlife management
T. Water quantity BMP installation (detention basin, rain garden, rain barrels, wetland, etc)
U. Karst dye tracing
V. Animal waste disposal
W. Lake/Reservoir dredging

## 6. BMP RECCOMENDATIONS

A total of 41 Action Items were selected for implementation associated with these BMPs. The Action Items are listed in Table 25 and discussed in Section 6 of the following report. Watersheds have varied responses to BMP application so it is difficult to predict with certainty the level of success and load reductions that will be achieved. The level of success is often determined by the level of community cooperation and involvement in implementation. Target loads for *E. coli*, nitrate & nitrite, phosphorous, and TSS may be achieved within seven years of the final date of this report.

## 7. BMP IMPLIMENTATION AND SUCCESS MONITORING

The MCCWMP is a dynamic, public document that is intended to assist in protection and enhancement of water quality within the MCCW in Hodgenville, LaRue County, Kentucky. The authors of this plan propose for the establishment of the role of MCCWMP Watershed Coordinator. The MCCWMP Watershed Coordinator will pursue BMP installation and construction; assist in securing funding through grants and other sources; ensure the MCCWMP is implemented in a manner consistent with its intent; and provide a main point of contact for volunteers and those interested in specific projects.

The plan will be presented in a public meeting to political leaders, stakeholders, civic and environmental groups, and the general public in early 2024, following EPA approval of the plan. The public meeting will include a review of the plan, steps for implementation, and future monitoring efforts. The locations where the public can review the document will be announced, but the plan will be available online via the KDOW and LaRue Fiscal Court websites.

The financial requirements for each Action Item vary greatly and may change based on the project scope once implementation begins. A number of potential funding sources have been identified in Section 7.3 to provide the financial assistance required for implementation.

To evaluate the effectiveness of BMP implementation and the progress made toward reaching benchmark concentrations, this plan proposes additional long-term success monitoring of watershed health. It is suggested that monitoring be completed seven years and fifteen years after implementation begins during spring or early summer. Monitoring should include three monthly sampling events from April to June. Sites selected for monitoring may align with the sites from this plan identified as having higher pollutant concentrations than benchmark level for comparison.

Evaluation of the plan should be conducted following the monitoring activities. The MCCWMP Watershed Coordinator should organize a meeting with watershed stakeholders to discuss the collected results. The effectiveness of the BMPs should be discussed. Alternative approaches should be considered in areas where BMPs are shown to not be feasible and/or effective. The MCCWMP is intended to be a living document, so modifications should be made based on changing conditions. Any modifications should be provided to all plan holders so that updated copies can be maintained by all parties.

# 1. INTRODUCTION

## 1.1. PROJECT OVERVIEW

LaRue County Fiscal Court contracted Palmer Engineering to provide consulting services for the development of a Watershed Management Plan (WMP) for the McDougal Creek – North Fork Nolin River and Castleman Creek – North Fork Nolin River (NFNR) watersheds in LaRue County, Kentucky. This project is funded in part by a grant from the US Environmental Protection Agency under Section 319(h) of the Clean Water Act through the Kentucky Division of Water (KDOW).

Preparation of the McDougal & Castleman Creek Watershed Management Plan (MCCWMP) has been based on EPA's *Handbook for Developing Watershed Plans to Restore and Protect Our Waters* and the State of Kentucky's *Watershed Planning Guidebook for Kentucky Communities.* The objective of the MCCWMP are to provide direction to the community regarding review of existing data; prioritize projects within the McDougal & Castleman Creek Watershed (MCCW); and produce a plan for the community that can lead to measurable results to improve water quality, watershed conditions, and enhance future funding opportunities for projects within the watershed.

The following is a list of the primary tasks performed by the project team. The tasks are discussed in detail in this plan.

1. Identification of stakeholders in conjunction with state and local officials and civic and environmental groups;
2. Public notification of the creation of the MCCWMP and an invitation to comment or get involved;
3. Public meetings with stakeholders to explain project objectives, enlist support, identify problem areas and potential pollutant sources, and develop indicators and prioritization processes;
4. Collection of existing watershed data including physical and natural features, population and land use, and previous studies and water quality sampling results;
5. Analysis of previously completed biological assessments of NFNR and tributaries;
6. Analysis of previously completed 2018 and 2019 TMDL monitoring in North Fork Nolin River provided by KDOW.
7. Identification of pollutant sources through field investigation, review of water quality testing, and existing available data;
8. Establishment of benchmark concentrations and comparisons for each parameter;
9. Estimation of pollutant loads and target reductions;
10. Identification of Best Management Practices (BMPs) and feasibility analysis of selected measures;
11. Estimation of technical and financial assistance needed to implement identified BMPs;
12. Schedule for implementation of BMPs;
13. Identification of measurable milestones for BMP implementation;
14. Development of monitoring objectives to evaluate the effectiveness in achieving water quality standards;
15. Development of the written MCCWMP to be maintained for public use and benefit; and
16. Presentation of MCCWMP and progress reports with political leaders, stakeholders, civic and environmental groups, and the general public.

The development of the MCCWMP has been jointly funded by the Section 319 grant and the required non-federal matching funds from the LaRue County Fiscal Court. After the finalization of the report, the LaRue County Fiscal Court shall be indemnified and held harmless to all actions taken by others as it relates to the implementation of the MCCWMP.

## 1.2. PROJECT TEAM

The LaRue County Fiscal Court awarded the contract for preparation of the Watershed Management Plan to Palmer Engineering. The main contact is Judge Blake Durrett of the LaRue County Fiscal Court. Judge Durrett is responsible for community organization and outreach efforts and review of all deliverables. The Project Manager from Palmer Engineering is Stephanie Blain, PE. Stephanie is assisted by two Project Engineers John Pike, and Erin Remley. Palmer Engineering is responsible for data review and analysis, field observations, writing the management plan and coordination with regulatory agencies.

## 1.3. PARTNERS AND STAKEHOLDERS

A vital part of the development of the MCCWMP was the involvement of the partners and stakeholders in the project area. In January 2023 the LaRue County Fiscal Court organized the McDougal and Castleman Creek Watershed Advisory Council. This council included City of Hodgenville, LaRue County, state and federal agencies, and various civic and environmental groups active within the community. A list of key partners and stakeholders is provided in Table 1. Throughout the preparation of this plan, the Watershed Advisory Council met four times. The focus of these meetings was to update all stakeholders on plan development progress and collect feedback on how best to proceed. Each stakeholder provided their perspective with goals and values to help the plan address the diverse needs of the community. Meeting minutes and sign-in sheets for each of the four Watershed Council meetings are located in APPENDIX A.

The project team involved interested members of the general public and residents of the watershed through public meetings of the Watershed Council at the LaRue County Fiscal Court Room. Announcements for the meetings were made through mailings, distribution of flyers at community events, posts on social media, emails and word of mouth. Anyone who signed in and provided an email at a meeting was directly invited to each subsequent meeting. The first meeting of the Watershed Council occurred on January 24, 2023. The focus of this meeting was informational and introductory. The project team determined it was important to gain a familiarity and trust with stakeholders. The project team's main message in this meeting was that participation in this process is voluntary but is most effective when all stakeholders participate to the best of their ability. The meeting presentation introduced the concept of the WMP, outlined the project scope, and provided a timeline for completion. Attendees of the meeting were given an opportunity to ask questions about the project, signup to assist in the project, and speak with the project team about their concerns. Table 1 presents a list of partners and stakeholders who attended this first public meeting and were identified as members of the Watershed Council.

Prior to the second public meeting, letters were sent to all property owners along NFNR and tributaries within the watershed to inform them of the development of the MCCWMP and invite them to the meeting. These letters also addressed the planned stream characterization visits where the project team intended to visit representative areas throughout the watershed to take notes on any changes in the conditions observed by KDOW in 2019. The project team received a small number of requests to not visit specific properties and coordinated with each property owner to follow their requests. During the stream characterization visits, many property owners met with the project team on their properties to discuss their opinions on management in the watershed. The second public meeting of the Watershed Council was held on April 18, 2023. In preparation for this meeting, Palmer prepared a list of preliminary goals and objectives. These items were presented to all members present at the meeting for opinions and feedback. As a result of the mailings to property owners related to the stream characterization visits, more residents attended the second public meeting than the first. Attendees provided feedback on proposed objectives and goals and the project team incorporated this feedback into the final objectives and goals presented in this plan.

The third public meeting of the Watershed Council was held on June 27, 2023. This meeting presented a preliminary version of the data analysis presented later in this report. After a look at the subwatersheds with the highest pollutant levels, the Watershed Council began brainstorming potential BMPs. This meeting had lower attendance than the two prior meetings.

The fourth and final public meeting of the Watershed Council was held on August 15, 2023. This meeting focused on a potential list of BMPs. Attendees provided feedback on which BMPs were preferred and would be most effective in the area. Attendees also recommended a few additional BMPs which were not initially considered. Attendance at this meeting was similar to the first meeting, with the Fiscal Court Room being full.

**Table 1.** MCCW Key Partners and Stakeholders

| **Organization** |
| --- |
| LaRue County Fiscal Court |
| Palmer Engineering |
| Kentucky Division of Water |
| LaRue County Conservation District |
| LaRue County Soil Conservation District |
| City of Hodgenville |
| Kentucky Cattlemen’s Association |
| LaRue County Cooperative Extension Service |
| LaRue County School District |
| Local Farmer Representatives |
| Lincoln Trail District Health Department |
| National Resource Conservation Service |

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# 2. McDOUGAL AND CASTLEMAN CREEK WATERSHEDS (MCCW)

## 2.1. WATERSHEDS OVERVIEW

### 2.1.1. WATERSHED BASICS

This plan focuses on two separate United States Geological Survey (USGS) Hydrologic Unit Code 12 watersheds; McDougal Creek – North Fork Nolin River (HUC #051100010905) and Castleman Creek – North Fork Nolin River (HUC #051100010904). These HUC 12 watersheds make up the northern portion of the HUC 10 watershed Upper Nolin River (HUC #0511000109) which also includes Lower Walters Creek – South Fork Nolin River, South Fork Branch – South Fork Nolin River and Upper Walters Creek to the south. Water from the Upper Nolin River Watershed flows to Nolin River Lake and then to the Green River as part of the HUC 8 Upper Green River Watershed in the larger Green River Basin. Ultimately, this water flows to the Ohio River which feeds the Mississippi River which empties into the Gulf of Mexico. The Castleman Creek – North Fork Nolin River contains approximately 23.21 square miles. The McDougal Creek – North Fork of Nolin River contains approximately 26.67 square miles. These two watersheds encompass the city of Hodgenville and surrounding pasture to the north, northeast, south and southeast of Hodgenville. The area is characterized by rolling karst plain containing depressions, ponds, sinking creeks, and dry valleys.

### 2.1.2. BASIS OF SELECTION OF WATERSHEDS

The two focus watersheds in this plan do contain all three KDOW Source Water Assessment and Protection Program (SWAPP) zones, indicating these are significant water sources for public drinking water supplies. Multiple reaches of open water within the Castleman Creek and McDougal Creek watersheds are listed on the 2022 303(d) list. This list is part of the 2022 Integrated Report to Congress on the Condition of Water Resources in Kentucky. The 303(d) list is a list of all waterbodies with water quality that fails to support its designated uses, such as warm water aquatic habitat or primary and secondary contact recreation. The 2022 303(d) list contains newly assessed waterbodies that fail to support their designated uses; some of which have been added as a result of the 2018 and 2019 TMDL studies for North Fork Nolin River which are discussed in this report.

In 2021, KDOW coordinated with Basin Teams in each of the seven major Kentucky River Basins. The Green River Basin Team identified the Upper Nolin River Watershed as a priority watershed. This plan will address the two northern-most subwatersheds of Upper Nolin River. Upper Nolin River was selected as a priority because it contains nutrient reduction priority areas, SWAPP Zone I, 303(d) impaired waters, waters that fail to meet their designated uses, and disadvantaged communities.

As a part of the KDOW SWAPP, a significant amount of water quality data has already been collected and has been utilized by the LaRue County Fiscal Court for plan preparation. The LaRue County Conservation District is active in the community, already working to implement projects to improve water quality in the neighboring Upper Bacon Creek watershed, as made possible by the Bacon Creek Watershed Management Plan, and will be a project partner with the Fiscal Court. The completion of the MCCWMP will promote continued water quality improvements and public education in LaRue County. While implementation is not a part of this project, the LaRue County Conservation District is excited about another watershed management plan in LaRue County to continue their goal to improve the quality of the environment and will aid in implementation of prioritized BMPs.

## 2.2. WATER RESOURCES

The North Fork Nolin River (NFNR) flows through the MCC focus watersheds which include many smaller tributaries such as Salem Creek, Wilkins Creek, Craddy Creek and Fork Creek. The MCCW contains multiple moderately sized lakes. This includes Salem Lake, McDougal Lake and the smaller Sportsman Lake. The main stem of NFNR is approximately 9.32 miles long. The main stem of Castleman Creek is approximately 7.65 miles. The main stem of McDougal Creek is approximately 10.15 miles. Figure 1 shows the project area, Castleman Creek and McDougal Creek watersheds. Water for the City of Hodgenville is sourced from the North Fork Nolin River. During times of low flow, the city can source water directly from Salem Lake or release more water from McDougal Lake. Castleman Creek and McDougal Creek watersheds include SWAPP Zones I, II and III for their contribution to North Fork Nolin River and Salem Lake.

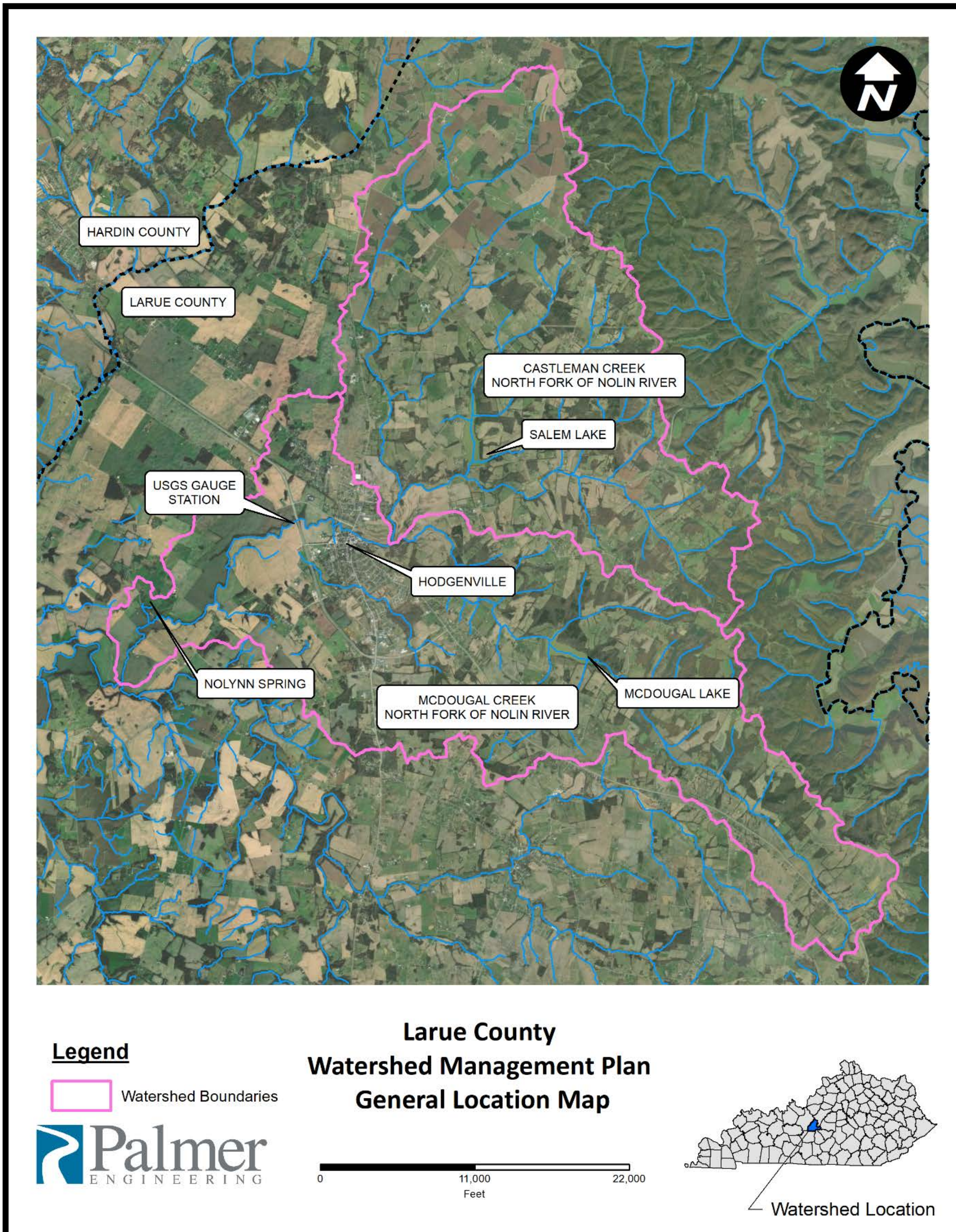



**Figure 1.** Limits of MCCW

### 2.2.1. HYDROLOGY

Stream flow in NFNR is derived from precipitation runoff and groundwater discharge. Thick layers of easily dissolved limestone underlay the watershed, creating frequent carbonate aquifers. Caves and springs are also common in the region due to groundwater flowing through channels in the limestone. The most prominent spring in the watershed is Nolynn Spring. The point where Nolynn Spring surfaces and flows into North Fork Nolin River was sampled by KDOW as part of the 2019 TMDL Monitoring Study.

MCCW experiences relatively non-flashy storm flows compared to more urbanized areas. The largely pervious Castleman and McDougal Creek watersheds will soak up and retain water from large rainfalls for many days. The water table can remain high for several days following the storm event, depending on the magnitude. It can take between 3-7 days for stream flows to return to antecedent conditions. This pattern can be seen in the continuous USGS stream flow data. North Fork Nolin River, Castleman Creek, and McDougal Creek are rock lined which promotes high stream velocities during storm events. Typical stream depth is around 1 foot but even smaller storm events can result in flooding. Water can be observed filling up to the top of bank in the reach of North Fork Nolin River flowing north of Hodgenville City Center. This is shown on the FEMA Flood Insurance Rate Maps and supported by community testimony.

LaRue County has a Midwestern Regional Climate Center station through Kentucky Mesonet. This station is located at 37.6 °N -85.7 °W. This is between Salem Lake Road and Salem Church Road, northeast of Salem Lake in the Castleman Creek watershed. Average annual precipitation data at this station from 2008 to 2022 is shown in Table 2. In the 1979 Hardin and Larue County Soil Survey, the climate is described as temperate and humid. The rainfall is fairly evenly distributed throughout the year providing favorable growing seasons for grasses and legumes.

**Table 2.** Precipitation Data

| Station ID | County | Annual Precipitation (in) | Annual Snowfall (in) |
|---|---|---|---|
| Hodgenville 2E (HGDV) | LaRue | 53.94 | 13.1 |

The USGS has one gauging station in the MCCW (USGS Site # 03310000). This station is located on the east side of the Lincoln Parkway Bridge above North Fork Nolin River. This flow data was compiled with flow data collected at the water quality sampling sites at the time of sampling and will be discussed later in this plan. The location of the gauging station is near stream site 5 on the upstream end and stream site 4 on the downstream end. Average annual snowfall data is gathered from USDA Soil Survey of Hardin and LaRue Counties, Kentucky.

### 2.2.2. GROUNDWATER-SURFACE WATER INTERACTION

The groundwater-surface water interaction has significant impact to MCCW. Due to the underlying limestone, MCCW contains locally integrated karst drainage. KDOW has developed a Groundwater Sensitivity Index to rate the ease and speed with which a contaminant can move into and within a groundwater system. The major factors in determining the sensitivity are recharge to the system, flow rate, and dispersion potential within the system. The index ranges from one (low) to five (high). Figure 2 depicts the index values for LaRue County and the surrounding region. MCCW is predominately rated five (purple shading), indicating widespread or radial extensive dispersion, conduit or enlarged fissure flow, and convergent recharge. There is a portion of lower rated areas to the northeast along the border of LaRue and Nelson counties. This area is not within MCCW and generally represents the outer boundary of the Castleman Creek watershed.

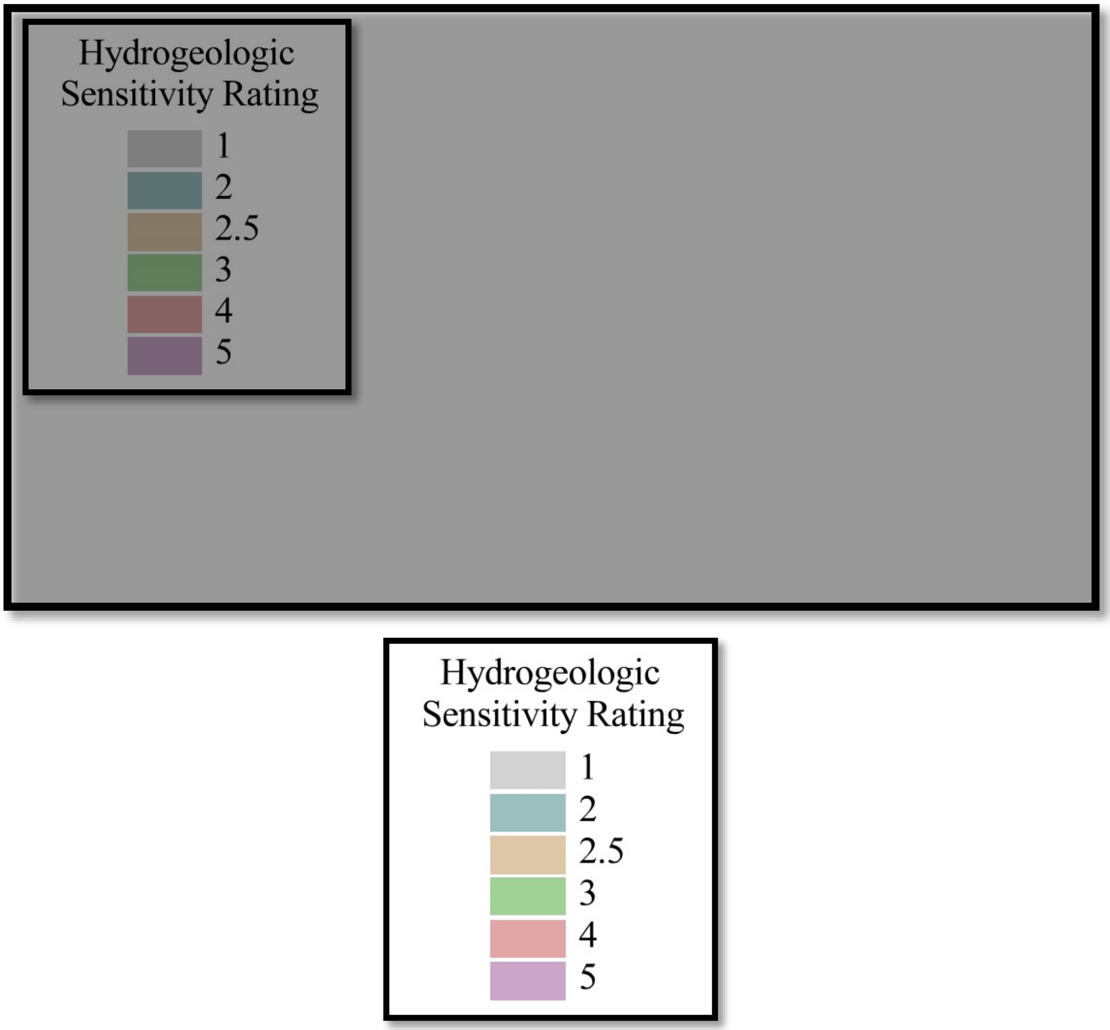



**Figure 2.** Hydrogeologic Sensitivity Index Map

The Kentucky Geological Survey has developed Karst Atlas maps of Kentucky that depict groundwater basins, sinkholes prone to flooding and the potential for the development of cover-collapse sinkholes. MCCW is located on the Elizabethtown Quadrangle and an excerpt of the region is shown in Figure 3. A large groundwater catchment basin is shown in the western portion of the watershed that drains into North Fork Nolin River at Nolynn Spring. See Section 2.3.1 for more information on the location and identification of karst topography.

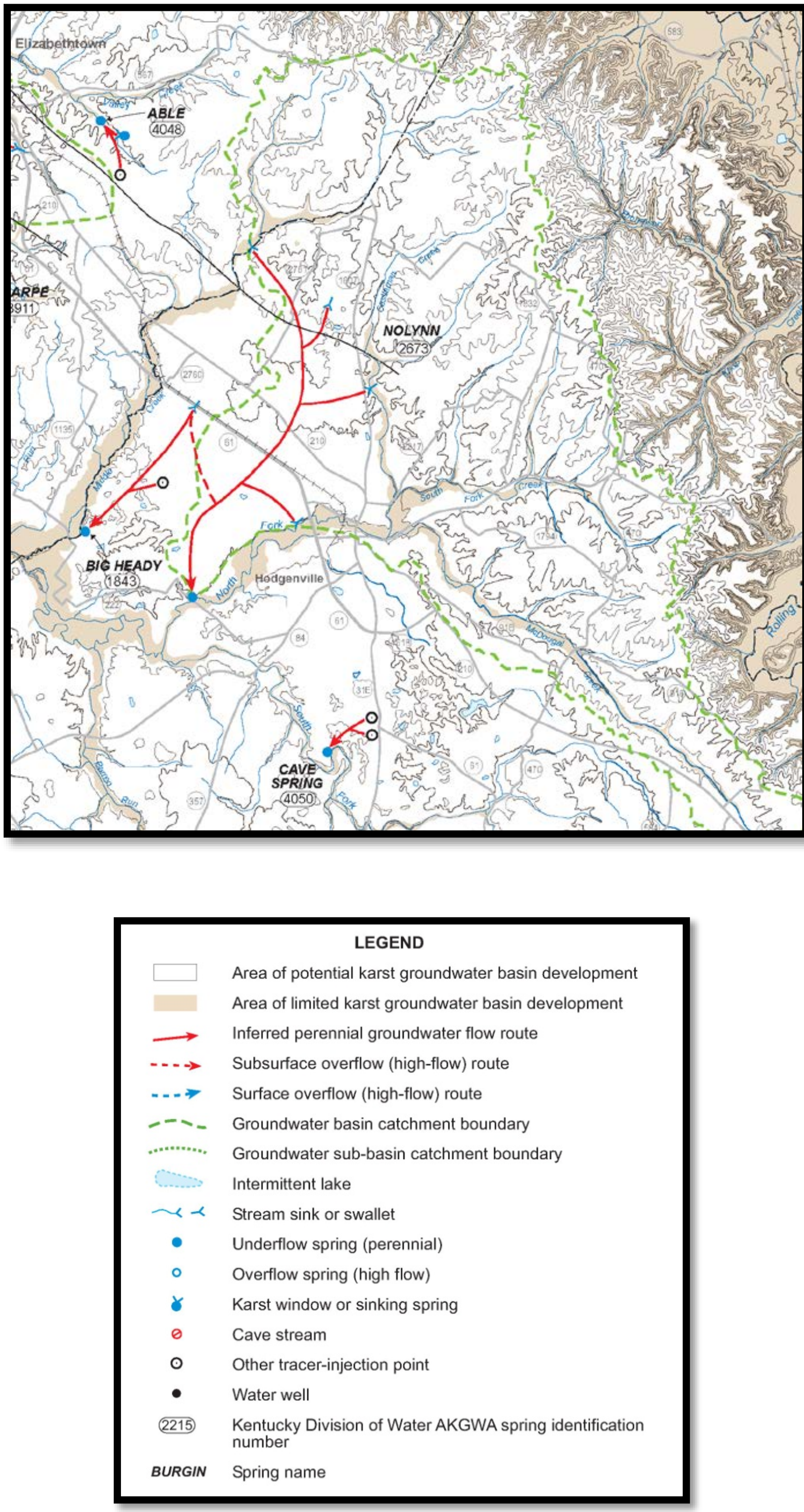



**Figure 3.** Excerpt from Karst Atlas of Kentucky and Legend

### 2.2.3. FLOODING

Figure 4 depicts the floodplain boundaries in MCCW as defined by the Federal Emergency Management Agency (FEMA). These boundaries are provided by FEMA and further described in the following FEMA Flood Insurance Rate Maps: 21123C0150C, 21123C0140C, 21123C0130C, 21123C0125C, and 21123C0050C; all effective January 16, 2009. Stakeholders of the Watershed Advisory Council identified flooding as a concern in MCCW. Floodplain width increases from upstream to downstream in the watershed. Upstream creeks in the Castleman Creek Watershed including Fork Creek, Wilkins Creek, unnamed tributary to Castleman Creek, and unnamed creek upstream of Salem Lake have floodplains which span 250 feet. The portions of mainstem NFNR and Castleman Creek have floodplains which span 600 feet. Downstream of the confluence of Castleman Creek and North Fork Nolin River, the floodplain increases to 1,700 feet before reducing down to 800 feet north of Hodgenville in the McDougal Creek Watershed. Upstream, the McDougal Creek floodplain is 450 feet wide before reaching McDougal Lake. Downstream of McDougal Lake until the confluence with NFNR, McDougal Creek has floodplain spanning 700 feet. The unnamed tributary to NFNR south of McDougal Creek has a floodplain which spans 450 feet. Downstream of the confluence of McDougal Creek and NFNR, floodplain ranges from 700 feet to 3,500 feet depending on the surrounding topography. Notably, FEMA has not mapped floodplain for every portion of blue line stream in these watersheds. Multiple unnamed tributaries of Fork Creek in the east portion of Castleman Creek Watershed are not mapped. Multiple unnamed tributaries to the north of McDougal Creek are also not mapped.

The largest areas of floodplain occur in low lying, rural areas of the watersheds. In the City of Hodgenville, there are a few buildings in the floodplain. This includes the Hodgenville City Wastewater Plant, Paula's Hot Biscuit restaurant, Garrett’s Furniture, Mam Candy, and Creekside Barbell. The unnamed tributary to North Fork Nolin River in the McDougal Creek Watershed passes through multiple properties in South Hodgenville between Lincoln Parkway, S. Lincoln Blvd, and South Greensburg Street. The floodplain of this tributary extends on to these properties.

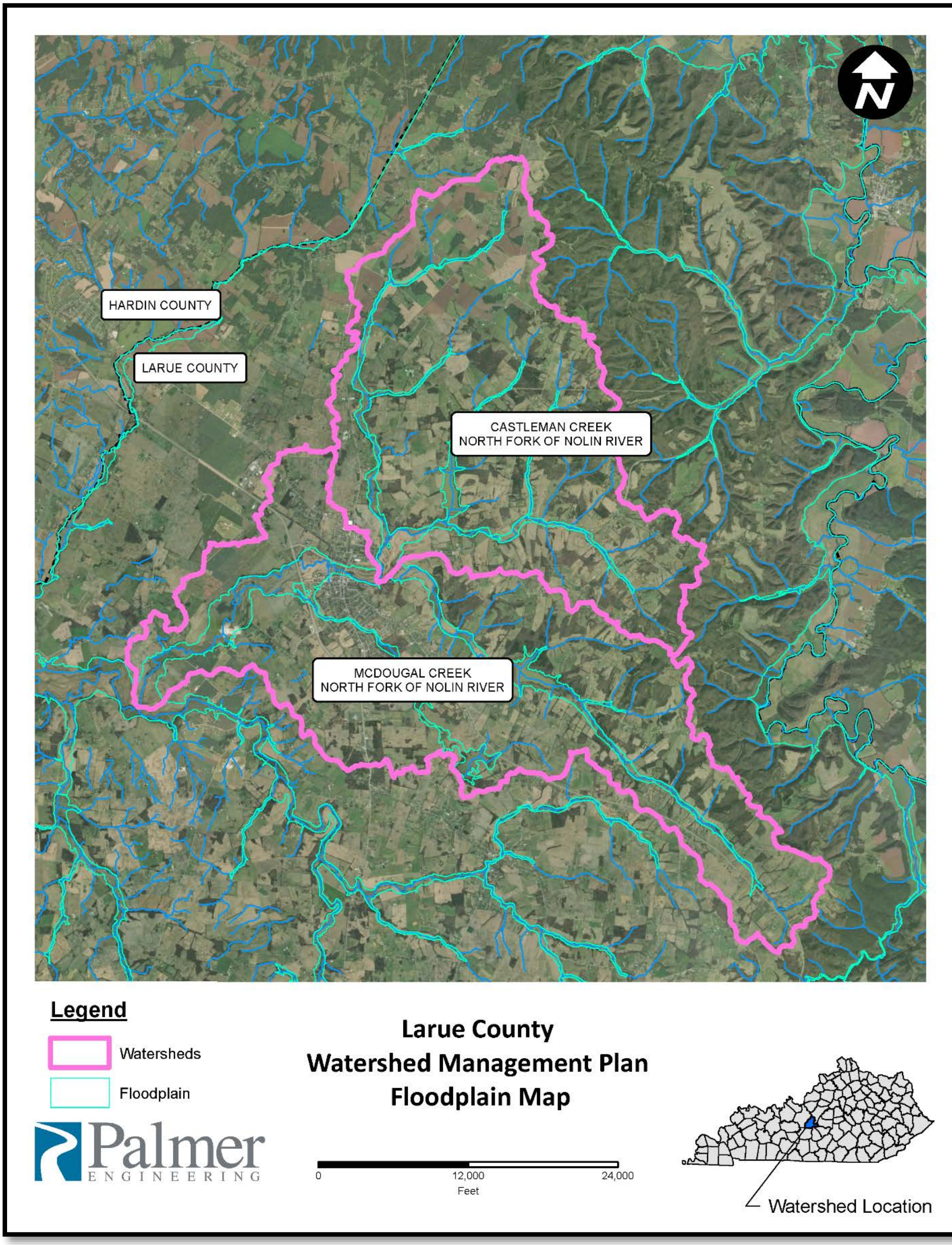



**Figure 4.** North Fork Nolin River Watersheds Floodplain Map

### 2.2.4. REGULATORY STATUS OF WATERWAY

The EPA water quality standards regulation necessitates that Kentucky must specify appropriate designated uses to be achieved and/or protected for all water bodies. Warm water aquatic habitat and primary contact recreation are the designated uses for North Fork Nolin River, its tributaries, and Salem Lake. Warm water aquatic habitat is defined as waters that provide suitable habitat for aquatic organisms and fish, excluding cold water species. Primary contact recreation is defined as the ability for humans to swim or wade without risk to their health.

The 303(d) list identifies all assessed and impaired streams and lakes within Kentucky. Each water body is listed as impaired for one or more pollutants if the pollutant levels do not allow the water body to meet one or more of the water quality standards. KDOW personnel, volunteer networks, and other local, state, and federal agencies identify impaired waters through assessment and monitoring programs. Table 3 provides a summary of all impaired waterbodies in McDougal and Castleman Creek Watersheds that are present on the 2022 303(d) list. In this table, impaired uses of primary contact recreation and warm water aquatic habitat are abbreviated as PCR and WAH.

**Table 3:** Summary of Impaired Waterbodies in McDougal and Castleman Creek on the 2022 303(d) List

| Waterbody Name | Impaired Uses | Parameters |
|---|---|---|
| McDougal Creek 0.0 to 3.55 | PCR & WAH | Sedimentation/Siltation-5; *E. coli*-5 |
| McDougal Creek 4.55 to 10.1 | PCR & WAH | Sedimentation/Siltation-5; *E. coli*-5 |
| North Fork Nolin River 0 to 0-1.3 | PCR | *E. coli*-5 |
| North Fork Nolin River 1.3 to 5.45 | PCR & WAH | Sedimentation/Siltation-5; Nutrient/Eutrophication Biological Indicators-5; *E. coli*-5 |
| North Fork Nolin River 5.45 to 7.05 | PCR & WAH | Sedimentation/Siltation-5; *E. coli*-5 |
| North Fork Nolin River 7.05 to 9.0 | PCR & WAH | Sedimentation/Siltation-5; *E. coli*-5 |
| North Fork Nolin River 9.0 to 9.85 | PCR | *E. coli*-5 |
| Salem Creek 1.3 to 3.6 | PCR & WAH | Sedimentation/Siltation-5; *E. coli*-5 |
| Castleman Creek 0.0 to 2.75 | PCR & WAH | Nutrient/Eutrophication Biological Indicators-5; Sedimentation/Siltation-5; *E. coli*-5 |
| Castleman Creek 2.75 to 7.6 | PCR & WAH | Nutrient/Eutrophication Biological Indicators-5; *E. coli*-5 |
| Castleman Creek UT 0.0 to 3.45 | PCR & WAH | Nutrient/Eutrophication Biological Indicators-5; *E. coli*-5 |
| Salem Lake | WAH | Nutrient/Eutrophication Biological Indicators-5 |

### 2.2.5. EXISTING WATER CHEMISTRY AND BIOLOGY KDOW SAMPLING DATA

Through an open records request, sampling data previously collected by KDOW was obtained. The data was collected from 2018 to 2020 and was collected by the Water Quality Branch, TMDL Section as part of the 2018 & 2019 Total Maximum Daily Load (TMDL) Monitoring in NFNR. This study included field and lab water quality data, *E. coli* measurements, and habitat and biology assessments. The study proceeded in two phases; Phase I monitoring in 2018 sampled 13 locations throughout the watershed in an effort to confirm pollutant concentrations and probable sources of pollutants within the main stem and larger tributaries of NFNR. Phase II sampling in 2019 included 8 locations; 4 of these locations were repeated from Phase I, and 4 were newly identified for Phase II. Phase II focused on characterizing the conditions above and below Nolynn Spring, Nolynn Spring proper, above the Wastewater Treatment Plant (WWTP) and above the Water Treatment Plant (WTP). This phase also included an attempt to capture water quality conditions in North Fork Nolin main stem above and below where it sinks and loses flow to the spring drainage area. This data will be further discussed in Section 3.

The Kentucky Watershed Watch (KWW) is a group of volunteers interested in water quality who collect data throughout the Green River Basin. KWW has one site within the McDougal & Castleman Creek watersheds with data collection. This site is 0.5 miles west of 210 Bridge in Hodgenville which is the same location as stream site 5 in this plan. From 2000 to 2007, 21 sampling events occurred at this location. Since the data has been collected by volunteers, it has not been consistently collected and is difficult to verify that proper quality assurance and quality control procedures were followed. The data is useful as a reference to consider how MCCW may have changed in the last 23 years. This data will be further discussed in Section 3.

### 2.2.6. GEOMORPHOLOGY

Geomorphology is defined as the study of landforms, starting with their origin through the processes that continue to shape them. Landforms are modified by a combination of surface processes and geologic processes. Surface processes are comprised of the actions of water, wind, ice, fire, and living organisms which are strongly mediated by climate. Geologic processes include the processes such as the uplift of mountain ranges and the growth of volcanoes. Landforms transform in response to the balance of additive processes, such as uplift and deposition, and subtractive processes, such as subsidence and erosion.

NFNR is in the Mississippian Plateaus area of Kentucky. Most of Larue County is a low, rolling plateau. Sinkholes are a common feature of the terrain in the western part of the county; elsewhere normal surface stream drainage predominates (McGrain and Currens 1978). The region is a part of the Interior Low Plateaus geomorphic province. In *Ecological Subregions of the United States*, McNab and Avers explain, “Platform deposition of continental sediments into a shallow inland sea was followed by uplifting to form a level-bedded plateau, which has been shaped by differential erosion to form a moderately dissected surface.” Equal amounts of irregular plains and open hills comprise 90 percent of the landforms in the region, with a small area of smooth plains.

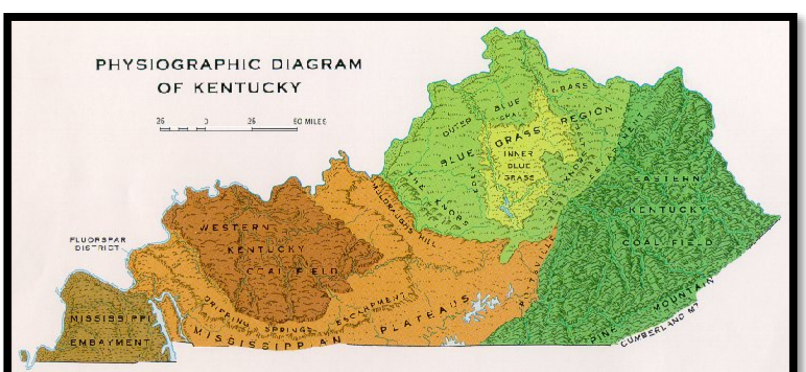



**Figure 5.** Physiographic Diagram of Kentucky

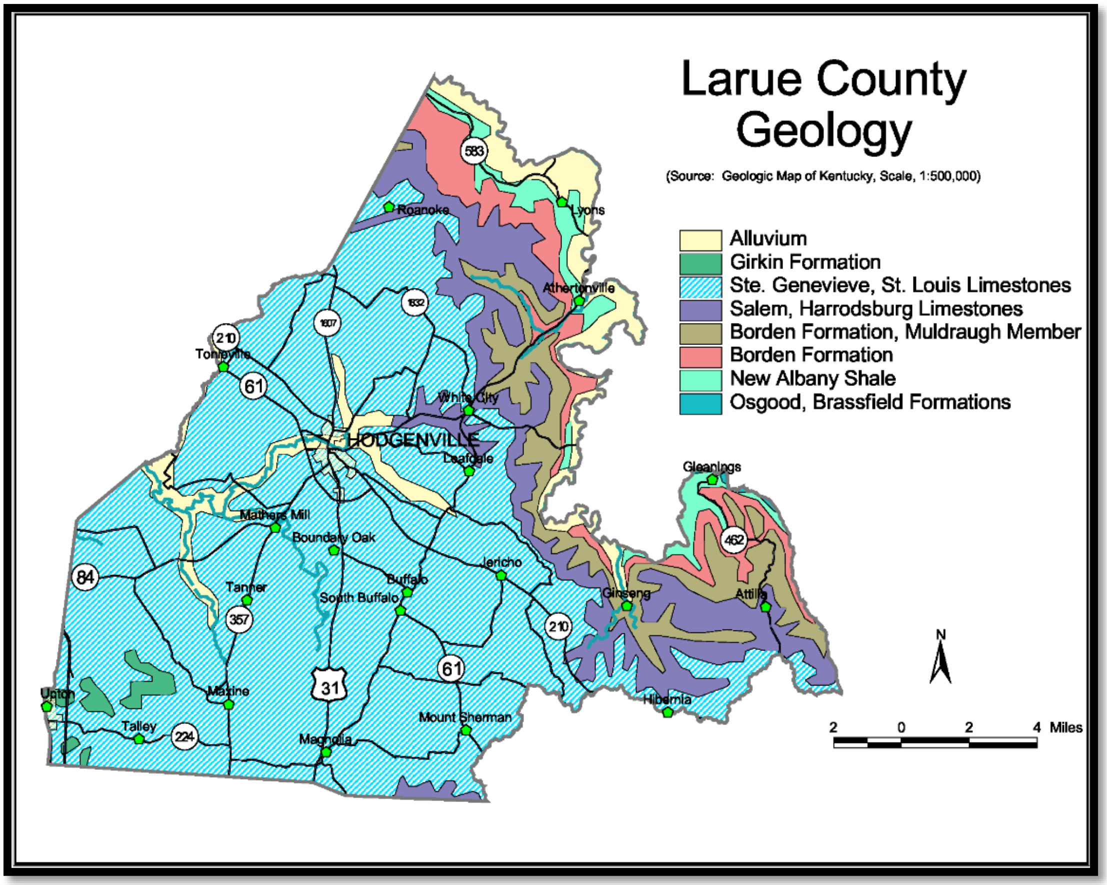



Figure 6. **LaRue County Geology**

## 2.3. NATURAL FEATURES

### 2.3.1. GEOLOGY

Geology is the study of Earth's crust and the process by which it changes. LaRue County is part of the Western Pennyroyal region. This is a sub region of the Mississippian Plateau physiographic region of Kentucky. Figure 5, from Kentucky Geological Survey, depicts the physiographical regions for the State of Kentucky. Water is obtained from consolidated sedimentary rocks of Silurian, Devonian, and Mississippian ages, and from unconsolidated sediments of Quaternary age. Geologists call the oldest rocks found at the surface in Larue County the Brassfield Dolomite. This formation is from the Silurian, which was deposited in warm seas 430 million years ago. Above the Silurian rocks is the Devonian New Albany shale, formed 400 million years ago when the deep-sea floor became covered with an organic black muck. The muck is now hard black shale (an oil shale) which is one of the most distinctive of all geologic formations in Kentucky. The Mississippian sandstones and siltstones are the result of a great influx of mud, silts, and sands brought in by rivers and streams from uplands many miles away and deposited as a great delta. As shown in Figure 6, the most common rock types in Larue County are Mississippian Limestones, which were deposited 350 million years ago in the bottom of a warm, shallow sea. Over the last 1 million years, unconsolidated Quaternary sediments have been deposited along the larger streams and rivers (Kentucky Geological Survey Atlas).

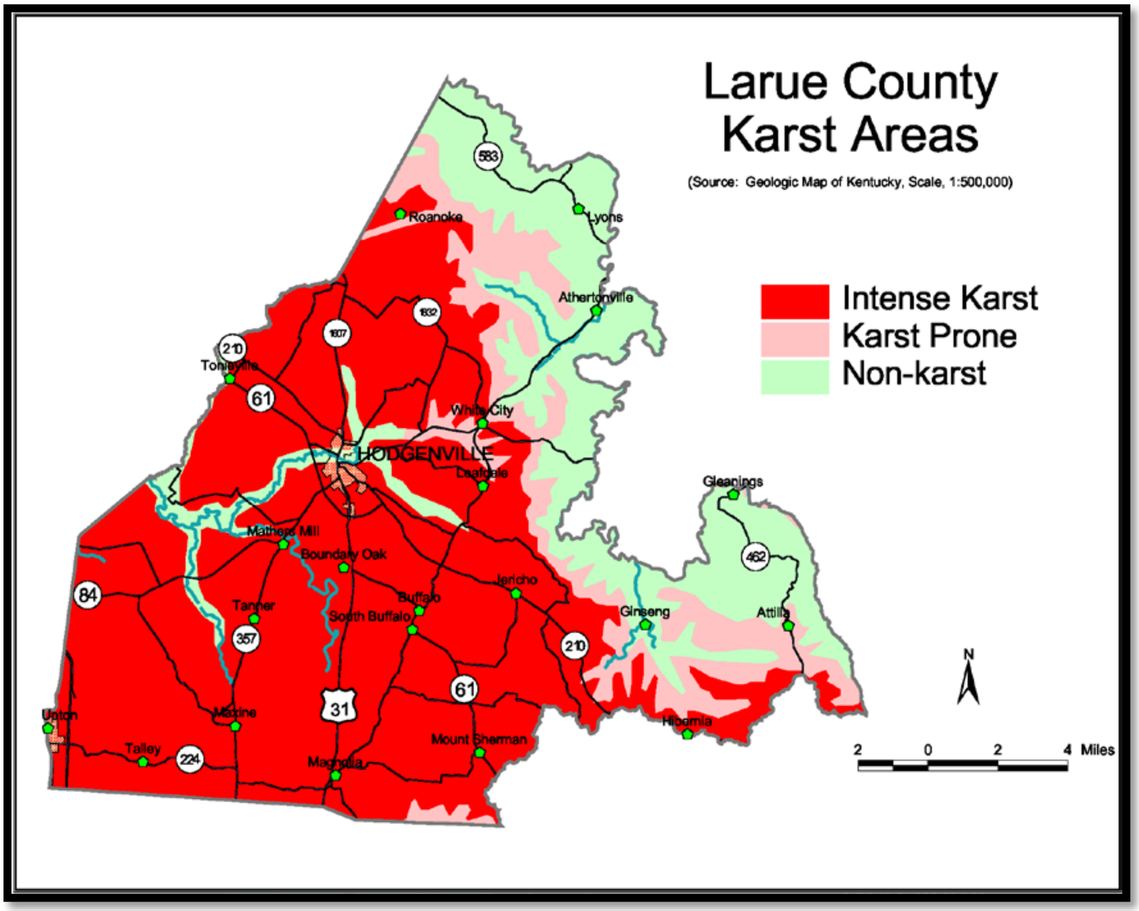



**Figure 7.** Karst Map of LaRue County

## 2.3.2. TOPOGRAPHY

The topography in MCCW ranges from rolling in the east to hilly in the west. The elevations range from less than 680 feet above mean sea level in McDougal Creek Watershed at the confluence with the South Fork Nolin River to almost 980 feet above mean sea level in northern areas of the Castleman Creek Watershed. North Fork Nolin River is located primarily on the Hodgenville (N32) and Tonieville (N31) 7.5-minute topographic quadrangle maps with some small areas being on Nelsonville (M32), Howardstown (N33) and Hibernia (O33). Figure 8, located on page 17, contains a portion of these maps in the vicinity of MCCW. According to the Hardin and Larue County Soil Survey (USDA 1979), topography in intense karst and karst prone regions is irregular and has several sinkhole-like depressions. In addition, the area has some steep slopes around sinkholes that may lead to subterranean caverns. Presence of karst underground flow paths in a watershed can reroute upstream pollution directly to Nolynn Spring. A map of karst intensity in LaRue County can be seen in Figure 7.

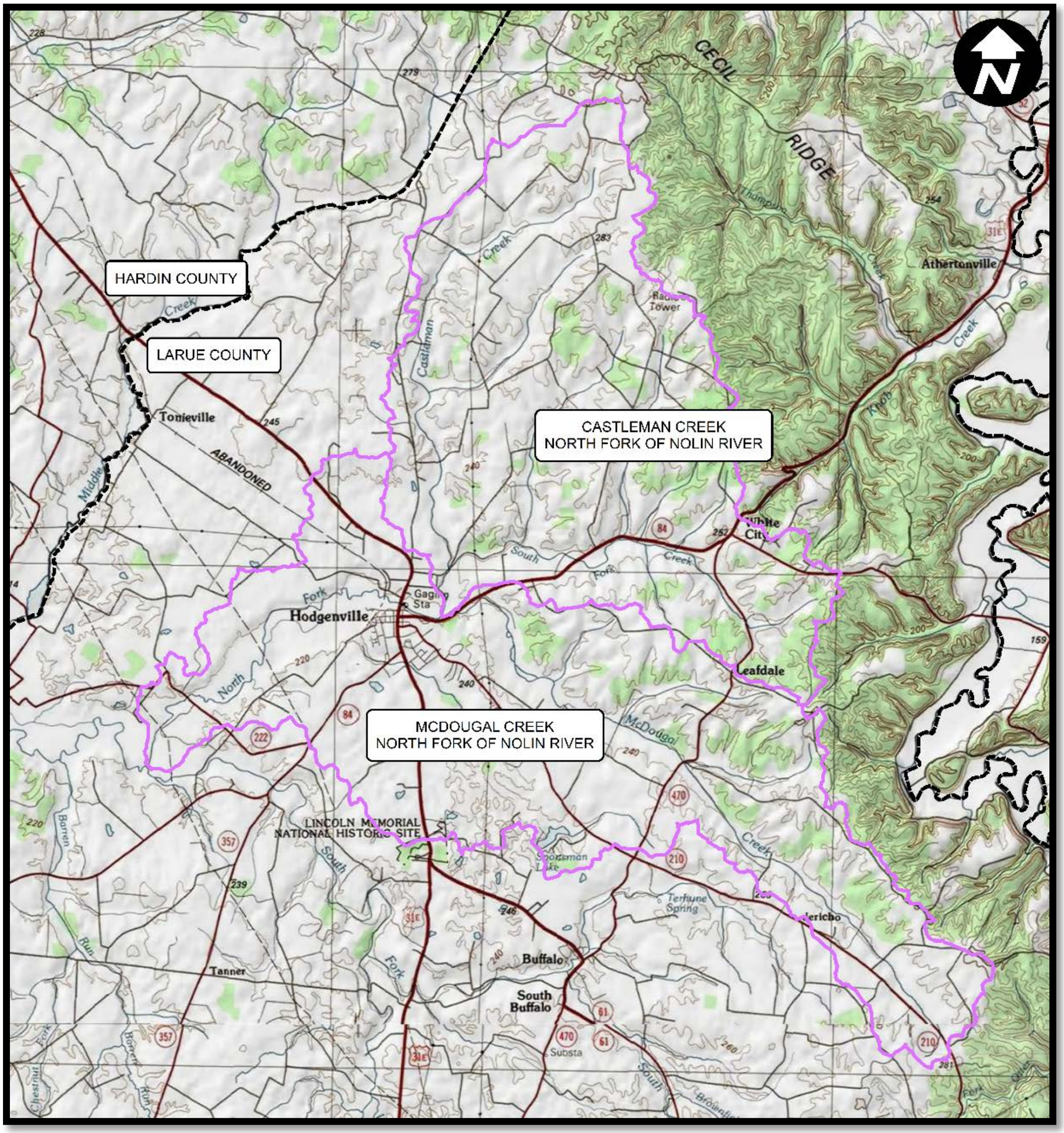



**Figure 8.** Topographic Map of MCCW

### 2.3.3. SOILS

According to the Larue County soils information provided through GIS data by the Natural Resources Conservation Service (NRCS), the soils in MCCW are predominately silt loam with varying slopes ranging from 0 percent to 30 percent and are part of hydrologic soil group C. Most of the soils are highly erodible, not hydric, and moderately well to well drained. A full summary of soils in the MCCW is provided in Table 4. Figure 9 depicts the location of the soil classifications within MCCW.

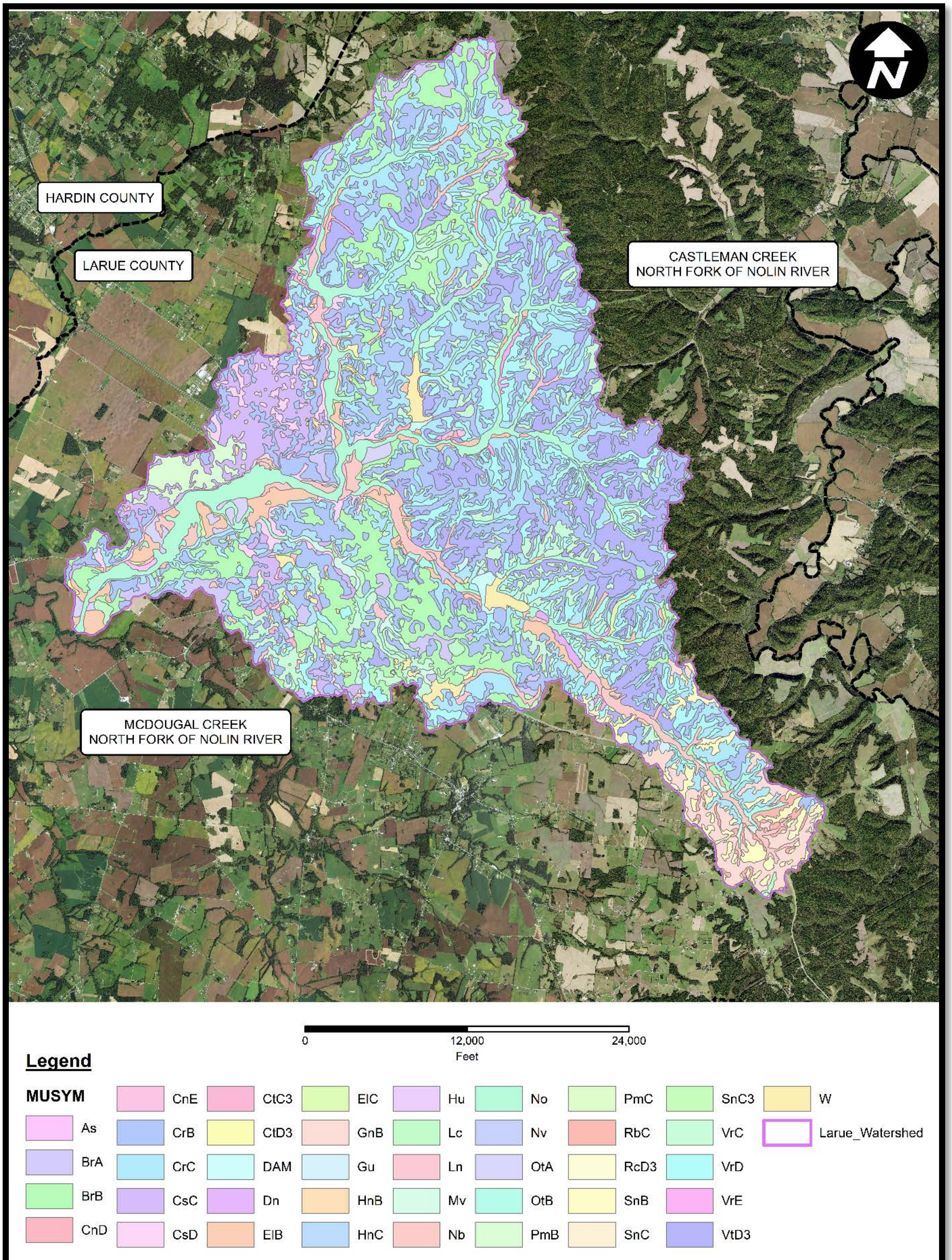



**Figure 9.** Soil Classification Map of MCCW

**Table 4.** NRCS MCCW Soil Classification

| Map Unit Symbol | Map Unit Name | Acres | Percentage of Area |
|---|---|---|---|
| As | Ashton silt loam, 0 to 4 percent slopes, occasionally flooded | 20.2 | 0.10% |
| BrA | Bedford silt loam, 0 to 2 percent slopes | 642.7 | 2.00% |
| BrB | Bedford silt loam, 2 to 6 percent slopes | 3,378.80 | 10.60% |
| CnD | Caneyville-Rock outcrop complex, 6 to 20 percent slopes | 23.8 | 0.10% |
| CnE | Caneyville-Rock outcrop complex, 20 to 30 percent slopes | 13.4 | 0.00% |
| CrB | Crider silt loam, 2 to 6 percent slopes | 5,871.90 | 18.40% |
| CrC | Crider silt loam, 6 to 12 percent slopes | 5,852.00 | 18.30% |
| CsC | Cumberland silt loam, 6 to 12 percent slopes | 1,234.70 | 3.90% |
| CsD | Cumberland silt loam, 12 to 20 percent slopes | 606 | 1.90% |
| CtC3 | Cumberland silty clay loam, 6 to 12 percent slopes, severely eroded | 35.2 | 0.10% |
| CtD3 | Cumberland silty clay loam, 12 to 20 percent slopes, severely eroded | 64.6 | 0.20% |
| DAM | Dam, large | 76.8 | 0.20% |
| Dn | Dunning silty clay loam, 0 to 2 percent slopes, frequently flooded | 47.5 | 0.10% |
| ElB | Elk silt loam, 2 to 6 percent slopes | 752.2 | 2.40% |
| ElC | Elk silt loam, 6 to 12 percent slopes | 75.7 | 0.20% |
| GnB | Gatton silt loam, 2 to 6 percent slopes | 690.2 | 2.20% |
| Gu | Gullied land (riney) | 54.6 | 0.20% |
| HnB | Hagerstown silt loam, 2 to 6 percent slopes | 4.2 | 0.00% |
| HnC | Hagerstown silt loam, 6 to 12 percent slopes | 6.2 | 0.00% |
| Hu | Huntington silt loam | 16.8 | 0.10% |
| Lc | Lawrence silt loam, 0 to 2 percent slopes, rarely flooded | 161.3 | 0.50% |
| Ln | Lindside silt loam, 0 to 2 percent slopes, frequently flooded | 264.7 | 0.80% |
| Mv | Melvin silt loam | 166 | 0.50% |
| Nb | Newark silt loam, 0 to 2 percent slopes, frequently flooded | 808.2 | 2.50% |
| No | Nolin silt loam, 0 to 2 percent slopes, frequently flooded | 2,068.30 | 6.50% |
| Nv | Nolin variant fine sandy loam (grigsby) | 21.2 | 0.10% |
| OtA | Otwood silt loam, 0 to 2 percent slopes, rarely flooded | 188.8 | 0.60% |
| OtB | Otwood silt loam, 2 to 6 percent slopes, occasionally flooded | 148.3 | 0.50% |
| PmB | Pembroke silt loam, 2 to 6 percent slopes | 364.4 | 1.10% |
| PmC | Pembroke silt loam, 6 to 12 percent slopes | 10 | 0.00% |
| RbC | Riney loam, 6 to 12 percent slopes | 149.4 | 0.50% |
| RcD3 | Riney sandy clay loam, 6 to 20 percent slopes, severely eroded | 12.6 | 0.00% |
| SnB | Sonora silt loam, 2 to 6 percent slopes | 491.4 | 1.50% |
| SnC | Sonora silt loam, 6 to 12 percent slopes | 34.8 | 0.10% |
| SnC3 | Sonora silt loam, 6 to 12 percent slopes, severely eroded | 6.5 | 0.00% |
| VrC | Vertrees silt loam, 6 to 12 percent slopes | 1,829.90 | 5.70% |
| VrD | Vertrees silt loam, 12 to 20 percent slopes | 2,280.70 | 7.10% |
| VrE | Vertrees silt loam, 20 to 30 percent slopes | 105.5 | 0.30% |
| VtD3 | Vertrees silty clay loam, 6 to 20 percent slopes, severely eroded | 2,923.30 | 9.20% |
| W | Water | 422.9 | 1.30% |

The soil classifications with the largest presence in the watershed are Crider silt loam, Bedford silt loam, Vertrees silt loam and Nolin silt loam. Crider silt loam is typically a deep, well-drained soil in bands on the upper parts of hillsides and the head of ravines and in blocks in karst areas. Crider series soils formed in loess and the underlying residuum from limestone. Bedford silt loam is a deep, moderately well drained soil formed in loess and the underlying loamy material over a paleosol from clayey residuum, the soil is found on hills underlain with limestone bedrock. Vertrees silt loam is a deep, well drained, sloping soil on narrow ridgetops and the upper parts of hillsides and in karst areas. Vertrees series soils formed in residuum from limestone that was interbedded with shale and siltstone. Nolin silt loam is a nearly level, well-drained soil in strips on floodplains and in circular and oval areas in depressions. Nolin series soil formed in alluvium that was derived chiefly from sandstone and loess. Crider silt loam, Bedford silt loam and Nolin silt loam, as well as most of the watershed, are designated as prime farmland or farmland of statewide importance. Vertrees silt loam is designated as not prime farmland (Arms 1979).

### 2.3.4. ECOREGIONS

Ecoregions in Kentucky have been designated by the EPA and denote areas of general similarity in the type, quality, and quantity of environmental resources. Ecoregions differentiate sections of the environment by its possible response to disturbance by recognizing the spatial differences in the capacities and potentials of the ecosystem. The United States had been broken up into a set of four levels of delineation, with level one being the coarsest and level four being the finest. There are seven level three ecoregions, and twenty five level four ecoregions in Kentucky. Ecological and biological diversity in Kentucky strongly correlates with regional physiographic characteristics, geology, land use, and soil properties according to the EPA.

MCCW is located in the Interior Plateau ecoregion at the level three designation and the Mitchell Plain ecoregion at the level four designation. A small portion of Castleman Creek Watershed is in the Knobs-Norman Upland ecoregion. Figure 10 depicts the ecoregion boundaries for the Commonwealth of Kentucky. The Interior Plateau ecoregion is made up of extensive plains interrupted by dissected uplands, knobs, a few deeply incised streams, and large areas of karst. The Mitchell Plain ecoregion is characterized by rolling karst plain containing depressions, ponds, sinking creeks, and dry valleys. Scattered ridges, knobs, and hills occur. Land use is predominantly cropland, pastureland, patches of woodland, and military reservation. Streams have moderate to low gradients. Stream density is low and incision is typically limited except along major rivers. Springs are common in incised areas (Woods 2002). Knobs-Norman Upland is characterized by steep knobs, hills and ridges. Figure 11 shows the dividing line of the Mitchell Plain and the Knobs-Norman Upland in the MCCW.

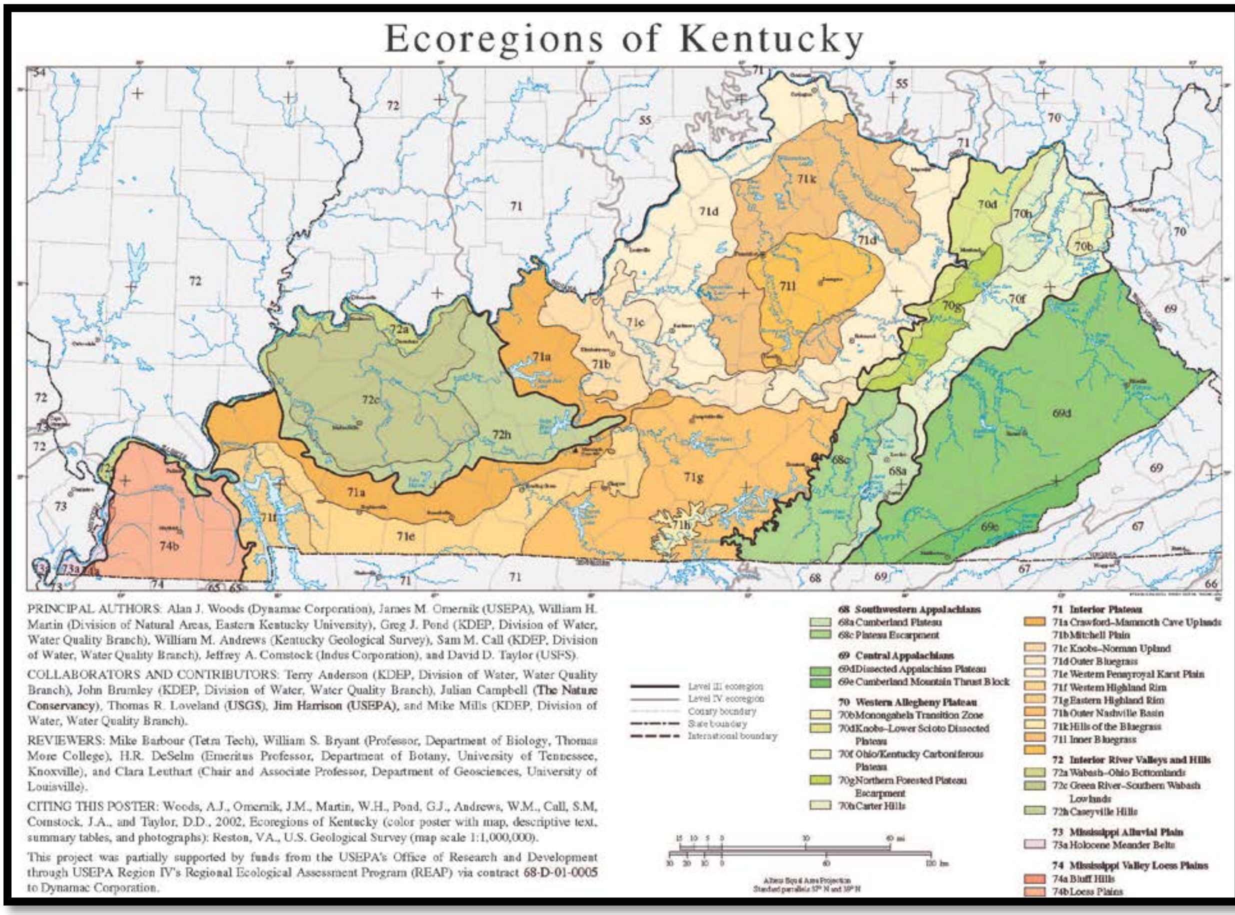



**Figure 10.** Ecoregions of Kentucky (Not to Scale)

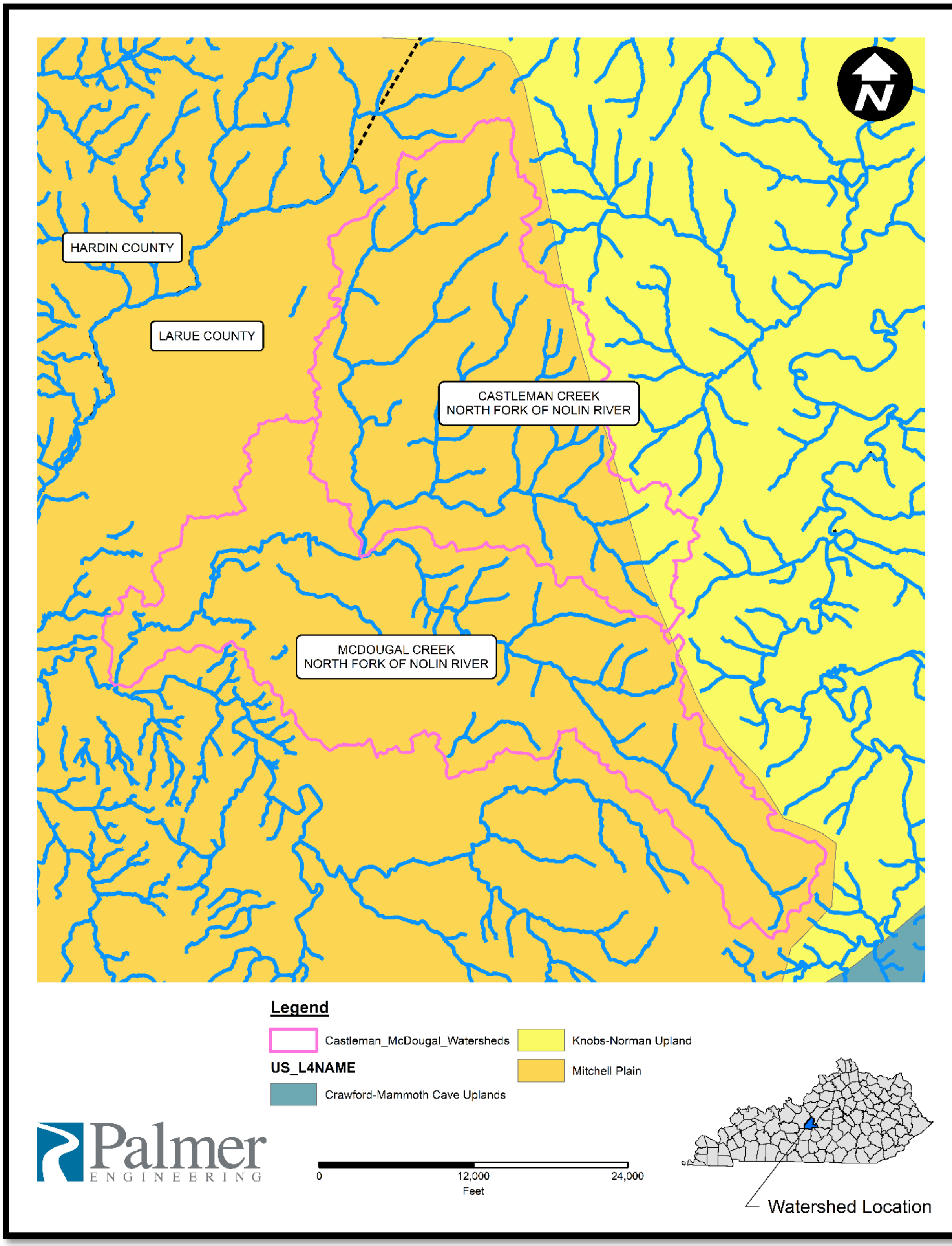



**Figure 11.** Ecoregion Map of MCCW

## 2.4. RIPARIAN/STREAMSIDE VEGETATION

Many streamside areas in the McDougal and Castleman Creek watersheds were observed to have limited riparian buffers/streamside vegetation. These observations make sense given the predominant land uses of cropland and pastureland in the area. Limited streamside vegetation was also observed along reaches of North Fork Nolin River near downtown Hodgenville. Agricultural landowners are financially motivated to utilize every square foot of usable land available to them for crop growth or pasture land because their land is associated with their livelihood. Homeowners in Hodgenville are also motivated to show pride in their property by mowing streamside grass to match the look of the other portions of their lawn. Both instances result in a situation where maintaining a wide riparian buffer is not a priority for the landowner.

The project team prepared a visual representation of the existing conditions of riparian/streamside vegetation in the McDougal and Castleman Creek watersheds. This can be seen in Figure 24 and Figure 25. These maps were a result of a GIS assessment of riparian vegetation and tree canopy which was performed utilizing notes from the visual assessment and aerial imagery. Small pockets of wide riparian area and tree canopy can be observed throughout the watershed. These locations extend roughly 300 feet beyond the streambank. Many of these pockets are adjacent to pasture and crop land. It’s possible this land is not utilized because the slope and soil conditions would not be suitable for growth. Other areas in the watershed have more intentional riparian and forested area adjacent to waterways. Both McDougal Lake and Salem Lake have up to 1,500 feet of forested area on one side, but have no streamside vegetation on the other side. Pearman forest is a dedicated nature preserve in the McDougal Creek Watershed which is adjacent to McDougal Creek on one side. Knobb Creek Conservancy utilizes these areas as part of their trail network.

The average tree cover and riparian/streamside vegetation corridor is approximately 100 feet wide, 50 feet to each side of the stream. This width, as seen on the aerial view, is often mostly tree cover. The presence of a diverse riparian buffer with grasses, shrubs and vines was not widely noted during the visual assessment. Figure 12 is a photo taken along NFNR, downstream of sample site 1 and approximately 4,000 ft upstream of the confluence of North and South Fork Nolin River. In this photo, it is evident that the NFNR streambanks have bare soil with exposed tree roots. Some of these trees appear to be days away from falling over into the river. These banks are vulnerable to undercutting and erosion from high velocity stream flows. Other than the trees, the streambanks are only covered with grass, clover and dead tree limbs. Figure 13 shows two Palmer Engineering employees standing on a mass of undercut soil which has toppled over in to Castleman Creek. This area is near Phillips Lane and had limited riparian buffer width because of the presence of the parallel roadway approximately 30 feet away. This erosion does not pose a threat to the nearby public infrastructure, but it is representative of the potential for significant loss of usable land on public and private streambanks.

**Figure 12.** Downstream North Fork Nolin Riverbank Conditions

**Figure 13**. Massive Streambank Erosion in Castleman Creek at Sample Site 12

## 2.5. THREATENED AND EXOTIC/INVASIVE PLANTS AND ANIMALS

The USFWS online resource Information for Planning and Consultation offers a list of endangered species and their critical habitats as managed by the Ecological Services Program of the USFWS. The endangered species within the MCCW include the following: Grey Bat, Indiana Bat, Northern Long-eared Bat, Clubshell Clam, Fanshell Clab, Longsolid Clam, Orangefoot Pimpleback Pearlymussel, Pink Mucket Pearlymussel, Rabbitsfoot clam, Ring Pink Mussel, Salamander Mussel, Snuffbox Mussel, and Monarch Butterfly.

Bald Eagles, which are protected under the Bald and Golden Eagle Protection Act are also noted to be in the MCCW project area. A list of migratory birds is provided based on which species occur in the USFWS Birds of Conservation Concern list. This list of birds includes the following: Black-billed Cuckoo, Bobolink, Cerulean Warbler, Chimney Swift, Eastern Whip-poor-will, Field Sparrow, Kentucky Warbler, Lesser Yellowlegs, Prairie Warbler, Prothonotary Warbler, Red-headed Woodpecker, Rusty Blackbird, and Wood Thrush.

iNaturalist is an open-source online hub for citizen observers to upload photos they've taken of plants and animals in an area. This information can support and potentially add to the list produced by USFWS. It should be noted that this data has not all been validated. It is possible that a species has been misidentified by the observers or the iNaturalist system. This data is also potentially skewed because observers will be more likely to log finds that stand out to them. The following endangered/threatened species have been photographed in LaRue County by iNaturalist observers: Dark-eyed Junco, Yellow Lady's Slipper, Blue Ash, Compass Plant, and Double-crested Cormorant.

The Kentucky Exotic Pest Plant Council (KY-EPPC), Kentucky affiliate of the Southeast Exotic Pest Plant Council, keeps a list of the most severely invasive plant threats to Kentucky. The project team identified multiple species from this list during their stream site visit. iNaturalist observers have also identified invasive species in the area. The following species have been observed: Bush Honeysuckle, Wild Garlic, Japanese Stiltgrass, and Multiflora Rose.

Many invasive species are considered a threat because their abundance directly reduces the potential for biodiversity of native species. These foreign plants lack natural controls (diseases, predation) which give them an advantage over native species. Foreign plans are often introduced because they display colorful flowers for home gardens but if left uncultivated will cause an imbalance in the ecosystem. For example, Bush Honeysuckle can rapidly invade and overtake a site, altering habitats by decreasing light availability, depleting soil moisture and nutrients, and possibly releasing toxic chemicals that prevent other plant species from growing in the vicinity (KDOW).

## 2.6. HUMAN INFLUENCES AND IMPACTS

The following sections will outline context for the relationship of human impact and the watershed. More detailed information on existing and planned land use in LaRue County can be found in the Land of Lincoln Comprehensive Plan 2017.

### 2.6.1. HISTORICAL CONTEXT AND CULTURAL RESOURCES

The National Register of Historic Places is the United States federal government's official list of districts, sites, buildings, structures, and objects deemed worthy of preservation for their historical significance or "great artistic value." Larue County hosts 31 total items on this register. MCCW hosts 11 of these 31 sites. Figure 14 shows the locations of the National Historic Register sites within McDougal and Castleman Creek watersheds. Predominantly included on this list is the Abraham Lincoln Birthplace National Historic Site, Hodgenville Christian Church, and Hodgenville Commercial Historic District. The Abraham Lincoln Birthplace National Historic Site is a U.S. historic park preserving the Sinking Spring Farm. This site contains a neoclassical memorial building and replica log cabin made to honor Abraham Lincoln, the 16$^{th}$ president of the United States. Hodgenville Christian Church is the oldest church in LaRue county and second oldest building in Hodgenville. The Hodgenville Commercial Historic District is the city center of Hodgenville and contains the historic Statue of Abraham Lincoln. Other historic sites in the watershed include houses of Kentucky state senator Smith and other preserved homes from the late 19$^{th}$ century.

LaRue County was formed from Southeast Hardin County in 1843 by act of the Kentucky Legislature. The county is named after John LaRue, one of the early settlers of Phillip's Fort. Phillip's Fort was established in 1780 and served to protect a mill on the river built by Robert Hodgen in 1788. In 1818, Hodgen's widow, Sarah, petitioned the courts to establish a town called Hodgenville, which officially incorporated as a city in 1893. Hodgenville was named as the county seat of LaRue County in 1843 (Larue County Fiscal Court 2019).

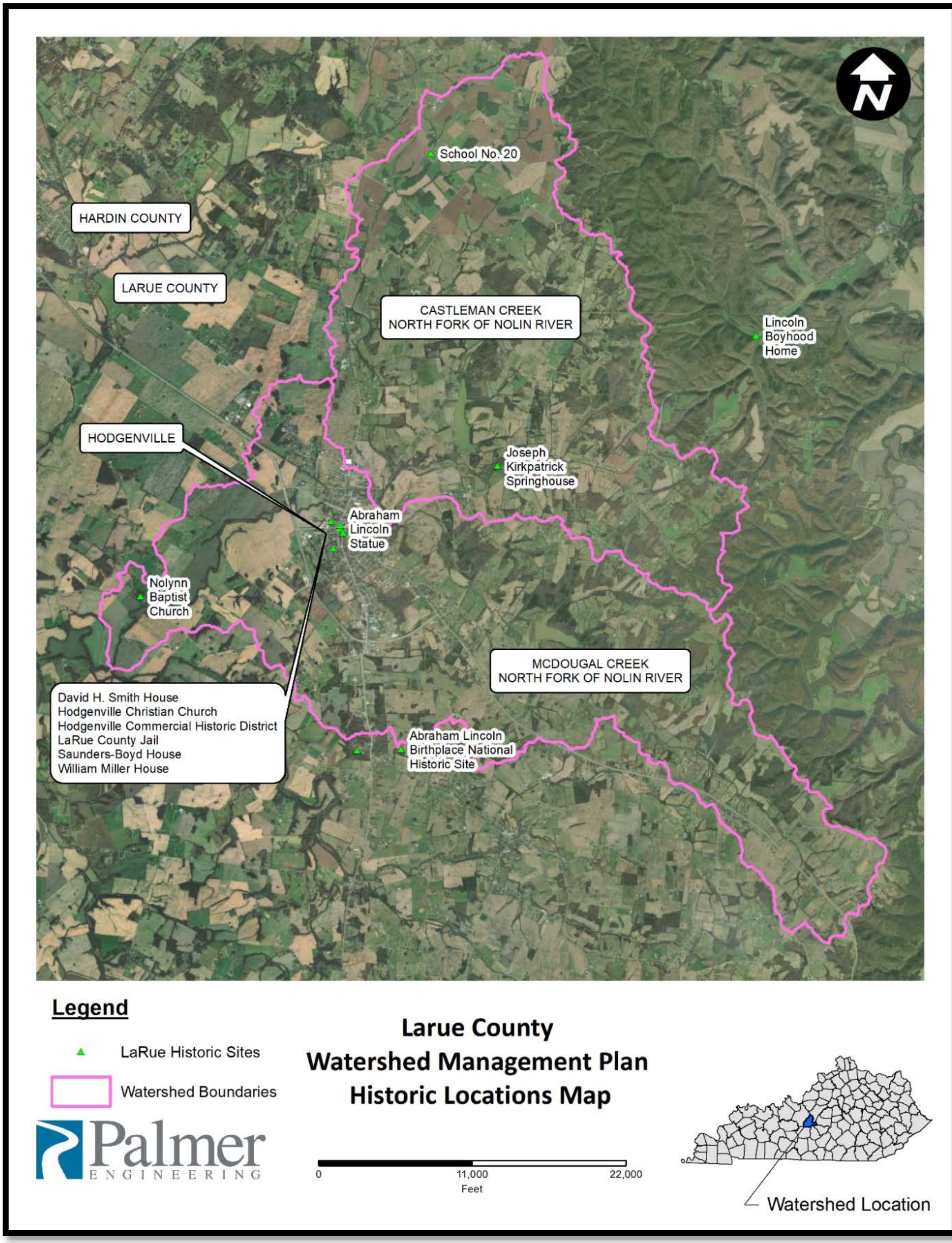



**Figure 14.** National Register of Historic Places Sites in NFNR

### 2.6.2. POPULATION INFORMATION

According to the Kentucky State Data Center in 2011, LaRue County's population was expected to increase 5.41% between 2010 and 2020. As shown in Table 5 U.S. Census data indicated that the county's population only grew 4.75% during that time. Future projections indicate that LaRue County's population will continue to increase beyond 2050 at a decelerated rate.

**Table 5.** LaRue County Population Data and Projections

| | 2010 Census | 2020 Census | 2030 Projection | 2040 Projection | 2050 Projection |
|---|---|---|---|---|---|
| LaRue County | 14,193 | 14,867 | 15,460 | 15,863 | 16,174 |

### 2.6.3. WATER USE

The sources of water for LaRue County are North Fork of Nolin River and Salem Lake. Hodgenville Water Plant, located at 207 E Water St., is a standard and emergency surface water withdraw in the McDougal Creek watershed. This plant is run by Hodgenville Water Works and typically withdraws water from North Fork Nolin River. Salem Lake, located in the Castleman Creek watershed is a surface water withdraw with a standard permit type run by Hodgenville Water Works. Although these two withdraws are in separate subwatersheds, Salem Lake is upstream of North Fork Nolin River and this should be considered as a connected system. The city sources water primarily from pumping from North Fork of Nolin River and only withdraws from Salem Lake as a backup source.

This system serves an estimated 14,797 people in 6,511 households (Kentucky Infrastructure Authority). According to the Lincoln Trail Area Development District's *Water-Resource Development: A Strategic Plan*, as of 1999, 60% of the residents of Larue County are serviced by public water systems. Based on the current estimated service population, and the total population in LaRue County, this percentage is now nearly 100%. The design capacity of the Hodgenville Water Treatment Plant is 0.5 million gallons per day (MGD) with an average daily production of 0.52 MGD. The total annual production is 191.17 million gallons. The system contains 238,884 LF of PVC and ductile iron service pipe. Estimated annual water loss in this system is 6%. LaRue County Water District #1 purchases water from Hodgenville Water Works to help serve LaRue County.

Salem Lake is also used for recreational activities such as fishing and boating. Per article 90, Lake Salem and Lake McDougal Rules and Regulations, of the Hodgenville, Kentucky Code of Ordinances, combustion motors are not allowed for use in the lake, only battery powered motors and engines. No combustible fuels or oil-based substances are allowed on the water at any time. Fishing is permitted in both Salem and McDougal Lake except for grass carp fishing.

### 2.6.4. EXISTING WATERSHED MANAGEMENT ACTIVITIES

No formal comprehensive watershed plan is currently in place for MCCW; however, the Commonwealth of Kentucky, City of Hodgenville, LaRue County, and LaRue County Conservation District have some existing watershed management activities in place in MCCW through regulations and planning documents. The LaRue County Conservation District serves the county by assisting landowners and land users in solving soil and water resource problems, setting priorities for conservation work to be accomplished and coordinating the federal, state and local resources to carry out these programs.

### 2.6.4.1. REGULATIONS AND ORDINANCES

The following regulations and ordinances have been approved and must be followed within the City of Hodgenville and/or LaRue County as noted:

**Storm and Water Drain Connections Prohibited – Code of Ordinances Chapter 51 Section 9 (City of Hodgenville):** "*No storm water drain shall be or remain connected or be connected with any separate sanitary sewer heretofore or hereafter constructed as, or made a part of, the sewer system of the city; nor shall any storm water be otherwise introduced into any such separate sanitary sewer."*

**All Septic Facilities not Connected to Sewers Prohibited – Code of Ordinances Chapter 51 Section 13 (City of Hodgenville):** *"It shall be unlawful for any person to construct or maintain a privy, well, vault cesspool, cistern, septic tank or similar contrivance for the reception of flowable sewage where sewers are available, and all such privies, wells, vaults, cesspools, cisterns, septic tanks, facilities, and similar contrivances shall be removed or disconnected by the owners and the occupants of premises to which sewers are made available in the city as soon as the same are made available to such premises. All such privies, facilities, and other means of casting or depositing sewage into a container above or below the surface of the ground, or upon or into the soil or into any running or percolating stream of water or into any cistern or well, whereby the soil is contaminated with such sewage, are hereby declared to be unlawful and to constitute a nuisance."*

**Unsanitary Deposits of Garbage and Discharge of Sewage or Other Wastes to Non-Sewer Facilities Prohibited – Code of Ordinances Chapter 51 Section 14 (City of Hodgenville):** *"It shall be unlawful for any person to place, deposit or permit to be deposited in any unsanitary manner upon public or private property within the city, any garbage or other objectionable waste, or to discharge to any natural outlet within the city, any sewage industrial wastes, or other polluted waters, except where suitable treatment has been provided under the supervision of the manager or other duly authorized city official."*

**Unlawful Discharge to Storm Sewers or Natural Outlets – Code of Ordinances Chapter 52 Section 16 (City of Hodgenville):** *"It shall be unlawful to discharge to any natural outlet or storm sewer within the city or in any area under the jurisdiction of said city, any sanitary waste water or other polluted waters, except where suitable treatment or management has been provided in accordance with subsequent provisions of this chapter."*

**Discharge of Unpolluted Waters Into Sewers – Code of Ordinances Chapter 52 Section 18 (City of Hodgenville):** *"*No person(s) shall discharge or cause to be discharged, through any leak, defect or connection any unpolluted waters such as storm water, ground water, roof runoff or subsurface drainage to any sanitary sewer, building sewer, building drain or building plumbing. The Superintendent or his or her representative shall have the right, at any time, to inspect the inside or outside of buildings or smoke test for connections, leaks or defects to building sewers and require disconnection or repair of any pipes carrying such water to the building sewer. No sanitary drain sump or sump pump discharge by manual switch-over of discharge connection shall have a dual use for removal of such water."

**Prohibited Discharges – Code of Ordinances Chapter 52 Section 19 (City of Hodgenville):** *"No user shall contribute or cause to be contributed, directly or indirectly, any pollutant waste water which will interfere with performance of the Publically Owned Treatment Works (POTW). A user shall not contribute* *the following substances to the POTW: Any liquids, solids or gases which by reason of their nature or quantity are, or may be, sufficient either alone or by interaction with other substances to cause fire or explosion or be injurious in any other way to the POTW or to the operation of the POTW. At no time shall the waste water exhibit a closed cup flashpoint of less than 140°F or 60°C using the test methods specified in 40 C.F.R. § 261.21; Any waters or wastes having a pH lower than five or higher than ten or having any other corrosive property capable of causing damage or hazard to structures, equipment and personnel of the POTW; Any slug load of pollutants, including oxygen demanding pollutants (BOD and the like) released at a flow rate and/or concentration that will cause interference with the normal operation of the POTW; Solid or viscous substances in quantities or of such size capable of causing obstruction to the flow in sewers, or other interference with the proper operation of the waste water facilities (i.e., wood, glass, ashes, sand, cinders, unshredded garbage, paper products such as cups, dishes, napkins and milk containers and the like); Any waste water having a temperature which will inhibit biological activity in the POTW treatment plant resulting in interference, but in no case waste water with a temperature at the introduction into the POTW that will result in a treatment plant influent temperature which exceeds 40°C (104°F); Any pollutant(s) which result in the presence of toxic gases, vapors or fumes within the POTW in a quantity that may cause acute worker health and safety problems; Any substance which may cause the POTW's effluent or any other product of the POTW such as residues, sludges or scum, to he unsuitable for reclamation and reuse or to interfere with the reclamation process where the POTW is pursuing a reuse and reclamation program. In no case shall a substance discharged to the POTW cause the POTW to be in non-compliance with sludge use or disposal criteria, guidelines or regulations developed under § 405 of the Act; any criteria, guidelines or regulations affecting sludge use or disposal developed pursuant to the Solid Waste Disposal Act being 42 U.S.C. §§ 6901 et seq., the Clean Air Act being 42 U.S.C. §§ 7401 et seq., the Toxic Substances Control Act being 15 U.S.C. §§ 2601 et seq. or state criteria applicable to the sludge management method being used; Any substance which will cause the POTW to violate its NPDES/KPDES permit and/or sludge disposal system permit; Petroleum oil, non-biodegradable cutting oil or products of mineral oil origin in amounts that will cause interference or pass through at the POTW; and/or Any trucked or hauled pollutants except at discharge points designed by the POTW."*

**Pollution Discharge Limits, Restricted Discharges – Code of Ordinances Chapter 52 Section 61 (City of Hodgenville):** *"Waste water containing more than 50 milligrams per liter of petroleum oil, non-biodegradable cutting oils or products of mineral oil origin; Waste water containing floatable oils, fat or grease, whether emulsified or not, in excess of 100 milligrams per liter (100 mg/l) or containing substances which may solidify or become viscous at temperatures 32-150°F (0-65°C); Any garbage that has not been properly shredded. Garbage grinders may be connected to sanitary sewers from homes, motels, institutions, restaurants, hospitals, catering establishments or similar places where garbage originates from the preparation of food in kitchens for the purpose of consumption on the premises or when served by caterers; Any waste water containing toxic pollutants in sufficient quantity, either singly or by interaction with other pollutants which: injure or interfere with any waste water treatment process; constitute a hazard to humans or animals; causes the city to violate the terms of its KPDES permit; prevents the use of acceptable sludge disposal methods; or exceed a limitation set forth in a categorical pretreatment standard; Any radioactive wastes or isotopes of such half-life or concentration as may exceed limits established by the city in compliance with applicable state and federal regulations; Any water or wastes which by interaction with other water or wastes in the public sewer system, release obnoxious gases, form suspended solids which interfere with the collection system or create a condition deleterious to structures and treatment processes; Any waste water with objectable color which cannot be removed to an acceptable level within the operation of the waste water treatment process; Waters or wastes containing substances which are not amendable to treatment or reduction by the waste water* *treatment processes employed to the extent required by the city's NPDES/KPDES permit; Any waste(s) or waste water(s) classified as a hazardous waste by the Resource Conservation and Recovery Act (RCRA) without a 60-day prior notification of such discharge to the Superintendent. This notification must include the name of the hazardous waste, the EPA hazardous waste number, type of discharge, volume/mass of discharge and time of occurrence(s). The Superintendent may prohibit or condition the discharge(s) at any time; Waste water identified as causing, alone or in conjunction with other sources, the treatment plant's effluent to fail a toxicity test; Recognizable portions of human or animal anatomy; Any wastes containing detergents, surface active agents or other substances which will cause excessive foaming in the municipal waste water system; Any water or wastes which have characteristics based on a 24-hour composite sample, grab or a shorter period composite sample, if more representative, that exceed the following normal maximum domestic waste water parameter concentrations in Table 6:*

**Table 6.** Hodgenville Pollutant Discharge Limits

| Parameter | Maximum Allowable Concentration Without Surcharges |
|---|---|
| BOD | 250 mg/l |
| COD | 375 mg/l |
| TSS | 250 mg/l |
| NH3-N | 40 mg/l |
| Oil and grease [total] | 100 mg/l |

**Industrial User Discharge Permits – Code of Ordinances Chapter 52 Section 80 (City of Hodgenville):** *"All significant industrial users proposing to connect to or to contribute to the POTW shall obtain an industrial user permit before connecting to or contributing to the POTW."*

**Local Administrator; Powers and Duties – Code of Ordinances Chapter 152 Section 25 (City of Hodgenville):** *"*The duties and responsibilities of the Floodplain Administrator shall include, but not be limited to the following: The proposed development does not adversely affect the carrying capacity of affected watercourses. For purposes of this chapter, ADVERSELY AFFECTS means that the cumulative effect of the proposed development when combined with all other existing and anticipated development will increase the water surface elevation of the base flood more than one foot at any point. Review and use of any other base flood data. When base flood elevation data has not been provided in accordance with § 152.07 of this chapter, the Floodplain Administrator shall obtain, review and reasonably utilize any base flood elevation and floodway data available from a federal or state agency, or other source, in order to administer §§ 152.40 through 152.46 of this chapter."

**Development Permit – Code of Ordinances Chapter 152 Section 26 (City of Hodgenville):** *"*A development permit shall be obtained before any construction or other development begins within any special flood hazard area established in § 152.07 of this chapter. Application for a development permit shall be made on forms furnished by Floodplain Administrator prior to any development activities, and may include, but not be limited to, the following: plans in duplicate drawn to scale showing the nature, location, dimensions and elevations of the area in question; ...ILLEGIBLE TEXT... the foregoing. Endorsement of the local Administrator is required before a state floodplain construction permit can be processed. Specifically, the following information is required. Description of the extent to which any watercourse will be altered or relocated as a result of proposed development.

**Flood Hazard Reduction, General Construction Standards – Code of Ordinances Chapter 152 Section 40 (City of Hodgenville):** "In all special flood hazard areas, the following provisions are required. Within Zones AH or AO, so that there are adequate drainage paths around structures on slopes to guide flood waters around and away from proposed structures. New and replacement water supply systems shall be designed to minimize or eliminate infiltration of flood waters into the system. New and replacement sanitary sewage systems shall be designed to minimize or eliminate infiltration of flood waters into the systems and discharges from the systems into flood waters.

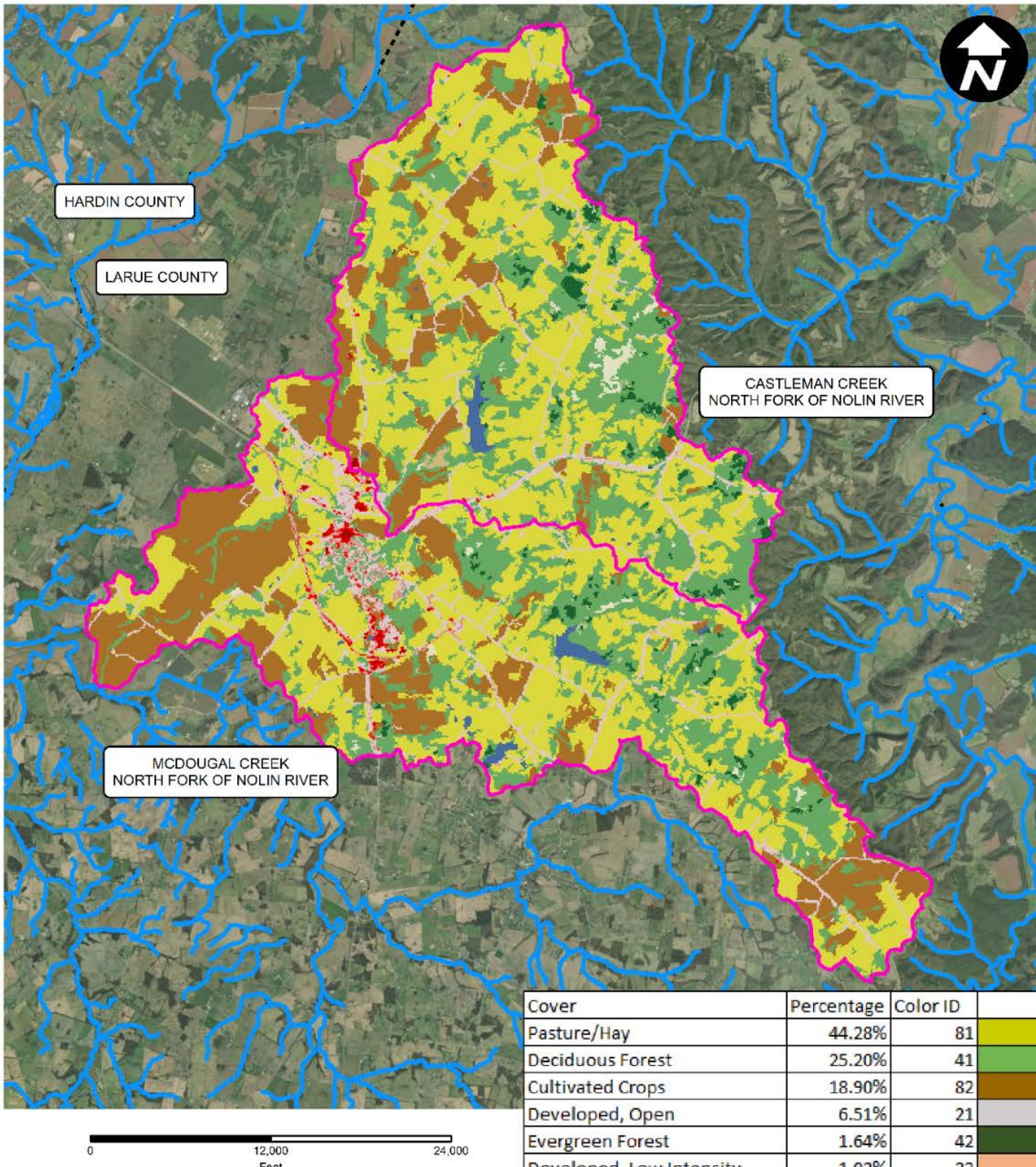
#### 2.6.4.2. KENTUCKY AGRICULTURE WATER QUALITY PLANS

In 1994, the Kentucky General Assembly passed the Kentucky Agriculture Water Quality Act (AWQA) to protect surface and groundwater resources from pollution as a result of agriculture and silviculture (forestry) activities. The Kentucky Agriculture Water Quality Act requires development of a Kentucky Agriculture Water Quality Act Plan by all landowners with 10 or more acres that are being used for agriculture or silviculture. The development, implementation, and revision of the Kentucky Agriculture Water Quality Plan for each property is the sole responsibility of the landowner, according to the KDOW website. All AWQA Plans in Kentucky should address BMPs dealing with silviculture, pesticides and fertilizers, farmstead, crops, livestock, streams, and other waters. In 2020, the statewide Kentucky AWQA Plan was updated by the Agriculture Water Quality Authority. In 2021, the Energy and Environment Cabinet (EEC) and Agriculture Water Quality Authority worked together to update the AWQA Planning Tool based on this statewide plan. More information about AWQA Plans, the Planning Tool (and user guide), and approved BMPs is available at the EEC Agriculture Water Quality Act webpage (https://eec.ky.gov/Natural-Resources/Conservation/Pages/AgWaterQualityPlan.aspx).

### 2.6.5. LAND USE

Primary land uses in MCCW include pasture, deciduous forest, cultivated crops, and developed (open). Outside of the city limits of Hodgenville, a majority of land is agricultural or forest. Overall, pasture is the most dominant land use with 44% of the total area. Deciduous forest is 25%, cultivated crops is 19% and total developed area of all intensities makes up 8%. Pastureland is concentrated throughout the watershed and most dominant in the central areas while deciduous forest is mostly concentrated in areas on the east side of the watershed. This area includes Pearman Forest and forests around Salem and McDougal Lakes. Cultivated crops are concentrated on the east edge and west tip of the McDougal Creek Watershed. Figure 15 shows the area and location of land use in MCCW.

As of 2020, the City of Hodgenville had 1,344 acres within its city limits. As the county seat and primary growth area in LaRue County, Hodgenville is the only incorporated city within LaRue County. Most of the city, as well as some areas immediately surrounding the city boundaries, are developed.




| Cover | Percentage | Color ID | |
|---|---|---|---|
| Pasture/Hay | 44.28% | 81 | |
| Deciduous Forest | 25.20% | 41 | |
| Cultivated Crops | 18.90% | 82 | |
| Developed, Open | 6.51% | 21 | |
| Evergreen Forest | 1.64% | 42 | |
| Developed, Low Intensity | 1.02% | 22 | |
| Open Water | 0.84% | 11 | |
| Grassland/Herbaceous | 0.64% | 71 | |
| Developed Medium Intensity | 0.45% | 23 | |
| Mixed Forest | 0.24% | 43 | |
| Developed, High Intensity | 0.14% | 24 | |
| Shrub/Scrub | 0.13% | 52 | |
| Barren land (Rock, Sand, Clay) | 0.01% | 31 | |

**Figure 15.** LaRue County Land Use Map

The Knob Creek Conservancy is an active conservation group in Larue County. This group maintains public hiking trail networks throughout the county. In the NFNR, this network includes the McDougal Lake Trails, the Hodgenville Elementary School Nature Trail, and Larue County Environmental Education and Research Center Trails at Pearman Forest. The National Park Service maintains the Abraham Lincoln Birthplace and Knob Creek Boyhood Home. Each of these locations have multiple trails where the public can enjoy hiking, trail running, mountain biking, and geocaching. Some trails have designated campsites. McDougal Lake and Salem Lake are open to the public for fishing, boating, and camping. Only non-gasoline powered boats (paddle, row, or boats with electric trolling motors) are permitted for use.

In 2017, the Land of Lincoln Planning Commission and Lincoln Trail Area Development District authored the Land of Lincoln Comprehensive Plan. The plan is intended to provide a comprehensive policy framework that can be used to manage and direct future developments in Hodgenville and LaRue County. The plan encourages guiding growth to existing population centers and limiting growth in the outlying rural areas of the county. This is meant to enable effective service of public water, fire and police protection to the maximum number of residents. The plan encourages residential development to occur in well drained areas removed from flood prone areas. Commercial development is encouraged to include landscaping and screening zones. The plan encourages development of standards to reduce pollution from industrial development.

### 2.6.6. LAND DISTURBANCES

Land disturbance within MCCW mainly results from new development and infrastructure projects. During the time of KDOW sampling, there were 9 active KPDES permits indicating highway and street construction in the boundary of MCCW. These projects include development of medical facilities, convenience stores, school improvements, and housing development. These projects are all focused around the City of Hodgenville. The city is expected to continue growing, so land disturbance from new construction is expected to continue.

All new developments in the city must obtain a development permit before any construction begins if they are within a special flood hazard area. This is detailed in the Hodgenville Code of Ordinances chapter 152 section 26. The permit includes language on the extent to which the development will alter or relocate any watercourse. These permits are reviewed by the Floodplain Administrator who is responsible for ensuring that the proposed development does not adversely affect the carrying capacity of nearby watercourses.

### 2.6.7. OTHER WATER DISTURBANCES

Other disturbances to the stream include livestock grazing, residential lawn and garden maintenance, and stormwater runoff. Livestock have direct access to portions of MCCW and its tributaries throughout the watershed. Impacts occur in areas where livestock have direct access to the stream causing bank trampling and direct input of pollutants through fecal matter. To help try to eliminate direct access to the stream by livestock, fences have been installed in some locations. The fences were originally installed at no cost to the owner, but after installation the owner is responsible for maintenance and repairs. Due to the high flows, flooding potential, and areas of limited floodplain access, fence maintenance and repair is a major concern for property owners. The fences that have been installed show evidence of damage due to high flows and/or large debris. Figure 16 depicts damage to an existing fence installed across a tributary to McDougal Creek. In areas where there is no direct access, runoff from pasture lands flows into MCCW and its tributaries. Stormwater runoff from the pastures may contain pollutants from livestock fecal matter or contaminants from fertilizers and pesticides used to maintain the pastures. Standard farming practices in MCCW often includes maximizing all possible farmable land. Farmers will remove natural riparian buffers to gain more farmland. The pollutants and contaminants in stormwater runoff are an even larger concern in areas with limited riparian vegetation because there is little opportunity for the pollutants and contaminants to be filtered out prior to entering the stream. The absence of the riparian buffer increases the impact of the excess fertilizer and pesticides within the stormwater runoff due to reduced opportunity for slowing the velocity of the water and infiltration. Infiltration will naturally remove some of the pollutants that cause adverse impacts to streams.

**Figure 16.** Fence Damage on Tributary to McDougal Creek

The City of Hodgenville makes up a small part of the center of the watershed. This area experiences more issues typical of urban areas than the rest of the watershed does. In Hodgenville, dog waste was observed in yards backing up to NFNR. In addition to dog waste, residents reported over fertilization in yards that can result in excess nutrients in the watershed. Homeowners take pride in their property and use chemicals to eliminate weeds and pests from pervious areas. While these chemicals may be useful when applied in moderation and according to proper procedures, excessive and/or improper usage can lead to polluted stormwater runoff entering NFNR. Property owners may also feel that the unkempt appearance of a natural riparian buffer is aesthetically unappealing. This has led to the removal of the riparian buffer behind homes in Hodgenville adjacent to NFNR. The natural riparian buffers have been replaced with short, manicured grass.

## 2.6.8. POINT SOURCE DISCHARGES

An open records request from KDOW, completed in November 2022, indicated 11 active Kentucky Pollutant Discharge Elimination System (KPDES) permits in the MCCW. Four of these permits were active during the period of data collection but have since been terminated. Ten permit sites are within the McDougal Creek Watershed. One permit site, the Hodgenville-Summersville 69kV Transmission Line Rebuild Project is in the Castleman Creek Watershed. Two permit sites are located in downtown Hodgenville for water and sewer systems. All remaining permit sites are for highway and street construction and are clustered around the intersection of Lincoln Parkway and Lincoln Farm Road. No known violations of these permits are known. Table 7 provides a list of KPDES permits with a map ID to correlate with the points in Figure 17.

**Table 7.** KDOW KPDES Permits in MCCW

| Map ID | Facility Name | Permit Description | Original Issue Date | Expiration Date | Termination Date |
|---|---|---|---|---|---|
| 1 | Hodgenville STP | Sewerage Systems | 11/3/2003 | 1/31/2023 | |
| 2 | Hodgenville, City of | Water Supply | 8/19/2004 | 7/31/2023 | |
| 3 | HMH Hodgenville | Highway And Street Construction | 6/25/2018 | 11/30/2019 | 4/13/2022 |
| 4 | Valero Convenience Store | Highway And Street Construction | 8/6/2018 | 11/30/2019 | 5/21/2021 |
| 5 | LaRue County High School Phase 1 Football Stadium & Greenhouse | Highway And Street Construction | 8/16/2019 | 11/30/2019 | 4/13/2022 |
| 6 | Dollar General | Highway And Street Construction | 10/16/2019 | 11/30/2019 | 6/11/2021 |
| 7 | Hodgenville-Summersville 69kV Transmission Line Rebuild Project | Highway And Street Construction | 5/26/2021 | 11/30/2024 | |
| 8 | AutoZone #5637 | Highway And Street Construction | 3/15/2022 | 11/30/2024 | |
| 9 | Justin Ward Property | Highway And Street Construction | 3/15/2022 | 11/30/2024 | |
| 10 | Strange Rd at Lincoln Parkway | Highway And Street Construction | 4/19/2022 | 11/30/2024 | |
| 11 | CID 22-4426 Safety Improvements at Hodgenville Elementary | Highway And Street Construction | 7/14/2022 | 11/30/2024 | |

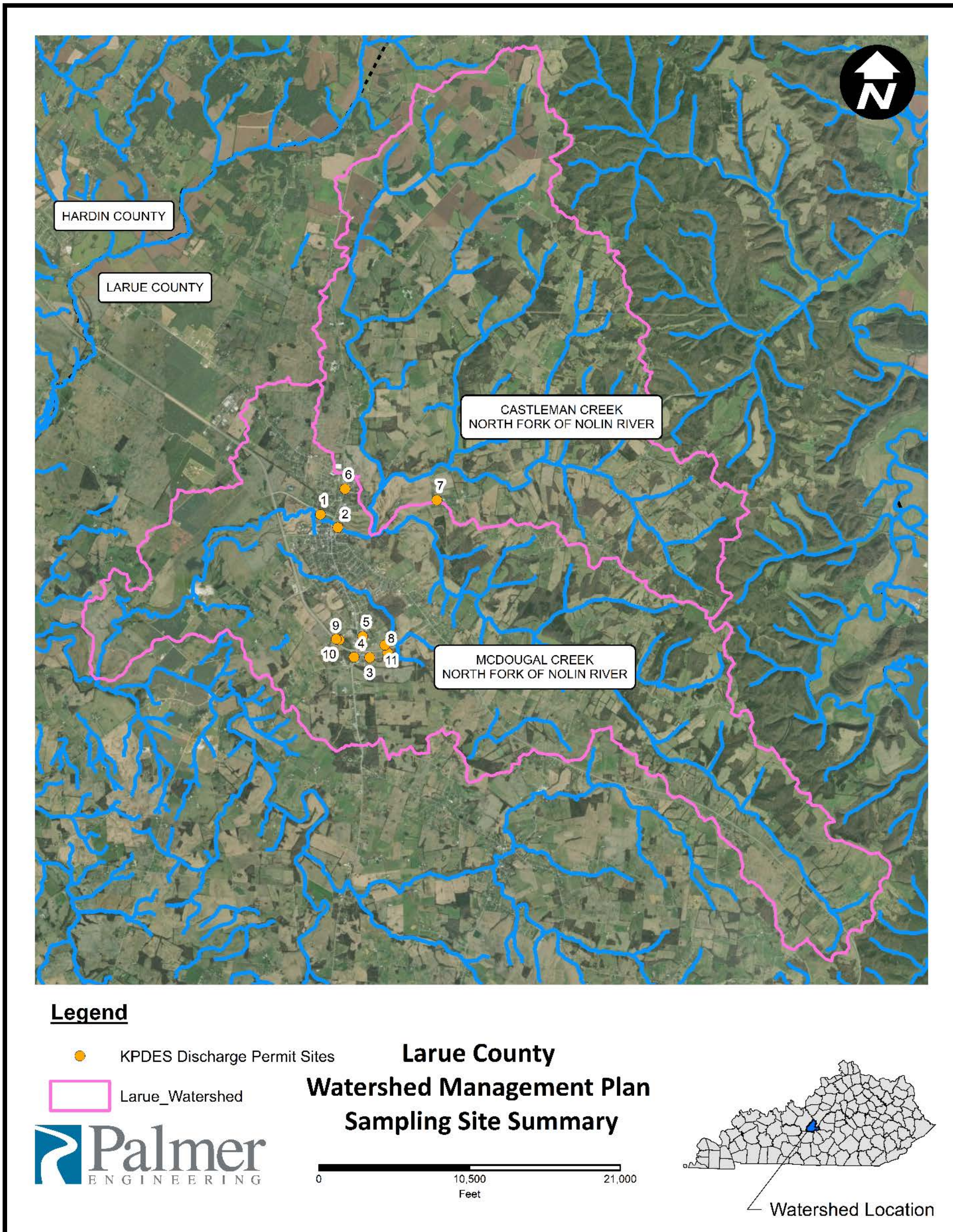



**Figure 17.** KDOW KPDES Permits in MCCW Map

### 2.6.9. HAZARDOUS MATERIALS

The discharge of hazardous material to MCCW is prohibited by the City of Hodgenville, LaRue County, and the State of Kentucky. A prohibited discharge ordinance (Code of Ordinances, Chapter 52, Section 19) has been enacted by the City of Hodgenville to protect residences from substances dangerous to human health that may contaminate the water. As of October 2023, the City of Hodgenville had no reported instances of illicit discharge. It is possible, however, that illicit discharges have taken place but were not reported.

## 2.7. DEMOGRAPHIC AND SOCIAL ISSUES

The demographics of MCCW can indicate how the watershed might develop and where the most impact can be made. As previously discussed in Section 2.6.2, the population for LaRue County increased by 4.75% between 2010 and 2020. The population increased slightly more than the overall state of Kentucky, which increased by 3.92%. Table 8 contains a summary of the US Census Bureau data available for the Larue County, and Kentucky. The census data indicates that LaRue County has lower averages in high school graduation, higher education, median household income, and persons below poverty line. Home ownership rate is higher in LaRue County than the state average.

Farming is a large and vital part of MCCW. According to the 2017 Census of Agriculture published by the United States Department of Agriculture, there are 718 farms in LaRue County totaling 110,371 acres. The median farm size is 50 acres and the average market value of products sold was $57,259 per farm. Crop sales made up 79% of the market value of the products sold. The National Agricultural Statistics Service counted 28,345 cattle in LaRue County in 2017, indicating almost two times more cattle than humans in the county. It is important to consider the potential impact that future projects within the watershed will have on farms and the way they conduct their operations.

**Table 8.** LaRue County Census Data Summary

| | *LaRue County* | *Kentucky* |
|---|---|---|
| *2020 Population* | 14,867 | 4,509,394 |
| *2010 Population* | 14,193 | 4,339,367 |
| *2010 to 2020 Population Growth* | 4.75% | 3.92% |
| *Average Household Size* | 2.42 | 2.48 |
| *High School Graduates* | 83.70% | 87.20% |
| *Bachelor's Degree or Higher* | 15.30% | 25% |
| *Median household Income* | $48,495 | $52,238 |
| *Per Capita Yearly Income* | $24,231 | $29,123 |
| *Persons Below Poverty Line* | 14.70% | 16.50% |
| *Home Ownership Rate* | 76.20% | 67.60% |

Many citizens in LaRue County, farmers in particular, have expressed a generational understanding of the relationship between human intervention and water quality. For example, where suburban homeowners may apply an excess of fertilizer to their front lawns, farmers understand exactly which fertilizer to apply and at what amounts to get the highest crop yield. Farmers will avoid applying an excess of fertilizer to save costs. Many farmers are already practicing BMPs which have been developed and passed down over generations. Some members of the community may not realize that their practices are already impacting water quality. It will be important to rely on this inherent understanding to further enhance the community's understanding of water quality issues.

The project team has observed some examples where education on water quality issues may be helpful. The project team observed multiple instances of dog droppings in backyards adjacent to the stream. Property owners may not be aware that this is harmful to the stream or continue to do so because of learned behaviors. Education on Riparian buffer establishment, maintenance, and benefits would be helpful as it was observed that many property owners have very little to no riparian buffer along streams on their land. Outreach efforts have recently begun in an effort to inform the public on water quality issues.

## 2.8. FIELD OBSERVATIONS

A visual assessment of MCCW was completed by Palmer Engineering on March 23 and April 3, 2023. This visual assessment was completed by walking chosen observation points along MCCW. Observation points were chosen based on prior sampling locations as well as notable features in the watershed such as lakes and confluences. Prior to the visual assessment, letters were sent to property owners to obtain permission to enter their property for the assessment. Some of the property owners did not grant permission or were nonresponsive, so these properties could not be directly assessed. The purpose of this assessment was to observe and photograph the creek channel; note areas of interest, such as severe bank erosion; characterize stream bed substrate and areas of high bed load; locate tributary confluences; and identify potential impacts to the stream water quality and degradation.

For the sake of discussion, MCCW had been divided into four sections. The first section is the confluence of North Fork Nolin River and McDougal Creek to the most downstream part of North Fork Nolin River. The second section is from the most upstream part of McDougal Creek subwatershed to the confluence of McDougal Creek and North Fork Nolin River. The third section is from the most upstream part of North Fork Nolin River to the same confluence. Lastly, the fourth section is from the most upstream point in Castleman Creek to the confluence of Castleman Creek and North Fork Nolin River. The order of these sections was determined by the order of sampling points by KDOW. Figure 18 below shows a map of the locations of these sections.

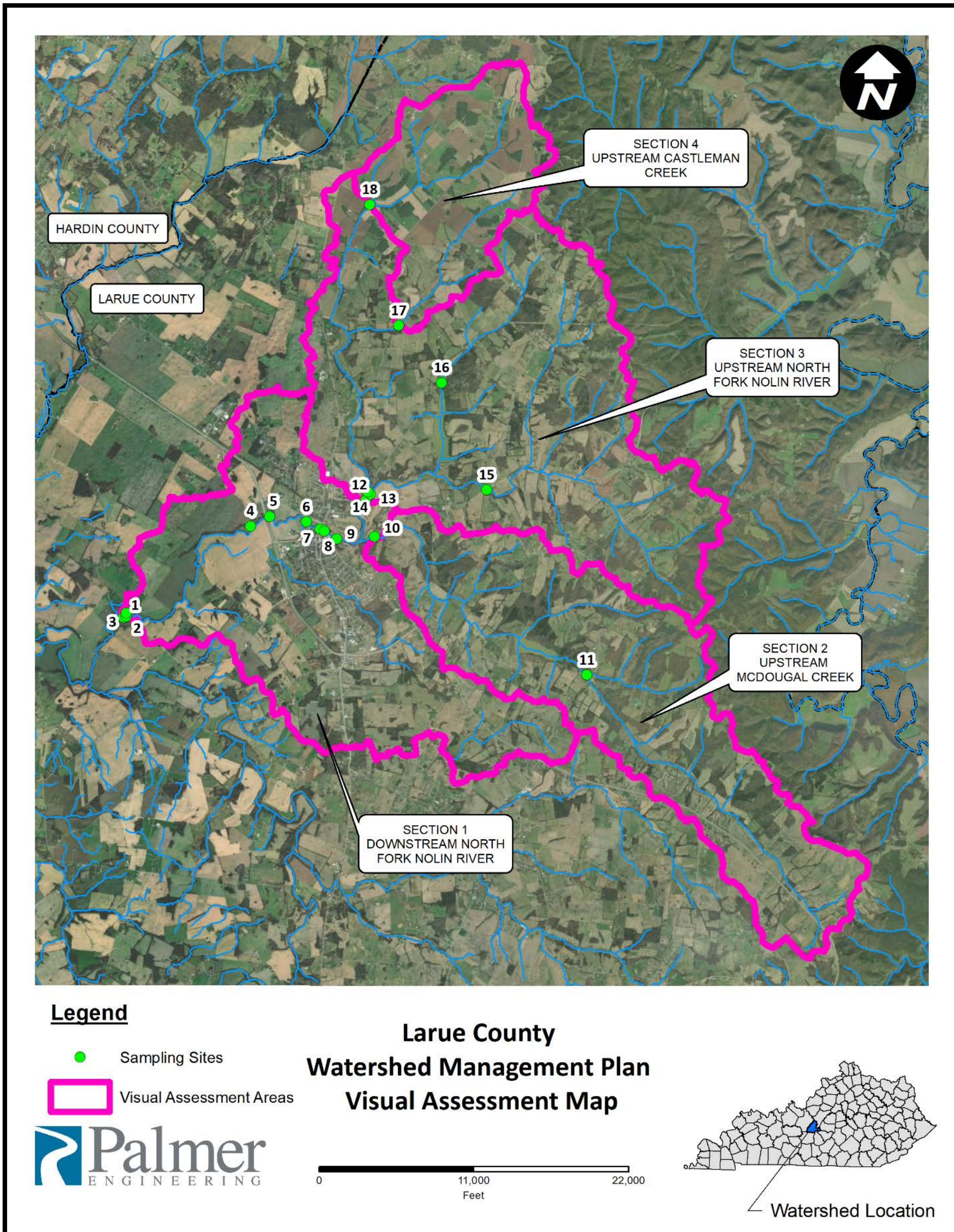



**Figure 18.** MCCW Visual Assessment Map

### 2.8.1. SECTION 1 – DOWNSTREAM NORTH FORK NOLIN RIVER

Section 1 begins at the confluence of McDougal Creek and North Fork Nolin River and continues to the most downstream part of the watershed. KDOW sampling sites 1-9 are in this section of the watershed. The stream bed of Section 1 consists primarily of sand and gravel. The stream banks are mostly eroded and incised with the exception of lower flow areas with less erosion. Vegetation was dominated by large deciduous trees and invasive bush honeysuckle and multifloral rose. Due to it being the most mature section, this part of the watershed predominately had typical pool and riffle structure.

Section 1 features diverse land use as this part of the watershed is comprised of both farmland and the City of Hodgenville. It was noted that at the most downstream point of NFNR the most prominent land cover was grain crop. There is sparse riparian area in this section. Mowing and farming practices were often nearly up to the edge of the stream leaving little to no room for riparian growth and habitat. Continuing upstream, the North Fork Nolin River passes through downtown Hodgenville. Some notable infrastructure along NFNR in town is the Hodgenville Water Plant, which treats water from NFNR for drinking water, and the Hodgenville City Waste Water Treatment Plant which releases effluent into NFNR. This is the most urban area within the watershed and therefore has urban pollutants. Trash, dog waste, and car oil were all urban pollutants observed near the banks of NFNR. On the other side of NFNR from the wastewater treatment plant is Creekfront Park, a public park that provides the community with access to walk along NFNR. Dredging of the creek bed was identified in Creekside Park. Noticeable stream characteristics within Hodgenville include little to no riparian area and more incising than the agricultural area of this section.

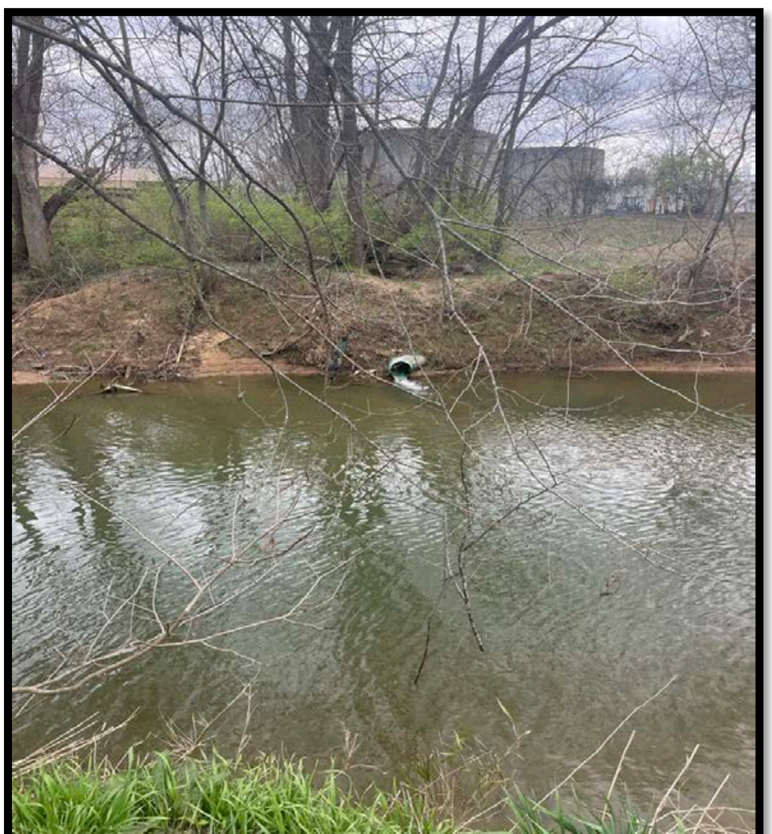


**Figure 19.** Wastewater Effluent into NFNR

### 2.8.2. SECTION 2 - UPSTREAM MCDOUGAL CREEK

Section 2 is the subwatershed from the most upstream part of McDougal Creek watershed to the confluence with NFNR. Sampling points 10 and 11 are within this portion of the watershed. Similar to downstream NFNR, McDougal Creek varies from sandy silty substrate to rocky substrate with deciduous tree and invasive bush honey suckle and multifloral rose vegetation. The land use in this section is dominated by cattle pastures and cropland. It was observed that in most cases where McDougal Creek passed through cattle pasture, cattle had direct access to the stream. There are multiple sections of cattle fencing that had fallen into the stream or were in disrepair. It is likely that bacteria is a pollutant in this section of the watershed due to unrestricted livestock access to the stream. The most notable water infrastructure in this section is McDougal Lake. McDougal Lake is used primarily for fishing recreation, but it is also a back-up drinking water supply for the people of Hodgenville. At the second Watershed Council public meeting, it was noted that McDougal Lake experiences concentrated algal blooms which make it impossible to utilize the drinking water source. The presence of McDougal Lake in the watershed alters the steam characteristics downstream. Upstream of McDougal Creek the stream bed is rockier and the channel is shallow. Downstream of McDougal Lake stream beds are silty-sand and are much deeper with slightly more unstable banks due to the outlet control structure shown in Figure 20.

**Figure 20.** McDougal Lake Outlet Structure

### 2.8.3. SECTION 3 - UPSTREAM NORTH FORK NOLIN RIVER

Section 3 is the most upstream reach of NFNR to the confluence of NFNR and McDougal Creek. Sampling points 12, 13, 14, 15, and 16 are within this section of the watershed. This section of watershed is characterized as having very silty, easily erodible substrate. There are heavily eroded banks along NFNR and large point bars/sedimentation islands were observed. Although tree damage and damming is present throughout the entire watershed, it is most damaging in this section. The most notable infrastructure in this section of the watershed is Salem Lake. Salem Lake was originally designed to be a flood control device for the City of Hodgenville. It now also serves as one of the drinking water sources for the community. Pollutants such as trash and oils and evidence of beavers were observed in and around Salem Lake. The upstream tributary of Salem Lake has stable banks with no erosion. The downstream end has unstable banks with more erosion. Downstream of Salem Lake has red, clay-like soils. The confluence of NFNR and McDougal Creek is behind properties at 530 E. Main St. There is heavy sedimentation and debris obstructing stream flow at the confluence of NFNR and McDougal Creek, as shown in Figure 21. Banks are not as incised in this area as in the downstream portions of the watershed.

**Figure 21.** NFNR and McDougal Creek Confluence

### 2.8.4. SECTION 4- UPSTREAM CASTLEMAN CREEK

Section 4 is defined as the most upstream reach of Castleman Creek to its confluence with NFNR. Sampling points 17 and 18 are within this section of the watershed. There is varied land use within the Castleman Creek watershed. The northernmost part of the watershed is residential with small houses on large lots. Houses are spaced out with interspersed forested areas. The stream in this area is small, has a bedrock bottom, and is heavily eroded. In the central portion of this section, land use transitions to predominately cattle pastures. Similar to other areas of the watershed, there is little to no riparian area and cattle fencing is in need of repair. Large populations of cattle have full access to the stream. The stream in this section has a bedrock bottom but is wider and the banks have little to moderate erosion. Among the cattle farms there are private ponds that are draining to tributaries of Castleman Creek. Vegetation in this section was similar to other sections of the watershed. The confluence is shown in Figure 22.

**Figure 22.** NFNR and Castleman Creek Confluence

## 2.9. CONCLUSIONS FROM EXISTING DATA

The existing data collection and review indicates that MCCW has a rich agricultural history with a past of dairy farming, beef cattle farming, and row crop farming. The watershed is filled with beautiful scenery and unique geologic formations, providing an ideal opportunity for public engagement with nature. The McDougal and Castleman Creek Watersheds are vital to the community as their main drinking water supply. Many in the watershed depend on using the land they own for their livelihood, so remaining sensitive to that during review of potential objectives and Action Items is pertinent. Many people in the community have shown an interest in potential BMPs that may be recommended as result of this plan, including the development and maintenance of riparian area throughout the watershed. The existing data indicates concerns with water quality due to pollutants entering the waterways, primarily from nonpoint sources with added challenges due to karst topography in the area. Through the implementation of measures in the nearby Bacon Creek Watershed, the community is primed for continued water quality improvements through implementing measures in the MCCW.

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# 3. MONITORING

## 3.1. MONITORING OVERVIEW

An integral part of the development of the MCCWMP is the review of existing monitoring data. Kentucky Division of Water collected data in MCCW as part of the 2018 & 2019 Total Maximum Daily Load (TMDL) Monitoring in North Fork Nolin River. This study included field and lab water quality data, *E. coli* measurements, and habitat and biology assessments. Phase I monitoring, in 2018, sampled 13 locations throughout the watershed in an effort to confirm pollutant concentrations and probable sources of pollutants within the main stem and larger tributaries of NFNR. Phase II sampling in 2019 included eight locations; four of these locations were repeated from Phase I, and four were newly identified for Phase II. Phase II focused on characterizing the conditions above and below Nolynn Spring, Nolynn Spring proper, above the Wastewater Treatment Plant (WWTP) and above the Water Treatment Plant (WTP). This phase also included an attempt to capture water quality conditions in North Fork Nolin main stem above and below where it sinks and loses flow to the spring drainage area. The KDOW 2018 & 2019 TMDL reports are included in APPENDIX B. The results from the KDOW sampling led to listings of McDougal Creek, Castleman Creek, North Fork Nolin River, and Salem Lake as impaired in the 2022 303(d) list mentioned previously in Chapter 2. These reports further outline the methods used in data collection and management.

Water chemistry measurements include: acidity, alkalinity (as CaCO3), aluminum, ammonia (as N), antimony, arsenic, barium, beryllium, bromide, cadmium, calcium, CBOD-5, chloride, chromium, cobalt, copper, fluoride, hardness (total as CaCO3), iron, lead, magnesium, manganese, mercury, molybdenum, nickel, nitrate & nitrite (as N), nitrate (as N), nitrite (as N), organic carbon total (TOC), orthophosphate (as P), phosphorus, total (as P), potassium, selenium, silver, sodium, solids (total dissolved), solids (total suspended), sulfate, thallium, total kjeldhal nitrogen (as N), turbidity, vanadium and zinc. Most instances of sampling experienced one or more missing data points.

The Kentucky Watershed Watch (KWW) is a group of volunteers interested in water quality who collect data throughout the Green River watershed. KWW has one site within McDougal and Castleman Creek watersheds with data collection. This site is 0.5 miles west of 210 Bridge in Hodgenville which is the same location as Site 5 in this plan. From 2000 to 2007, 21 sampling events occurred at this location. Samples include data for flow rate, rainfall, oxygen, pH, temperature, conductivity, nitrate (as N), phosphorus (total), fecal coliform, *E. coli*, and other pesticides and metals. Since the data has been collected by volunteers, it has not been consistently collected and is difficult to verify that proper quality assurance and quality control procedures were followed. The results of the KWW data collection will be discussed with other results from Site 5 in the following sections. This sample site is no longer active, it appears that only one volunteer collected samples at this site. As BMPs implementation begins in the watersheds, KWW may be interested in re-activating this site to measure the magnitude of change caused by the BMPs.

## 3.2. MONITORING PARAMETERS

The *Watershed Planning Guidebook for Kentucky Communities* specifies parameters that are recommended to be collected for WMP development for 319(h) grant funded projects. These parameters were also identified as critical parameters because they are directly related to the objectives of this study. The critical parameters, sampling frequencies, and related standard operating procedures are listed in Table 9. The critical parameters can be broken down into seven main groups -- bacteria, nutrients, sediment, flow, field data, habitat, and biology. Since data collection was not a part of this study, the project team was only able to analyze the previous data collected by KDOW, which did not exactly match the identified parameters in the table, however, the data collected does provide meaningful evaluation for the community and provide a basis of comparison for future monitoring efforts.

**Table 9.** Monitoring Parameters

| Group | Parameter | Monthly | 5X/30 days May or June | 1X/year | Every Time | Standard Operating Procedure (SOP) |
|---|---|---|---|---|---|---|
| Bacteria | *E. coli* (*Escherichia coli*) | X | X | | | DOWSOP03015 |
| Nutrient | NO3/NO2 (Nitrate / Nitrite) | X | | | | DOWSOP03015 |
| | NH3-N (Ammonia – Nitrogen) | X | | | | DOWSOP03015 |
| | TKN (Total Kjeldahl Nitrogen) | X | | | | DOWSOP03015 |
| | TP (Total Phosphorus) | X | | | | DOWSOP03015 |
| | OP (Orthophosphate) | X | | | | DOWSOP03015 |
| | BOD5 (Biochemical Oxygen Demand) | X | | | | DOWSOP03015 |
| Sediment | TSS (Total Suspended Solids) | X | | | | DOWSOP03015 |
| | Turbidity (actual or estimated) | X | | | | DOWSOP03014/ DOWSOP0315 |
| Flow | Stream Discharge | | | | X | DOWSOP03019 |
| Field Data | pH | | | | X | DOWSOP03014 |
| | DO (Dissolved Oxygen) | | | | X | DOWSOP03014 |
| | Specific Conductivity | | | | X | DOWSOP03014 |
| | % Saturation (Percent of DO) | | | | X | DOWSOP03014 |
| | Temperature | | | | X | DOWSOP03014 |
| Habitat | Habitat Assessment (KDOW Method) | | | X | | DOWSOP03024 |
| Biology | Biological Assessment (KDOW Method) | | | X | | DOWSOP03003 / DOWSOP03005 |

### 3.2.1. BACTERIA

Bacteria are microscopic organisms that cannot be seen with the naked eye. Bacteria are found everywhere and some even assist in keeping human's bodies functioning properly. *E. coli* is a type of bacteria in the fecal coliform group which are only found in fecal waste of humans and other warm-blooded animals. *E. coli* is a gram-negative rod-shaped bacterium that is commonly found in the lower intestine of warm-blooded organisms. Most strains are harmless to humans. Determining the most probable number (MPN) of *E. coli* found in a water sample of a given size serves as an indicator to whether pathogens are possibly present. Pathogens are defined as bacteria, viruses, and parasites that cause disease and illness. The pathogens of primary concern in water with temperatures of less than 30 degrees Celsius include Bacteroides species; Salmonella; Shigella; Aeromonas; Enamoeba histolytica; and the O157:H7 strain of *E. coli*. The higher the level of *E. coli*, the more likely the water contains other harmful pathogens. *E. coli* was measured using the multi-well enzyme substrate method for the enumeration of *E. coli* and total coliforms (APHA 2012). *E. coli* is reported in MPN per 100 ml; the minimum detection limit was 1 MPN/100 mL. The typical maximum reporting limit of the *E. coli* sampling method used is 2,420 MPN/100mL. In some cases, the raw KDOW data contained samples below the detection limit. In all of these instances, a second sample was collected at the same location and at the same time. These samples were assumed to be control samples and not included as part of the data analysis. If the sample was above the detection limit, a value of 2,420 MPN/100mL was used in the data analysis. The project team recognizes that *E. coli* concentrations may be higher than 2,420 MPN/100mL in these instances. The exception to the maximum reporting limit of 2,420 MPN/100mL occurs when the laboratory tested the sample as a 1:10 dilution. This allows the laboratory to report concentrations up to 24,200 MPN/100mL. No samples exceeded the 1:10 limit of 24,200 MPN/100mL. The full standard operating procedure can be found in the KDOW document "Standard Operating Procedure Enzyme Substrate Test for the Detection of Total Coliforms and *Escherichia coli* in Ambient Waters" (2018).

### 3.2.2. NUTRIENTS

Nutrients are natural elements found in soil, water, and organisms that are essential for plant and animal growth, maintenance, and reproduction. Excess nutrients are usually the result of pollution from land use activities and can be detrimental in stream ecosystems. Stormwater runoff, decomposition of organic matter, discharges from wastewater systems, failing septic systems, excess use of fertilizers, and waste products from farm animals and domestic pets are common sources of nutrients. High concentrations of nutrients within a water body promote excessive growth of algae, causing bacteria to break down the decomposing algae and depleting the water of available oxygen. The depletion of oxygen can lead to the death of other organisms such as fish. This process is called eutrophication. Excess algae can cause unpleasant conditions, odors, and poor habitat.

Nitrogen and phosphorus are the two primary nutrients targeted by water quality sampling. Nitrogen and phosphorus are found in fertilizers applied to farmland and residential lawns and gardens and are essential for plant growth. Nitrogen and phosphorus can be measured in several forms. The critical parameters for phosphorus are total phosphorus (TP) and orthophosphate (OP). Orthophosphate is the portion of total phosphorus that is soluble in water and available to organisms for growth. Total phosphorus and orthophosphate were measured using laboratory tested grab samples and reported in milligrams (mg) per liter (L). The critical parameters for nitrogen are total kjeldahl nitrogen (TKN), nitrate-nitrogen, nitrite-nitrogen, and ammonia nitrogen. Total kjeldahl nitrogen represents the portion of total nitrogen that is unavailable for growth or bound up in organic form. Elevated nitrogen and phosphorus levels may indicate the presence of a pollution source. Total kjeldahl nitrogen, nitrate-nitrogen, nitrite-nitrogen and ammonia nitrogen were measured using laboratory tested grab samples and reported in milligrams (mg) per liter (L). For full details on KDOW nutrient sampling procedures, see "Standard Operating Procedure Sampling Surface Water Quality in Lotic and Wetland Systems" (2022).

Biochemical Oxygen Demand (BOD) is the measure of the amount of oxygen consumed by microorganisms as organic matter is decomposed in a water body. The amount of dissolved oxygen in a water body is directly affected by the level of BOD; the higher the BOD, the less the amount of dissolved oxygen available to organisms. BOD can be affected by temperature, pH, presence of certain microorganisms, and types of organic and inorganic material in the water. Higher levels of BOD can indicate the presence of a source of pollution. BOD5 is the critical parameter that is measured after a five-day incubation period. CBOD-5 was measured using the method SM 5210 B and reported in milligrams per liter. The minimum detection limit was 2 mg/L. All instances where a numeric value for CBOD-5 is not provided, the measurement was below the detection limit, or the sample was not collected by KDOW during the sampling event. The total number of samples collected was utilized for analysis whether below the detection limit or not.

### 3.2.3. FLOW

Flow is determined by measuring stream discharge. Stream discharge is the volume of water that passes through a stream in one second. Stream discharge is calculated using measurements of stream width, depth, and velocity. To measure flow, a cross section of the stream representing the most uniform flow is determined. At this location, a tagline is placed perpendicular to stream flow. The wetted perimeter of the stream is determined. The stream width is divided into an appropriate number of vertical measurement stations. At each vertical station, along the tagline, a handheld Acoustic Doppler Velocimeter unit is used to measure stream velocity. Discharge in cubic feet per second is calculated for each vertical section based on the velocity and flow area. The sum of flow in each section is added together to calculate the full stream flow. The full standard operating procedure for measuring flow can be found in the document Kentucky Division of Water "Standard Operating Procedure Measuring Stream Discharge" (2020). The stream is separated into sections because water depth and velocity are not consistent across the channel, so only measuring the velocity and depth in one location would not provide accurate information. The KDOW data did not include flow for every instance of sampling at every site. The project team has used three methods to estimate flow for use in calculations when no flow is provided in the KDOW data. These methods are outlined, in detail, in Section 4.2.2.

### 3.2.4. SEDIMENTS

Total suspended solids concentrations and turbidity are critical parameters used to measure the amount of solid material suspended in the water. High levels of total suspended solids and turbidity will often cause the water to appear muddy or cloudy. Suspended materials allow for less light to be able to reach plants at deeper depths in the water body. Suspended materials often carry other pollutants such as metals and bacteria. Turbidity is the cloudiness or haziness of a fluid caused by suspended solids and measures the amount of light scattered. The total suspended solids test measures the actual weight of material in a given volume of water. High total suspended solids concentrations and turbidity values can be an indicator of a source of sediment. In situ turbidity was measured using the methods outlined in the document from the Kentucky Division of Water "In Situ Water Quality Measurements and Meter Calibration for Lotic Waters Standard Operating Procedure" (2018) and reported in nephelometric turbidity units (NTUs). Total suspended solids were measured using the method SM 2540 D and reported in milligrams per liter. The minimum detection limit was 2 mg/L.

### 3.2.5. FIELD DATA

Field data was collected at each sample site in conjunction with the water sample collection and flow measurements. Full procedures for in situ data collection are outlined in "In Situ Water Quality Measurements and Meter Calibration for Lotic Waters Standard Operating Procedure" (2018). KDOW utilizes multiple different instruments, all manufactured by YSI. The following instruments are used based on availability: YSI EXO 1 Sonde, YSI EXO 2 Sonde, YSI 556 Multi Probe System, YSI Professional Plus (Pro Plus) Instrument and YSI Professional Digital Sampling System (ProDSS). In situ water quality parameters include water temperature, dissolved oxygen (DO), pH, specific conductivity, and turbidity.

Water temperature quantitatively assigns a value to the notion of hot and cold. Aquatic organisms can be greatly affected by the water temperature. The optimal water temperature can vary greatly by the species, but variations above or below a normal range can impact organisms' processes. Temperatures will vary during the day, especially near the water surface or in shallow waters. Aquatic organisms adjust to temperature changes by moving to other areas in the water body according to their desired temperature. Extended periods of temperature variation can cause stress and death of organisms. Water temperature can be changed by the removal of trees and other vegetation that normally provides shade; dam construction or other impoundments; industrial or urban stormwater discharges; and groundwater flows. Water temperature was measured in degrees Celsius.

Dissolved oxygen (DO) is the amount of oxygen that is present in the water. Most aquatic organisms get the oxygen they need to survive from the DO in the water. Water is oxygenated by diffusion from the surrounding air, aeration through rapid movement, and as a waste product of photosynthesis. Colder water typically has higher levels of DO. Dissolved oxygen can be affected by high levels of bacteria which consume oxygen as organic matter decays. Dissolved oxygen was measured using a polarographic sensor and reported in milligrams per liter. Percent saturation of DO was the amount of oxygen dissolved in the water sample compared to the maximum amount possible at the same temperature. If the percent saturation of DO is equal to 100%, the water is said to be saturated. Water can become supersaturated with oxygen when percent saturation of DO exceeds 100%. According to the YSI Professional Plus manufacturer's information, typically percent saturation of DO exceeds 100% due to the production of pure oxygen by photosynthetically-active organisms or non-ideal equilibrium of dissolved oxygen between the water and air above it. Percent saturation of DO was measured using a polarographic senor and reported as a percentage.

Potential Hydrogen (pH) is a measure of the concentration of hydrogen ions in a water sample and indicates whether a sample is acidic or basic. pH values are unit-less and range from zero to 14, with pure water measuring seven. Water samples with a pH below seven are considered acidic. Water samples with a pH above seven are considered basic. Most organisms are more successful in a pH range of 6.5 to 8. pH values outside of this range can lessen diversity due to reductions in reproduction and stress on organisms. Very acidic solutions can change the solubility of materials, causing harmful metals or other compounds to be leached into water in previously insoluble compounds. Water in the central Kentucky region tends to be slightly basic due to the underlying limestone. As the limestone dissolves, hydroxide ions are released into the water increasing the pH. The pH can also be affected by the pH of rainfall. Acid rain can lower the pH of a stream. The pH was measured with a glass combination electrode senor.

The measure of a material's ability to conduct electricity is known as conductivity. According to the EPA, conductivity can indicate the presence of inorganic dissolved solids such as chloride, nitrate, sulfate, and phosphate anions or sodium, magnesium, calcium, iron, and aluminum cations. Pure water has a very low conductivity. Water temperature also effects conductivity; typically the warmer the water, the higher the conductivity. Conductivity can also be affected by the geology of the region in which stream is located. Areas where the stream flows through limestone and clay soils tend to have high conductivity. Discharges into streams may also change the conductivity. Discharge from a failing septic system would raise the conductivity due to the presence of chloride, phosphate, and nitrate. Specific conductivity was measured because it normalizes the reading to 25 degrees Celsius. Specific conductivity was measured in microsiemens per centimeter (µS/cm) using a four electrode cell sensor.

### 3.2.6. HABITAT

Stream habitat is vital for successful plant and animal communities within waterways. Stream habitat is the areas where plants and animals live, including on, under, and between rocks; in or on plant and woody debris; and in mud or sand. Stream habitat is not limited to the area within the channel banks, but also includes the riparian zone. If a variety of habitats are available within the stream corridor, there is more opportunity for multiple plant and animal species to thrive. Assessing the habitat can help in determining the health of the stream. Stream habitat assessment looks at particular features within a section of stream and analyzes how those features function. Habitat assessments were performed using the Rapid Bioassessment Protocols (RBPs) developed by KDOW. Two sets of RBPs have been established, one for high gradient stream and one for low gradient streams. High gradient streams are defined as streams with velocities greater than 0.5 feet per second (ft/s) that exhibit rapid changes in stream gradient and a high frequency of riffle habitat. Low gradient streams are defined as streams with velocities less than 0.5 ft/s and often lacking rifle habitat. All MCCW sampling site locations are classified as high gradient streams therefore collection methods will follow high gradient procedures. The RBPs for high gradient streams include the assessment of ten major parameters: epifaunal substrate and available cover; embeddedness; velocity and depth regime; sediment deposition; channel flow status; channel alteration; frequency of riffles; bank stability; vegetation protection; and riparian vegetative zone width.

KDOW has established specific criteria for the time of year habitat assessment should be completed based on stream size and drainage area. Streams are classified as headwaters or wadeable based on these factors. Headwater streams have a surface drainage area less than five square miles while wadeable streams have a surface drainage area of more than five square miles. The Standard Operating Procedure (SOP) developed by KDOW, DOWSOP03024, specifies that habitat assessment for wadeable streams should be conducted from June 1st until September 30th and headwater streams from March 1st until May 31st. The habitat assessments for the wadeable streams sampled for MCCWMP were assessed from June to September. The habitat assessments for the headwater streams sampled for MCCWMP were assessed in March and May. An unfilled RBP assessment form is located in APPENDIX C.

### 3.2.7. BIOLOGY

Biological assessments can also help determine the health of a watershed. Different organisms can tolerate varying levels of pollution in the water. If organisms with a very low pollution tolerance are found, it can be an indicator of good water quality. A large portion of the organisms living in streams are benthic macroinvertebrates. These organisms live close to or on the bottom of the stream, do not have backbones, and can be seen with the naked eye. Benthic macroinvertebrates may be immature forms of organism that live on land once full grown. Benthic macroinvertebrates serve important roles in stream ecosystems, providing food for larger organisms, eating algae and bacteria, and breaking down decaying material and debris. *Watershed Planning Guidebook for Kentucky Communities* indicates that benthic macroinvertebrates are good indicators of the health of a watershed "because they:

- live in the water for all or most of their lives
- stay in areas suitable for their survival
- are easy to collect
- tolerate different amounts and types of pollution
- are easy to identify in a laboratory
- often live for more than one year
- do not move very far in the stream
- are exposed to all conditions and pollution in the stream."

The Macroinvertebrate Biotic Index (MBI) is used to classify the water based on benthic macroinvertebrates that are found within a stream reach. KDOW uses seven core metrics in the MBI computation: Taxa Richness (G-TR); Ephemeroptera, Plecoptera, Trichoptera Richness (EPT); Modified Hilsenhoff Biotic Index (mHBI); Modified Percent EPT Abundance (m%EPT); Percent Ephemeroptera (%EPHEM); Percent Chironomidae + Oligochaeta (%Chir+%Olig); and Percent Primary Clingers (%Clingers). Table 10 lists these metrics and defines their function and response to disturbance.

**Table 10.** Metrics to Develop an MBI for Water Quality Analysis and Responses to Disturbances

| Metric | Function | Response to Disturbance |
|---|---|---|
| G-TR | Refers to total number of taxa present | Negative |
| EPT | Number of taxa within these pollution-sensitive insect orders | Negative |
| mHBI | Assesses impacts other than organic enrichment | Positive |
| m%EPT | Measures relative abundance of pollution-sensitive organisms | Negative |
| %EPHEM | Measures impacts in response to metals and high conductivity | Negative |
| %Chir+%Olig | Measures relative abundance of pollution tolerant organisms | Positive |
| %Clingers | Habitat metric for organisms that need hard silt-free substrate | Negative |

Similar to the habitat assessment, KDOW stipulates specific times of the year when benthic macroinvertebrate should be collected to obtain accurate, comparable results for wadeable and headwater streams. Benthic macroinvertebrate collection for wadeable streams should be conducted from June 1st until September 30th and headwater streams from March 1st until May 31st.

## 3.3. PHASE I MONITORING

Phase I monitoring in 2018 sampled 13 locations throughout the MCCW in an effort to confirm pollutant concentrations and probable sources of pollutants within the main stem and larger tributaries of NFNR. The following sampling sites were included as part of Phase I monitoring: 1, 2, 5, 6, 8, 10, 11, 12, 13, 14, 15, 16, 17 and 18. See the full KDOW project study plan and project management plan on Phase I sampling in APPENDIX B. Figure 23 depicts where each site lies within MCCW and Table 11 summarizes the location of each.

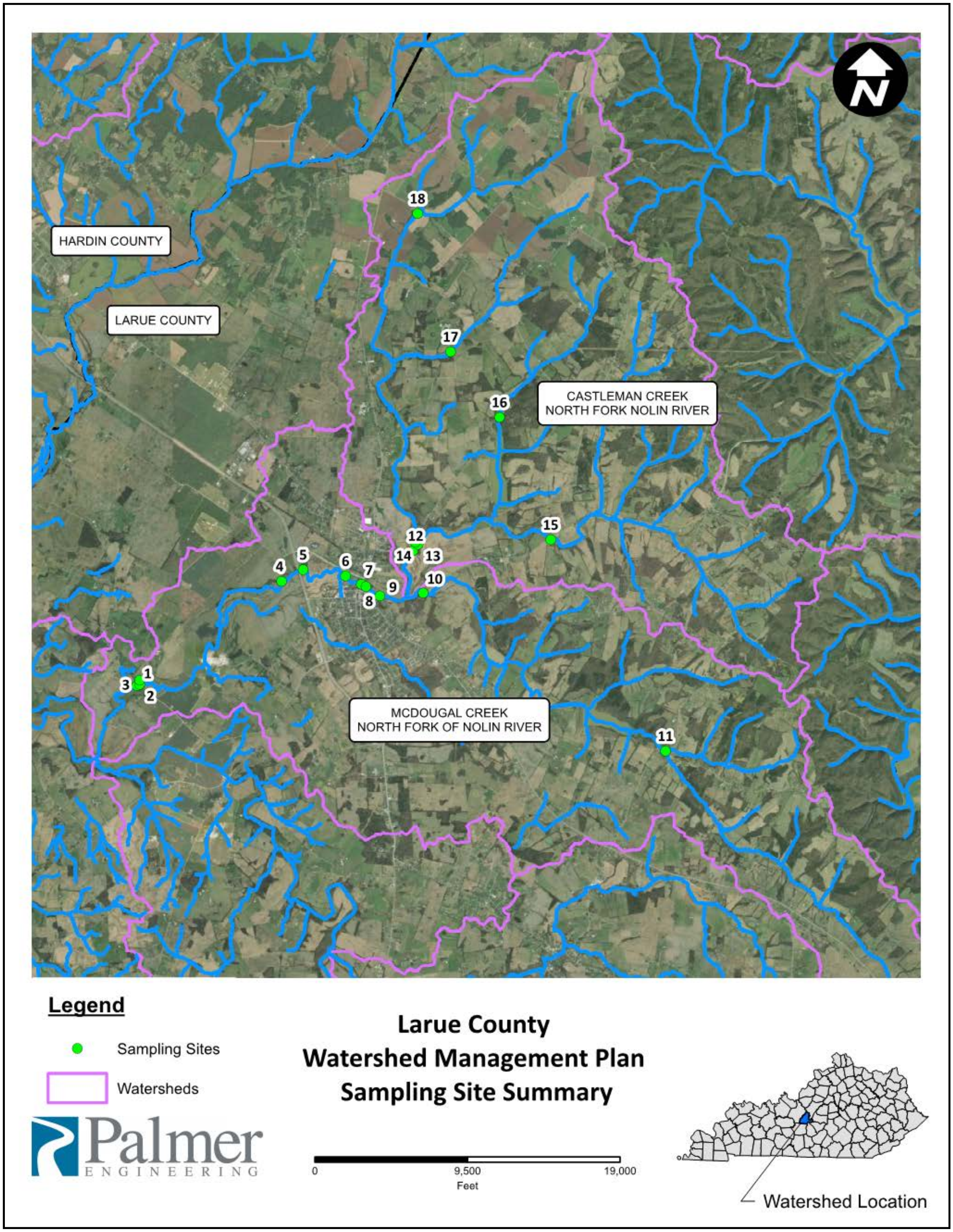


**Figure 23.** MCCW KDOW Sampling Sites Map

**Table 11.** MCCW KDOW Sampling Sites Details

| KDOW Station ID | Project Site ID | Phase | Location | Latitude | Longitude | Drainage Area (sq mi) |
|---|---|---|---|---|---|---|
| DOW03028005 | 1 | 1 & 2 | North Fork Nolin River, Below SR222 bridge; Below Nolynn Spring | 37.5587 | -85.7885 | 49.06 |
| DOW03028006 | 2 | 1 & 2 | North Fork Nolin River, Above SR222 bridge; Above Nolynn Spring run | 37.5589 | -85.7879 | 49.05 |
| GW90002673 | 3 | 2 | Nolynn Spring, At Private Residence | 37.5596 | -85.7879 | |
| DOW03028017 | 4 | 2 | North Fork Nolin River, ~0.25mi below SR61 bridge; below stream sink | 37.5765 | -85.7574 | 39.05 |
| DOW03028007 | 5 | 1 & 2 | North Fork Nolin River, Above SR61 bridge | 37.5785 | -85.7528 | 38.12 |
| KY0026379-001 | 6 | 1 & 2 | North Fork Nolin River, Hodgenville STP | 37.5774 | -85.7437 | 36.71 |
| DOW03028018 | 7 | 2 | North Fork Nolin River, Below SR210 | 37.5760 | -85.7403 | 36.52 |
| KYG640033-001 | 8 | 1 | North Fork Nolin River, Hodgenville Water Treatment Plant | 37.5756 | -85.7393 | 36.50 |
| DOW03028019 | 9 | 2 | North Fork Nolin River, Above Water treatment plant; near Fisher Autoparts off US31. | 37.5740 | -85.7363 | 36.37 |
| DOW03028008 | 10 | 1 | McDougal Creek, Above US31E bridge | 37.5745 | -85.7270 | 12.83 |
| DOW03028009 | 11 | 1 | McDougal Creek, Above SR470 bridge off Dangerfield Rd. | 37.5475 | -85.6750 | 7.10 |
| DOW03028010 | 12 | 1 | North Fork Nolin River, Off SR2217; ~100m below Castleman Cr. confluence | 37.5817 | -85.7292 | 23.00 |
| DOW03028014 | 13 | 1 | North Fork Nolin River, Off SR2217; above Castleman Creek confluence | 37.5828 | -85.7281 | 13.16 |
| DOW03028011 | 14 | 1 | Castleman Creek, Above SR2217 bridge | 37.5832 | -85.7287 | 9.82 |
| DOW03028016 | 15 | 1 | North Fork Nolin River, Above US31E bridge | 37.5836 | -85.6996 | 7.97 |
| DOW03028015 | 16 | 1 | Salem Creek, Above SR2217 bridge | 37.6045 | -85.7106 | 2.44 |
| DOW03028012 | 17 | 1 | Castleman Creek UT 2.75, Below Goodin Williams Rd. | 37.6157 | -85.7211 | 2.00 |
| DOW03028013 | 18 | 1 | Castleman Creek, Below SR1832 bridge | 37.6393 | -85.7282 | 3.36 |

## 3.4. PHASE II MONITORING

Phase II sampling in 2019 included eight locations; four of these locations were repeated from Phase I, and four were newly identified for Phase II. Phase II focused on characterizing the conditions above and below Nolynn Spring, Nolynn Spring proper, above the Wastewater Treatment Plant (WWTP) and above the Water Treatment Plant (WTP). This phase also included an attempt to capture water quality conditions in North Fork Nolin main stem above and below where it sinks and loses flow to the spring drainage area. The following sample sites are included as part of Phase II monitoring: 1, 2, 3, 4, 5, 6, 7 and 9. See the full KDOW project study plan and project management plan on Phase II sampling in APPENDIX B. See Figure 23 for a view of where each site lies within MCCW. Table 11 provides details and GPS coordinates for each KDOW sample site location.

## 3.5. SAMPLING RAINFALL CONDITIONS

It is important that water quality sampling events occur during a range of weather conditions during and preceding the sampling event. The Watershed Planning Guidebook for Kentucky Communities comments that sampling events capture a minimum of two wet weather events and two dry weather events. "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 runoff 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." Capturing a minimum of two events each with these conditions can inform the project team on the impact of point and nonpoint sources of pollution on water quality. Nonpoint source pollution, which can come from a wide area instead of a single point, such as fertilizer application or animal manure, will most likely reach the stream through runoff. This runoff occurs during a wet weather event. Point source pollution comes from a single point, usually a pipe conveying pollutants with an outlet directly into the stream. These pollutant sources will be less impactful during wet weather events as rainwater will dilute the polluted discharge. During dry weather events, point discharges will be a much larger part of the total flow in the stream. Table 12 provides an overview of the rainfall conditions preceding every sampling event, indicating the comparative percentile of flow at the closest USGS rain gaging station. One wet weather event was captured with flows in the 97$^{th}$ percentile among all flows during the sampling period. Six intermediate events were captured with flows in the 66$^{th}$ to 80$^{th}$ percentile. The remaining 25 events were classified as dry based on stream flow, but many of these events occurred with preceding light rain.

**Table 12.** Sampling Event Rainfall Conditions

| Event Data | | | | USGS Gage Data | |
|---|---|---|---|---|---|
| Sample Date | # of Sites Sampled | Event Type | Preceding Weather | Average Daily Stream Flow (cfs) | % Flows Exceeding* |
| 3/22/18 | 12 | Intermediate | Snow | 60.4 | 35.8% |
| 4/19/18 | 12 | Intermediate | Light Rain | 51.6 | 39.2% |
| 4/24/18 | 2 | Intermediate | | 40.1 | 46.1% |
| 5/1/18 | 13 | Dry | Sunny | 21.1 | 59.3% |
| 5/3/18 | 2 | Dry | | 18.4 | 61.5% |
| 5/8/18 | 13 | Dry | Light Rain | 32.3 | 52.0% |
| 5/15/18 | 12 | Dry | Sunny | 15 | 66.0% |
| 5/22/18 | 13 | Dry | Light Rain | 12 | 68.6% |
| 5/29/18 | 12 | Dry | Light Rain | 18.2 | 61.9% |
| 6/19/18 | 14 | Dry | Sunny | 7.57 | 83.1% |
| 7/10/18 | 2 | Dry | | 9.88 | 74.4% |
| 7/11/18 | 2 | Dry | | 9.37 | 75.9% |
| 7/12/18 | 2 | Dry | | 8.85 | 78.0% |
| 7/17/18 | 13 | Dry | Light Rain | 7.41 | 83.5% |
| 8/9/18 | 13 | Dry | Light Rain | 21.1 | 59.2% |
| 9/11/18 | 11 | Dry | Light Rain | 6.12 | 87.4% |
| 10/18/18 | 13 | Dry | Sunny | 17.9 | 62.1% |
| 11/29/18 | 13 | Dry | Sunny | 27 | 55.2% |
| 1/17/19 | 13 | Intermediate | Light Rain | 40.1 | 45.9% |
| 2/21/19 | 12 | Wet | Heavy Rain | 461 | 3.4% |
| 4/24/19 | 5 | Dry | Sunny | 71 | 31.4% |
| 5/20/19 | 8 | Dry | Light Rain | 11.8 | 69.3% |
| 6/19/19 | 2 | Dry | Light Rain | 53.6 | 38.3% |
| 6/26/19 | 7 | Dry | Light Rain | 71.8 | 30.8% |
| 7/23/19 | 8 | Dry | Light Rain | 9.96 | 74.3% |
| 8/20/19 | 1 | Dry | | 2.91 | 98.7% |
| 8/28/19 | 6 | Dry | Light Rain | 4.13 | 93.6% |
| 9/26/19 | 5 | Dry | Light Rain | 4.23 | 93.3% |
| 10/29/19 | 5 | Dry | Light Rain | 9.29 | 76.2% |
| 11/21/19 | 4 | Dry | Light Rain | 5.53 | 89.4% |
| 12/11/19 | 4 | Intermediate | Sunny | 81.8 | 26.0% |
| 3/5/20 | 5 | Intermediate | Sunny | 101 | 20.1% |

*% flows exceeding represents how many of the measured USGS stream flow instances - measured daily from 3/1/2018 to 3/31/2020 – exceed the USGS measurement during the sampling event.

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# 4. ANALYSIS

## 4.1. ANALYSIS OVERVIEW

To evaluate the nature and level of the pollutants within MCCW, it was necessary to compare the monitoring results with a set of water quality benchmarks. The water quality benchmarks used for MCCW are a combination of documented legal limits and referencing benchmarks from watershed management plans in comparable watersheds combined with engineering judgement.

The legal limits for surface water standards are published in 401 KAR 10:301. As stated in 401 KAR 10:031, this "regulation establishes water quality standards that consist of designated uses of the surface waters of the commonwealth and the associated water quality criteria necessary to protect those uses." The parameters listed for warm water aquatic habitat and primary contact recreation waters were used as benchmarks for comparison. The regulation lists specific numeric parameters for *E. coli*, pH, dissolved oxygen, and temperature. These values are listed in Table 13. No specific values are listed in 401 KAR 10:031 for specific conductivity, flow, and total suspended solids, but it is indicated that levels "shall not be changed to the extent that the indigenous aquatic community is adversely affected." The regulation also specifies that "where eutrophication problems exist, nitrogen, phosphorous, carbon, and contributing trace element discharges shall be limited in accordance with: 1. the scope of the problem; 2. the geography of the affected area; and 3. relative contributions from existing and proposed sources."

After legal limits, the project team sourced benchmarks from a similar watershed management plan in a similar watershed, Bacon Creek, and discussion with KDOW staff. Upper Bacon Creek Watershed is approximately 7 miles south of McDougal and Castleman Creek Watersheds. A small portion of the watershed is in LaRue County, but the majority is in Hart County. This watershed has a comparable mix of land use with the highest uses being pasture, crop and forest. KDOW created project specific benchmarks for Upper Bacon Creek and in making those recommendations KDOW provided documents *Benchmark Recommendations for Nutrient Parameters* and *Benchmark Recommendations for Non-Nutrient Parameters*, both dated 8/1/2012. The benchmarks provided were "estimates of typical in-stream concentrations below which it is unlikely that nutrients are a cause of observed impairments." Several factors were used to develop these recommendations, including regional and watershed specific nutrient expectations, indicators of nutrient enrichment found in the watershed, and regional scale patterns in biological effects. The document summarized reference stream data for ecoregions 71a, 72h, and 71e, which are adjacent to ecoregion 71b where KDOW does not have any reference streams. The project team in consultation with KDOW focused on the 90th percentile of reference data for ecoregion 71a as the best fit for the McDougal and Castleman Creek Watersheds. For TSS and Turbidity, the KDOW document was limited in recommending benchmarks that could be used outside of hydrologically stable spring-summer conditions. The project team consulted with DOW for updated reference data for TSS and Turbidity. New benchmarks for TSS and Turbidity were provided based on additional reference reach data from ecoregion 71a collected since 2012. For a BOD benchmark, KDOW recommended a value of 2.0 mg/L CBOD-5 as being appropriate for most natural streams.

**Table 13.** Project Water Quality Benchmarks

| Parameter | Min Limit | Max Limit | Notes | Source |
|---|---|---|---|---|
| *E. coli* | --- | 240 colonies/100 ml | Shall not exceed 130 colonies/100 ml as a geometric mean based on not less than five samples taken in 30 days | 401 KAR 10:031 |
| Nitrate-Nitrite-N | --- | 2.0 mg/L | | Reference Reach |
| Ammonia-Nitrogen (un-ionized) | --- | 0.05 mg/L | | 401 KAR 10:031 |
| Total Kjeldahl Nitrogen | --- | 0.50 mg/L | | Reference Reach |
| Total Phosphorous (TP) | --- | 0.075 mg/L | | Reference Reach |
| CBOD-5 | --- | 2.0 mg/L | No specific legal or local standard | KDOW Recommendation (2024) |
| TSS | --- | 12.0 mg/L | | Reference Reach |
| Stream Discharge | --- | --- | No overall specific stream discharge requirements; varies based on drainage area size and characteristics | |
| Turbidity | --- | 19 NTU | | Reference Reach |
| pH | 6.0 | 9.0 | Cannot vary more than 1.0 units over a 24 hour period | 401 KAR 10:031 |
| DO | 5.0 mg/L* | --- | Instantaneous minimum shall not be less than 4.0 mg/L | 401 KAR 10:031 |
| Conductivity | --- | 400 (µS/cm) | | Reference Reach |
| Temperature | --- | 31.7 C (89 F) | | 401 KAR 10:031 |
| Habitat Assessment (RBP Scoring) | 146 (wadeable or headwater) | --- | Habitat rating of good | DOWSOP03024 |
| Biological Assessment (MBI Scoring) | 65 (wadeable) 72 (headwater) | --- | Biological classification of good or excellent | Kentucky Macroinvertebrate Bioassessment Index |

*Outstanding State Resource Waters have a standard of 5.0mg/L instantaneous and 6.0 mg/L as 24-hour average

The habitat assessment benchmark was specified as receiving a "good" rating as listed in *Methods for Assessing Habitat in Wadeable Waters* (DOWSOP03024), dated March 2011. The habitat parameters were assessed and cumulative score designated as "good", "fair", or "poor" according to the ratings as shown in Table 14. The biological assessment benchmark was specified as receiving an "excellent" or "good" rating as listed in *The Kentucky Macroinvertebrate Bioassessment Index*, dated September 2003. Similar to the habitat parameters, the biological parameters were assessed and the cumulative score designated as "excellent", "good", "fair", "poor", or "very poor" according to the ratings as shown in Table 15. Habitat and Macroinvertebrate rating criteria are specialized for the Pennyroyal Bioregion.

**Table 14.** Habitat Ratings

| Rating | Wadeable or Headwater |
|---|---|
| Good | ≥ 146 |
| Fair | 132-145 |
| Poor | ≤ 131 |

**Table 15.** Biological Ratings

| Rating | Headwater (<5.0 sq. miles) | Wadeable (>5.0 sq. miles) |
|---|---|---|
| Excellent | ≥ 72 | ≥ 81 |
| Good | 65-71 | 72-80 |
| Fair | 43-64 | 49-71 |
| Poor | 22-42 | 25-48 |
| Very Poor | 0-21 | 0-24 |

## 4.2. PHASE I AND PHASE II ANALYSIS

### 4.2.1. COMPARISON TO WATER QUALITY BENCHMARKS

Phase I monitoring began on March 22, 2018 and continued to February 21, 2019 at sites 1, 2, 5, 6, 8, 10, 11, 12, 13, 14, 15, 16, 17 and 18. Phase II monitoring began on April 24, 2019 and continued to March 5, 2020 at sites 1, 2, 3, 4, 5, 6, 7 and 9. Sample sites 1, 2, 5 and 6 were sampled in Phase II and Phase II. The critical parameters identified in Table 9 were collected and then compared with the project water quality benchmarks in Table 13. APPENDIX D contains a summary table for monitoring results at each site. Although Site 8 was identified by KDOW, no samples were taken at Site 8 during either phase, so it will not be included in any of the following tables or sections. The drainage area for Site 8 will be incorporated in to Site 7 for analysis and BMP recommendations.

Some critical parameters had no occurrences of exceeding water quality benchmarks, this includes the following: ammonia (un-ionized), pH, and temperature. Dissolved oxygen had two isolated occurrences at Site 14. The following remaining critical parameters had multiple exceedances at multiple sites: *E. coli*, CBOD-5, TKN, conductivity, nitrate & nitrite, total phosphorus (TP), total suspended solids (TSS), and turbidity. Table 16 shows the number of sampling events that exceeded the water quality benchmarks for each site. The first number represents the number of events exceeding water quality benchmarks and the second number represents the total number of sampling events (exceedances/number of samples). For CBOD-5, the total number of samples includes the samples which were measured to be below the detection limit. In Phase I, a total of 16 sampling events occurred. In Phase II, a total of 11 sampling events occurred. In Table 16, the total number varies due to some sites being sampled in both phases and instances when a parameter or site was not sampled during a sampling event. Total suspended solids and turbidity were sampled at each of the twelve monthly sampling events, but the benchmarks are only valid for comparison from April through October. In the above table, only TSS and turbidity samples from April through October are included.

The project team determined that exceeding the water quality benchmark more than once (a possible anomaly) indicated a potential issue. The shading in Table 16 indicates that the critical parameter exceeded the project water quality benchmark at least twice at the indicated site. Site specific exceedances for *E. coli*, nitrate & nitrite, total phosphorus and TSS will be summarized in Sections 4.2.3, 4.2.4, and 4.2.5.

**Table 16.** MCCW Phase I & Phase II Water Quality Exceedances (Number Exceeding / Total Samples)

| | *E. coli* | Ammonia (un-ionized) | TKN | CBOD-5 | Dissolved Oxygen | pH | Conductivity | Temperature | Nitrate & Nitrite | TP | TSS | Turbidity |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Site ID | MPN/100mL | mg/L | mg/L | mg/L | mg/L | s.u. | µS/cm @ 25C | °C | mg/L | mg/L | mg/L | NTU |
| 1 | 4/9 | 0/5 | 3/11 | 2/21 | 0/25 | 0/25 | 2/25 | 0/25 | 16/20 | 6/17 | 9/11 | 2/12 |
| 2 | 7/9 | 0/12 | 4/11 | 1/17 | 0/21 | 0/21 | 1/21 | 0/21 | 12/16 | 4/15 | 4/10 | 1/10 |
| 3 | N/A | 0/1 | 0/2 | 0/11 | 0/11 | 0/11 | 1/10 | 0/11 | 9/10 | 4/10 | 4/7 | 3/6 |
| 4 | N/A | 0/3 | 2/3 | 0/3 | 0/3 | 0/3 | 0/3 | 0/3 | 1/3 | 2/3 | 2/3 | 0/3 |
| 5 | 9/10 | 0/15 | 4/14 | 1/18 | 0/22 | 0/22 | 0/22 | 0/22 | 4/17 | 11/16 | 5/12 | 1/11 |
| 6 | N/A | 0/13 | 4/7 | 5/16 | N/A | N/A | N/A | N/A | 14/15 | 15/15 | 0/11 | 0/12 |
| 7 | N/A | 0/10 | 3/8 | 0/11 | 0/11 | 0/11 | 0/11 | 0/11 | 0/11 | 1/10 | 2/8 | 0/8 |
| 9 | N/A | 0/5 | 2/3 | 0/6 | 0/6 | 0/6 | 0/6 | 0/6 | 0/6 | 0/6 | 0/4 | 0/4 |
| 10 | 8/10 | 0/9 | 5/9 | 1/11 | 0/15 | 0/16 | 0/16 | 0/16 | 0/11 | 1/10 | 0/7 | 0/7 |
| 11 | 6/10 | 0/4 | 1/5 | 0/10 | 0/16 | 0/16 | 0/16 | 0/16 | 0/12 | 0/8 | 0/2 | 0/7 |
| 12 | 8/10 | 0/9 | 2/7 | 3/12 | 0/16 | 0/16 | 0/16 | 0/16 | 1/12 | 1/13 | 1/6 | 1/7 |
| 13 | 7/10 | 0/8 | 2/9 | 2/12 | 0/16 | 0/16 | 0/16 | 0/16 | 0/12 | 0/3 | 1/7 | 0/7 |
| 14 | 5/10 | 0/8 | 1/7 | 0/11 | 2/16 | 0/16 | 7/16 | 0/16 | 7/12 | 2/10 | 1/7 | 1/7 |
| 15 | 9/10 | 0/5 | 0/2 | 0/12 | 0/16 | 0/16 | 0/16 | 0/16 | 0/12 | 0/6 | 0/4 | 0/6 |
| 16 | 6/10 | 0/3 | 1/5 | 1/11 | 0/15 | 0/16 | 0/16 | 0/16 | 1/12 | 1/7 | 0/4 | 0/7 |
| 17 | 10/10 | 0/7 | 4/8 | 4/11 | 0/16 | 0/16 | 3/16 | 0/16 | 12/12 | 4/8 | 2/4 | 0/7 |
| 18 | 10/10 | 0/4 | 2/5 | 2/11 | 0/16 | 0/16 | 0/15 | 0/16 | 10/11 | 4/9 | 0/5 | 1/6 |

**Table 17.** Phase I *E. coli* Primary Contact Recreation Season Mean Values

| Site # | Arithmetic Mean (MPN/100 mL) | Geometric Mean (MPN/100 mL) |
|---|---|---|
| 1 | 288.00 | 133.50 |
| 2 | 232.80 | 219.56 |
| 5 | 563.00 | 553.65 |
| 10 | 397.60 | 340.86 |
| 11 | 314.60 | 251.44 |
| 12 | 985.40 | 749.24 |
| 13 | 1,013.20 | 817.98 |
| 14 | 354.20 | 184.05 |
| 15 | 867.00 | 567.48 |
| 16 | 957.60 | 606.06 |
| 17 | 6,024.40 | 2,750.57 |
| 18 | 7,519.00 | 2,688.05 |

Five *E. coli* samples were taken within 30 days to assess the presence of bacteria during primary contact recreation season in accordance with the requirements set forth in *Watershed Planning Guidebook for Kentucky Communities*. Samples were taken on May 1st, 8th, 15th 22nd and 29th all in 2018. The arithmetic and geometric means for the five *E. coli* samples taken in May 2018 are listed in Table 17. Every single site exceeded the geometric mean benchmark of 130 MPN/100 mL for five samples in a 30 day period.

Habitat was assessed at the following sites: 5, 7, 10, 11, 12, 14, 15, 16, 17 and 18. Results were compared with habitat rating benchmarks listed in Table 14. All eleven sites scored below a "good" rating in accordance with *Methods for Assessing Habitat in Wadeable Waters* (DOWSOP03024), dated March 2011. Table 18 identifies the scoring value for each habitat parameter. Riparian zone width, bank stability, sediment deposition, and vegetative protection were the habitat parameters which scored the lowest among all stations.

**Table 18.** MCCW Habitat Assessment Results

| | **SITE ID** | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **PARAMETER** | **5** | **7** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** | **18** |
| Date Sampled (all in 2018) | 7/18 | 8/20 | 7/11 | 7/10 | 7/12 | 7/12 | 7/10 | 7/11 | 5/3 | 5/3 | 4/24 |
| Stream Class | W | W | W | W | W | W | W | W | H | H | H |
| Epifaunal Sub/Available Cover | 12 | 7 | 12 | 10 | 7 | 9 | 11 | 13 | 14 | 11 | 14 |
| Embeddedness | 4 | 7 | 13 | 13 | 7 | 6 | 12 | 16 | 14 | 16 | 14 |
| Velocity Depth Regime | 16 | 11 | 16 | 16 | 16 | 15 | 12 | 13 | 16 | 8 | 13 |
| Sediment Deposition | 8 | 7 | 8 | 8 | 5 | 4 | 7 | 10 | 7 | 16 | 11 |
| Channel Flow Status | 15 | 13 | 16 | 9 | 13 | 15 | 9 | 14 | 13 | 12 | 15 |
| Channel Alteration | 14 | 14 | 15 | 15 | 13 | 12 | 15 | 12 | 15 | 13 | 13 |
| Frequency of Riffles (or Bends) | 5 | 6 | 11 | 15 | 10 | 10 | 7 | 13 | 13 | 13 | 15 |
| Bank Stability | 12 | 7 | 7 | 8 | 4 | 5 | 8 | 9 | 8 | 7 | 16 |
| Vegetative Protection | 11 | 8 | 7 | 12 | 6 | 4 | 8 | 10 | 6 | 5 | 16 |
| Riparian Zone Width | 10 | 4 | 5 | 6 | 4 | 5 | 7 | 4 | 4 | 10 | 9 |
| *RBP Score* | 107 | 84 | 110 | 112 | 85 | 85 | 96 | 114 | 110 | 111 | 136 |
| *RBP Zone Rating* | Poor | Poor | Poor | Poor | Poor | Poor | Poor | Poor | Poor | Poor | Fair |

Formal habitat assessment through RBP was only performed at the aforementioned locations. To provide an indication of the quality of habitat for stream reaches not monitored, a GIS assessment of riparian vegetation and tree canopy was performed using notes and photographs from the visual assessment completed in March 2023 and aerial imagery. Figure 24 and Figure 25 show the result of this assessment. Small pockets of wide riparian area and tree canopy can be observed throughout the watershed. These locations extend around 300 feet beyond the streambank. Many of these pockets are adjacent to pasture and crop land. It's possible this land is not utilized because the slope and soil conditions would not be suitable for growth. Other areas in the watershed have more intentional riparian and forested area adjacent to waterways. Both McDougal Lake and Salem Lake have up to 1,500 feet of forested area on one side but have no streamside vegetation on the other side. Pearman Forest is a dedicated nature preserve in the McDougal Creek Watershed which is adjacent to McDougal Creek on one side. Knobb Creek Conservancy utilizes these areas as part of their trail network.

The average tree cover and riparian/streamside vegetation corridor is approximately 100 feet wide, 50 feet to each side of the stream. This width, as seen on the aerial view, is often mostly tree cover. The presence of a diverse riparian buffer with grasses, shrubs and vines was not widely noted during the visual assessment. Figure 12, on page 24, is a photo taken along NFNR, downstream of sample Site 1 and approximately 4,000 ft upstream of the confluence of North and South Fork Nolin River. In this photo, it is evident that the NFNR streambanks have bare soil with exposed tree roots. Some of these trees appear to be almost falling over into the river. These banks are vulnerable to undercutting and erosion from high velocity stream flows. Other than the trees, the streambanks are only covered with grass, clover and dead tree limbs. Figure 13, on page 24, shows two Palmer Engineering employees standing on a mass of undercut soil which has toppled over in to Castleman Creek. This area is near Phillips Lane and had limited riparian buffer width because of the presence of the parallel roadway approximately 30 feet away. This erosion does not pose a threat to the nearby public infrastructure, but it is representative of the potential for significant loss of usable land on public and private streambanks.

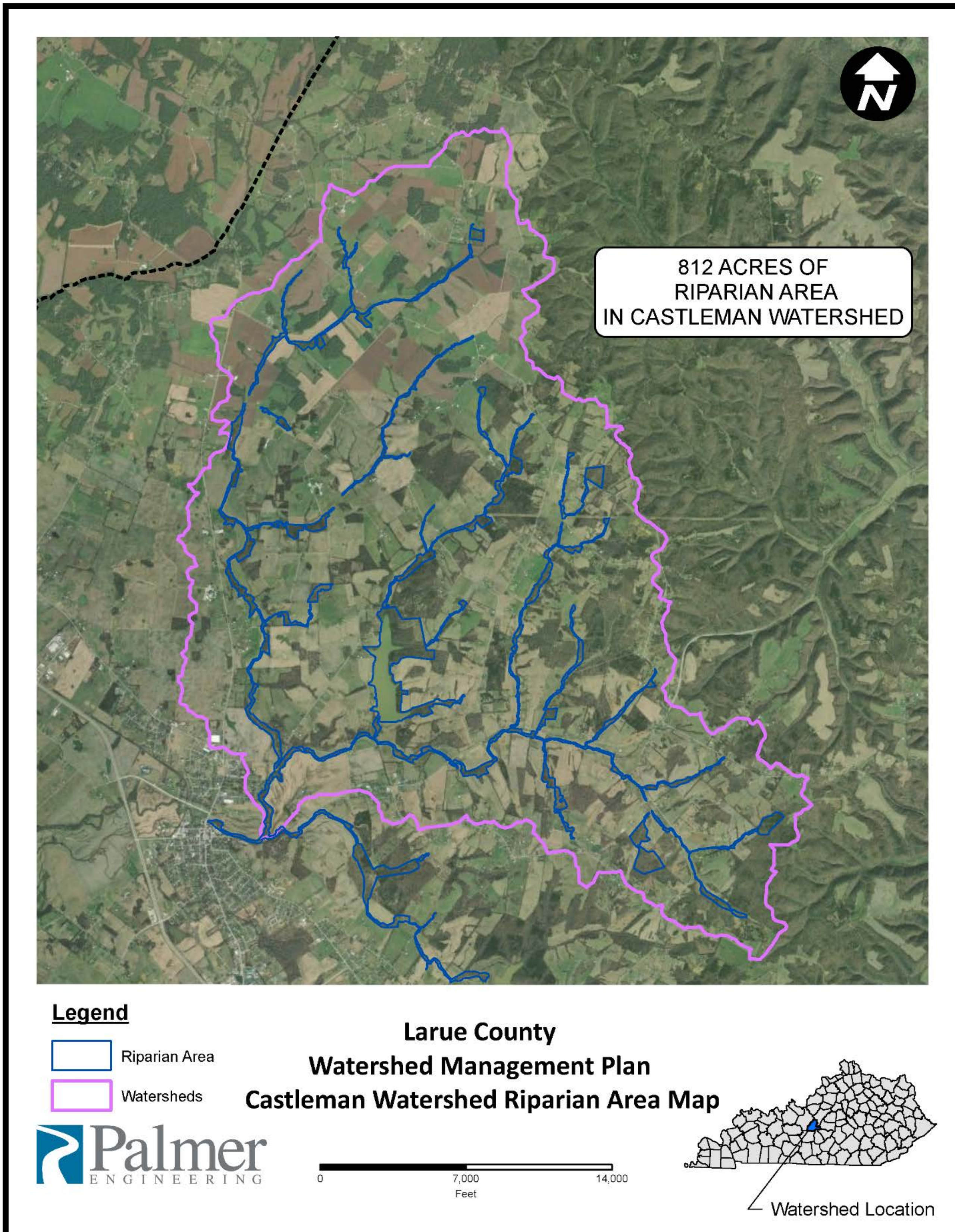


**Figure 24**. Castleman Creek Watershed Riparian Area Map

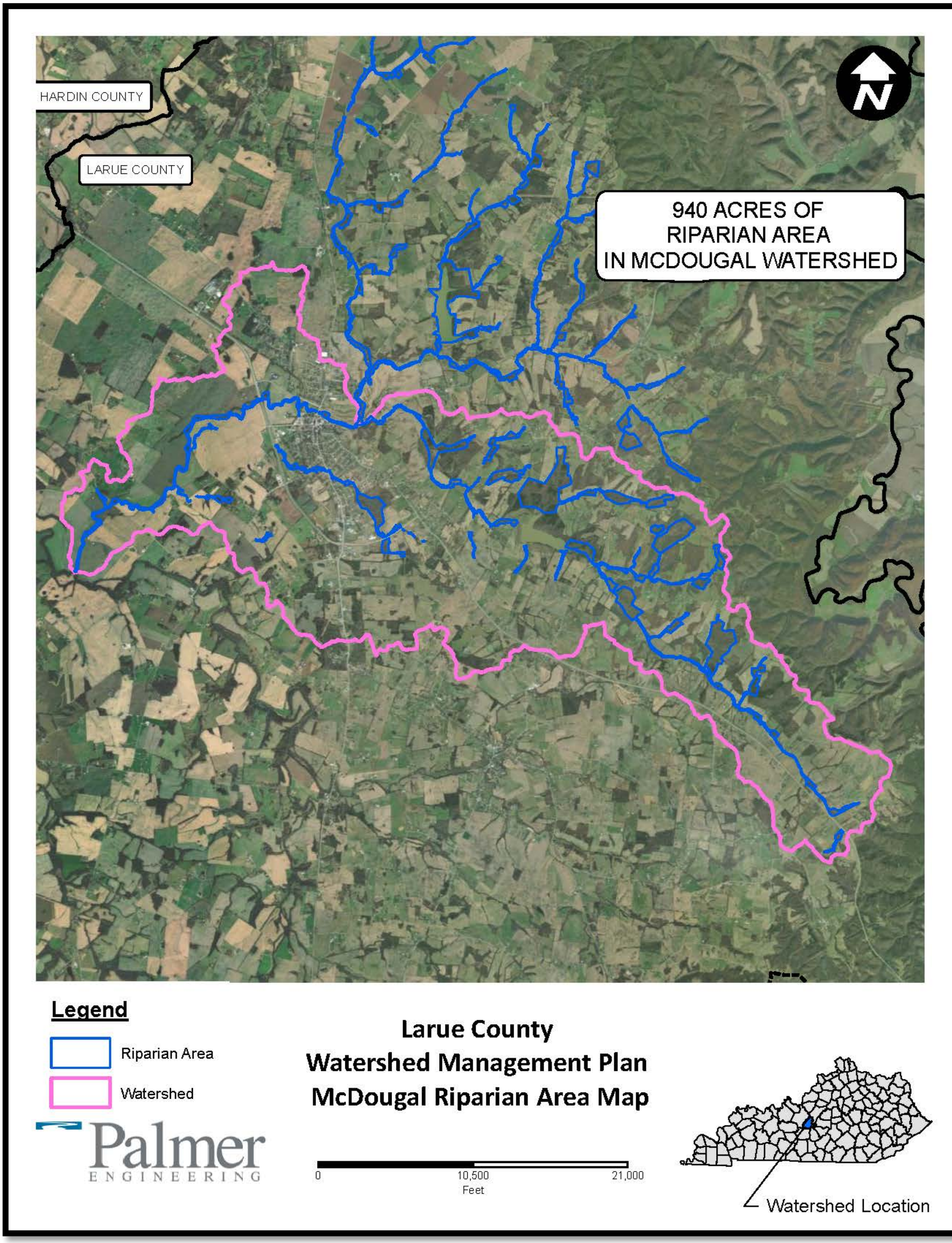


**Figure 25.** McDougal Creek Watershed Riparian Area Map

The benthic macroinvertebrates were assessed and compared with the benchmarks listed in Table 15. The following sites were assessed 5, 10, 11, 12, 13, 14, 15, 16, 17 and 18. These are the same sites assessed for habitat, except for Site 7. All 10 sites received a rating of "Fair" in accordance with *The Kentucky Macroinvertebrate Bioassessment Index*, dated September 2003. The lowest metrics were % modified EPT and % Ephem - Mayflies. Biological assessments were not conducted outside of the aforementioned locations. Full results can be found in Table 19.

**Table 19.** MCCW Macroinvertebrate Bioassessment Index Results

| | SITE ID | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **PARAMETER** | **5** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** | **18** |
| Date Sampled (all in 2018) | 7/18 | 7/11 | 7/10 | 7/12 | 7/12 | 7/10 | 7/11 | 5/3 | 5/3 | 4/24 |
| Stream Class | W | W | W | W | W | W | W | H | H | H |
| Taxa Richness-genus level | 54.0 | 59.0 | 37.0 | 68.0 | 59.0 | 51.0 | 75.0 | 80.0 | 51.0 | 52.0 |
| EPT Richness-genus level | 13.0 | 13.0 | 8.0 | 15.0 | 12.0 | 8.0 | 15.0 | 24.0 | 7.0 | 14.0 |
| mHBI | 5.2 | 5.5 | 5.3 | 6.1 | 5.7 | 5.8 | 5.6 | 5.2 | 5.4 | 5.6 |
| % modified EPT | 13.2 | 18.3 | 31.7 | 21.0 | 17.7 | 33.0 | 26.1 | 35.4 | 12.0 | 29.3 |
| % Mayflies | 1.3 | 18.0 | 21.8 | 20.1 | 16.3 | 29.7 | 14.3 | 25.2 | 10.4 | 27.6 |
| % Midges & Worms | 6.0 | 7.6 | 32.0 | 17.8 | 12.2 | 20.3 | 26.1 | 54.1 | 76.6 | 51.5 |
| % Clingers | 96.4 | 80.4 | 75.6 | 67.0 | 77.1 | 64.0 | 71.1 | 38.4 | 68.0 | 36.4 |
| *MBI Score* | 59 | 64 | 56 | 63 | 61 | 60 | 63 | 59 | 45 | 52 |
| *MBI Zone Rating* | Fair | Fair | Fair | Fair | Fair | Fair | Fair | Fair | Fair | Fair |

### 4.2.2. POLLUTANT LOAD PREDICTION

Pollutant load predictions in MCCW were based on the concentration of the pollutant and the stream flow. The concentrations of the pollutants were utilized from the sampling results discussed in Section 4.2.1. Based on the requirements outlined in the *Watershed Planning Guidebook for Kentucky Communities*, pollutant loads were calculated for *E. coli*, total nitrogen, total phosphorous, and total suspended solids. Site 6 Stream flow was collected by KDOW samplers for most sites during most events. In the case of missing flow data, three estimation methods were used. It was determined necessary to estimate flow in cases where entire sites or a critical sampling event was missing flow. These sites and events were valuable for inclusion in loading calculations.

The first flow estimation method utilized the close proximity among sites. Site 7 is located 0.3 river miles above Site 6 and 0.2 river miles below site 9. When flow data was collected at Site 7, but absent from sites 6 or 9, flow data from 7 was used. Site 1 is located a few hundred feet downstream of Site 2. Site 1 represents the combination of flow from Site 2 and from Site 3 (Nolynn Spring). Site 3 had no recorded flow measurements, so Site 2 flow readings were used when Site 1 flow was missing.

The second flow estimation method utilized a relationship between drainage area and measured flow. For all instances where Site 6 had no flow data and no data could be referenced for Site 7, the project team developed a linear relationship between drainage area and flow from all other sites. For most events, 11 sites had flow data to develop the relationship. This includes multiple sites with more drainage area than Site 6, and multiple sites with less drainage area than Site 6.

The third flow estimation method was used to estimate a gap in flow data during the February 21, 2019 event at all sites. This was the highest flow event. Samplers noted that during the event, water was "too fast to safely measure flow." To estimate flow during this event, the project team utilized available USGS stream gauge data from gauge 3310000 – North Fork Nolin River at Hodgenville KY. This gauge is located on the SR61 bridge, which is near sample Sites 4 and 5. For each site which had a sampling event for February 21, 2019, the project team developed a linear relationship between 3 low flow and 3 medium flow events which were measured, and the USGS measured flow at the time of sampling. A linear relationship was determined between USGS flow and measured flow for these 6 events. This relationship was used to extrapolate sample site flow during the high flow event on February 21, 2019. As a check, the project team confirmed that USGS flow and measured site flow at sample Site 5 was approximately equal, which was expected.

For the process of loading calculations and BMP implementation, Sites 1 & 2 and Sites 4 & 5 were combined due to their close proximity. Loading for Site 3 (Nolynn spring) was not calculated because of an absence in flow data and difficulty in estimating flow for a spring site. Loading for Site 8 was not calculated because no sampling events were recorded for Site 8. Loading for Site 12 was not calculated because this site represents the confluence of Castleman Creek and North Fork Nolin River. A majority of drainage to Site 12 is captured by flow at Sites 14 and 13.

Loading at Site 6 was treated differently than at other sites because this site represents the point source contribution of nutrients from the Hodgenville Wastewater Treatment Plant. Estimated loading for this site was calculated using flow data from the facility's monthly discharge monitoring reports from 1/1/18 to 12/31/19. These reports provide a single monthly average of flow in million gallons per day. This flow data was multiplied by the pollutant concentration for nitrogen & nitrate and total phosphorus, then averaged, to yield the average annual load contribution from the Hodgenville Wastewater Treatment Plant. The pollutant concentration in the effluent from this plant is governed by the facility's KPDES permit, and does not fall under the scope of this management plan. As a result, no benchmark loading, reduction to achieve target, or percent reduction to achieve target has been calculated for loading at Site 6.

Pollutant load predictions and target load reductions for *E. coli* were derived from the following formula:

$$\underset{\text{(MPN/yr)}}{\textit{E. coli}\text{ Loading}} = \underset{\text{(MPN/100mL)}}{\text{Concentration}} \times \underset{\text{(cfs)}}{\text{Discharge}} \times \underset{\text{(Annual Load Conversion)}}{8{,}907{,}973{,}920}$$

For *E. coli* loading calculations, the above formula was applied to the data from each sampling event. The value of the annual load conversion factor was sourced from the *Watershed Planning Guidebook for Kentucky Communities*. All sampling events were then averaged using the arithmetic mean to obtain an average annual load. Although a portion of MCCW is on the 303(d) list for impaired streams, no TMDLs have been provided by KDOW. The benchmark of 240 MPN/100 mL was used to calculate the target loads. Based on these calculations, the *E. coli* loading and target reductions are shown in Table 20. The reduction to achieve the target loading was calculated by subtracting the *E. coli* loading from the *E. coli* target loading. The percent reduction target was calculated by dividing the required value for the reduction to achieve the target loading by the *E. coli* loading present expressed as a percentage. A visualization of percent *E. coli* reduction to achieve target is shown in Figure 26. Subwatersheds are color coded so that red represents reduction above 50%, yellow represents reduction between 0% and 50% and green represents no reduction.

*E. coli* loadings were greater than benchmark loadings for all sites with *E. coli* data. *E. coli* loading was not calculated for Sites 6, 7 & 9 because they all did not have any *E. coli* measurements from any sampling event. The closest downstream site where loading from sites would appear in the data is Site 5. Of the sites with data, only two sites, 10 & 11, have relatively low required reductions to meet benchmark levels. The remaining eight sites all have required reductions above 50%. Sites 17 and 18 have required reductions of 94.6% and 96.1% respectively, to meet benchmark levels. These two sites are in the northwest portion of Castleman Creek Watershed. The two sampling events with the highest *E. coli* loading among all sites were 5/8/18 and 8/9/18. These two events were the highest flow events among the events where *E. coli* loading occurred. This indicates particular concern for *E. coli* loading during wet weather events. These results suggest that *E. coli* is a critical parameter of concern in all portions of the watershed, particularly the northwest portions of Castleman Creek Watershed.

**Table 20.** *E. coli* Loading and Target Reductions

| Site # | Average Annual *E. coli* Loading (MPN/yr) | Benchmark *E. coli* Target Loading (MPN/yr) | Reduction to Achieve Target (MPN/yr) | Percent Reduction to Achieve Target |
|---|---|---|---|---|
| 1 & 2 | 1.72861E+14 | 3.46059E+13 | 1.38256E+14 | 79.98% |
| 4 & 5 | 8.88369E+13 | 3.21318E+13 | 5.67052E+13 | 63.83% |
| 10 | 2.8711E+13 | 1.54357E+13 | 1.32753E+13 | 46.24% |
| 11 | 1.13043E+13 | 7.43866E+12 | 3.86561E+12 | 34.20% |
| 13 | 3.98444E+13 | 1.34535E+13 | 2.63909E+13 | 66.23% |
| 14 | 1.3017E+13 | 2.11504E+12 | 1.09019E+13 | 83.75% |
| 15 | 2.12845E+13 | 6.93924E+12 | 1.43452E+13 | 67.40% |
| 16 | 1.15378E+13 | 2.38933E+12 | 9.14845E+12 | 79.29% |
| 17 | 4.03244E+13 | 2.1749E+12 | 3.81495E+13 | 94.61% |
| 18 | 9.35423E+13 | 3.63424E+12 | 8.9908E+13 | 96.11% |

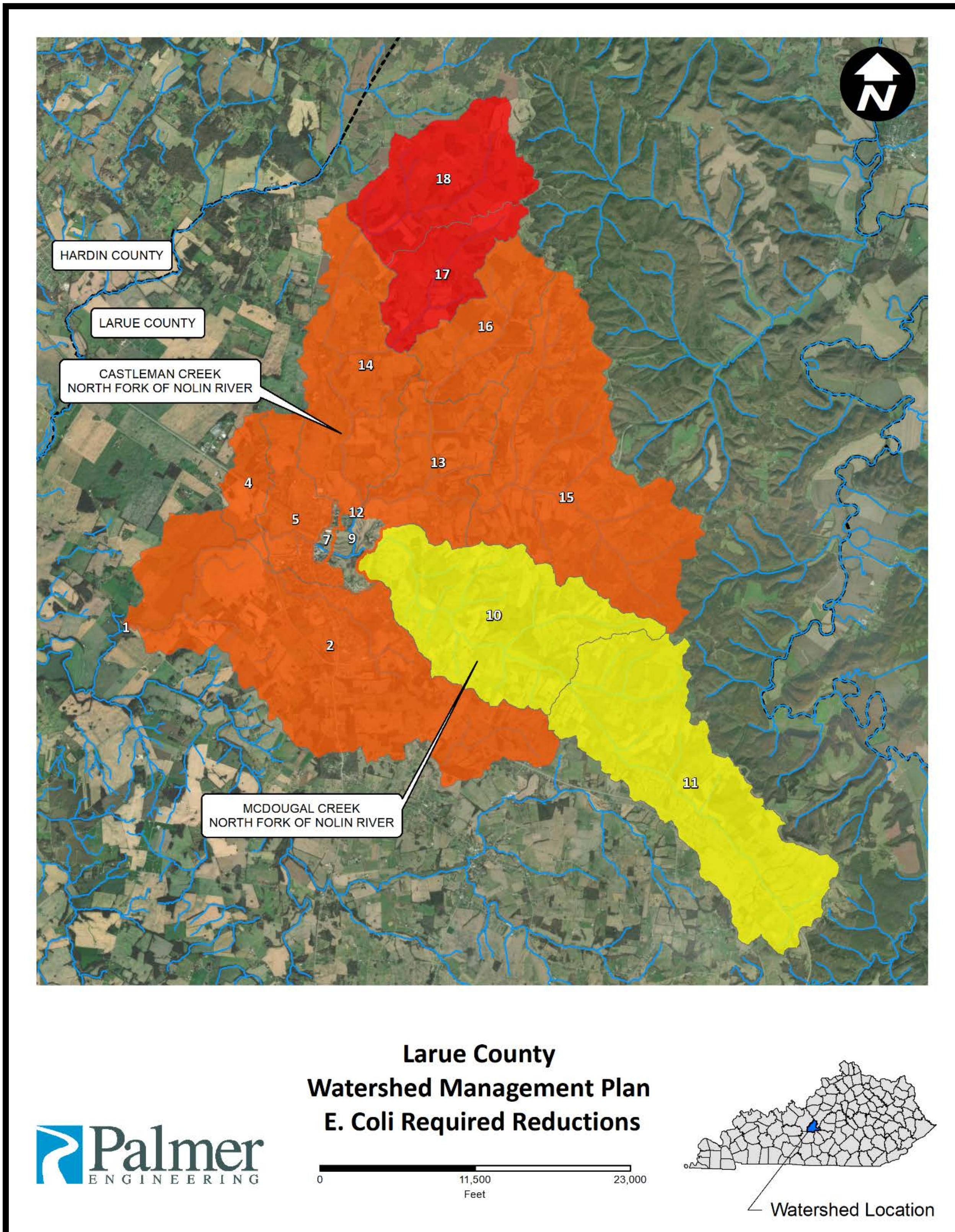


**Figure 26.** *E. coli* Percent Reduction to Achieve Target Map

Pollutant load predictions and target load reductions for nitrate & nitrite, total phosphorous, and total suspended solids were derived from the following formula:

$$\underset{(lbs/yr)}{\text{Nutrient/TSS Loading}} = \underset{(mg/L)}{\text{Concentration}} \times \underset{(cfs)}{\text{Discharge}} \times \underset{(\text{Annual Load Conversion})}{1968.80}$$

The value of the annual load conversion factor was sourced from the *Watershed Planning Guidebook for Kentucky Communities*. For nitrate & nitrite and total phosphorous, the above formula was used for each sampling event and then all the values were averaged together to obtain an average annual load. For total suspended solids, the above formula was applied to samples collected in August through October and April through July and then all the values were averaged together to obtain an average annual load. Total suspended solids results from November to March were excluded in accordance with the recommendations from KDOW. Although a portion of MCCW is on the 303(d) list for impaired streams, no TMDLs have been approved by KDOW. The water quality benchmark concentrations in Table 13 were used for target load calculations, which were: 0.075 mg/L for total phosphorous; 2.0 mg/L for nitrate & nitrite; and 12 mg/L for total suspended solids. Based on these calculations, the calculated and target loadings for total nitrogen is shown in Table 21, for total phosphorous in Table 22, and for total suspended solids in Table 23. The percent reductions for nitrate & nitrite, phosphorus and total suspended solids can be visualized in Figure 27, Figure 28, and Figure 29 respectively. Subwatersheds are color coded so that red represents reduction above 50%, yellow represents reduction between 0% and 50% and green represents no reduction.

**Table 21.** Nitrate & Nitrite Loading and Target Reductions

| Site # | Average Annual Nitrite & Nitrate Loading (lbs/yr) | Benchmark Nitrite & Nitrate Target Loading (lbs/yr) | Reduction to Achieve Target (lbs/yr) | Percent Reduction to Achieve Target |
|---|---|---|---|---|
| 1 & 2 | 324487.44 | 338860.45 | 0 | N/A |
| 4 & 5 | 214690.43 | 168504.41 | 46186.02 | 21.51% |
| 6 | 26393.77 | - | - | - |
| 7 | 35896.63 | 56743.88 | 0 | N/A |
| 9 | 52466.92 | 75366.65 | 0 | N/A |
| 10 | 21623.26 | 39791.95 | 0 | N/A |
| 11 | 38652.64 | 73136.26 | 0 | N/A |
| 13 | 54333.81 | 93599.80 | 0 | N/A |
| 14 | 48930.25 | 29847.11 | 19083.14 | 39.00% |
| 15 | 35895.57 | 57863.10 | 0 | N/A |
| 16 | 17321.25 | 21735.22 | 0 | N/A |
| 17 | 37310.68 | 18958.13 | 18352.54 | 49.19% |
| 18 | 45005.21 | 26866.35 | 18138.86 | 40.30% |

**Table 22.** Phosphorus Loading and Target Reductions

| Site # | Average Annual Phosphorus Loading (lbs/yr) | Benchmark Phosphorus Target Loading (lbs/yr) | Reduction to Achieve Target (lbs/yr) | Percent Reduction to Achieve Target |
|---|---|---|---|---|
| 1 & 2 | 20404.23 | 13874.00 | 6530.23 | 32.00% |
| 4 & 5 | 8500.75 | 6232.89 | 2267.86 | 26.68% |
| 6 | 4535.59 | - | - | - |
| 7 | 1378.52 | 2127.90 | 0 | N/A |
| 9 | 1970.42 | 2826.25 | 0 | N/A |
| 10 | 4561.75 | 3394.02 | 1167.73 | 25.60% |
| 11 | 668.81 | 2023.66 | 0 | N/A |
| 13 | 2731.70 | 4446.60 | 0 | N/A |
| 14 | 1236.17 | 1170.46 | 65.71 | 5.32% |
| 15 | 1240.75 | 3402.56 | 0 | N/A |
| 16 | 529.46 | 1078.28 | 0 | N/A |
| 17 | 606.36 | 874.47 | 0 | N/A |
| 18 | 1519.86 | 1023.44 | 496.42 | 32.66% |

**Table 23.** TSS Loading and Target Reductions

| Site # | Average Annual TSS Loading (lbs/yr) | Benchmark TSS Target Loading (lbs/yr) | Reduction to Achieve Target (lbs/yr) | Percent Reduction to Achieve Target |
|---|---|---|---|---|
| 1 & 2 | 606953.48 | 326995.18 | 279958.30 | 46.13% |
| 4 & 5 | 387157.17 | 308459.47 | 78697.71 | 20.33% |
| 6 | - | - | - | - |
| 7 | 404455.37 | 306758.17 | 97697.20 | 24.16% |
| 9 | 153098.48 | 223198.92 | 0 | N/A |
| 10 | 93462.03 | 139330.29 | 0 | N/A |
| 11 | 23216.58 | 52200.76 | 0 | N/A |
| 13 | 71189.84 | 113426.51 | 0 | N/A |
| 14 | 19460.04 | 23925.98 | 0 | N/A |
| 15 | 12032.32 | 41746.44 | 0 | N/A |
| 16 | 4489.36 | 23891.39 | 0 | N/A |
| 17 | 28139.07 | 34257.12 | 0 | N/A |
| 18 | 18131.47 | 36685.83 | 0 | N/A |

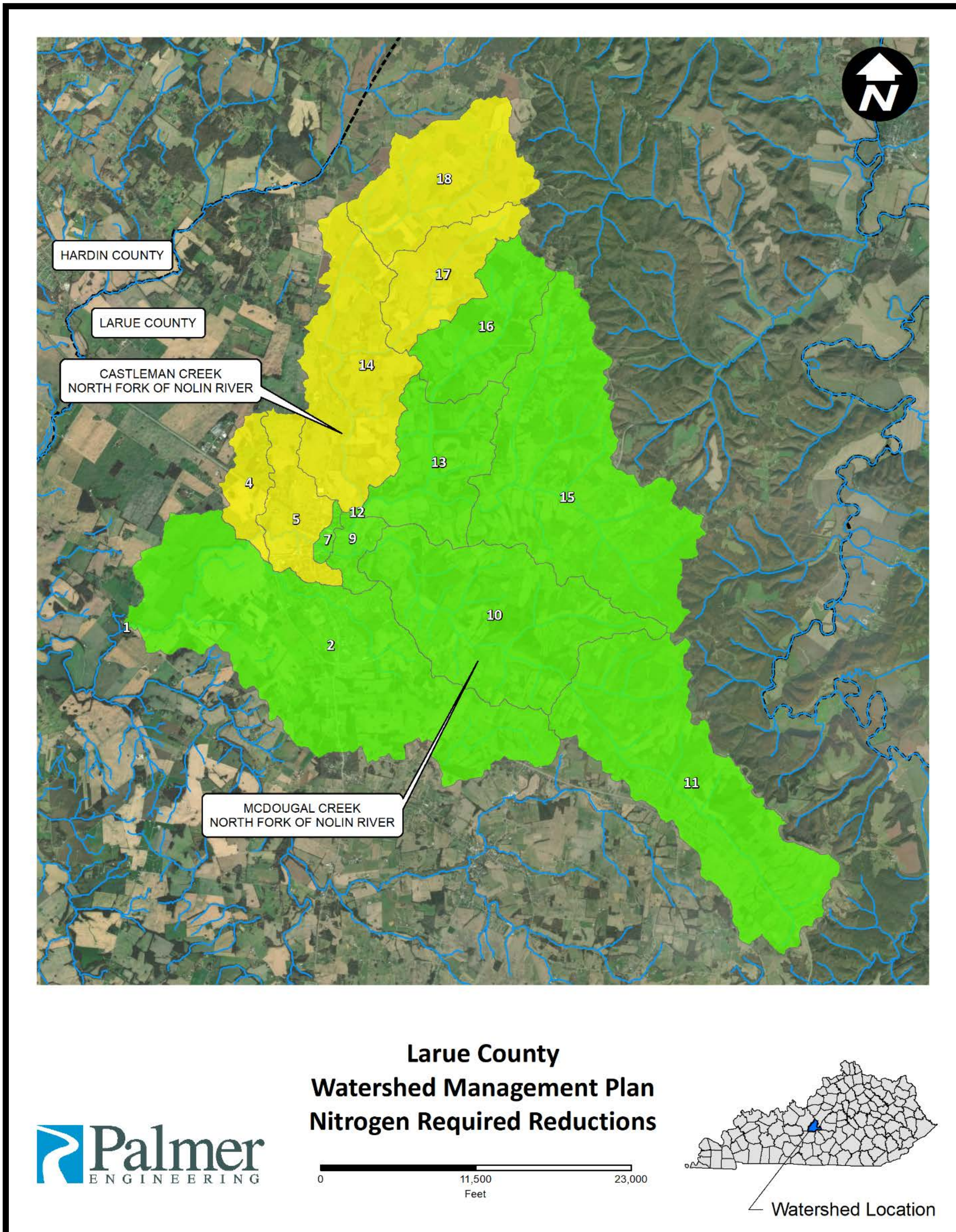


**Figure 27.** Nitrogen Percent Reduction to Achieve Target Map

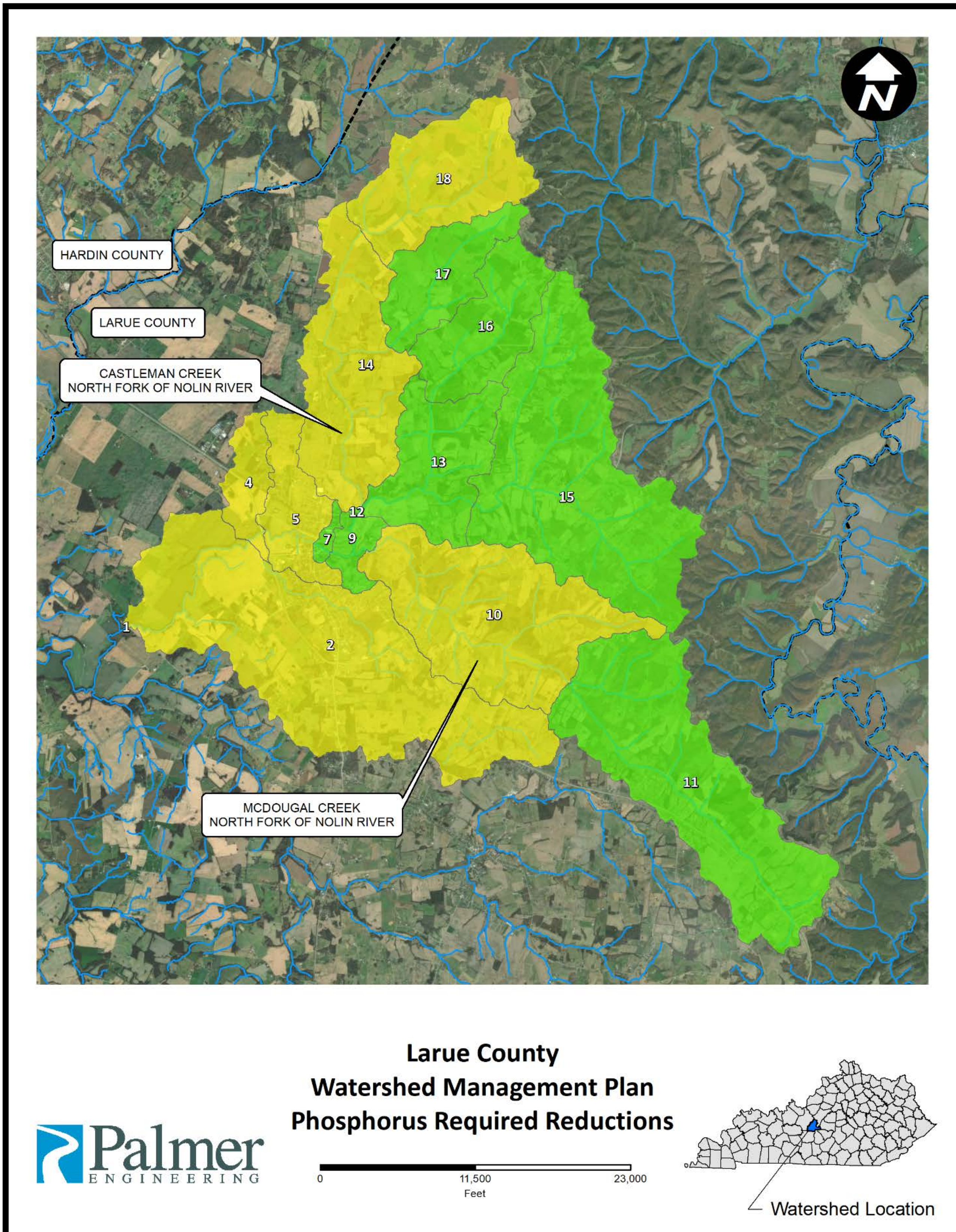


**Figure 28.** Phosphorus Percent Reduction to Achieve Target Map

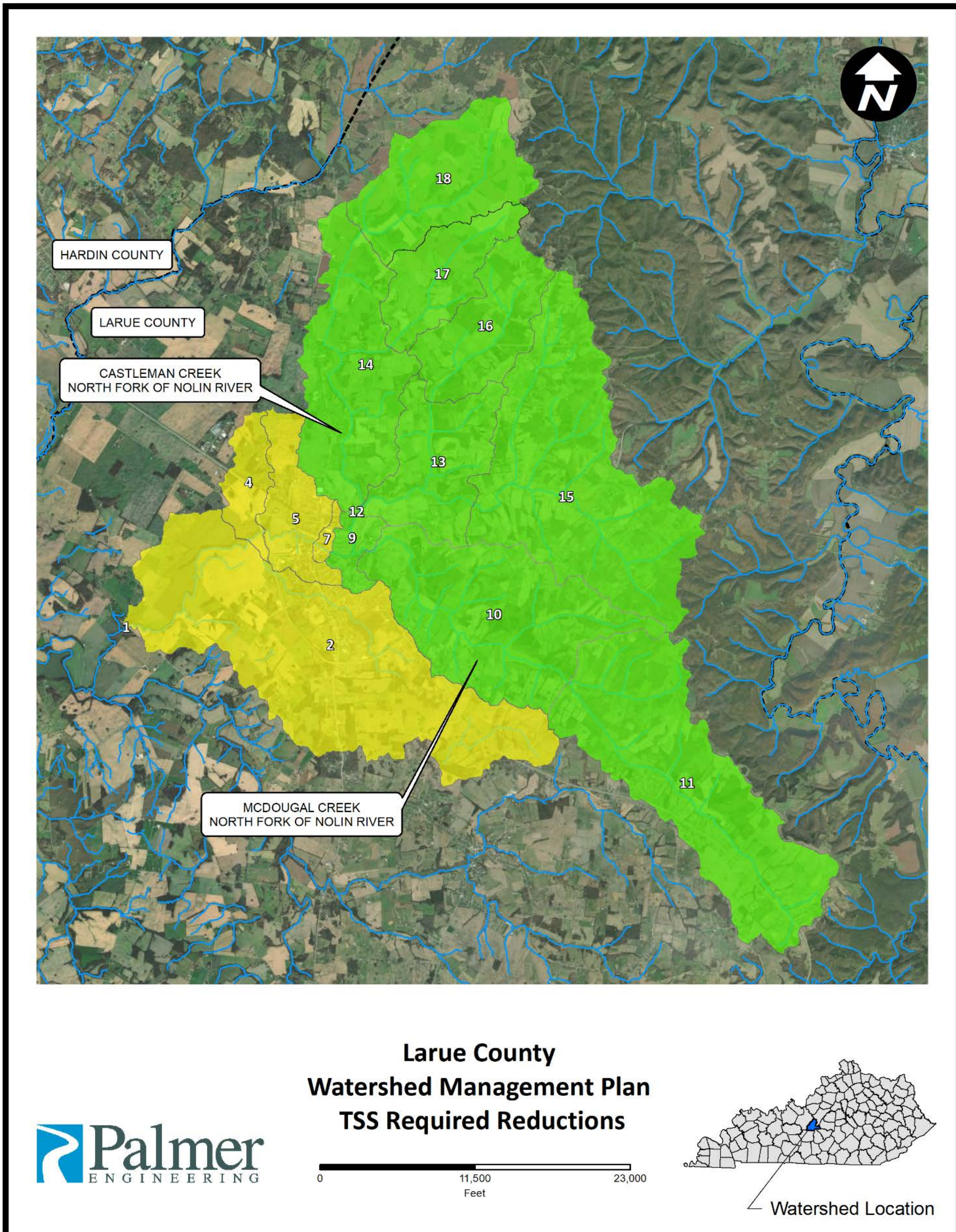


**Figure 29.** Total Suspended Solids Percent Reduction to Achieve Target Map

Nitrate & Nitrite (as N) loadings were within benchmark loadings for 8 of the 12 assessed sites. Four sites require reductions of less than 50% to reach benchmark levels. Total phosphorus loadings were within benchmark levels for 7 of the 12 assessed sites. Five sites require reduction of less than 35% to reach benchmark levels.

Total suspended solids loadings were within target loadings at each of the 12 sites except Sites 1 & 2, 4 & 5 and Site 7. It is expected that these downstream sites would have the highest calculated loading. The visual assessment of the watershed identified that the downstream reaches of NFNR were most at risk from bank erosion, which is often a primary cause of TSS pollution.

Conductivity is often used to estimate the total ion concentration of surface water and as an alternative measure of dissolved solids. Conductivity can vary as a function of flow. As flow decreases, the concentration of total dissolved solids may also increase, in turn increasing conductivity. Elevated conductivity can result from a number of factors, including the geology of the area, failing sewage systems, industrial discharges, fertilization, chemical application, and land disturbance. The practices applicable to reduction in *E. coli* and nutrient loadings will also address reductions in conductivity loading. Conductivity will not be analyzed separately from *E. coli* and nutrients in the remainder of this report.

Biochemical Oxygen Demand (BOD) is the measure of the amount of oxygen consumed by microorganisms as organic matter is decomposed in a water body. Higher levels of BOD can indicate the presence of a source of pollution. Six sites experienced BOD levels above the benchmark of 2.0 mg/L, but no sites experienced more than 50% of samples above benchmark. All of the six sites with BOD levels above benchmark are also observed to have high levels of *E. coli*, nitrogen and total phosphorus. It is likely that the presence of these other pollutants are contributing to high BOD levels. The practices applicable to reduction in *E. coli* and nutrient loadings will also address reductions in BOD loading. BOD will not be analyzed separately from *E. coli* and nutrients in the remainder of this report.

### 4.2.3. SITE SPECIFIC ANALYSIS OF *E. COLI* RESULTS

All sites with *E. coli* samples had at least half of the samples exceed the benchmark limit of 240 MPN/100mL. This suggests that *E. coli* is the most prevalent pollutant in the Castleman and McDougal Creek watersheds. Since the presence of pollution is widespread in the watersheds, site specific discussion will focus on the estimated *E. coli* loading and amount of reduction required for each subwatershed to have its loading reduced to the benchmark level of 240 MPN/100mL. When applicable, outstanding individual samples will be compared to the weather and flow conditions during that sample to determine if each site is at risk from point or nonpoint source pollution.

In this section, when referring to a site or grouping of sites, the project team is referring to both the sampling location at the provided GPS coordinates in Table 11 and the entire subwatershed which is contributing flow and pollutants to that site. Figure 30, on page 77, showcases the boundary and location of each subwatershed associated with each sampling site.

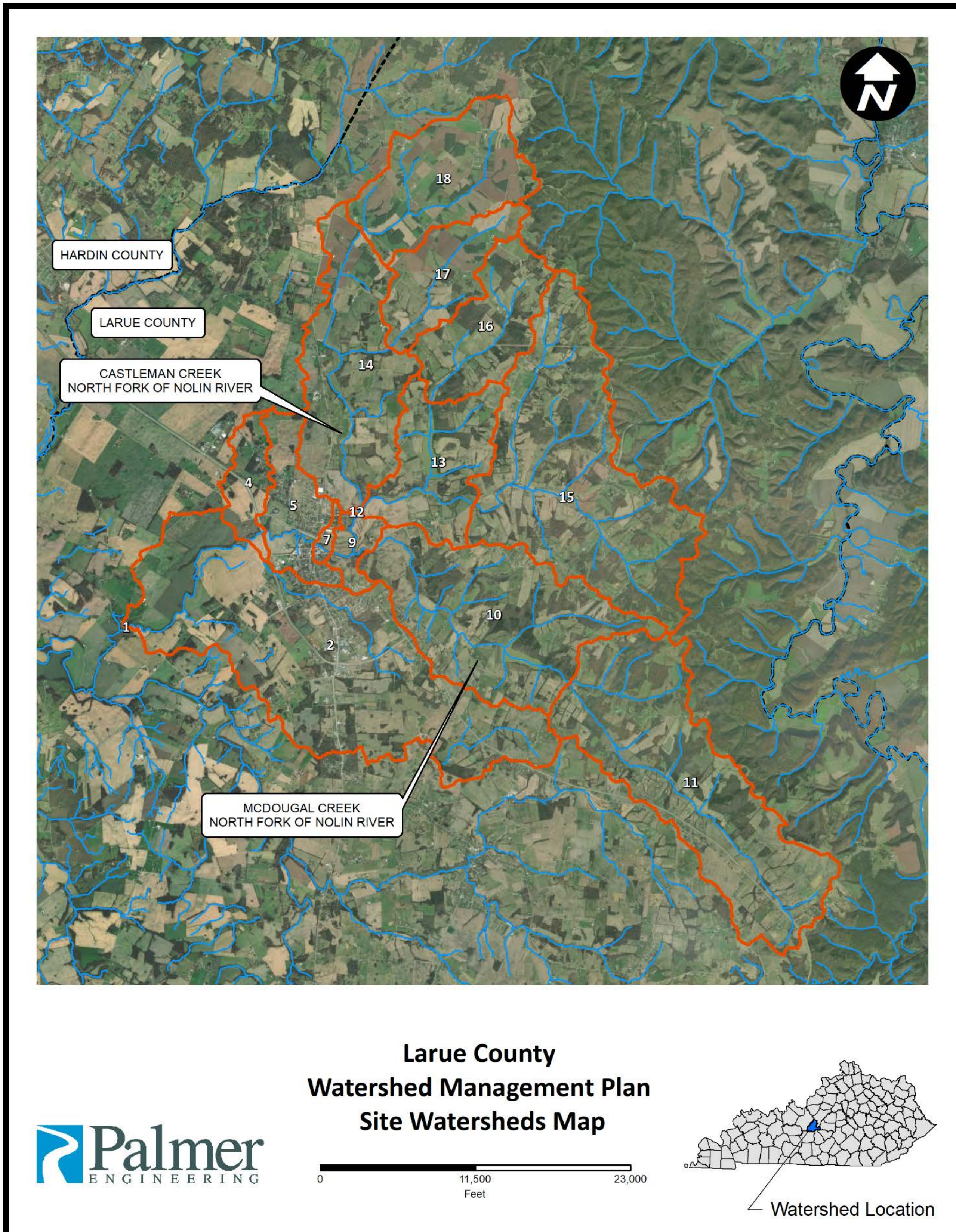


**Figure 30.** MCCW Sampling Site Subwatersheds Map

#### 4.2.3.1. SITE 1 & SITE 2 *E. COLI* ANALYSIS

Of the 10 sites which were assessed for *E. coli* loading, Sites 1 & 2 combined had the highest average annual loading. This is most likely a result of these sites being the most downstream point in the watershed. This combination of sites had the fourth highest percent required reduction, to reach benchmark levels, at 79.9%. The highest *E. coli* sample at Sites 1 & 2 occurred during the 8/9/18 sampling event. The sample at Site 1 was 7,270 MPN/100 mL and the sample at Site 2 was 3,968 MPN/100mL. This sample at Site 1 was the fourth highest *E. coli* sample among all samples. The 8/9/18 event is categorized as dry with light rain. This was the third highest flow event at these sites which had *E. coli* samples. The nearly doubled *E. coli* sample at Site 1 during the 8/9/19 sampling event suggests that Nolynn Spring contributed a significant concentration *E. coli* to NFNR. This doubling also occurred during the 5/8/18 event and 5/28/18 event which are also categorized as dry with light rain. During the remaining six events, two of which were categorized as dry with light rain, *E. coli* at Site 2 was higher than at Site 1 which suggests that Nolynn spring contributed flow with relatively less *E. coli* concentration to dilute the flow from Site 2. At Site 1, the three lowest *E. coli* samples occurred during the 5/15/18, 6/19/18, and 7/17/18 events which were three of the lowest flow events sampled. At Site 2, the two lowest *E. coli* samples occurred during the 5/1/18 and 5/15/18 sampling events. The 5/1/18 event was one of the highest flow events sampled.

Since these sites represent the culmination of *E. coli* pollution throughout the watershed, it is useful to compare samples at Sites 1 and 2 with the nearest upstream site with *E. coli* readings, Site 5. For most sampling events, *E. coli* samples at Site 5 were higher than at Site 1 and 2. Two instances where *E. coli* readings at Site 5 were lower than at Site 2 were during the two lowest flow events of 6/19/18 and 7/17/18. During the 8/9/18 high flow event, the *E. coli* sample at Site 2 was double that at Site 5. This suggests that during normal flow conditions, *E. coli* concentration is diluted in NFNR between Site 5 and Site 2. During low and high flow conditions, concentration is increased between Site 5 and Site 2. This suggests that Site 1 and Site 2 are vulnerable from point and nonpoint source pollution. The vulnerability shows up in the change in *E. coli* concentration from upstream to downstream during low and high flow events.

#### 4.2.3.2. SITE 4 & SITE 5 *E. COLI* ANALYSIS

Of the 10 sites which were assessed for *E. coli* loading, Site 5 had the third highest average annual loading. No *E. coli* loading from Site 4 was calculated because there were no *E. coli* samples at Site 4. The average annual loading at this site is similar in magnitude to the loading at Site 18. High loading is most likely a result of the site being nearly the most downstream point in the watershed. Only Sites 1 & 2 are more downstream. This site had the third lowest percent required reduction to reach benchmark levels, at 63.8%. Note that *E. coli* loading at Site 5 is the best representation available for loading at Sites 7 and 9 which have no *E. coli* samples to calculate loading with. The highest *E. coli* sample at Site 5 was 2,064 MPN/100mL taken during the 8/9/18 event. This event is categorized as dry with light rain. No other samples at Site 5 were above 770 MPN/100mL. The three lowest *E. coli* readings at Site 5 occurred during the sampling events with the lowest flow. This alone suggests that Site 5 (and 7 & 9) are most vulnerable to nonpoint source pollution reaching the stream through stormwater runoff.

Since Site 5 (and 7 & 9) represent the culmination of *E. coli* from several subwatersheds, it is useful to compare samples at Site 5 with the nearest upstream site with *E. coli* readings, Site 12. Site 12 is the confluence of Castleman Creek and North Fork Nolin River. This confluence occurs upstream of Hodgenville. During four samples, *E. coli* concentration decreased from Site 12 to Site 5. All four of these instances occurred during low flow events. Four times *E. coli* concentration remained similar from Site 12 to Site 5. These four instances occurred during low/normal flow events. Two times *E. coli* concentrations increased from Site 12 to Site 5. This occurred during high flow events. Site 5 (and 7 & 9) is also downstream of Site 10 which is the confluence of McDougal Creek and North Fork Nolin River. Similar to what occurred between Site 12 to Site 5, from Site 10 to Site 5, *E. coli* concentration increased during high flow events and decreased during low flow events. These findings further support the conclusion that Site 5 (and 7 & 9) is not vulnerable to point source pollution which would increase concentrations during low flow events. Site 5 (and 7 & 9) does appear to be overly vulnerable to nonpoint source pollution.

The KWW *E. coli* samples taken at Site 5 also agree with this finding. The highest measured *E. coli* sample occurred during the sampling event with the highest rainfall. Of the 12 *E. coli* samples, 11 were above the benchmark level.

#### 4.2.3.3. SITE 7 *E. COLI* ANALYSIS

Site 7 had no *E. coli* samples and was not assessed for *E. coli* loading or benchmark exceedances.

#### 4.2.3.4. SITE 9 *E. COLI* ANALYSIS

Site 9 had no *E. coli* samples and was not assessed for *E. coli* loading or benchmark exceedances.

#### 4.2.3.5. SITE 10 *E. COLI* ANALYSIS

Of the 10 sites which were assessed for *E. coli* loading, Site 10 had the sixth highest average annual loading. This site had the second lowest percent required reduction to reach benchmark levels, at 46.2%. The required reduction is significant, but this site, which represents the McDougal Creek Watershed, can be considered less of a critical priority than other sites with required reductions above 50%. The highest *E. coli* sample of 1,046 MPN/100mL at Site 10 was taken during the 7/17/18 event. This event is categorized as dry with light rain, but it is one of the lowest flow events with *E. coli* samples at Site 10. Two other *E. coli* samples were above 816 MPN/100mL at Site 10. Each of these samples occurred during low flow events. This suggests that Site 10 is more vulnerable from point source *E. coli* pollution directly in the stream.

Site 10 represents the culmination of the McDougal Creek Watershed before it joins with NFNR. The other upstream site on McDougal Creek is Site 11. During six sampling events with normal/high flow, *E. coli* concentration at Site 10 was nearly the same as Site 11, which suggests there are similar *E. coli* pollutants in the two subwatersheds as to not dilute or increase concentration. During four sampling events with low flow, *E. coli* concentrations at Site 10 increased significantly (2.8 times increase on average) from concentrations at Site 11. This evidence further supports the conclusion that Site 10 is experiencing *E. coli* pollution from point source pollution which is most impactful during low flow events.

#### 4.2.3.6. SITE 11 *E. COLI* ANALYSIS

Of the 10 sites which were assessed for *E. coli* loading, Site 11 had the lowest average annual loading. The average annual loading at this site is similar in magnitude to loading at Sites 14 and 16. This site had the lowest percent required reduction to reach benchmark levels, at 34.2%. The required reduction is significant, but this site, which represents the McDougal Creek Watershed, can be considered less of a critical priority than other sites with required reductions above 50%. The highest *E. coli* sample at Site 10, 770 MPN/100mL, occurred during the 5/29/18 sampling event. This event is categorized as dry with light rain and was the third highest flow event with *E. coli* samples. The second highest flow event also had the second highest *E. coli* sample, but the highest flow event had the sixth highest sample. This suggests that Site 11 is vulnerable to nonpoint source pollution up to a certain level of precipitation, but after that amount, the remaining rain water dilutes *E. coli* concentration. It is possible that Site 11 has a finite source of *E. coli* pollution which runs out after the first few inches of a rainfall event. This pattern suggests that hysteresis could be present in this subwatershed since the data indicates a marked increased concentration on the onset of a storm event, but dilution as the event continues. Addressing pollutant removal during the first flush should be prioritized in this watershed.

#### 4.2.3.7. SITE 13 *E. COLI* ANALYSIS

Of the 10 sites which were assessed for *E. coli* loading, Site 13 had the fifth highest average annual loading. The average annual loading at this site is similar in magnitude to the loading at Site 17. This site had the fourth lowest percent required reduction, to reach benchmark levels, at 66.2%. The highest *E. coli* sample at Site 13 was 2,420 MPN/100mL. This sample occurred during the 5/29/18 sampling event which is categorized as dry with light rain. This was the fourth highest flow event sampled for *E. coli* at this site. The highest flow event sampled had an *E. coli* result of 770 MPN/100mL which was the second highest sample. The four lowest flow events sampled all had an *E. coli* reading under 500 MPN/100mL. This suggests that Site 13 is more vulnerable from nonpoint source pollution.

Site 13 represents North Fork Nolin River before the confluence of Castleman Creek and McDougal Creek. This site is downstream of Site 16, upstream of Salem Lake and Site 15 in upstream NFNR. Flow at Site 16 is typically much less than at flow at Sites 15 and 13. Flow from Site 16 to Site 13 is also greatly impacted by Salem Lake. For these reasons, change in concentration from Site 16 to Site 13 will not be considered. During the two highest flow events, *E. coli* concentration at Site 13 is greater than concentration at Site 15. *E. coli* concentration at Site 13 is less than concentration at Site 15 during most other low/normal flow events. This further suggests that Site 13 is more vulnerable from nonpoint source pollution during storm events.

#### 4.2.3.8. SITE 14 *E. COLI* ANALYSIS

Of the 10 sites which were assessed for *E. coli* loading, Site 14 had the third lowest average annual loading. The average annual loading at this site is similar in magnitude to loading at Sites 11 and 16. This site had the third highest percent required reduction to reach benchmark levels, at 83.7%. Even though Site 14 had among the lowest recorded loading, the benchmark loading was also lowest among all sites. This occurred because even though Site 14 does not have the lowest drainage area, it experienced eleven sampling events below 2 cfs. The highest *E. coli* sample was 3,448 MPN/100mL which occurred during the 8/9/18 event which was categorized as a dry event with light rain. The 8/9/18 event was the highest flow event which had *E. coli* samples at this site. The second highest *E. coli* sample occurred during the 5/29/18 event which was also categorized as a dry event with light rain. The two lowest *E. coli* samples occurred during the 5/1/18 and 5/8/18 sampling events which were categorized as dry events with sunny weather. This suggests that Site 14 is vulnerable to nonpoint source pollution which is captured by stormwater runoff.

Site 14 is downstream of Site 17 and Site 18 which are separate subwatersheds with the highest *E. coli* concentrations. For eight out of the ten sampled events, *E. coli* concentration was much lower at Site 14 than at Sites 17 and 18. This occurred during low and normal flow events. Only twice was *E. coli* concentration at Site 14 higher than concentrations at Sites 17 and 18. This occurred during the highest flow event (8/9/18) and one of the lowest flow events (7/17/18). This suggests that Site 14 is vulnerable to point source and nonpoint source pollution during the extremes of high and low flow. During normal flow conditions, subwatershed 14 is diluting the high concentrations from upstream.

#### 4.2.3.9. SITE 15 *E. COLI* ANALYSIS

Of the 10 sites which were assessed for *E. coli* loading, Site 15 had the fourth lowest average annual loading. This site had the fifth lowest percent required reduction, to reach benchmark levels, at 67.4%. The highest *E. coli* sample of 2,420 MPN/100mL at Site 15 occurred during the 5/29/18 sampling event. This event is categorized as dry with light rain and is the third highest flow event with *E. coli* samples at Site 15. The two second highest *E. coli* samples occurred during the 6/19/18 and 7/17/18 events which are categorized as dry with sunny and light rain respectively. These are the second and third lowest flow events with *E. coli* samples at Site 15. This suggests that Site 15 is vulnerable to *E. coli* pollution from point source and nonpoint source pollution.

#### 4.2.3.10. SITE 16 *E. COLI* ANALYSIS

Of the 10 sites which were assessed for *E. coli* loading, Site 16 had the second lowest average annual loading. The average annual loading at this site is similar in magnitude to loading at Sites 11 and 14. This site had the fifth highest percent required reduction to reach benchmark levels, at 79.3%. The highest *E. coli* sample of 2,420 MPN/100mL at Site 16 occurred during the 8/9/18 sampling event. This event is categorized as dry with light rain and was the second highest flow event (1.73 cfs) sampled for *E. coli* at site 16. The highest flow event (2.38 cfs) on 5/1/18 experienced the lowest *E. coli* sample of 91 MPN/100mL. The preceding weather on 5/1/18 was sunny and the preceding weather on 8/9/18 was light rain. The other high *E. coli* samples at site 16 occurred predominantly during the high flow events, but one reading of 1,120 MPN/100mL occurred during 7/17/18 which was the second lowest flow event sampled at the site. This event is categorized as dry with light rain. This suggests that Site 16 is vulnerable from nonpoint source pollution.

#### 4.2.3.11. SITE 17 *E. COLI* ANALYSIS

Of the 10 sites which were assessed for *E. coli* loading, Site 17 had the fourth highest average annual loading. The average annual loading at this site is similar in magnitude to loading at Site 13. This site had the second highest percent required reduction to reach benchmark levels, at 94.6%. Required reduction at this site stands out due to its high magnitude. Estimated loading at this site is approximately 18 times higher than the estimated benchmark load. This site has the lowest drainage area of all sites which suggests the *E. coli* pollution is more concentrated than at other sites. Site 17 experienced one outstanding *E. coli* sample of 19,860 MPN/100mL. This sample is the second highest recorded sample among all samples. This occurred during the 5/29/18 event which is categorized as a dry event with light rain. This was the third highest flow event sampled at this site. The second highest *E. coli* sample was 6,131 MPN/100mL. This sample is the fifth highest recorded sample among all samples. This was sampled during the 5/22/18 event which is categorized as dry with light rain. These two samples occurred in back to back sampling events. The lowest *E. coli* sample at Site 17 was 261 MPN/100mL which was sampled during the 7/17/18 event. This event is categorized as dry with light rain. *E. coli* samples above 1,300 MPN/100mL occurred during low flow and high flow events which suggest this site is vulnerable to point source and nonpoint source *E. coli* pollution. If the highest *E. coli* sample of 19,860

MPN/100mL was to be considered an outlier and removed from the average, this site would still require a reduction of 84.8% to reach benchmark levels. This reduction, with highest sample removed, is still the second highest required reduction.

#### 4.2.3.12. SITE 18 *E. COLI* ANALYSIS

Of the 10 sites which were assessed for *E. coli* loading, Site 18 had the second highest average annual loading. This site had the highest percent required reduction, to reach benchmark levels, at 96.1%. Required reduction at this site stands out due to its high magnitude. Estimated loading at this site is approximately 26 times higher than the estimated benchmark load. Site 18 had the highest and third highest *E. coli* samples of 24,190 and 10,462 MPN/100mL. These samples occurred during the 5/29/18 and 5/22/18 events respectively. These events are both categorized as dry with light rain. These are the same two sampling events which produced the two highest samples at Site 17. This is curious because Sites 17 and 18 are not in the same drainage area, although they are both in the northwest portion of Castleman Creek watershed. It is possible that the same pollutant source is occurring over a wide area which includes the 2 square miles of Site 17 drainage area and 3.36 square miles of Site 18 drainage area. There are no active KPDES permits in either watershed. It may be necessary to utilize microbial source tracking, or other similar testing methods to determine if *E. coli* pollution in these watersheds is from human or animal sources. Site 18 experienced three low samples of 326, 345, and 345 MPN/100mL during the 5/1/18, 9/11/18, and 10/18/18 events. The 5/1/18 and 10/18/18 sampling events are categorized as dry events with sunny weather. The 9/11/18 sampling event is categorized as dry with light rain. Site 18 experienced *E. coli* samples above 1,000 MPN/100mL during low and high flow events which suggest this site is vulnerable to point and nonpoint source pollution. If the highest *E. coli* sample of 24,190 MPN/100mL was to be considered an outlier and removed from the average, this site would still require a reduction of 88.9% to reach benchmark levels. This reduction, with highest sample removed, is still the second highest required reduction.

### 4.2.4. SITE SPECIFIC ANALYSIS OF NUTRIENT RESULTS

Eight of the 17 total sites had more than one sample of nitrate & nitrite above the benchmark limit of 2.0 mg/L. This makes nitrate and nitrite the third most common pollutant exceeding benchmarks of the four assessed for loading. Since some sites are within benchmark levels and some are above, site specific discussion will focus on the number and ratio of exceedances. Load reductions will be discussed in depth only for sites which require load reductions to meet benchmark levels. When applicable, outstanding individual samples will be compared to the weather and flow conditions during that sample to determine if each site is at risk from point or nonpoint source pollution.

Nine of the 17 sampled sites had more than one sample of total phosphorus above the benchmark limit of 0.075 mg/L. This makes phosphorus the second most common pollutant exceeding benchmarks of the four assessed for loading.

In this section, when referring to a site or grouping of sites, the project team is referring to both the sampling location at the provided GPS coordinates in Table 11 and the entire subwatershed which is contributing flow and pollutants to that site. The one exception to this is with Site 6, which has only been assessed for the point source discharge from the Hodgenville Wastewater Treatment Plant.

#### 4.2.4.1. SITE 1 & SITE 2 NUTRIENT ANALYSIS

Sixteen of the 20 nitrate and nitrite samples were above benchmark levels at Site 1. The four samples below the benchmark level of 2 mg/L ranged from 1.82 to 2.0 mg/L, all near the benchmark. The sixteen samples above the benchmark ranged from 2.05 to 3.43 mg/L. The highest sample at Site 1 occurred during 6/19/18 which was categorized as a dry event with sunny weather. This suggests that Site 1 is vulnerable from point source nitrate and nitrite pollution.

Twelve of 16 nitrate and nitrite samples were above benchmark levels at Site 2. The four samples below the benchmark level ranged from 1.44 to 1.86 mg/L. The twelve samples above the benchmark ranged from 2.04 to 3.03 mg/L. The highest sample at Site 2 also occurred during 6/19/18 which was categorized as a dry event with sunny weather. This suggests that Site 2 is vulnerable from point source nitrate and nitrite pollution.

Estimated nitrate and nitrite loading for Site 1 and Site 2 is 4.43% lower than benchmark loading. This means that the site is only marginally within benchmark limits. Suggested BMPs throughout the other subwatersheds are expected to have a positive impact on nitrate and nitrite loading to give Site 1 and Site 2 more room below benchmark levels.

Six of the 17 total phosphorus samples were above benchmark levels at Site 1. These six samples ranged from 0.08 mg/L to 0.33 mg/L. The highest sample occurred during the 8/9/18 flow event. This event is categorized as dry with light rain preceding. Four of the 15 total phosphorus samples were above benchmark levels at Site 2. These four samples ranged from 0.08 mg/L to 0.25 mg/L. The highest sample at Site 2 also occurred during the 8/9/18 flow event.

Estimated total phosphorus loading for Site 1 and Site 2 is 32% higher than benchmark loading. This is the second highest required reduction to reach benchmark levels for phosphorus among all sites, by a margin of 0.66%. BMPs will be suggested to reduce phosphorus nonpoint source pollution in the Site 1 & Site 2 subwatershed, but water quality at this location will also benefit from many proposed upstream BMPs throughout McDougal and Castleman Creek watersheds.

#### 4.2.4.2. SITE 3 NUTRIENT ANALYSIS

Nine of the 10 nitrate and nitrite samples were above benchmark levels at Site 3. The one nitrate and nitrite reading below benchmark was 1.81 mg/L. The nine readings above benchmark levels ranged from 2.02 to 3.9 mg/L. The highest sample occurred during the 4/24/19 sampling event which is categorized as dry with sunny weather. This suggests that the Site 3, karst drainage area is vulnerable from point source pollution. Site 3 was not included in loading calculations due to a lack of flow data for this site. As is shown in Figure 7, the karst drainage area for Site 3 contains a large portion of Cattleman Creek Watershed, including Sites 17 and 18 which are the most polluted for nitrate and nitrite. Improvements in other subwatersheds will have a positive impact on nitrate and nitrite pollution at this site.

Four of the 15 total phosphorus samples at Site 3 were above benchmark levels. These four samples ranged from 0.08 mg/L to 0.16 mg/L. The maximum sample occurred during the 6/19/19 sampling event which was categorized as dry following a light rain. Site 3 was not included in loading calculations due to a lack of flow data for this site. Improvements in other subwatersheds will have a positive impact on phosphorus pollution at this site.

#### 4.2.4.3. SITE 4 & SITE 5 NUTRIENT ANALYSIS

One of three nitrate and nitrite samples was above benchmark levels at Site 4. Nitrate and nitrite samples at Site 4 ranged from 1.45 to 2.06 mg/L. There are not enough total samples in Site 4 to judge pollutant level. It is assumed that conditions at Site 5, which has more a more robust dataset, are equivalent to Site 4.

Four of 17 nitrate and nitrite samples were above benchmark levels at Site 5. The four samples below the benchmark ranged from 0.972 to 1.99 mg/L. The seventeen samples above the benchmark ranged from 2.03 to 3.18 mg/L. The highest sample of 3.18 mg/L occurred during the 2/21/19 sampling event which was the highest flow event among all events. This was a wet weather event with heavy rain. High nitrate and nitrite concentrations during this event suggest that Sites 4 and 5 are vulnerable from nonpoint source nitrate and nitrite pollution. The low concentration nitrate and nitrite samples at this site occurred during low flow events which suggest that these sites are not vulnerable from point source nitrate and nitrite pollution. Estimated nitrate and nitrite loading for Site 4 and Site 5 is 21.5% higher than benchmark loading. This is the lowest required reduction among the five sites which have required nitrate and nitrite required reductions to reach benchmark levels. Total average annual loading of nitrate and nitrite (lbs/year) at this site is the second highest among the five sites with required reductions. High loading at this site is likely impacted by nitrate and nitrite pollution at Site 6. See the following section for more details on Site 6.

KWW sampled four events with nitrate and nitrite data. A single sample of 2.3 mg/L was above the benchmark. This sample occurred during the lowest recorded flow rate of all samples which supports the findings of the KDOW data.

Two of the 3 total phosphorus samples at Site 4 were above benchmark levels. These two samples ranged from 0.091 mg/L to 0.19 mg/L. The highest sample occurred during the 5/20/19 flow event. This event is categorized as dry preceded by light rain. Eleven out of 16 total phosphorus samples at Site 5 were above benchmark levels. These eleven samples ranged from 0.099 mg/L to 0.29 mg/L. The highest sample at Site 2 also occurred during the 6/26/19 flow event. This event is also categorized as dry with light rain preceding. Estimated total phosphorus loading for Site 4 and Site 5 is 27% higher than benchmark loading. This is the third highest required reduction to reach benchmark levels for phosphorus. High loading at this site is likely impacted by the STP effluent at Site 6. See the following section for more details on Site 6.

KWW sampled five instances of total phosphorus. One sample of 0.179 mg/L was above the 0.075 mg/L benchmark. This sample occurred during the same low flow sampling event where the high nitrate and nitrite sample was taken. The KWW samples agree with the findings of the KDOW samples.

#### 4.2.4.4. SITE 6 NUTRIENT ANALYSIS

Fourteen out of 15 nitrate and nitrite samples were above benchmark levels at Site 6. The only sample below benchmark levels was 1.95 mg/L. The 14 samples above the benchmark ranged from 4.14 to 22.7 mg/L. These were by far the highest concentration nitrate and nitrite samples among any site. Site 6 is the point representing the point source Hodgenville Sewage Treatment Plant (STP) discharge to North Fork Nolin River. Sewage treatment plants are known for releasing point source nitrate & nitrite or phosphorus pollution as part of their standard operations. The pollutant concentration in the effluent of the Hodgenville STP is governed by the facility’s KPDES permit. This KPDES permit does not list a specific maximum effluent concentration for nitrogen, or phosphorus. It should be noted that the high nutrient levels seem to be diluted by the next downstream site (Site 5) so the impact of the STP is not widespread.

All 15 of the 15 total phosphorus samples at Site 6 were above benchmark levels. Samples ranged from 1.4 to 4.23 mg/L. The 4.23 mg/L occurred during the 9/26/19 sampling event. The 9/26/19 sampling event also produced one of the highest nitrate and nitrite samples at Site 6. Similarly to with nitrate and nitrite pollution, the high levels of total phosphorus at this site are due to its proximity to the Hodgenville Sewage Treatment Plant.

#### 4.2.4.5. SITE 7 NUTRIENT ANALYSIS

No nitrate and nitrite samples were above benchmark levels at Site 7. Estimated nitrate and nitrite loading for Site 7 is 58.0% lower than benchmark loading. This means that the site is well within benchmark limits. Nitrate and nitrite are not considered as a critical pollutant for Site 7.

One of the 10 total phosphorus samples was above benchmark levels at Site 7. The one sample which exceeded benchmark levels was 0.084 mg/L. This sample occurred during the 9/26/19 sampling event. This event was dry, preceded by light rain. Estimated total phosphorus loading for Site 7 is 54.4% lower than benchmark loading for the site. The site is well within benchmark limits for total phosphorus. Total phosphorus is not considered as a critical pollutant for Site 7.

#### 4.2.4.6. SITE 9 NUTRIENT ANALYSIS

No nitrate and nitrite samples were above benchmark levels at Site 9. Estimated nitrate and nitrite loading for Site 9 is 43.7% lower than benchmark loading. This means that the site is well within benchmark limits. Nitrate and nitrite are not considered as a critical pollutant for Site 9.

None of the total phosphorus samples were above benchmark levels at Site 9. Estimated total phosphorus loading for Site 9 is 43.4% lower than benchmark loading for the site. The site is well within benchmark limits for total phosphorus. Total phosphorus is not considered as a critical pollutant for Site 9.

#### 4.2.4.7. SITE 10 NUTRIENT ANALYSIS

No nitrate and nitrite samples were above benchmark levels at Site 10. Estimated nitrate and nitrite loading for Site 10 is 84.0% lower than benchmark loading. This means that the site is well within benchmark limits. Nitrate and nitrite are not considered as a critical pollutant for Site 10.

One of the 10 total phosphorus samples was above benchmark levels at Site 10. This one sample had a concentration of 0.137 mg/L. This sample occurred during the 2/21/19 sampling event. This was a wet event with heavy rain. The extreme flows during this event yielded an annual loading which was 2 magnitudes higher than any other calculated load. This one sample brings the average annual loading much higher than it otherwise would be. With the potential outlier included, estimated total phosphorus loading for Site 10 is 25.6% higher than benchmark loading for the site. This is the second lowest required reduction to reach benchmark levels for phosphorus among all sites.

#### 4.2.4.8. SITE 11 NUTRIENT ANALYSIS

No nitrate and nitrite samples were above benchmark levels at Site 11. Estimated nitrate and nitrite loading for Site 11 is 89.2% lower than benchmark loading. This means that the site is well within benchmark limits. Nitrate and nitrite are not considered as a critical pollutant for Site 11.

None of the total phosphorus samples were above benchmark levels at Site 11. Estimated total phosphorus loading for Site 11 is more than 100% lower than benchmark loading for the site. This means that the site is well within benchmark limits for total phosphorus. Total phosphorus is not considered as a critical pollutant for Site 11.

#### 4.2.4.9. SITE 12 NUTRIENT ANALYSIS

One nitrate and nitrite sample was above benchmark levels at Site 12. The only sample above the benchmark was 2.07 mg/L. This sample occurred during the 2/21/19 event which is categorized as a wet weather event with heavy rain. This suggests that Site 12 may be vulnerable to nitrate and nitrite nonpoint source pollution only during the highest flow wet weather events. No loading was calculated for Site 12 since Site 12 represents the immediate confluence of Site 13 and Site 14. BMPs proposed in Sites 13 and 14 and the above subwatersheds will improve nutrient conditions at Site 12.

One of the 13 total phosphorus samples was above benchmark levels at Site 12. The one sample which exceeded benchmark levels was 0.121 mg/L. This sample occurred during 8/9/18 sampling event. This event was considered as dry with light rain. Since there was only one sample above the benchmark, total phosphorus is not considered as a critical pollutant for Site 12.

#### 4.2.4.10. SITE 13 NUTRIENT ANALYSIS

No nitrate and nitrite samples were above benchmark levels at Site 14. Estimated nitrate and nitrite loading for Site 13 is 72.3% lower than benchmark loading. This means that the site is well within benchmark limits. Nitrate and nitrite are not considered as a critical pollutant for Site 13.

None of the total phosphorus samples were above benchmark levels at Site 13. Estimated total phosphorus loading for Site 13 is more than 100% lower than benchmark loading for the site. This means that the site is well within benchmark limits for total phosphorus. Total phosphorus is not considered as a critical pollutant for Site 13.

#### 4.2.4.11. SITE 14 NUTRIENT ANALYSIS

Seven out of 12 nitrate and nitrite samples were above benchmark levels at Site 14. The five samples below benchmark levels ranged from 0.36 to 1.91 mg/L. The seven samples above benchmark levels ranged from 2.04 to 3.56 mg/L. All of the samples below the benchmark occurred during low flow events. All of the samples above the benchmark occurred during high flow events. This suggests that Site 14 is vulnerable to nonpoint source nitrate and nitrite pollution. Estimated nitrate and nitrite loading for Site 14 is 39% higher than benchmark loading. This is the second lowest required reduction among the five sites which have nitrate and nitrite required reductions to reach benchmark levels. Total average annual loading of nitrate and nitrite (lbs/year) at this site is the third highest among the five sites with required reductions. Total loading at this site is similar in magnitude to total loading at Site 18.

Two of the 10 total phosphorus samples were above benchmark levels at Site 14. These two samples ranged from 0.089 mg/L to 0.16 mg/L. The highest sample occurred during the 8/9/18 flow event. This event was dry preceded by light rain.

Estimated total phosphorus loading for Site 14 is 5.3% higher than benchmark loading. This is the lowest required reduction to reach benchmark levels for phosphorus among all sites. BMPs utilized to reduce *E. coli* and nitrogen pollution in subwatershed 14, and the upstream subwatersheds 17 and 18 will likely result in a 5.3% reduction in phosphorus loading.

#### 4.2.4.12. SITE 15 NUTRIENT ANALYSIS

No nitrate and nitrite samples were above benchmark levels at Site 15. Estimated nitrate and nitrite loading for Site 15 is 61.2% lower than benchmark loading. This means that the site is well within benchmark limits. Nitrate and nitrite are not considered as a critical pollutant for Site 15.

None of the total phosphorus samples were above benchmark levels at Site 15. Estimated total phosphorus loading for Site 15 is more than 100% lower than benchmark loading for the site. This means that the site is well within benchmark limits for total phosphorus. Total phosphorus is not considered as a critical pollutant for Site 15.

#### 4.2.4.13. SITE 16 NUTRIENT ANALYSIS

One nitrate and nitrite sample was above benchmark levels at Site 16. The one sample above benchmark levels was 2.31 mg/L during the 10/18/18 sampling event. This event was one of the normal flow events and maybe an anomaly since it does not specifically suggest point or nonpoint pollution. Estimated nitrate and nitrite loading for Site 16 is 25.5% lower than benchmark loading. This means that the site is within benchmark limits. Nitrate and nitrite are not considered as a critical pollutant for Site 16.

One of the 7 total phosphorus samples was above benchmark levels at Site 16. The one sample which exceeded benchmark levels was 0.132 mg/L. This sample occurred during 8/9/18 sampling event. This event was considered as dry with light rain. Estimated total phosphorus loading for Site 15 is more than 100% lower than benchmark loading for the site. This means that the site is well within benchmark limits for total phosphorus. Total phosphorus is not considered as a critical pollutant for Site 16.

#### 4.2.4.14. SITE 17 NUTRIENT ANALYSIS

Twelve out of 12 nitrate and nitrite samples were above benchmark levels at Site 17. Nitrate and nitrite samples at this site were the second highest among all sites. This was the only site where every single sample taken was above benchmark levels. Nitrate and nitrite samples at this site ranged from 2.99 to 4.6 mg/L. Generally, concentrations were higher during higher flow events which suggests that this site is vulnerable to nonpoint source nitrate and nitrite contamination. Low flow events were also above the benchmark so point source pollution should also be considered at this site. Estimated nitrate and nitrite loading for Site 17 is 49.2% higher than benchmark loading. This is the second highest required reduction among the five sites which have nitrate and nitrite required reductions to reach benchmark levels. Total average annual loading of nitrate and nitrite (lbs/year) at this site is the lowest among the five sites with required reductions.

Four of the 8 total phosphorus samples were above benchmark levels at Site 17. These four samples ranged from 0.086 mg/L to 0.108 mg/L. The highest sample occurred during the 8/9/18 flow event. This event is categorized as dry with light rain preceding. Estimated total phosphorus loading for Site 17 is 44.2% lower than benchmark loading.

#### 4.2.4.15. SITE 18 NUTRIENT ANALYSIS

Ten out of 11 nitrate and nitrite samples were above benchmark levels at Site 18. Nitrate and nitrite samples at this site were the third highest among all sites, only exceeded by Sites 6 and 17. The one sample which measured below the benchmark was 1.94 mg/L which occurred during the lowest sampled flow event. The 10 nitrate and nitrite samples above the benchmark at this site ranged from 2.07 to 4.16 mg/L. Generally, concentrations were higher during higher flow events which suggests that this site is vulnerable to nonpoint source nitrate and nitrite pollution. Low flow events were also above the benchmark so point source pollution should also be considered at this site. Estimated nitrate and nitrite loading for Site 18 is 40.3% higher than benchmark loading. This is the third highest required reduction among the five sites which have nitrate and nitrite required reductions to reach benchmark levels. Total average annual loading of nitrate and nitrite (lbs/year) at this site is the second lowest among the five sites with required reductions. Total loading at this site is similar in magnitude to total loading at Site 14.

Four of the nine total phosphorus samples were above benchmark levels at Site 18. These four samples ranged from 0.092 mg/L to 0.319 mg/L. The highest sample at Site 18 occurred during the 5/22/18 flow event. This event is also categorized as dry with light rain preceding. Estimated total phosphorus loading for Site 18 is 32.7% higher than benchmark loading. This is the highest required reduction to reach benchmark levels for phosphorus among all sites.

### 4.2.5. SITE SPECIFIC ANALYSIS OF TSS RESULTS

For total suspended solids, benchmark exceedances and pollutant load calculations were only performed on samples collected in August through October and April through July. Total suspended solids results from November to March were excluded in accordance with the recommendations from KDOW. This was done because Kentucky experiences an extended period of high flows from November to March. These high flows directly correlate with high TSS concentrations and have the potential to produce outliers in the data.

Seven of the 17 total sites had more than one sample of TSS above the benchmark of 12 mg/L. Load reductions for TSS concentrations to reach benchmark levels are only required for Sites 1 & 2, 4 & 5 and 7. All of the remaining sites are calculated to have average annual loading at least 20% below benchmark loading. Since some sites are within benchmark levels and some are above, site specific discussion will focus on the number and ratio of exceedances. Load reductions will be discussed in depth only for sites which require load reductions to meet benchmark levels. When applicable, outstanding individual samples will be compared to the weather and flow conditions during that sample to determine if each site is at risk from point or nonpoint source pollution.

In this section, when referring to a site or grouping of sites, the project team is referring to both the sampling location at the provided GPS coordinates in Table 11 and the entire subwatershed which is contributing flow and pollutants to that site.

#### 4.2.5.1. SITE 1 & SITE 2 TSS ANALYSIS

Site 1 experienced nine TSS samples above the benchmark. Only two samples were below the benchmark. Site 2 experienced four TSS samples above the benchmark out of a total of 10 samples. The highest TSS sample with an associated flow value at Site 1 was 72 mg/L. This occurred during the second highest flow event that had a TSS sample. The low flow events experienced samples of TSS with 15.5

mg/L and 14.5 mg/L which suggests sediment pollution is a concern during all-weather types. The highest TSS sample with an associated flow value at Site 2 was 35 mg/L. This occurred during the same flow event as the highest TSS sample for Site 1. At Site 2, the low flow events experienced samples of TSS with 8.5, 4 and 2.5 mg/L. Generally, sediment concentrations at Site 2 were less than at Site 1. This suggests that flow contribution from Nolynn spring contributed a significant TSS concentration. Even without flow data for Site 3, the TSS data alone supports this claim. During the 6/19/2019 sampling event, TSS concentration at site 3 was 94 mg/L. TSS concentration at Site 2 was 4 mg/L. These concentrations combine at Site 1 to yield a concentration of 79.5 mg/L.

Calculated average annual loading for TSS at Sites 1 & 2 is 46.13% above benchmark loading. These are only one of three subwatersheds which require reductions in TSS load to meet benchmark load. These sites have the highest reduction required in magnitude and percentage.

#### 4.2.5.2. SITE 3 TSS ANALYSIS

Site 3 experienced four TSS samples above the benchmark out of a total of seven samples. There is no flow data for Site 3, so no loading was calculated. As discussed in the previous section, TSS samples at Site 3 are much higher than TSS samples at the nearby Site 2 during the same events. This suggests that Nolynn spring may be a significant source of sediment pollution to Nolin River. Future work may need to be completed to fully understand the influence of subsurface drainage in the McDougal and Castleman Creek Watersheds, and how flow through karst contributes to sediment pollution.

#### 4.2.5.3. SITE 4 & SITE 5

Site 4 experienced two TSS samples above the benchmark out of a total of three samples. Site 5 experienced five TSS samples above the benchmark out of a total of twelve samples. The two TSS samples above the benchmark at Site 4 were 33 mg/L during a flow of only 2.63 cfs and 17.5 mg/L during a flow of 82.39 cfs. This suggests that Site 4 is vulnerable to sediment pollution during all event types. The highest TSS sample at Site 5 was 38 mg/L. This occurred during one of the lowest flow events sampled. It should be noted that both Sites 4 and 5 had the highest TSS sample during low flow events. Calculated average annual loading for TSS at Sites 4 & 5 are 20.33% above benchmark loading. These are only one of three sites which require reductions in TSS load to meet benchmark load. These sites have the lowest required reduction, but the amount required is similar in magnitude and percentage to Site 7.

The KWW dataset includes nine samples of turbidity. There are no TSS samples. The turbidity samples range from 2.76 NTU to 20.4 NTU with a median of 7 NTU. Without precise flow data, it is difficult to draw any conclusions from these samples, but the range does fall in the same range as the KDOW samples at Site 5. The median of the KDOW turbidity samples is 7.7 NTU. This backs up the accuracy of the KDOW samples and tells us that there may not have been many changes in the watershed from 2003 to 2023 to cause an increase or decrease in sediment pollution.

#### 4.2.5.4. SITE 7 TSS ANALYSIS

Site 7 experienced two TSS samples above the benchmark out of a total of eight samples. Calculated average annual loading for TSS at Site 7 is 24.16% above benchmark loading. The highest TSS sample at Site 7 was 21 mg/L. This sample was taken during the highest flow event recorded at Site 7. This suggests that high sediment concentrations at Site 7 are caused by rainfall and high flows. This site has the second highest reduction required. It is noteworthy that Site 7 is located approximately 500 ft downstream of a dam in North Fork Nolin River. This dam is used by the Hodgenville Water Plant to ensure a higher upstream volume of water to pull drinking water from. This site is also located under a small bridge which has visible bank erosion due to restriction of flow and velocity increases through the bridge culvert.

#### 4.2.5.5. SITE 9 TSS ANALYSIS

Site 9 experienced no TSS sample above the benchmark out of a total of four samples. Calculated average annual loading for TSS at Site 9 is 46% below benchmark loading. Sediment is not considered a priority pollutant at this site.

#### 4.2.5.6. SITE 10 TSS ANALYSIS

Site 10 experienced no TSS sample above the benchmark out of a total of seven samples. Calculated average annual loading for TSS at Site 10 is 49% below benchmark loading. Sediment is not considered a priority pollutant at this site.

#### 4.2.5.7. SITE 11 TSS ANALYSIS

Site 11 experienced no TSS samples above the benchmark out of a total of two samples. Calculated average annual loading for TSS at Site 11 is more than 100% below benchmark loading. This is a wide margin and sediment is not considered a priority pollutant at this site.

#### 4.2.5.8. SITE 13 TSS ANALYSIS

Site 13 experienced one TSS samples above the benchmark out of a total of seven samples. The two high TSS samples were 13 mg/L and 12 mg/L. These occurred at relatively low flow events compared to all events with a TSS sample. Calculated average annual loading for TSS at Site 13 is 59% below benchmark loading. This is a wide margin. Even though there were more than one exceedance, the calculated loadings are low enough that sediment is not considered a priority pollutant at this site.

#### 4.2.5.9. SITE 14 TSS ANALYSIS

Site 14 experienced one TSS sample above the benchmark out of a total of seven samples. Calculated average annual loading for TSS at Site 14 is only 23% below benchmark loading. Extra care must be taken in this watershed to ensure sediment pollution is not increased. This is not considered an immediate priority pollutant but should be monitored for any future changes.

#### 4.2.5.10. SITE 15 TSS ANALYSIS

Site 15 experienced no TSS samples above the benchmark out of a total of four samples. Calculated average annual loading for TSS at Site 15 is more than 100% below benchmark loading. This is a wide margin and sediment is not considered a priority pollutant at this site.

#### 4.2.5.11. SITE 16 TSS ANALYSIS

Site 16 experienced no TSS samples above the benchmark out of a total of four samples. Calculated average annual loading for TSS at Site 16 is more than 100% below benchmark loading. This is a wide margin and sediment is not considered a priority pollutant at this site.

#### 4.2.5.12. SITE 17 TSS ANALYSIS

Site 17 experienced two TSS samples above the benchmark out of a total of four samples. The two high TSS samples at site 17 were 12.5 and 14.5 mg/L. The 14.5 mg/L sample occurred the third highest recorded flow event at the site. The 12.5 mg/L sample occurred during one of the lower flow events at the site. This suggests that Site 17 is vulnerable from sediment pollution during all event types. Calculated average annual loading for TSS at Site 17 is 22% below benchmark loading. Extra care must be taken in this watershed to ensure sediment pollution is not increased. This is not considered an immediate priority pollutant but should be monitored for any future changes.

#### 4.2.5.13. SITE 18 TSS ANALYSIS

Site 18 experienced no TSS samples above the benchmark out of a total of five samples. Calculated average annual loading for TSS at Site 18 is more than 100% below benchmark loading. This is a wide margin and sediment is not considered a priority pollutant at this site.

### 4.2.6. SITE SPECIFIC HABITAT & MACROINVERTEBRATES ANALYSIS

Habitat was assessed at the following sites: 5, 7, 10, 11, 12, 14, 15, 16, 17 and 18. Results were compared with habitat rating benchmarks listed in Table 14. All eleven sites scored below a "good" rating in accordance with *Methods for Assessing Habitat in Wadeable Waters* (DOWSOP03024), dated March 2011. Table 18 identifies the scoring value for each habitat parameter. Riparian zone width, bank stability, sediment deposition and vegetative protection were the habitat parameters which scored the lowest among all stations. A low score means that the site is failing to support that parameter and has room for improvement. A high score means that this parameter is good at a site. Habitat assessment is an inherently objective process. Two assessors may assign different scores to the same stream with the same conditions. This means that there is some variability and uncertainty in the results.

The benthic macroinvertebrates were assessed and compared with the benchmarks listed in Table 15. The following sites were assessed 5, 10, 11, 12, 13, 14, 15, 16, 17 and 18. These are the same sites assessed for habitat, except for site 7. All 10 sites received a rating of “Fair” in accordance with *The Kentucky Macroinvertebrate Bioassessment Index*, dated September 2003. The lowest metrics were % modified EPT and % Ephem - Mayflies. Biological assessments were not conducted outside of the aforementioned locations. These results are summarized in Table 19.

As previously discussed in Sections 2.4 and 3.2.6, based on a visual and GIS assessment, riparian vegetation and tree canopy is limited in select areas in the watershed. A majority of the areas lacking riparian vegetation and tree canopy are located in the lower portions of McDougal and Castleman Creek Watersheds, near the City of Hodgenville and the lower reaches of North Fork Nolin River. Watershed wide BMPs will be evaluated later in this report to address limited riparian vegetation and tree canopy.

#### 4.2.6.1. SITE 5 HABITAT & MACROINVERTEBRATES ANALYSIS

Site 5 received an RBP score of 107. This is the fourth highest RBP score among wadeable streams, but the site still earns a rating of poor. The lowest rated parameters at Site 5 are embeddedness and frequency of riffles (or bends). This site scored the lowest in both of these categories among all assessed sites. Embeddedness is a measure of how buried gravel, cobble and boulders are in the stream. A low score of Embeddedness means that all rocks are more than 75% buried and do not contribute very much to the geometry and performance of the stream. Riffles are shallow, fast sections of stream. Riffles are often created by the presence of rocks on the stream channel. Embeddedness at this site may be responsible for the infrequency of riffles.

The highest rated parameter at this site was velocity depth regime. This means that there is a variety of velocities at different depths in the stream. This variety enhances habitat diversity to maintain a stable aquatic environment. Sites 10, 11, 12 & 16 all also received a score of 16 for velocity depth regime.

Site 5 received an MBI score of 59. This earns a rating of fair for the site. Site 5 had the lowest % mayflies, with only 1.3% among all sites. Abundance of mayflies is calculated to detect impacts of metals and high conductivity. Mayfly population will normally decline if the stream is polluted by brine, metal contamination or increased conductivity. Dissolved solids loading from wastewater treatment plants, one of which is upstream of Site 5, may be a disturbance which leads to reduction in mayfly population. Site 5 had the highest % clingers among all sites. An abundance of clingers correlates with an abundance of non-silted substrate in the stream for them to "cling" to. This is an interesting result because the habitat assessment determined that most rocks in the stream at this site were embedded in silt.

#### 4.2.6.2. SITE 7 HABITAT ANALYSIS

Site 7 received an RBP score of 84. This is the lowest RBP score among wadeable streams and earns site 7 a rating of poor. The lowest rated parameter at Site 7 is riparian zone width. During the visual assessment, the project team found that there was almost no riparian zone on the Hodgenville side of Nolin River at this site. Currently the riparian buffer on the Hodgenville side is a single row of trees and some smaller shrubs.

The highest score at Site 7 is channel alternation, but no scores are particularly high which aligns with this site being the lowest scored of all assessed sites. The score at Site 7 for channel alteration was 15, which is tied for the highest among all sites. This may be slightly misleading because there is a bridge and dam just upstream of the site, which both significantly alter the conditions of the channel at Site 7.

#### 4.2.6.3. SITE 10 HABITAT & MACROINVERTEBRATES ANALYSIS

Site 10 received an RBP score of 110. This is the third highest RBP score among wadeable streams, but the site still earns a poor rating. The lowest rated parameter at Site 10 is riparian zone width. Site 10 is adjacent to active crop land to the north, and a private gravel road to the south. These adjacencies severely constrain the potential for riparian buffer growth. The highest scores at Site 10 area for velocity depth regime and channel flow status. This site received the highest score for channel flow status among all sites. This means that this site has the least amount of exposed bed and substrate. A majority of the channel is full up to each bank.

Site 10 received an MBI score of 64. This earns a rating of fair for the site. This is the highest score among all assessed wadeable sites. Site 10 had no outstanding parameters. Every parameter was generally higher than the average among all assessed wadeable sites.

#### 4.2.6.4. SITE 11 HABITAT & MACROINVERTEBRATES ANALYSIS

Site 11 received an RBP score of 112. This is the second highest RBP score among wadeable streams, but the site still earns a poor rating. The lowest score at Site 11 is riparian zone width. Site 11 is constrained by an asphalt road on the east side and crop land on the west side. There is slightly more riparian zone width on the west side, but riparian buffer at this site is still constrained by its surroundings. The highest score at this site is velocity depth regime.

Site 11 received an MBI score of 56. This earns a rating of fair for the site. This is the lowest score among wadeable sites. Site 11 is tied for the lowest value for EPT Richness-genus level. This parameter is the total number of unique species found at the site. This metric will increase with increasing water quality, habitat diversity and habitat sustainability. This site has the highest % midges & worms and nearly the highest % modified EPT among all assessed wadeable streams. Midges and worms are pollution tolerant organisms. A high concentration of midges and worms may correlate with decreased water quality conditions.

#### 4.2.6.5. SITE 12 HABITAT & MACROINVERTEBRATES ANALYSIS

Site 12 received an RBP score of 85. This is tied with Site 14 for the second lowest RBP score among wadeable streams. The site earns a poor rating. The lowest score at Site 12 is bank stability and riparian zone width. This site had the lowest score for bank stability among all sites. During the visual assessment, the project team observed a large mass of failed bank which had slipped and fallen into the stream at this site. This likely occurred after habitat was assessed in 2018 and was a product of the conditions observed at that time. This site is constrained on the east by Phillips Lane and on the west by cropland. This section of stream is sinuous, so there is some room for riparian buffer within the curves, but the buffer does not extend far beyond that. The highest score at this site is velocity depth regime.

Site 12 received an MBI score of 63. This earns a rating of fair for the site. Site 12 had no parameters that were low, relative to other wadable stream sites. Site 12 had the highest Modified Hilsenhoff Biotic Index (mHBI). This parameter is a formula which considers the average of the total number of species and the tolerance of that species. A high mHBI score correlates with decreasing water quality.

#### 4.2.6.6. SITE 13 HABITAT & MACROINVERTEBRATES ANALYSIS

Site 13 received an RBP score of 85. This is tied with site 12 for the second lowest RBP score among wadeable streams. The site earns a poor rating. The lowest scores at site 13 are sediment deposition and vegetative protection. This site has the lowest score among all sites for each of these categories. During the visual assessment, the project team observed large deposits of fine sediment on the banks and in the center of the stream. These deposits were so significant and compacted, the project team walked along and across them. The project team also observed a minimal amount of vegetation on the stream banks. This is likely because so much erosion on the stream banks have moved healthy soil for plant growth from the banks to the stream channel. The highest scores at this site are velocity depth regime and channel flow status. Site 13 received an MBI score of 61. This earns a rating of fair for the site. Site 13 had no outstanding parameters, high or low, compared to other wadeable sites.

#### 4.2.6.7. SITE 14 HABITAT & MACROINVERTEBRATES ANALYSIS

Site 14 received an RBP score of 96. This score is in the middle compared with other wadeable streams. The site earns a poor rating. Site 14 has no scores lower than 7. This means that no parameters at this site are in critical condition, relative to other sites assessed. The highest score at site 14 is channel alteration.

Site 14 received an MBI score of 60. This earns a rating of fair for the site. Site 14 had many parameters on the high and low end compared to other wadeable sites. EPT-Richness genus level was tied for the lowest among wadeable sites. % clingers was the lowest among wadeable sites. % modified EPT and % mayflies are the highest at this site among wadeable sites. % modified EPT is a measure of the abundance of pollution-sensitive species. This value and the high mayfly % suggest that water quality and habitat conditions at this site are relatively good.

#### 4.2.6.8. SITE 15 HABITAT & MACROINVERTEBRATES ANALYSIS

Site 15 received an RBP score of 114. This is the highest score among wadeable streams an qualifies as a poor rating. The lowest score at Site 15 is riparian zone width. Site 15 received a score of 4 in this category which is tied as the lowest score among other wadable stream sites. Many of the other parameters are among the highest to make up for this low score and make site 15 the only fair site. Site 15 is adjacent to crop land on both sides which explains why riparian zone width is so limited. The highest score for site 15 was for embeddedness.

Site 15 received an MBI score of 63. This earns a rating of fair for the site. Site 15 had no parameters that were the lowest among wadeable sites. Taxa Richness-genus level at this site was the highest among all wadeable sites. This is the total number of species, at the genus level, sampled at the site. A high value in this parameter correlates with increased water quality, habitat diversity and habitat sustainability.

#### 4.2.6.9. SITE 16 HABITAT & MACROINVERTEBRATES ANALYSIS

Site 16 received an RBP score of 110. This is the lowest score among headwater streams. The site earns a poor rating. The lowest score at this site was for riparian zone width. Even though this site received a low score for riparian zone width, a noticeable riparian zone does exist. This site is the tributary of Salem Creek to Salem Lake and has about 400 feet of riparian width on each side. This rating may have been a mistake by the assessment team. The highest score at this site is velocity depth regime.

Site 16 received an MBI score of 59. This earns a rating of fair for the site. This was the highest rating received among the three headwater sites. This site had the highest value in the following parameters: Taxa-Richness genus level, EPT Richness-genus level, % modified EPT. All of these parameters correlate with increased water quality and habitat conditions.

#### 4.2.6.10. SITE 17 HABITAT & MACROINVERTEBRATES ANALYSIS

Site 17 received an RBP score of 110. This is one point away from being the lowest score among headwater streams. The site earns a poor rating. The lowest score at Site 17 is vegetative protection. This site has significant vegetation to the south but is adjacent to crop land on the north which has limited vegetative protection. The highest scores at Site 17 are embeddedness and sediment deposition.

Site 17 received an MBI score of 45. This earns a rating of fair for the site. This site received the lowest score among all assessed headwater and wadeable sites. This site had the lowest value for % modified EPT, and the highest value for % midges and worms. Both of these results correlate with decreasing water quality and habitat conditions.

#### 4.2.6.11. SITE 18 HABITAT & MACROINVERTEBRATES ANALYSIS

Site 18 received an RBP score of 136. This is by far the highest score among the three headwater streams, and is the only site to receive a fair rating. No scores at Site 18 were low compared to other sites. The highest scores are bank stability and vegetative protection. These are the two highest scores in these categories among all sites. This site has a rock lined channel and flat banks which are close in elevation to the channel bed. This site is also at the highest point in the watershed and receives less flow than most other sites. If there ever is high velocity flow at this site, water will flow out of the channel, over the banks, and into the adjacent property instead of eroding and destabilizing the banks. Site 18 received an MBI score of 52. This earns a rating of fair for the site. Site 18 had no outstanding parameters in any category.

### 4.2.7. SUMMARY OF SITE SPECIFIC ANALYSIS RESULTS

*E. coli* is the most critical pollutant of the four pollutant parameters reviewed in-depth. Calculated *E. coli* yearly loading at all assessed sites was at least 34% higher than benchmark loading. Calculated yearly loading was over 50% higher than benchmark loading at eight sites. *E. coli* loading was highest, relative to benchmark levels, at Sites 17 and 18, where reduction to meet benchmark is 94.6% and 96.1%. Sites 17 and 18 also had four of the five highest single *E. coli* samples. Sites 7 and 9, in downtown Hodgenville, did not experience any *E. coli* sampling, but it is assumed that these locations in NFNR have similar *E. coli* pollution to Site 5 downstream and Sites 10, 13 and 14 upstream. Throughout the watershed, high *E. coli* samples occurred during low flow, normal flow, and high flow events. This signals that a wide variety of potential *E. coli* pollutant sources may be present in the watershed. During low flow sampling events, *E. coli* pollution may come from failing septic systems, sanitary straight pipes, or livestock with direct stream access. During high flow sampling events, *E. coli* pollution may be picked up and taken to the stream through stormwater runoff from sources such as pets, wildlife and livestock. BMP implementation targeting *E. coli* pollution will need to be throughout the watershed and targeting all types of potential *E. coli* pollutant sources.

Phosphorus is the second most critical of the four pollutant parameters reviewed in-depth. Many subwatersheds have calculated phosphorus loading within benchmark levels, particularly in the central and east portions of the watershed. Subwatersheds with calculated phosphorus loading above benchmark levels include 1 & 2, 4 & 5, 10, 14, and 18.

Nitrogen is the third most critical of the four pollutant parameters reviewed in-depth. Many subwatersheds have calculated nitrate & nitrite loading within benchmark levels, particularly in the central, east, and south portions of the watershed. Subwatersheds with calculated nitrate & nitrite loading above benchmark levels include 4 & 5, 14, 17, and 18. Subwatersheds 17, 18 and their downstream watershed 14 are the same locations which have the highest *E. coli* pollution. This suggests that the same sources of *E. coli* pollution in this part of Castleman Creek watershed are contributing to nitrogen pollution.

Total suspended solids is the fourth most critical of the four pollutant parameters reviewed in-depth. Calculated TSS loading is within benchmark loading for the entire Castleman Creek watershed and in many areas of the McDougal Creek watershed, particularly in subwatersheds 10 and 11 which cover McDougal Lake and McDougal Creek. Subwatersheds 1 & 2, 4 & 5, and 7 are the only subwatersheds which have calculated loading above benchmark levels. All of these sites are in the tail waters of North Fork Nolin River where total flows are highest. These high flows tear away at stream bank soils over time leading to bank erosion. The team observed high levels of bank soil failures in these areas, and minimal levels of bank armoring through riparian buffers or other means. High TSS samples were taken at these sites during all event types, so streambank erosion is likely present throughout the year. Site 7 may additionally be experiencing TSS pollution due to the nearby presence of upstream dam and bridge culvert. BMP implementation targeting TSS pollution will need to focus on reducing streambank erosion through bank armoring and riparian buffer installation. Additionally, practices can be put in place throughout the watershed to reduce stormwater runoff flows and velocities. These practices can be informed by a new stormwater management manual and implemented in the urban areas of Hodgenville and the rural areas of LaRue County.

Habitat and macroinvertebrate results also show a need for improvement compared to benchmark levels. Ten of the eleven sites assessed for habitat received the lowest possible rating of poor. Site 18 at the highest point in Castleman Creek Watershed was the only site which received a fair rating. Riparian zone width, bank stability, sediment deposition and vegetative protection were the habitat parameters which scored the lowest among all stations. BMP implementation targeting habitat improvements will need to focus on improving the conditions of the riparian zone and reducing the potential for erosion in the streambanks and throughout the watershed. All 10 sites received a rating of “Fair” in accordance with *The Kentucky Macroinvertebrate Bioassessment Index*, dated September 2003. The lowest metrics were % modified EPT and % Ephem - Mayflies. The project team anticipates that BMPs proposed to address habitat, and other critical pollutants in the watershed, will have a positive impact on MBI metrics.

# 5. BEST MANAGEMENT PRACTICES (BMP) SELECTION PROCESS AND FEASIBILITY

## 5.1. GOAL, OBJECTIVE, AND BMP OVERVIEW

### 5.1.1. GOAL AND OBJECTIVE SELECTION

To direct BMP selection, the project team, with the assistance of stakeholders, established goals and objectives for MCCW. Goals and objectives were selected based on existing watershed data, sampling results, field observations, stakeholder input, and engineering judgment. At the second public Watershed Council meeting, preliminary goals and objectives were presented to all attendees. Feedback from this meeting was incorporated into the final objectives and goals presented here.

The following four goals were chosen for MCCW:

1. Improve water quality for aquatic life support and safe recreational use.
2. Increase watershed awareness and education in the community.
3. Improve stormwater management to reduce flooding during large rain events.
4. Promote measures that protect the stream and riparian zone during future development and current practices in the watershed.

Goal selection provided a broad plan of action, but identified priorities that were not strictly measurable or tangible. Objectives were selected to assist in achieving the above identified goals. Objectives identified specific issues in the watershed and allowed for measurable benchmarks to be established to determine if they were accomplished. The following objectives were chosen for MCCW:

1. Reduce human fecal inputs to aid in bacteria reduction to benchmark levels.
2. Reduce livestock fecal inputs to aid in bacteria reduction to benchmark levels.
3. Reduce fecal inputs from wildlife to aid in bacteria reduction to benchmark levels.
4. Incorporate agricultural best management practices.
5. Expand riparian zone to filter runoff and provide habitat.
6. Stabilize stream bank to reduce erosion.
7. Inform the public of the water quality status of MC & CC watersheds.
8. Evaluate codes and ordinances for incorporation of water quality standards and issues.
9. Incorporate educational signage and inform the public of water quality issues.
10. Develop a stormwater management plan that identifies flood prone areas.
11. Reduce flooding by clearing waterways of obstructions such as large debris and beaver dams.
12. Reduce flooding by reducing or slowing storm water runoff.
13. Encourage the use of green infrastructure and low impact development.
14. Retrofit existing development to incorporate green infrastructure.
15. Provide resources for environmentally friendly agricultural practices.
16. Identify sink holes via dye tracing.
17. Provide resources for environmentally friendly waste disposal, including dead animals.
18. Promote water quality improvements to manmade infrastructure in the watershed.

### 5.1.2. POTENTIAL BMP IDENTIFICATION

The project team prepared a list of preliminary BMPs for presentation at the third public Watershed Council meeting. The list of potential BMPs was developed by the project team as a wide range of possible options. Research was conducted by the project team to identify practices used in other communities for inclusion on the BMP list. After presenting to the Watershed Advisory Council, additional BMPs were added per stakeholder request. The final list of potential BMPs is as follows:

A. Sanitary lateral line repair
B. Replace failing septic systems or eliminate straight pipes
C. Livestock alternate water source and shade
D. Livestock stream access control (exclusion fencing, stream crossing, etc.)
E. Livestock field rotation
F. Streamside filter strips
G. Public education on pet waste disposal
H. Public education on Ag Water Quality Plans and Nutrient Management Plans
I. Cover crops practices
J. No-till / reduced till practices
K. Heavy use area practices
L. Decommission abandoned manure lagoons
M. Riparian buffer development
N. Stream restoration / streambank stabilization
O. Public education on general water quality improvement practices
P. Review of planning, code & ordinance documents
Q. Installation of educational signage
R. Stormwater management plan / flood hazard mitigation plans
S. Beaver wildlife management
T. Water quantity BMP installation (detention basin, rain garden, rain barrels, wetland, etc)
U. Karst dye tracing
V. Animal waste disposal
W. Lake/Reservoir sediment removal

Specific Action Items for selected BMPs considered for implementation are discussed in Section 6. It is also noted that other BMPs on this list may be available in the future to assist in accomplishing the objectives lined out for these watersheds.

## 5.2. BMP FEASIBILITY AND SELECTION

After receiving input from the project stakeholders, the project team assessed the feasibility of potential BMPs based on existing watershed data, sampling results, stakeholder input, and engineering judgment. The project team identified which suggested BMPs would be most appropriate to treat exceedances in each subwatershed. The recommendation process considered which pollutants required reduction in each subwatershed and recommend BMPs that reduce that pollutant. The following is a list of specific BMPs recommended for implementation in each watershed. Many of the subwatersheds contain the same pollutant sources and the same land uses. As a result, the same BMPs are suggested for most subwatersheds. Subwatersheds have various recommended quantity and concentration of each BMP based on the land use in the area. For example, the smaller subwatersheds near Hodgenville will need to be treated differently than larger subwatersheds full of crop and pastureland. Figure 30 on page 77 provides a map of McDougal and Castleman Creek Watersheds with each subwatershed delineated. Figure 26, Figure 27, Figure 28, and Figure 29 show color coded priority for each critical pollutant, in each subwatershed, based on how much percent reduction in calculated loading would be required to meet benchmark loading.

A. Subwatershed 1 & 2 (require reductions in E coli, TP, and TSS to meet benchmark)
    a. Sanitary lateral line repair
    b. Replace failing septic systems or eliminate straight pipes
    c. Livestock alternate water source and shade
    d. Livestock stream access control (exclusion fencing, stream crossing, etc.)
    e. Livestock field rotation
    f. Streamside filter strips
    g. Public education on pet waste disposal
    h. Public education on Ag Water Quality Plans and Nutrient Management Plans
    i. Cover crops practices
    j. No-till / reduced till practices
    k. Heavy use area practices
    l. Decommission abandoned manure lagoons
    m. Riparian buffer development
    n. Stream restoration / streambank stabilization;
    o. Public education on general water quality improvement practices
    p. Installation of educational signage
    q. Water quantity BMP installation (detention basin, rain garden, rain barrels, wetland, etc)
    r. Animal waste disposal

B. Subwatershed 3

    Karst dye tracing is the initial BMP that is proposed for Subwatershed 3. This Subwatershed represents Nolynn Spring. The project team anticipates that BMPs implemented in other Subwatersheds will overlap with the catchment area for Nolynn Spring and will contribute to reducing pollutant levels for Subwatershed 3, but this will need to be confirmed. The exact area draining to Subwatershed 3 is not known.

C. Subwatersheds 4 & 5 (require reductions in *E. coli*, TSS, TP, and Nitrogen to meet benchmark)
    a. Sanitary lateral line repair
    b. Replace failing septic systems or eliminate straight pipes
    c. Livestock alternate water source and shade
    d. Livestock stream access control (exclusion fencing, stream crossing, etc.)
    e. Livestock field rotation
    f. Streamside filter strips
    g. Public education on pet waste disposal
    h. Public education on Ag Water Quality Plans and Nutrient Management Plans
    i. Cover crops practices
    j. No-till / reduced till practices
    k. Heavy use area practices
    l. Decommission abandoned manure lagoons
    m. Riparian buffer development

n. Stream restoration / streambank stabilization
o. Public education on general water quality improvement practices
p. Installation of educational signage
q. Water quantity BMP installation (detention basin, rain garden, rain barrels, wetland, etc)
r. Animal waste disposal

D. Subwatershed 7 (requires reductions in TSS to meet benchmark)
   a. Streamside filter strips
   b. Riparian buffer development
   c. Stream restoration / streambank stabilization
   d. Public education on general water quality improvement practices
   e. Installation of educational signage
   f. Water quantity BMP installation (detention basin, rain garden, rain barrels, wetland, etc)

E. Subwatershed 9

BMPs in this watershed are not currently a high priority due to all sampled pollutant concentrations being below benchmark values. However, the RBP score was below the benchmark.

F. Subwatershed 10 (requires reductions in *E. coli* and TP to meet benchmark)
   a. Sanitary lateral line repair
   b. Replace failing septic systems or eliminate straight pipes
   c. Livestock alternate water source and shade
   d. Livestock stream access control (exclusion fencing, stream crossing, etc.)
   e. Livestock field rotation
   f. Streamside filter strips
   g. Public education on pet waste disposal
   h. Public education on Ag Water Quality Plans and Nutrient Management Plans
   i. Cover crops practices
   j. No-till / reduced till practices
   k. Heavy use area practices
   l. Decommission abandoned manure lagoons
   m. Riparian buffer development
   n. Stream restoration / streambank stabilization
   o. Public education on general water quality improvement practices
   p. Installation of educational signage
   q. Lake/reservoir sediment removal
   r. Water quantity BMP installation (detention basin, rain garden, rain barrels, wetland, etc)
   s. Animal waste disposal

G. Subwatershed 11 (requires reductions in *E. coli* to meet benchmark)
   a. Replace failing septic systems or eliminate straight pipes
   b. Livestock alternate water source and shade
   c. Livestock stream access control (exclusion fencing, stream crossing, etc.)

d. Livestock field rotation
e. Streamside filter strips
f. Public education on pet waste disposal
g. Public education on Ag Water Quality Plans and Nutrient Management Plans
h. Cover crops practices
i. No-till / reduced till practices
j. Heavy use area practices
k. Decommission abandoned manure lagoons
l. Riparian buffer development
m. Stream restoration / streambank stabilization
n. Public education on general water quality improvement practices
o. Installation of educational signage
p. Water quantity BMP installation (detention basin, rain garden, rain barrels, wetland, etc)
q. Animal waste disposal

H. Subwatersheds 12 and 13 (require reductions in *E. coli* to meet benchmark)
   a. Replace failing septic systems or eliminate straight pipes
   b. Livestock alternate water source and shade
   c. Livestock stream access control (exclusion fencing, stream crossing, etc.)
   d. Livestock field rotation
   e. Streamside filter strips
   f. Public education on pet waste disposal
   g. Public education on Ag Water Quality Plans and Nutrient Management Plans
   h. Cover crops practices
   i. No-till / reduced till practices
   j. Heavy use area practices
   k. Decommission abandoned manure lagoons
   l. Riparian buffer development
   m. Stream restoration / streambank stabilization
   n. Public education on general water quality improvement practices
   o. Installation of educational signage
   p. Lake/reservoir sediment removal
   q. Water quantity BMP installation (detention basin, rain garden, rain barrels, wetland, etc)
   r. Animal waste disposal

I. Subwatershed 14 (requires reductions in *E. coli*, Nitrogen, and TP to meet benchmark)
   a. Replace failing septic systems or eliminate straight pipes
   b. Livestock alternate water source and shade
   c. Livestock stream access control (exclusion fencing, stream crossing, etc.)
   d. Livestock field rotation
   e. Streamside filter strips
   f. Public education on pet waste disposal
   g. Public education on Ag Water Quality Plans and Nutrient Management Plans
   h. Cover crops practices
   i. No-till / reduced till practices
   j. Heavy use area practices

k. Decommission abandoned manure lagoons
l. Riparian buffer development
m. Stream restoration / streambank stabilization
n. Public education on general water quality improvement practices
o. Installation of educational signage
p. Water quantity BMP installation (detention basin, rain garden, rain barrels, wetland, etc)
q. Animal waste disposal

J. Subwatershed 15 (requires reductions in *E. coli* to meet benchmark)
   a. Replace failing septic systems or eliminate straight pipes
   b. Livestock alternate water source and shade
   c. Livestock stream access control (exclusion fencing, stream crossing, etc.)
   d. Livestock field rotation
   e. Streamside filter strips
   f. Public education on pet waste disposal
   g. Public education on Ag Water Quality Plans and Nutrient Management Plans
   h. Cover crops practices
   i. No-till / reduced till practices
   j. Heavy use area practices
   k. Decommission abandoned manure lagoons
   l. Riparian buffer development
   m. Stream restoration / streambank stabilization
   n. Public education on general water quality improvement practices
   o. Installation of educational signage
   p. Water quantity BMP installation (detention basin, rain garden, rain barrels, wetland, etc)
   q. Animal waste disposal

K. Subwatershed 16 (requires reductions in *E. coli* to meet benchmark)
   a. Replace failing septic systems or eliminate straight pipes
   b. Livestock alternate water source and shade
   c. Livestock stream access control (exclusion fencing, stream crossing, etc.)
   d. Livestock field rotation
   e. Streamside filter strips
   f. Public education on pet waste disposal
   g. Public education on Ag Water Quality Plans and Nutrient Management Plans
   h. Cover crops practices
   i. No-till / reduced till practices
   j. Heavy use area practices
   k. Decommission abandoned manure lagoons
   l. Riparian buffer development
   m. Stream restoration / streambank stabilization
   n. Public education on general water quality improvement practices
   o. Installation of educational signage
   p. Water quantity BMP installation (detention basin, rain garden, rain barrels, wetland, etc)
   q. Animal waste disposal

L. Subwatershed 17 (requires reductions in *E. coli* and Nitrogen to meet benchmark)
   a. Replace failing septic systems or eliminate straight pipes
   b. Livestock alternate water source and shade
   c. Livestock stream access control (exclusion fencing, stream crossing, etc.)
   d. Livestock field rotation
   e. Streamside filter strips
   f. Public education on pet waste disposal
   g. Public education on Ag Water Quality Plans and Nutrient Management Plans
   h. Cover crops practices
   i. No-till / reduced till practices
   j. Heavy use area practices
   k. Decommission abandoned manure lagoons
   l. Riparian buffer development
   m. Stream restoration / streambank stabilization
   n. Public education on general water quality improvement practices
   o. Installation of educational signage
   p. Water quantity BMP installation (detention basin, rain garden, rain barrels, wetland, etc)
   q. Animal waste disposal

M. Subwatershed 18 (requires reductions in *E. coli*, Nitrogen, and TP to meet benchmark)
   a. Replace failing septic systems or eliminate straight pipes
   b. Livestock alternate water source and shade
   c. Livestock stream access control (exclusion fencing, stream crossing, etc.)
   d. Livestock field rotation
   e. Streamside filter strips
   f. Public education on pet waste disposal
   g. Public education on Ag Water Quality Plans and Nutrient Management Plans
   h. Cover crops practices
   i. No-till / reduced till practices
   j. Heavy use area practices
   k. Decommission abandoned manure lagoons
   l. Riparian buffer development
   m. Stream restoration / streambank stabilization
   n. Public education on general water quality improvement practices
   o. Installation of educational signage
   p. Water quantity BMP installation (detention basin, rain garden, rain barrels, wetland, etc)
   q. Animal waste disposal

The project team recommends a few BMPs which are not watershed specific. The following BMPs are recommended:

A. Beaver Population Management
B. Flooding Hazard Mitigation Plans
C. Karst Dye Tracing
D. Review of planning, code & ordinance documents

These BMPs were requested by watershed stakeholders for the following reasons:

1. LaRue County has an unmanaged beaver population resulting in localized flooding. This flooding may pull additional pollutants from the floodplain into the streams and increases bank erosion. Beaver population management would result in a decrease of all critical pollutants.
2. Flood Hazard Mitigation Plans help to identify and plan for flooding conditions in high-risk areas throughout the watershed. The water quality benefit from successful implementation of these plans is the same as the flooding reduction from beavers. A Flood Hazard Mitigation Plan could be regulated by the City of Hodgenville or LaRue County Fiscal Court.
3. High level karst dye tracing has already been performed by the Kentucky Division of Water. Additional, targeted karst dye tracing would allow the community to better define the Nolynn Spring catchment area and target hotpots of potential pollution entering the groundwater.

As development of the community increases, it is recommended that review of planning, code, and ordinance documents be completed routinely to ensure they are maintaining water quality standards. Although some watersheds already show pollutant concentrations within benchmark levels, this plan aims to protect and preserve water quality to benchmark levels. With McDougal and Castleman Creek being source water protection areas, it is the goal of this plan to promote the highest contaminant reduction possible with the outlined BMPs. Action Items will be detailed in Section 6.

# 6. BMP RECCOMENDATIONS AND ACTION ITEMS

## 6.1. ACTION ITEM IDENTIFICATION AND PRIORITIZATION

Each recommended BMP directly supports one or more of the plan objectives. For each BMP, at least one Action Item was identified to provide a means to implement the BMP. These Action Items act as a succinct description of what needs to be done to implement the BMP. Table 25, beginning on page 110, identifies each objective with the recommended BMPs and associated Action Items. The BMPs are labeled by letters corresponding with the list provided in Section 5.1.2. The Action Items are labeled with numbers that correspond with the following discussion of each. The page number for these discussions is provided with a clickable link to the page. Some Action Items help to satisfy more than one BMP, so the same number may be listed under different BMPs. A total of 30 BMPs and 41 Action Items are recommended for implementation.

Following Table 25, the responsible party, technical assistance, total costs, funding mechanism, outcome indicators, prioritization, measurable milestones for implementation and potential load reductions will be discussed for each Action Item. The Action Items are prioritized into three categories for implementation. Category One items are the highest priority and have an implementation time of within two years. Category Two items are second priority with an implementation time frame of three to seven years. Category Three items are the lowest priority and have an implementation time frame of over seven years. In Table 25, Action Items have been color coded to visualize their priority. Category one items are colored gold, category two items are colored silver and category three items are bronze.

The project team has prioritized subwatersheds for implementation for Objectives 2, 3, 4, 5, 6, 9, 12, 13, 14, and 16. Objectives 1, 7, 8, 10, 11, 15 and 17 require implementation in the full McDougal and Castleman Creek Watersheds, so no priority has been assigned. The prioritization process has been informed by the percent reduction amounts required to reach benchmark levels, as discussed in Section 4.2.2. Subwatersheds which require the highest amount of percent reduction for a pollutant are prioritized highest for objectives which aim to reduce that pollutant.

Up to the top five subwatersheds for each objective have been prioritized in the list below. Some objectives are listed as full watershed implementation as discussed in the paragraph above.

- Objective 1: Reduce human fecal inputs
    1. Full watershed implementation

- Objective 2: Reduce livestock fecal inputs
    1. Subwatershed 18
    2. Subwatershed 17
    3. Subwatershed 14
    4. Subwatersheds 1 & 2
    5. Subwatersheds 4 & 5

- Objective 3: Reduce fecal inputs from wildlife
    1. Subwatershed 15
    2. Subwatersheds 1 & 2
    3. Subwatershed 11

4. Subwatershed 10

- Objective 4: Incorporate agricultural best management practices
    1. Subwatershed 17
    2. Subwatershed 18
    3. Subwatershed 14
    4. Subwatersheds 1 & 2

- Objective 5: Expand riparian zone to filter run off and provide habitat
    1. Subwatershed 7
    2. Subwatershed 13
    3. Subwatershed 14
    4. Subwatersheds 4 & 5

- Objective 6: Stabilize stream bank to reduce erosion
    1. Subwatersheds 1 & 2
    2. Subwatershed 7
    3. Subwatersheds 4 & 5

- Objective 7: Inform the public of the water quality status of MC & CC watershed
    1. Full watershed implementation

- Objective 8: Evaluation codes and ordinances for incorporation of water quality standards and issues
    1. Full watershed implementation

- Objective 9: Incorporate educational signage at public parks
    1. Subwatershed 5 at Creekfront Park
    2. Subwatershed 10 at Pearman Forest
    3. Subwatershed 13 at Salem Lake
    4. Subwatershed 10 at McDougal Lake
    5. Subwatershed 2 at HEC Educational Trail

- Objective 10: Develop a stormwater management plan that identifies flood prone areas
    1. Full watershed implementation

- Objective 11: Reduce flooding by clearing waterways of obstructions such as large debris and beaver dams
    1. Full watershed implementation

- Objective 12: Reduce flooding by reducing or slowing storm water runoff
    1. Subwatershed 7 (Hodgenville City Center)
    2. Subwatershed 5 (North and Northwest Hodgenville)
    3. Subwatershed 2 (South Hodgenville)

- Objective 13: Encourage the use of green infrastructure and low impact development
    1. Subwatershed 7 (Hodgenville City Center)

2. Subwatershed 5 (North and Northwest Hodgenville)
3. Subwatershed 2 (South Hodgenville)

- Objective 14: Retrofit existing development to incorporate green infrastructure
    1. Subwatershed 7 (Hodgenville City Center)
    2. Subwatershed 5 (North and Northwest Hodgenville)
    3. Subwatershed 2 (South Hodgenville)

- Objective 15: Provide resources for environmentally friendly agricultural practices
    1. Full watershed implementation

- Objective 16: Identify sink holes via dye tracing
    1. Subwatershed 14
    2. Subwatershed 2
    3. Subwatershed 4
    4. Subwatershed 5

- Objective 17: Provide resources for environmentally friendly waste disposal include dead animals
    1. Full watershed implementation

- Objective 18: Promote water quality improvements to manmade infrastructure in the watershed
    1. Subwatershed 13
    2. Subwatershed 10

## 6.2. SUBWATERSHED PRIORITIZATION

Subwatersheds have also been evaluated to establish priority for which watersheds would benefit the most from focused attention of BMP implementation. Subwatershed prioritization has assigned a score to each watershed based on the following values: percentage of pollutant samples above benchmark levels and percentage load reduction required for pollutant levels to reach benchmark levels. *E. coli*, Nitrate & Nitrite, TP and TSS samples were included, for a total of eight values. These eight percentages were summed together for each subwatershed, with a weighting value applied based on severity of each pollutant. *E. coli* was weighted at 100% since it is the most polluted throughout the watershed, Nitrate & Nitrite was weighted at 80%, TP was weighted at 90% and TSS samples were weighted at 70%. The total sum prioritization values for each subwatershed were then divided by the maximum value among the watersheds so that each subwatershed has a priority value from 0 – 1. This last step was done to clearly show how high priority each subwatershed is, relative to each other. For subwatersheds that did not have sampled *E. coli* data (7 and 9), the values used were equal to the arithmetic mean of values from bounding upstream and downstream sites (4 & 5, 10, 13, 14). APPENDIX E provides a summary of the full subwatershed prioritization calculations. This metric was not included in the prioritization score, but it should be noted that subwatersheds at the most upstream points of Castleman and McDougal Creek should be prioritized because benefits in these areas will contribute to multiple downstream locations. For example, improvements to subwatersheds 17 and 18 will benefit water quality at sites 14, 9, 7, 4 & 5 and 1 & 2. Table 24 provides the prioritization scores for each subwatershed. Subwatersheds have been separated and color coded in to four different categories, with 1st priority being the highest and 4th priority being the lowest. The color coding in this table serves as a legend for the color coding in Figure 31 where subwatersheds have been colored to visualize the locations of highest and lowest priority.

**Table 24.** Subwatershed Prioritization Values

| Subwatershed Name | Prioritization Score | Prioritization Category |
|---|---|---|
| 17 | 1.00 | 1st Priority |
| 18 | 0.94 | 1st Priority |
| 1 & 2 | 0.85 | 2nd Priority |
| 4 & 5 | 0.84 | 2nd Priority |
| 14 | 0.62 | 2nd Priority |
| 7 | 0.47 | 3rd Priority |
| 16 | 0.40 | 3rd Priority |
| 15 | 0.40 | 3rd Priority |
| 10 | 0.40 | 4th Priority |
| 13 | 0.37 | 4th Priority |
| 9 | 0.36 | 4th Priority |
| 11 | 0.24 | 4th Priority |

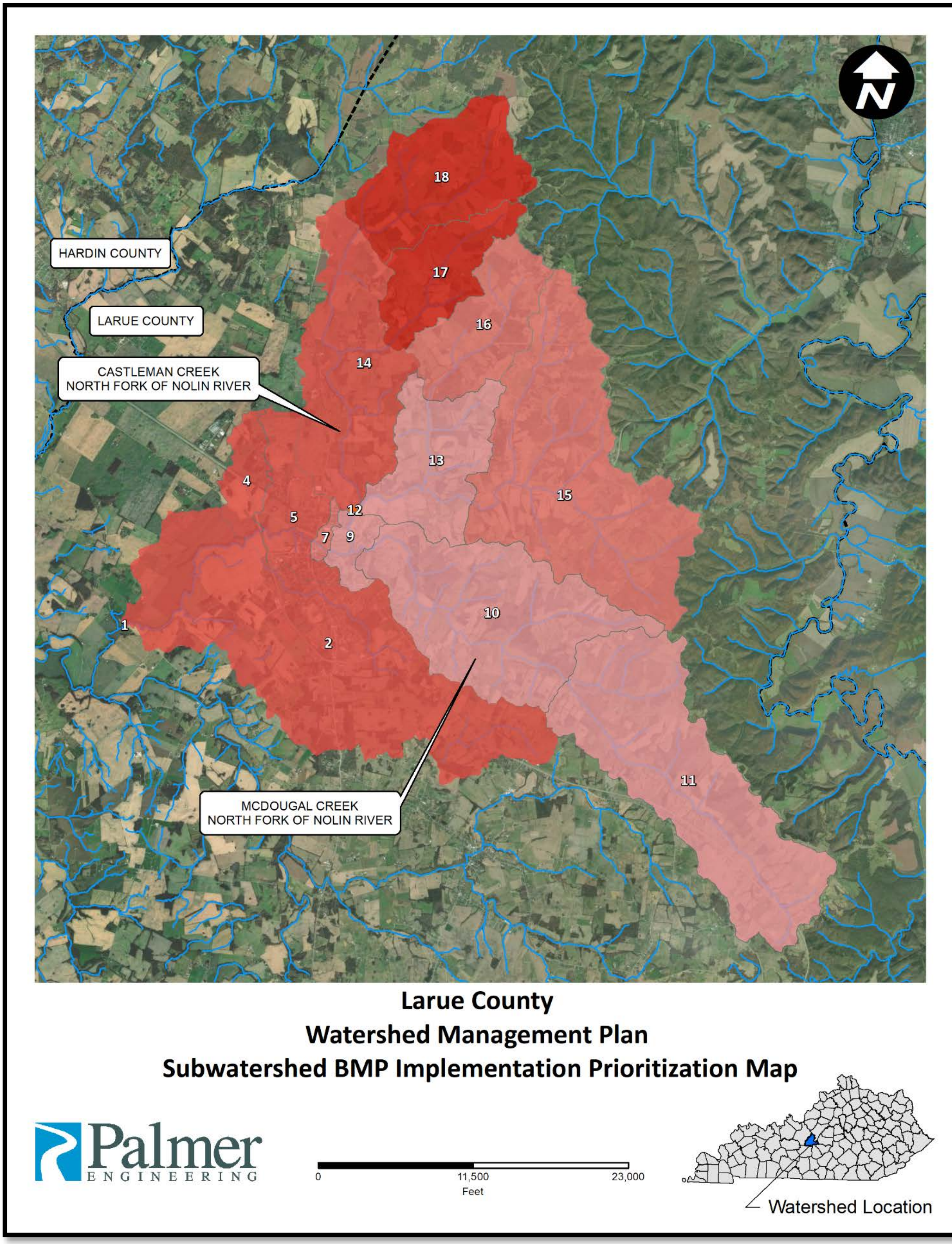


**Figure 31.** Subwatershed BMP Implementation Prioritization Map

## 6.3. ACTION ITEM IDENTIFICATION TABLE AND DESCRIPTIONS

The following identifies each objective with the recommended BMPs and associated Action Items. The BMPs are labeled by letters corresponding with the list provided in Section 5.1.2. The Action Items are labeled with numbers that correspond with the following discussion of each. The page number for these discussions is provided with a clickable link to the page. Some Action Items help to satisfy more than one BMP, so the same number may be listed under different BMPs. A total of 30 BMPs and 41 Action Items are recommended for implementation. Category one items are colored gold, category two items are colored silver and category three items are bronze.

**Table 25.** BMP and Action Item Identification

| OBJECTIVE | BMP | ACTION ITEMS |
|---|---|---|
| 1. Reduce human fecal inputs to aid in bacteria reduction to benchmark levels. | A. Make provisions to identify and repair areas where the sanitary sewer system is experiencing inflow, infiltration and exfiltration of lateral lines. | 1. Develop a system for the anonymous public reporting of potential sanitary sewer leaks and cross connections with the storm sewer system. See page 115. |
| | | 2. Investigate exfiltration in lateral connections and remediate. See page 116. |
| | | 3. Identify funding sources for necessary repairs to existing sanitary sewers. See page 116. |
| | | 40. Conduct microbial source tracking to determine origin of bacterial levels. See page 134. |
| | B. Identify and replace failing or improperly maintained septic systems or straight pipes. | 4. Develop a system for anonymous public reporting of potential straight pipes and failing septic systems. See page 117. |
| | | 5. Notify property owners of any confirmed straight pipes or failing septic systems. See page 117. |
| | | 6. Educate community on septic system maintenance through community workshops and field days with installers, real estate agents and community groups. See page 118. |
| | | 40. Conduct microbial source tracking to determine origin of bacterial levels. See page 134. |
| 2. Reduce livestock fecal inputs to aid in bacteria reduction to benchmark levels.<br><br>&<br><br>3. Reduce fecal inputs from | C. Provide off stream watering and shade for livestock. | 7. Hold an information session to inform the agricultural community on options for keeping livestock out of the stream. See page 118. |
| | | 8. Investigate the feasibility of providing an alternative water source for livestock. See page 119. |

| OBJECTIVE | BMP | ACTION ITEMS |
|---|---|---|
| wildlife to aid in bacteria reduction to benchmark levels. | | 9. Utilize NRCS Cost Sharing program for spring development (Practice #574) or watering facility (Practice #614). See page 119. |
| | D. Limit livestock direct access to stream. | 10. Utilize NRCS Cost Sharing program for livestock exclusion fencing (Practice #472) in feasible locations in MCCW. See page 120. |
| | | 11. Utilize NRCS Cost Sharing Program for Stream Crossings (Practice #578). See page 120. |
| | E. Encourage livestock field rotation with limited time in fields with access to streams. | 12. Hold an information session to inform the agricultural community on the benefits of livestock field rotation. See page 121. |
| | F. Install filter strips to reduce fecal input from runoff. | 13. Educate the community on the benefits filter strips can provide. See page 121. |
| | | 14. Utilize NRCS Cost Sharing program for filter strip (Practice #393) installation. See page 122. |
| | G. Implement proper pet waste disposal practices. | 15. Educate the community on the hazards of improper animal waste disposal. See page 122. |
| | H. Work with agricultural community to update or write Agricultural Water Quality (AWQ) Plans and Nutrient Management Plans. | 16. Engage and support local farming groups on Agricultural Water Quality Plans and Nutrient Management Plans. See page 123. |
| | | 17. Work directly with landowners to complete their AWQ & NM plans. See page 123. |
| 4. Incorporate agricultural best management practices. | I. Implement Cover Crop planting to reduce erosion. | 18. Utilize NRCS Cost Sharing Program for Cover Crop (Practice #340). See page 124. |
| | J. Implement No-till / reduced till practices to reduce soil erosion. | 19. Utilize NRCS Cost Sharing Program for Residue and Tillage Management, Reduced Till (Practice #345). See page 124. |
| | K. Implement the practice of Heavy use areas to reduce soil erosion and protect water quality. | 20. Utilize NRCS Cost Sharing Program for Heavy Use Area Protection (Practice #561). See page 125. |
| | L. Decommission abandoned manure lagoons to prevent the seepage of animal waste into the water system. | 21. Utilize NRCS Cost Sharing Program for Waste Facility Closure (Practice #360). See page 125. |
| 5. Expand riparian zone to filter runoff and provide habitat | M(1). Conduct tree and vegetation planting along streams. | 22. Utilize NRCS Cost Sharing program for riparian forested buffer (Practice #391) and tree planting (Practice #612). See page 125. |

| OBJECTIVE | BMP | ACTION ITEMS |
|---|---|---|
| | M(2). Require a minimum riparian buffer on all new construction projects. | 23. Recommend updates to City and County Codes and Ordinances. See page 126. |
| 6. Stabilize stream banks to reduce erosion | N(1). Perform stream restoration to repair areas of eroded banks and limited access to floodplain. | 24. Identify, design, and implement stream restoration on impaired reaches. See page 127. |
| | N(2). Conduct tree and vegetation planting along streams. | 22. Utilize NRCS Cost Sharing program for riparian forested buffer (Practice #391) and tree planting (Practice #612). See page 125. |
| 7. Inform the public of the water quality status of MC & CC watersheds | O. Increase public education of the watershed. | 6. Educate community on septic system maintenance. See page 118. |
| | | 7. Hold an information session to inform the agricultural community on options for keeping livestock out of the stream. See page 118. |
| | | 12. Hold an information session to inform the agricultural community on the benefits of livestock field rotation. See page 121. |
| | | 13. Educate the community on the benefits filter strips can provide. See page 121. |
| | | 15. Educate the community on the hazards of improper animal waste disposal. See page 122. |
| | | 25. Educate the community on the benefits of rain gardens and/or streamside wetlands and implement. See page 127. |
| | | 26. Develop public displays or educational flyers on water quality issues. See page 128. |
| | | 27. Incorporate water quality education curriculum at local elementary, middle, and high schools. See page 128. |
| | | 28. Include information on water quality in MCCW on local government and community web pages. See page 128. |
| 8. Evaluation codes and ordinances for incorporation of water quality standards and issues. | P. Internal or external review of the following documents: Zoning Ordinances for Hodgenville and Larue County, Comprehensive plan for Larue County, Hodgenville Kentucky code of ordinances. | 23. Recommend updates to City and County Codes and Ordinances. See page 126. |

| OBJECTIVE | BMP | ACTION ITEMS |
|---|---|---|
| 9. Incorporate educational signage at public parks. | Q. Design and implement educational signage on water quality and environmental issues. | 26. Develop public displays or educational flyers on water quality issues. See page 128. |
| | | 29. Develop stand-alone signage to install at public parks discussing issues or solutions visible in the surrounding area, for example: at Streambank / Riparian buffer at Creekfront Park,Habitat and pollution filtration at Pearman Forest Water resources management, and designated uses at McDougal & Salem Lake. See page 129. |
| 10. Develop a stormwater management plan that identifies flood prone areas. | R. Develop a stormwater management plan that identifies flood prone areas. | 30. Incorporate floodplain management regulations recommendations in stormwater management plan / flood hazard mitigation plan. See page 129. |
| | | 31. Utilize existing FEMA floodplain mapping and community feedback to identify priority flooding areas. See page 130. |
| 11. Reduce flooding by clearing waterways of obstructions such as large debris and beaver dams. | S. Beaver wildlife management. | 32. Work with Kentucky Department of Fish and Wildlife or other groups to develop methods to discourage beaver dam construction in priority flooding areas and educate the community on benefits of beaver dams. See page 130. |
| 12. Reduce flooding by reducing or slowing storm water runoff. | T(1). Water quantity BMP installation. | 33. Identify areas where potential for BMP implementation aligns with need for stormwater peak flow reduction. See page 131. |
| 13. Encourage the use of green infrastructure and low impact development. | T(2). Water quantity and quality BMP installation in new developments. | 23. Recommend updates to City and County Codes and Ordinances. See page 126. |
| | | 34. Require implementation or award credit to developments that voluntarily install BMPs. See page 131. |
| 14. Retrofit existing development to incorporate green infrastructure. | T(3). Water quantity and quality BMP installation in existing developments. | 33. Identify areas where potential for BMP implementation aligns with need for stormwater peak flow reduction. See page 131. |
| | | 35. Implement grant program to award funding to priority Stormwater infrastructure projects. See page 132. |

| OBJECTIVE | BMP | ACTION ITEMS |
|---|---|---|
| 15. Provide resources for environmentally friendly agricultural practices. | U(1). Engage and offer educational resources for community members. | 7. Hold an information session to inform the agricultural community on options for keeping livestock out of the stream. See page 118. |
| | | 12. Hold an information session to inform the agricultural community on the benefits of livestock field rotation. See page 121. |
| | | 13. Educate the community on the benefits filter strips can provide. See page 121. |
| | | 15. Educate the community on the hazards of improper animal waste disposal. See page 122. |
| | | 16. Community engagement by reaching out to local farming groups, mail, and public bulletins on AWQ plan benefits and requirements. See page 123. |
| | | 17. Work directly with landowners to complete their AWQ & NM plans. See page 123. |
| | | 25. Educate the community on the benefits of rain gardens and/or streamside wetlands and implement. See page 127. |
| | | 26. Develop public displays or educational flyers on water quality issues. See page 128. |
| | | 28. Include information on water quality in MCCW on local government and community web pages. See page 128. |
| | U(2). Provide BMP cost sharing mechanisms | 10. Utilize NRCS Cost Sharing program for livestock exclusion fencing (Practice #472) in feasible locations in MCCW. See page 120. |
| | | 9. Utilize NRCS Cost Sharing program for spring development (Practice #574). See page 119. |
| | | 14. Utilize NRCS Cost Sharing program for filter strip (Practice #393) installation. See page 122. |
| | | 25. Utilize NRCS Cost Sharing program for riparian forested buffer (Practice #391) and tree planting (Practice #612) See page 127. |

| OBJECTIVE | BMP | ACTION ITEMS |
|---|---|---|
| 16. Identify sink holes via dye tracing. | V. Identify sink holes via dye tracing. | 36. Identify funding source and utilize dye tracing to identify potential sources and sinks of pollution in karst basin. See page 132. |
| 17. Provide resources for environmentally friendly waste disposal, including dead animals. | W. Provide resources for environmentally friendly waste disposal, including dead animals. | 14. Educate the community on the hazards of improper animal waste disposal. See page 122. |
| | | 37. Work with farmers groups to develop dead animal disposal community program. See page 132. |
| | | 38. Utilize NRCS Cost Sharing Program for Emergency Animal Mortality Management (Practice #368). See page 133. |
| | | 39. Utilize NRCS Cost Sharing Program for Animal Mortality Facility (Practice #316). See page 133. |
| 18. Promote water quality improvements to manmade infrastructure in the watershed. | X. Microbial Source Tracking | 40. Conduct microbial source tracking to determine origin of bacterial levels. See page 134. |
| | Y. Lake dredging | 41. Complete dredging of Salem and McDougal Lakes. See page 134. |

Each Action Item is detailed below with information on description, responsible party, technical assistance, anticipated costs, funding mechanism, outcome indicators, prioritization, measurable milestones, and potential load reductions:

## ACTION ITEM 1

*Action Item 1:* Develop a system for the anonymous public reporting of potential sanitary sewer leaks and cross connections with the storm sewer system.

*Description:* Initiate and publicize program for public to report potential sanitary sewer system leaks and cross connections with the storm sewer system. Reports can be handwritten forms with responses including the location of the suspected leak or cross connection, why this location is suspected, and provide a place for contact information for the person reporting or an online system may be created

*Responsible Party:* LaRue County Fiscal Court and City of Hodgenville

*Technical Assistance:* Hodgenville City Waste Water

*Total Costs:* $2,000 for materials and staff time

*Funding Mechanism:* Not applicable

*Outcome Indicators:* Legitimate public reports

*Prioritization:* Category One (implement within 2 years)

*Measurable Milestones:* Development of reporting system within two years.

*Potential Load Reduction:* Expected to reduce *E. coli*, nitrogen and phosphorus pollutant loading. Assuming 2.5 people per home, each repaired leak is expected to reduce *E. coli* loading by 1.5695E+12 CFU/year (Horsley and Whitten, 1996: KDOW, 2015), nitrogen loading by 16 lb/year and phosphorus loading by 6 lb/year (Cane Run WBP 2019).

## ACTION ITEM 2

*Action Item 2:* Investigate exfiltration in lateral connections and remediate.
*Description:* Perform testing for lateral connection leaks or exfiltration using smoke testing or other methods. Coordinate with Hodgenville City Waste Water on necessary repairs.
*Responsible Party:* Hodgenville City Waste Water
*Technical Assistance:* Engineering and testing consultants
*Total Costs:* $400 per home for lateral connection investigations and $4,000 per home for lateral connection remediation
*Funding Mechanism:* 319(h) grants
*Outcome Indicators:* Identification and repair
*Prioritization:* Category One
*Measurable Milestones:* Begin investigation of lateral connections within three years.
*Potential Load Reduction:* Expected to reduce *E. coli*, nitrogen, and phosphorus pollutant loading. Assuming 2.5 people per home, each repaired leak is expected to reduce *E. coli* loading by 1.5695E+12 CFU/year (Horsley and Whitten, 1996: KDOW, 2015), nitrogen loading by 16 lb/year and phosphorus loading by 6 lb/year (Cane Run WBP 2019).

## ACTION ITEM 3

*Action Item 3:* Identify funding sources for necessary repairs to existing sanitary sewers.
*Description:* Identify funding sources (such as Community Development Block Grants, CWSRF KIA loans, local funding) to repair areas where leaks or exfiltration issues are identified within the existing sanitary sewer system.
*Responsible Party:* MCCWMP Watershed Coordinator
*Technical Assistance:* Hodgenville City Waste Water
*Total Costs:* $2,000 for coordinator time
*Funding Mechanism:* Community Development Block Grants (CWBG); CWSRF KIA loans; local funding
*Outcome Indicators:* Necessary funding available
*Prioritization:* As necessary repairs are identified
*Measurable Milestones:* As necessary repairs are identified
*Potential Load Reduction:* Expected to reduce *E. coli*, nitrogen, and phosphorus pollutant loading. Assuming 2.5 people per home, each repaired leak is expected to reduce *E. coli* loading by 1.5695E+12 CFU/year (Horsley and Whitten, 1996: KDOW, 2015), nitrogen loading by 16 lb/year and phosphorus loading by 6 lb/year (Cane Run WBP 2019). This Action Item will not directly result in reductions but will provide the necessary resources to implement Action Items 1 & 2.

## ACTION ITEM 4

*Action Item 4:* Develop a system for anonymous public reporting of potential straight pipes or failing septic systems.

*Description:* Initiate and publicize program for public to report potential sanitary sewer system leaks and cross connections with the storm sewer system. Reports can be handwritten forms with responses including the location of the suspected leak or cross connection, why this location is suspected, and provide a place for contact information for the person reporting.

*Responsible Party:* LaRue County Health Department

*Technical Assistance:* Hodgenville City Waste Water

*Total Costs:* $2,000 for staff time

*Funding Mechanism:* Not applicable

*Outcome Indicators:* Legitimate public reports

*Prioritization:* Category One

*Measurable Milestones:* Development of reporting system within two years.

*Potential Load Reduction:* Expected to reduce *E. coli*, nitrogen, and phosphorus pollutant loading. Assuming 2.5 people per home, each replaced straight pipe or repaired septic system is expected to reduce *E. coli* loading by 1.5695E+12 CFU/year (Horsley and Whitten, 1996: KDOW, 2015), nitrogen loading by 16 lb/year and phosphorus loading by 6 lb/year (Cane Run WBP 2019). This Action Item will not directly reduce loading but will assist in identifying systems to be replaced or repaired.

## ACTION ITEM 5

*Action Item 5:* Notify property owners of any confirmed straight pipes or failing septic systems.

*Description:* Owners of properties where confirmed straight pipes or failing septic systems are identified should be notified by the LaRue County Health Department. These issues should be repaired by the property owner. The MCCWMP Watershed Coordinator will be responsible coordinating with the LaRue County Health Department on notification and repairs.

*Responsible Party:* MCCWMP Watershed Coordinator, LaRue County Health Department

*Technical Assistance:* Not applicable

*Total Costs:* Approximately $4000 per repair of failing septic system; $15,000 for new septic system installation

*Funding Mechanism:* Landowner expense or 319(h) grant

Outcome Indicators: *E. coli* and conductivity

*Prioritization:* As necessary straight pipes and failing septic systems are identified are repaired

*Measurable Milestones:* Elimination of straight pipes and failing septic systems as they are identified

*Potential Load Reduction:* Expected to reduce *E. coli*, nitrogen, and phosphorus pollutant loading. Assuming 2.5 people per home, each replaced straight pipe or repaired septic system is expected to reduce *E. coli* loading by 1.5695E+12 CFU/year (Horsley and Whitten, 1996: KDOW, 2015), nitrogen loading by 16 lb/year and phosphorus loading by 6 lb/year (Cane Run WBP 2019). This Action Item will not directly reduce loading but will inform and encourage homeowners to replace or repair their sanitary facilities.

## ACTION ITEM 6

*Action Item 6:* Educate community on septic system maintenance through community workshops and field days with installers, real estate agents and community groups.

*Description:* Provide education to the portion of the community with septic systems on proper maintenance and indicators of poor performance. Hold a training session on proper septic system maintenance and repair. Have educational materials available at the LaRue County Cooperative Extension Office, such as *A Homeowner's Guide to Septic Systems* developed by the EPA. Provide link on LaRue County Cooperative Extension Office website to educational materials. Mail copies of educational material to community residents who live outside of the sewer service boundary.

*Responsible Party:* LaRue County Cooperative Extension Office

*Technical Assistance:* LaRue County Health Department

*Total Costs:* $500 per training session and $500 for distribution of educational materials

*Funding Mechanism:* Bluegrass Greensource grants and 319(h) grants

*Outcome Indicators:* Hold one training session biannually and have educational information available

*Prioritization:* Category One

*Measurable Milestones:* Education materials on proper maintenance and indicators of poor performance available at the LaRue County Cooperative Extension Office within two years. Distribute copies of educational material to community residents who live outside of the sewer service boundary within two years. Hold first training session on proper septic system maintenance and repair within two years.

*Potential Load Reduction:* Expected to reduce *E. coli*, nitrogen, and phosphorus pollutant loading. Assuming 2.5 people per home, each replaced straight pipe or repaired septic system is expected to reduce *E. coli* loading by 1.5695E+12 CFU/year (Horsley and Whitten, 1996: KDOW, 2015), nitrogen loading by 16 lb/year and phosphorus loading by 6 lb/year (Cane Run WBP 2019).

## ACTION ITEM 7

*Action Item 7:* Hold an information session to inform the agricultural community on options for keeping livestock out of the stream.

*Description:* Conduct an information session on methods and techniques for keeping cattle out of the stream, such as off stream watering, planting for creating off stream shade, and livestock exclusion fence. Discuss benefits to water quality, livestock health, and available grant money. This information session can be held in conjunction with the ones in Action Item 12, 13, 15, 16, and 25. Post information on LaRue Fiscal Court or LaRue County Cooperative Extension Office website. Limiting or discouraging direct cattle access to the stream can reduce potential for *E. coli*, nitrogen and phosphorus pollution from cattle droppings in the stream, and reduce TSS pollution from trampling of streambank soils.

*Responsible Party:* MCCWMP Watershed Coordinator

*Technical Assistance:* LaRue County Extension Office and engineering consultant

*Total Costs:* $2,500 for engineering consultant presentation preparation and consultation

*Funding Mechanism:* 319(h) grants, other water quality grants, or private funding

*Outcome Indicators:* Successful events

*Prioritization:* Category One

*Measurable Milestones:* Conduct at least one informational session within two years.

*Potential Load Reduction:* Expected to reduce *E. coli*, nitrogen, phosphorus, and sediment pollutant loading. Assuming an even distribution of cows throughout available pastureland, at 1.5 cows per acre, restricting or bypassing access to 1 acre of stream is expected to reduce *E. coli* loading by 1.40E+11 CFU/year (City of Tallahassee). Alternative water source is anticipated to remove 75% of nitrogen loading, 78% of phosphorus loading, and 80% of sediment loading. Exclusion fencing is anticipated to remove 65% of nitrogen loading, 60% of phosphorus loading and 70% of sediment loading (Geist/Fall Creek Watershed Alliance). This Action Item does not directly reduce pollutant loading and instead seeks to inform and encourage farm owners in the watershed to follow through with the recommended practices.

## ACTION ITEM 8

*Action Item 8:* Investigate the feasibility of providing an alternative water source for livestock.
*Description:* Explore options for providing an alternative water source for livestock, such as spring development, water wells, or providing water using pumps. Assess the feasibility and cost of implementing these measures. Use of alternate water sources redirects cattle from having to drink or bathe in streams. This can reduce potential for *E. coli*, nitrogen, and phosphorus pollution from cattle droppings in the stream, and reduce TSS pollution from trampling of streambank soils.
*Responsible Party:* MCCWMP Watershed Coordinator
*Technical Assistance:* Hodgenville City Waste Water and LaRue County Cooperative Extension Office
*Total Costs:* $2,000 for coordinator time
*Funding Mechanism:* Not applicable
*Outcome Indicators:* Feasibility analysis
*Prioritization:* Category Two
*Measurable Milestones:* Provide a summary of the alternatives and their feasibility within two years.
*Potential Load Reduction:* Expected to reduce *E. coli*, nitrogen, phosphorus, and sediment pollutant loading. Assuming an even distribution of cows throughout available pastureland, at 1.5 cows per acre, bypassing access to 1 acre of stream is expected to reduce *E. coli* loading by 1.40E+11 CFU/year. Alternative water source is anticipated to remove 75% of nitrogen loading, 78% of phosphorus loading, and 80% of sediment loading (Geist/Fall Creek Watershed Alliance).

## ACTION ITEM 9

*Action Item 9:* Utilize NRCS Cost Sharing program for spring development (Practice #574) or watering facility (#614).
*Description:* In conjunction with Action Item 10, an additional water source is often needed after the installation of livestock exclusion fences or for proper field rotation practices. Utilize NRCS Cost Sharing program for spring development to provide an additional water source.
*Responsible Party:* Property owners with livestock and MCCWMP Watershed Coordinator
*Technical Assistance:* NRCS
*Total Costs:* $2000-$5000 for each facility
*Funding Mechanism:* NRCS Conservation Stewardship Program and landowner
*Outcome Indicators:* Developed springs
*Prioritization:* Category Two

*Measurable Milestones:* Implementation of approximately 15 alternative watering sources (serving 600 acres) in conjunction with the livestock exclusion fence installation within seven years.

*Potential Load Reduction:* Expected to reduce *E. coli*, nitrogen, phosphorus, and sediment pollutant loading. Assuming an even distribution of cows throughout available pastureland, at 1.5 cows per acre, bypassing access to 1 acre of stream is expected to reduce *E. coli* loading by 1.40E+11 CFU/year (City of Tallahassee). Alternative water source is anticipated to remove 75% of nitrogen loading, 78% of phosphorus loading, and 80% of sediment loading (Geist/Fall Creek Watershed Alliance).

## ACTION ITEM 10

*Action Item 10:* Utilize NRCS Cost Sharing program for livestock exclusion fencing (Practice #472) in feasible locations of MCCW.

*Description:* Install livestock exclusion fencing on agricultural properties used for livestock grazing where there is direct access to streams. Priority should be given to subwatersheds identified to have high *E. coli* loading and high pastureland concentration. Livestock exclusion fence is only recommended in areas where other BMPs are impractical or not successful. Property owners should utilize the NRCS Cost Sharing program for the installation of livestock exclusion fences in feasible locations.

*Responsible Party:* MCCWMP Watershed Coordinator and property owners with livestock

*Technical Assistance:* NRCS

*Total Costs:* $50 per foot, but will vary based on type of fencing and whether other improvements will also be necessary, such as providing an alternative water source

*Funding Mechanism:* NRCS Conservation Stewardship Program and landowner

*Outcome Indicators: E. coli* and conductivity

*Prioritization:* Category Two

*Measurable Milestones:* Implementation of approximately 12,000 linear feet of livestock exclusion fence within seven years.

*Potential Load Reduction:* Expected to reduce *E. coli*, nitrogen, phosphorus, and sediment pollutant loading. Assuming an even distribution of cows throughout available pastureland, at 1.5 cows per acre, restricting access to 1 acre of stream is expected to reduce *E. coli* loading by 1.40E+11 CFU/year (City of Tallahassee). Exclusion fencing is anticipated to remove 65% of nitrogen loading, 60% of phosphorus loading and 70% of sediment loading (Geist/Fall Creek Watershed Alliance).

## ACTION ITEM 11

*Action Item 11:* Utilize NRCS Cost Sharing program for Stream Crossing (Practice #578) installation.

*Description:* Install a stabilized area or structure constructed across a stream to provide controlled access for people, livestock, equipment, or vehicles. The width of the stream crossing can be designed to discourage cattle from loitering in the stream.

*Responsible Party:* Property owners with livestock and/ or machinery and MCCWMP Watershed Coordinator

*Technical Assistance:* NRCS

*Total Costs:* $4000 - $10,000 depending on method used

*Funding Mechanism:* NRCS Conservation Stewardship Program and landowner
*Outcome Indicators: E. coli*, conductivity, and nutrients
*Prioritization:* Category Two
*Measurable Milestones:* Implementation of approximately 10 stream crossings within seven years to reduce nutrient and bacteria loading. Implementation along North Fork Nolin River and tributaries to reduce nutrient loads to within target loadings.
*Potential Load Reduction:* Expected to reduce *E. coli*, nitrogen, phosphorus, and sediment pollutant loading. This Action Item, on its own, is not expected to reduce pollutant loadings to the same magnitude as providing exclusionary fencing. This Action Item can be considered supplemental to Action Item 11, when it is not feasible for farm owners to fully restrict their livestock from crossing the stream.

## ACTION ITEM 12

*Action Item 12:* Hold an information session to inform the agricultural community on the benefits of livestock field rotation.
*Description:* Conduct an information session on practices and benefits of livestock field rotation. Discuss benefits to water quality and property maintenance. This information session can be held in conjunction with the ones in Action Items 7, 13, 15, 16, and 25. Post information on LaRue County Fiscal Court or LaRue County Cooperative Extension Office website. Livestock field rotation will split a pasture into sections that are utilized on a consistent schedule. Each section is given time for plants to regrow and develop deeper roots so that there is plentiful material available for grazing and to prevent topsoil erosion.
*Responsible Party:* MCCWMP Watershed Coordinator
*Technical Assistance:* LaRue County Extension Office and engineering consultant
*Total Costs:* No additional costs if held in conjunction with Action Items 7, 13, 15, 16, and 25, otherwise $2,500 per event
*Funding Mechanism:* Not applicable
*Outcome Indicators:* Successful events
*Prioritization:* Category One
*Measurable Milestones:* Conduct at least one informational session within two years.
*Potential Load Reduction:* Expected to reduce *E. coli*, nitrogen, phosphorus, and sediment pollutant loading. Livestock field rotation is expected to remove 20% of nitrogen loading, 20% of phosphorus loading, and 40% of sediment loading (Geist/Fall Creek Watershed Alliance).

## ACTION ITEM 13

*Action Item 13:* Educate the community on the benefits filter strips can provide.
*Description:* Conduct an information session on practices and benefits of filter strips. Discuss benefits to water quality, livestock health, and available grant money. This information session can be held in conjunction with the ones in Action Items 7, 12, 15, 16, and 25. Post information on LaRue County Fiscal Court or LaRue County Extension Office website.
*Responsible Party:* MCCWMP Watershed Coordinator
*Technical Assistance:* LaRue County Cooperative Extension Office and engineering consultant
*Total Costs:* No additional costs in held in conjunction with Action Items 7, 12, 15, 16, and 25, otherwise $2,500 per event

*Funding Mechanism:* Not applicable
*Outcome Indicators:* Successful events
*Prioritization:* Category One
*Measurable Milestones:* Conduct at least one informational session within two years.
*Potential Load Reduction:* Expected to reduce *E. coli*, nitrogen, phosphorus, and sediment pollutant loading. Filter strips are expected to remove 70% of nitrogen loading, 75% of phosphorus loading, and 65% of sediment loading (Geist/Fall Creek Watershed Alliance). This Action Item does not directly reduce pollutant loading and instead seeks to inform and encourage farm owners in the watershed to follow through with the recommended practice.

## ACTION ITEM 14

*Action Item 14:* Utilize NRCS Cost Sharing program for filter strip (Practice #393) installation.
*Description:* Install filter strips along areas where contaminants run off directly from livestock fields and crop land to remove contaminants prior to the water entering in the stream. Utilize NRCS Cost Sharing program for filter strip installation.
*Responsible Party:* Property owners with livestock and MCCWMP Watershed Coordinator
*Technical Assistance:* NRCS
*Total Costs:* $250 - $600 per acre depending on type of vegetated planted
*Funding Mechanism:* NRCS Conservation Stewardship Program and landowner
*Outcome Indicators: E. coli*, conductivity, and nutrients
*Prioritization:* Category Two
*Measurable Milestones:* Implementation of approximately 10,000 linear feet of filter strips or riparian buffers zones within seven years to reduce nutrient and bacteria loading. Implementation along North Fork Nolin River and tributaries to reduce nutrient loads to within target loadings.
*Potential Load Reduction:* Expected to reduce *E. coli*, nitrogen, phosphorus, and sediment pollutant loading. Expected to reduce *E. coli*, nitrogen, phosphorus, and sediment pollutant loading. Filter strips are expected to remove 70% of nitrogen loading, 75% of phosphorus loading, and 65% of sediment loading (Geist/Fall Creek Watershed Alliance).

## ACTION ITEM 15

*Action Item 15:* Educate the community on the hazards of improper animal waste disposal.
*Description:* Educate the community on the hazards of improper waste disposal through public displays, educational flyers, and/or an information session. This Action Item hopes to empower community members with awareness of how their actions can support water quality. Low or no cost habits such as proper disposal of pet waste, and efficient use of fertilizer for lawn care will be encouraged.
*Responsible Party:* MCCWMP Watershed Coordinator
*Technical Assistance:* LaRue County Cooperative Extension Office and engineering consultants
*Total Costs:* No additional cost if combine with other activities, otherwise $2,500 per event
*Funding Mechanism:* 319(h) grant
*Outcome Indicators:* Successful events and material available
*Prioritization:* Category One
*Measurable Milestones:* Conduct at least one educational activity within two years.

*Potential Load Reduction:* Expected to reduce *E. coli*, nitrogen, and phosphorus pollutant loading. Assuming all pet waste is disposed of correctly, *E. coli* loading is expected to be reduced by 1.88E+9 CFU/acre/year and nitrogen loading by 4.09 lbs/acre/year (TMDL Report by Ormsbee et al).

## ACTION ITEM 16

*Action Item 16:* Engage and support local farming groups on Agricultural Water Quality Plans and Nutrient Management Plans.
*Description:* Community engagement by reaching out to local farming groups through mail, and public bulletins and/or an information session on AWQP & NMP benefits and requirements.
*Responsible Party:* MCCWMP Watershed Coordinator
*Technical Assistance:* LaRue County Cooperative Extension Office and engineering consultants
*Total Costs:* No additional cost if combine with other activities, otherwise $2,500 per event
*Funding Mechanism:* 319(h) grant
*Outcome Indicators:* Successful events and material available
*Prioritization:* Category One
*Measurable Milestones:* Conduct at least one educational activity within two years.
*Potential Load Reduction:* Expected to reduce *E. coli*, nitrogen, phosphorus, and sediment pollutant loading. This Action Item does not directly reduce pollutant loading and instead seeks to inform and encourage farm owners in the watershed to follow through with the recommended practices.

## ACTION ITEM 17

*Action Item 17:* Work directly with landowners to complete their Agricultural Water Quality Plans and Nutrient Management Plans.
*Description:* Host work sessions for landowners to ask question and receive direct technical support for the production of their plans.
*Responsible Party:* MCCWMP Watershed Coordinator
*Technical Assistance:* LaRue County Cooperative Extension Office and engineering consultants
*Total Costs:* $2,500 per event if not combined with other educational outreach events.
*Funding Mechanism:* 319(h) grant
*Outcome Indicators:* Successful events available
*Prioritization:* Category One
*Measurable Milestones:* Conduct at least one technical assistance activity within two years.
*Potential Load Reduction:* Expected to reduce *E. coli*, nitrogen, phosphorus, and sediment pollutant loading. This Action Item does not directly reduce pollutant loading and instead seeks to directly assist farm owners in the watershed to follow through with the recommended practices.

## ACTION ITEM 18

*Action Item 18:* Utilize NRCS Cost Sharing program for Cover Crops (Practice #340).

*Description:* Plant cover crops for seasonal vegetative cover to reduce erosion in subwatersheds with exceedances in TSS. Farmers can utilize resources from the USDA to determine the best cover crop species to achieve specific cover cropping goals (improving organic matter, preventing erosion, nitrogen scavenging or fixation, etc.). Property owners should utilize the NRCS Cost Sharing program for Cover Crop costs.

*Responsible Party:* MCCWMP Watershed Coordinator and agricultural property owners

*Technical Assistance:* NRCS

*Total Costs:* $25 - $500 per acre, cost becomes cheaper as scale of implementation is increased

*Funding Mechanism:* NRCS EQIP Cost Share and landowner

*Outcome Indicators:* Amount of land planted

*Prioritization:* Category Two

*Measurable Milestones:* Implementation of approximately 1,100 acres of farmland where cover crops have been planted.

*Potential Load Reduction:* Expected to reduce nitrogen, phosphorus, and sediment pollutant loading. Utilization of cover crops are expected to reduce nitrogen loading by 40%, phosphorus loading by 45%, and sediment loading by 40% (Geist/Fall Creek Watershed Alliance). These reductions only apply to the area of farmland where cover crops are implemented.

## ACTION ITEM 19

*Action Item 19:* Utilize NRCS Cost Sharing program for Residue and Tillage Management, Reduced Till/ No Till (Practice #345 and #329).

*Description:* Managing the amount, orientation, and distribution of crop and plant residue on the soil surface to reduce erosion in subwatersheds with exceedances in TSS. Benefits of no-till farming include an increase in soil organic matter and decrease in erosion. These benefits will lead to more fertility, less fertilizer and higher crop yields. Property owners should utilize the NRCS Cost Sharing program for Cover Crop costs.

*Responsible Party:* MCCWMP Watershed Coordinator and agricultural property owners

*Technical Assistance:* NRCS

*Total Costs:* $25 per acre

*Funding Mechanism:* NRCS EQIP Cost Share and landowner

*Outcome Indicators:* Amount of land with till reduced

*Prioritization:* Category Two

*Measurable Milestones:* Implementation of approximately 1,100 acres of farmland where residue and tillage management, reduced till/ no till has been implemented.

*Potential Load Reduction:* Expected to reduce nitrogen, phosphorus, and sediment pollutant loading. Utilization of reduced till / no till is expected to reduce nitrogen loading by 55%, phosphorus loading by 45%, and sediment loading by 75% (Geist/Fall Creek Watershed Alliance). These reductions only apply to the area of farmland where reduced till / no till is implemented.

## ACTION ITEM 20

*Action Item 20:* Utilize NRCS Cost Sharing program for Heavy Use Area Protection (Practice #561).

*Description:* Stabilize and protect intensively used areas to reduce erosion in subwatersheds with exceedances in TSS. Protection can be achieved through a variety of materials such as gravel, geotextile, concrete and reinforced concrete. Property owners should utilize the NRCS Cost Sharing program for Heavy Use Area costs.

*Responsible Party:* MCCWMP Watershed Coordinator and agricultural property owners

*Technical Assistance:* NRCS

*Total Costs:* $2 - $20 per square foot based on material used

*Funding Mechanism:* NRCS Conservation Stewardship Program and landowner

*Outcome Indicators:* Amount of land protected

*Prioritization:* Category Two

*Measurable Milestones:* Implementation of protections in approximately 20 heavy use areas.

*Potential Load Reduction:* Expected to reduce nitrogen, phosphorus, and sediment pollutant loading. Exact expected reduction amounts have not been calculated.

## ACTION ITEM 21

*Action Item 21:* Utilize NRCS Cost Sharing program for Waste Facility Closure (Practice #360).

*Description:* Decommission a facility where agricultural waste was been stored and is no longer in use to reduce animal waste in subwatersheds with exceedances in *E. coli* and nutrients. Closing or converting these unused facilities will minimize the potential for pollution through groundwater leeching or surface water overflow. Property owners should utilize the NRCS Cost Sharing program for Waste Facility closure costs.

*Responsible Party:* MCCWMP Watershed Coordinator and agricultural property owners

*Technical Assistance:* NRCS

*Total Costs:* $10,000 - $15,000 per facility closure depending on size

*Funding Mechanism:* NRCS Conservation Stewardship Program and landowner

*Outcome Indicators:* Amount of land protected

*Prioritization:* Category Two

*Measurable Milestones:* Decommissioning of approximately 15 animal waste facilities.

*Potential Load Reduction:* Expected to reduce *E. coli*, nitrogen, and phosphorus pollutant loading. Since there is a wide range of scale and condition of abandoned waste facilities, exact reduction amounts have not been calculated.

## ACTION ITEM 22

*Action Item 22:* Utilize NRCS Cost Sharing program for riparian forested buffer (Practice #391) and tree planting (Practice #612).

*Description:* Install riparian forested buffer and/or tree planting in areas identified as lacking riparian zone on the map in Figure 38. Riparian buffers act as a natural filter to protect the stream from upstream pollutants and stabilize banks with root structures to reduce erosion and provide habitat. Property owners should utilize the NRCS Cost Sharing program for the riparian forested buffer and tree planting.

*Responsible Party:* MCCWMP Watershed Coordinator and agricultural property owners

*Technical Assistance:* NRCS

*Total Costs:* $500 per acre, varies based on amount and type of vegetation and condition of existing buffer

*Funding Mechanism:* NRCS Conservation Stewardship Program and landowner

*Outcome Indicators:* Amount of land planted

*Prioritization:* Category Two

*Measurable Milestones:* Implementation of approximately 11,000 linear feet of filter strips or riparian buffers zones in areas along North Fork Nolin River and tributaries within seven years to reduce nutrient and bacteria loading.

*Potential Load Reduction:* Expected to reduce *E. coli*, nitrogen, phosphorus, and sediment pollutant loading. For cropland and pastureland, a wildlife concentration of 5 deer, 5 geese, 10 ducks, 1 beaver and 2 raccoons is assumed per square mile. For urban land, a wildlife concentration of 5 geese, 10 ducks and 2 raccoons is assumed per square mile. Assuming all of the fecal load produced by the above concentrations is treated by riparian buffer, the expected *E. coli* load reduction is 1.55E+11 CFU/acre/year (Bacterial Indicator Tool, 2001). Length of riparian buffer is converted to area of riparian buffer by assuming the drainage area to the riparian buffer is a square. Riparian buffer is expected to reduce nitrogen loading by 40%, phosphorus loading by 45%, and sediment loading by 75% (Geist/Fall Creek Watershed Alliance).

## ACTION ITEM 23

*Action Item 23:* Recommend updates to City and County Codes and Ordinances.

*Description:* Assess the City and County Codes and Ordinances to find deficiencies in regulating water quantity and quality. Update the City and County Codes and Ordinances to address any deficiencies. Implement a water quality standard treatment requirement. Establish operation and maintenance procedures. Define inspection procedures for during and post construction. Additional review can be given to the LaRue County comprehensive plan, although this document is not enforceable in the way codes and ordinances are. The comprehensive plan can serve as a roadmap to support future changes to codes and ordinances.

*Responsible Party:* City of Hodgenville and LaRue County Fiscal Court

*Technical Assistance:* Engineering consultants

*Total Costs:* $200 per hour for review by engineering consultant

*Funding Mechanism:* City of Hodgenville, LaRue County Fiscal Court, and 319(h) grants

*Prioritization:* Category One

*Outcome Indicators:* Revised codes and ordinances

*Measurable Milestones:* Assess and revise City and County Codes and Ordinances within two years. Reassess City and County Codes and Ordinances after seven years.

*Potential Load Reduction:* Expected to reduce *E. coli*, nitrogen, phosphorus, and sediment pollutant loading. This Action Item does not directly reduce pollutant loading and instead seeks to evaluate the opportunity for modifications to planning documents to encourage or require utilization of other Action Items.

## ACTION ITEM 24

*Action Item 24:* Identify, design, and implement stream restoration on impaired reaches.

*Description:* Locate and assess impaired reaches that would benefit from stream restoration to stabilize unstable banks or reestablish connection to the floodplain outside the scope of this study. Streambank erosion has been observed as a critical concern in the watershed and a high contributor to TSS pollution. Stabilizing streambanks will reduce potential for erosion and preserve valuable streamside land. Potential funding sources should be identified, and selected projects should be designed and implemented.

*Responsible Party:* MCCWMP Watershed Coordinator

*Technical Assistance:* Engineering consultants

*Total Costs:* Approximately $250 per linear foot, but varies based on selected project

*Funding Mechanism:* Kentucky Department of Fish and Wildlife in-lieu fee mitigation funds, other offsite mitigation banking, or 319(h) grants

*Prioritization:* Category Three

*Measurable Milestones:* Identify a list of prioritized reaches for restoration within seven years.

*Potential Load Reduction:* Expected to reduce *E. coli*, nitrogen, phosphorus, and sediment pollutant loading. Stream restoration is expected to reduce nitrogen loading by 0.075 lb/ft/year, phosphorus loading by 0.068 lb/ft/year, and sediment loading by 44.88 lb/ft/year (Chesapeake Stormwater Network).

## ACTION ITEM 25

*Action Item 25:* Educate the community on the benefits of rain gardens and/or streamside wetlands and implement.

*Description:* Hold an informational meeting or workshop on the benefits of rain gardens and streamside wetlands to improve water quality. Include information on how rain gardens can be implemented by homeowners.

*Responsible Party:* MCCWMP Watershed Coordinator

*Technical Assistance:* Engineering consultants

*Total Costs:* $2,500 for engineering consultant presentation preparation and consultation; property estimated at $12 to $20 a linear foot for conservation easement along the stream; rain garden installation and riparian zone enhancement estimated at $2 to $5 per square foot

*Funding Mechanism:* 319(h) grants

*Outcome Indicators:* Nutrients

*Prioritization:* Category One

*Measurable Milestones:* Conduct at least one informational meeting or workshop within two years

*Potential Load Reduction:* Expected to reduce *E. coli*, nitrogen, phosphorus, and sediment pollutant loading. Rain gardens are expected to remove 20% of nitrogen loading, 20% of phosphorus loading, and 80% of sediment loading. Wetlands are expected to remove 45% of nitrogen loading, 55% of phosphorus loading, and 80% of sediment loading.

## ACTION ITEM 26

*Action Item 26:* Develop public displays or educational flyers on water quality issues.

*Description:* Develop public displays to be posted at the library or other public spaces and/or education flyers that explain the importance of water quality. The displays should focus on water quality best management practices that directly affect property owners, such as yard waste, pet waste and chemical disposal; rain barrels and rain garden installation; and maintaining naturally vegetated riparian buffers along streams.

*Responsible Party:* City of Hodgenville and LaRue County Public Library

*Technical Assistance:* MCCWMP Watershed Coordinator and engineering consultants

*Total Costs:* Varies based on type and number of displays

*Funding Mechanism:* 319(h) grants

*Outcome Indicators:* Number of displays/flyers

*Prioritization:* Category One

*Measurable Milestones:* Develop at least one display to be posted within two years.

*Potential Load Reduction:* Expected to reduce *E. coli*, nitrogen, phosphorus, and sediment pollutant loading. This Action Item does not directly reduce pollutant loading and instead seeks to inform and encourage the general public to support implementation of water quality practices throughout the watersheds.

## ACTION ITEM 27

*Action Item 27:* Incorporate water quality education curriculum at local elementary, middle, and high schools.

*Description:* Incorporate water quality education curriculum such as material developed by Bluegrass Greensource into the LaRue County school system.

*Responsible Party:* LaRue County Board of Education

*Technical Assistance:* Bluegrass Greensource

*Total Costs:* Not applicable

*Funding Mechanism:* Not applicable

*Outcome Indicators:* Water quality education of students

*Prioritization:* Category Three

*Measurable Milestones:* Implementation of water quality education into LaRue County school system within ten years.

*Potential Load Reduction:* Expected to reduce *E. coli*, nitrogen, phosphorus, and sediment pollutant loading. This Action Item does not directly reduce pollutant loading and instead seeks to inform and encourage the young public to support implementation of water quality practices throughout the watersheds.

## ACTION ITEM 28

*Action Item 28:* Include information on water quality in MCCW on local government and community web pages.

*Description:* Place water quality information concerning MCCW on the City of Hodgenville and LaRue County Fiscal Court websites. Information should include information on the MCCWMP, current projects, upcoming meetings or workshops, and a link to sign up to volunteer for activities within the watershed. Create a database of emails of interested parties.

*Responsible Party:* City of Hodgenville, and LaRue County Fiscal Court

*Technical Assistance:* Website developer

*Total Costs:* Not applicable

*Funding Mechanism:* Not applicable

*Outcome Indicators:* Information on websites

*Prioritization:* Category One

*Measurable Milestones:* Have information on City of Hodgenville, and LaRue County Fiscal Court websites (or a link to a central location with all information) within two years.

*Potential Load Reduction:* Expected to reduce *E. coli*, nitrogen, phosphorus, and sediment pollutant loading. This Action Item does not directly reduce pollutant loading and instead seeks to inform and encourage the general public to support implementation of water quality practices throughout the watersheds.

## ACTION ITEM 29

*Action Item 29:* Develop stand-alone signage to install at public parks discussing issues or solutions visible in the surrounding area.

*Description:* Develop public displays to be posted at visible locations in public parks to educate and engage the community. Displays should focus on an element of watershed quality which is visibly evident in the surrounding area. For example, signage on streambank degradation and benefits of riparian buffer can be placed at Creekfront Park. Signage on forested habitat and benefits of native plants for pollution filtration can be placed at Pearman Forest. Signage on flood management and designated uses of waterways can be posted at McDougal & Salem Lakes.

*Responsible Party:* City of Hodgenville and LaRue County Fiscal Court

*Technical Assistance:* MCCWMP Watershed Coordinator and graphic design consultants

*Total Costs:* Varies based on type and number of signs

*Funding Mechanism:* 319(h) grants

*Outcome Indicators:* Number of signs

*Prioritization:* Category One

*Measurable Milestones:* Develop at least one sign to be placed within two years.

*Potential Load Reduction:* Expected to reduce *E. coli*, nitrogen, phosphorus, and sediment pollutant loading. This Action Item does not directly reduce pollutant loading and instead seeks to inform and encourage the general public to support implementation of water quality practices throughout the watersheds.

## ACTION ITEM 30

*Action Item 30:* Incorporate floodplain management regulations recommendations in stormwater management plan / flood hazard mitigation plan.

*Description:* As an element of a proposed stormwater management plan, review existing floodplain management regulations and recommend any adjustments to decrease flood risk in priority areas and address water quantity issues

*Responsible Party:* City of Hodgenville and LaRue County Fiscal Court

*Technical Assistance:* MCCWMP Watershed Coordinator and engineering consultants
*Total Costs:* $200 per hour for review by engineering consultant
*Funding Mechanism:* City of Hodgenville, LaRue County Fiscal Court, and 319(h) grants
*Prioritization:* Category One
*Outcome Indicators:* Developed stormwater management plan
*Measurable Milestones:* Develop Stormwater management plan within two years. Reassess Stormwater management plan after seven years.
*Potential Load Reduction:* Expected to reduce sediment pollutant loading. Exact load reduction amounts are not calculated.

## ACTION ITEM 31

*Action Item 31:* Utilize existing FEMA floodplain mapping and community feedback to identify priority flooding areas.
*Description:* As an element of a proposed Stormwater Management Plan, review existing FEMA mapped floodplain to identify areas where flood damage would be most harmful. This review should be supplemented with community feedback on where flooding has been observed in MCCW.
*Responsible Party:* City of Hodgenville and LaRue County Fiscal Court
*Technical Assistance:* MCCWMP Watershed Coordinator and engineering consultants
*Total Costs:* $120 per hour for review by engineering consultant
*Funding Mechanism:* City of Hodgenville, LaRue County Fiscal Court, and 319(h) grants
*Prioritization:* Category One
*Outcome Indicators:* Developed Stormwater management plan
*Measurable Milestones:* Develop Stormwater management plan within two years. Reassess Stormwater management plan after seven years.
*Potential Load Reduction:* Expected to reduce sediment pollutant loading. Exact load reduction amounts are not calculated.

## ACTION ITEM 32

*Action Item 32:* Work with Kentucky Department of Fish and Wildlife or other organizations to develop methods to discourage beaver dam construction in priority flooding areas and educate the community on benefits of beaver dams.
*Description:* Engage community members to help identify locations where beaver dam construction is resulting in increased floodplain on vulnerable properties. The project team acknowledges that beaver dams do provide many environmental benefits such as providing fish habitat, filtering out sediment and pollutants, and slowing down stream flows during storm events. Any work to remove beaver dams should to be paired with an education and outreach strategy to inform stakeholders on these benefits. This strategy should include fliers or posters in public areas about the benefits of beaver dams. In areas where Beaver Dam removal is deemed necessary, work with non-game Kentucky Department of Fish and Wildlife Resources to safely remove harmful dams and discourage future dam construction. Removal of dams will decrease flood risk and keep floodwater from eroding bank soils and pulling pollutants from the floodplain into the stream.
*Responsible Party:* City of Hodgenville and LaRue County Fiscal Court
*Technical Assistance:* MCCWMP Watershed Coordinator and Kentucky Department of Fish and

Wildlife

*Total Costs:* $12,500 per beaver dam removal and education and outreach, but may vary based on scope

*Funding Mechanism:* TBD

*Prioritization:* Category Three

*Outcome Indicators:* Reduced flood damage from beaver dams and implement an education and outreach program

*Measurable Milestones:* Identify solutions for beaver related localized flooding

*Potential Load Reduction:* Expected to reduce sediment pollutant loading. Exact load reduction amounts are not calculated.

**ACTION ITEM 33**

*Action Item 33:* Identify areas where potential for BMP implementation aligns with need for stormwater peak flow reduction

*Description:* In an effort to reduce flooding by reducing or slowing storm water runoff, identify areas where flooding may be caused or made worse by excess peak flows. Explore opportunities in these areas for development of water quantity BMPs such as detention basins, rain gardens, rain barrels, wetlands, etc. Work with engineer to develop and implement BMPs.

*Responsible Party:* MCCWMP Watershed Coordinator

*Technical Assistance:* Engineering consultant

*Total Costs:* varies based on type of BMP

*Funding Mechanism:* 319(h) grants

*Prioritization:* Category Three

*Outcome Indicators:* Installation of BMPs and evidence of flood reduction

*Measurable Milestones:* Installation of BMPs and evidence of flood reduction within seven years.

*Potential Load Reduction:* Expected to reduce *E. coli*, nitrogen, phosphorus, and sediment pollutant loading. This Action Item does not directly reduce pollutant loading and instead seeks to identify and plan for optimal locations to implement stormwater peak flow reduction BMPs. Many of these BMPs will have side effects which reduce all critical pollutant loads.

**ACTION ITEM 34**

*Action Item 34:* Require implementation or award credit to developments that voluntarily install BMPs

*Description:* To increase the use of green infrastructure and low impact development in new developments, require minimum standards for environmental impact or award credits to development projects which install environmentally friendly practices above and beyond the requirements. This BMP can be incorporated in to the documents discussed in Action Item 18.

*Responsible Party:* City of Hodgenville and LaRue County Fiscal Court

*Technical Assistance:* Engineering consultants

*Total Costs:* $120 per hour for review by engineering consultant

*Funding Mechanism:* City of Hodgenville, LaRue County Fiscal Court, and 319(h) grants

*Prioritization:* Category One

*Outcome Indicators:* Revised codes and ordinances

*Measurable Milestones:* Assess and revise City and County Codes and Ordinances within two years. Reassess City and County Codes and Ordinances after seven years.

*Potential Load Reduction:* Expected to reduce *E. coli*, nitrogen, phosphorus, and sediment pollutant loading. This Action Item does not directly reduce pollutant loading and instead seeks to encourage developments to incorporate other Action Items into their designs.

## ACTION ITEM 35

*Action Item 35:* Implement grant program to award funding to priority Stormwater infrastructure Projects.
*Description:* Develop new grant program to funnel available funding to individual landowners and Stormwater projects.
*Responsible Party:* LaRue County Fiscal Court and City of Hodgenville
*Technical Assistance:* None required
*Total Costs:* Administrative costs will be required to set-up and operate.
*Funding Mechanism:* LaRue County Fiscal Court and 319(h) grants
*Prioritization:* Category Three
*Outcome Indicators:* Active grant program
*Measurable Milestones:* Active grant program with available funding after seven years.
*Potential Load Reduction:* Expected to reduce *E. coli*, nitrogen, phosphorus, and sediment pollutant loading. This Action Item does not directly reduce pollutant loading and instead seeks to facilitate a program for the general public to obtain funding to implement other Action Items.

## ACTION ITEM 36

*Action Item 36:* Identify funding source and utilize dye tracing to identify potential sources and sinks of pollution in karst basin.
Description: Utilize targeted dye tracing to identify if critical potential pollutant sources are part of the karst drainage basin.
*Responsible Party:* LaRue County Fiscal Court and MCCWMP Watershed Coordinator
*Technical Assistance:* None required
*Total Costs:* $5,000
*Funding Mechanism:* 319(h) grants
*Prioritization:* Category Three
*Outcome Indicators:* Detailed map of modifications to the existing karst drainage basin based on new findings
*Measurable Milestones:* Karst dye tracing has been completed within seven years.
*Potential Load Reduction:* Expected to reduce *E. coli*, nitrogen, phosphorus, and sediment pollutant loading. This Action Item does not directly reduce pollutant loading and instead seeks to gather more information about the watersheds so that other Action Items can be placed in the most effective locations to treat karst-bound water.

## ACTION ITEM 37

*Action Item 37:* Work with farmers groups to develop dead animal disposal community program.
Description: Develop public displays and information sessions to be shared that explain the existing options for dead animal disposal (Kentucky Department of Agriculture, LaRue County

Conservation District). If a need is identified for a locally sponsored program, develop new dead animal disposal program for the community.

*Responsible Party:* LaRue County Fiscal Court and MCCWMP Watershed Coordinator

*Technical Assistance:* None required

*Total Costs:* Varies based on program need

*Funding Mechanism:* LaRue County Fiscal Court

*Prioritization:* Category Three

*Outcome Indicators:* Community is showing environmentally conscious disposal of dead animals

*Measurable Milestones:* Dead animal disposal program has been supplemented or developed within seven years.

*Potential Load Reduction:* Expected to reduce *E. coli*, nitrogen, and phosphorus pollutant loading. Exact load reductions have not been calculated for this Action Item.

## ACTION ITEM 38

*Action Item 38:* Utilize NRCS Cost Sharing program for Emergency Animal Mortality Management (Practice #368).

*Description:* On-site burial or other methods to manage animal mortalities resulting from emergency catastrophic events not related to disease. Proper management of animals will minimize potential for pollution of nutrients and pathogens into nearby waterways. Property owners should utilize the NRCS Cost Sharing program for Emergency Animal Mortality Management costs.

*Responsible Party:* MCCWMP Watershed Coordinator and agricultural property owners

*Technical Assistance:* NRCS

*Total Costs:* $100 - $600 per animal depending on animal size and method used

*Funding Mechanism:* NRCS EQIP Program and landowner

*Outcome Indicators:* Number of facilities installed

*Prioritization:* Category Two

*Measurable Milestones:* In the case of a catastrophic event, animal mortalities are properly managed to minimize pollution.

*Potential Load Reduction:* Expected to reduce *E. coli*, nitrogen, and phosphorus pollutant loading. Exact load reductions have not been calculated for this Action Item.

## ACTION ITEM 39

*Action Item 39:* Utilize NRCS Cost Sharing program for Animal Mortality Facility (Practice #316).

*Description:* A storage facility to reduce the impact of animal carcasses subwatersheds with exceedances in *E. coli* and nutrients. This Action Item differs from the above Action Item for emergency animal mortality management Property owners should utilize the NRCS Cost Sharing program for Animal Mortality Facility costs.

*Responsible Party:* MCCWMP Watershed Coordinator and agricultural property owners

*Technical Assistance:* NRCS

*Total Costs:* $30,000 - $80,000 per storage facility depending on type of facility

*Funding Mechanism:* NRCS conservation Stewardship Program and landowner

*Outcome Indicators:* Number of facilities installed

*Prioritization:* Category Two

*Measurable Milestones:* Installation of approximately 20 Animal Mortality facilities.
*Potential Load Reduction:* Expected to reduce *E. coli*, nitrogen, and phosphorus pollutant loading. Exact load reductions have not been calculated for this Action Item.

**ACTION ITEM 40**

*Action Item 40:* Conduct microbial source tracking to determine origin of bacteria levels.
*Description:* Collection of water samples to be analyzed with microbial source tracking to assist in determining whether bacteria levels are primarily human or non-human. The results of this testing could help further direct applicable BMPs for installation.
*Responsible Party:* MCCWMP Watershed Coordinator
*Technical Assistance:* Engineering consultants and laboratory technicians
*Total Costs:* Approximately $500 per site per sampling event
*Funding Mechanism:* LaRue Fiscal Court, City of Hodgenville, 319(h) grants
*Outcome Indicators:* Determining bacterial load sources
*Prioritization:* Category One (implement within 2 years)
*Measurable Milestones:* Completing microbial source tracking at stream sites.
*Potential Load Reduction:* No exact reduction would be anticipated from this Action Item, but it would help direct applicable BMPs for installation that would increase effectiveness.

**ACTION ITEM 41**

*Action Item 41:* Complete dredging of Salem and McDougal Lakes.
*Description:* Dredge Salem and McDougal Lakes to reduce sediment and restore the lakes to full volume potential. Removed sediment is expected to contain phosphorus and nitrogen content that would otherwise be contributing to increased pollutant concentration in the lakes.
*Responsible Party:* MCCWMP Watershed Coordinator
*Technical Assistance:* Engineering and geotechnical consultants
*Total Costs:* $20,000 to $75,000 per acre depending on depth removed (McDougal Lake is approximately 72 acres and Salem Lake is approximately 92 acres)
*Funding Mechanism:* LaRue Fiscal Court
*Outcome Indicators:* Successfully dredge Salem and McDougal lakes.
*Prioritization:* Category Three
*Measurable Milestones:* Successfully dredge Salem and McDougal lakes.
*Potential Load Reduction:* Expected to reduce nitrogen, and phosphorus pollutant loading. Lake dredging is expected to remove pollutants through direct relocation of stored nitrogen and phosphorus in the bed soils. No exact reduction amount is calculated in this Action Item.

The total cost estimates were based on research of similar projects implemented and will vary based on the scope of each Action Item applied. Some input on cost information was obtained from the Geist/Fall Creek Watershed Alliance located in central Indiana and USDA 2023 Conservation Practice Scenarios for Kentucky. The implementation of these Action Items will be discussed in Section 7.

## 6.3.1. EXPECTED OUTCOMES AND LOAD REDUCTIONS

Watersheds have varied responses to BMP application so it is difficult to predict with certainty the level of success and load reductions that will be achieved. The level of success is often determined by the level of community cooperation and involvement in implementation. A watershed model was not prepared to estimate load reductions, so estimates from similar projects were used in conjunction with published sources. To monitor the level of success and load reductions, monitoring should be performed as outlined in Section 7.4. BMPs should be implemented by the prioritization category listed above for each Action Item. Target loads for *E. coli*, total nitrogen, total phosphorous, and total suspended solids may be assessed within seven years of the final date of this report. Many of the BMPs will assist in improvements in more than one aspect. For example, allowing un-mowed natural riparian vegetation in an agricultural area can reduce *E. coli* and nutrients by slowing and filtering stormwater runoff and create better habitat. At the same time, the riparian buffer will help armor streambank soils to reduce erosion. The aspects of the stream are dynamic and interconnected, making it difficult to specify expected outcomes. Objectives 1, 2, and 3 most directly addresses *E. coli* pollution, Objectives 4, 13 and 15 most directly addresses nutrient pollution, Objectives 5 most directly addresses habitats, Objective 6 most directly addresses total suspended solids pollutant and Objectives 10, 11 and 12 most directly addresses flooding. Objectives 7, 8, 9, 14, 16, and 17 play a role in each of the noted pollutants. BMPs in addition or in place of those listed may be utilized it deemed favorable. The estimates are provided to estimate the scope of work and the expected outcome and resulting load reduction. Watersheds are continually changing as landowners move, development occurs, and conditions are altered. The monitoring and evaluation processes discussed in Section 7.4 should be followed to ensure that the BMPs recommended continue to be the most appropriate for MCCW.

### 6.3.1.1. *E. COLI*

*E. coli* load reductions were required at all sites that had *E. coli* samples. Sites 7 and 9 did not have any *E. coli* sampling from KDOW, but it is assumed that these sites areas also require load reductions for *E. coli* to meet benchmark levels. Potential sources for *E. coli* loading include human waste inputs from leaking sanitary sewer, damaged septic tanks and straight pipes. Livestock, pets, and native wildlife can create *E. coli* pollution through waste runoff or inputs directly in the stream. The City of Tallahassee's *Think About Personal Pollution* website indicates that on average each human produces feces that contain 1.9 billion fecal coliform per day and each dog produces feces that contains 7.7 billion fecal coliform per day, which appears to be consistent with estimates in the EPA's Better Assessment Science Integrating Point and Nonpoint Source (BASINS) modeling software. Reducing pollutants from human and pet sources will be difficult to implement because they mostly require a change in behavior from the community. Action Items 1 – 6 will help to identify and resolve any instances of human based *E. coli* pollution. Action Items 7 – 12 will work to encourage a change in community behavior and implementation of new best management practices to decrease opportunities for pollution from native wildlife, pets and livestock. Action Items 13, 14, and 22 will assist in filtering runoff prior to it entering the stream for bacteria removal and infiltration.

The project team has referenced multiple sources to help quantify the amount of reduction achieved by the implementation of BMPs. The City of Tallahassee's *Think About Personal Pollution* website indicates that on average a cow produces approximately 5.4 billion fecal coliform per day. Using the ratio of 130 *E. coli*: 200 fecal coliform specified in the Kentucky water quality standards, cattle produce 3.5 billion MPN *E. coli* per day. It is estimated that cattle spend up to 30% of the time in the stream during July and August and up to 10% of the time in the stream during the rest of the year if access is granted. This assumption would result in 0.14 trillion MPN of *E. coli* per cow directly input into the stream. To reduce the amount of livestock access to the stream, Action Items 7, 8, 9, 10, and 11 should be implemented. Exclusion fence should be placed only in areas where it is known that cattle have direct access to the stream. If the community is not interested in utilizing livestock exclusion fencing, alternatives may be considered. Additional *E. coli* removal can be achieved through the installation of filter strips. Filter strips or riparian buffer installation used in conjunction with livestock exclusion fences in areas where livestock are adjacent to the stream would be most effective in removing *E. coli* loading.

#### 6.3.1.2. NUTRIENTS

Nutrient load reductions were required at Sites 1 & 2, 4 & 5, 10, 14, 17, and 18 based on the sampling data collected. Many of the practices proposed to reduce *E. coli* pollution from humans and animals will achieve similar reductions in nutrient pollution as well. There are additional BMPs and Action Items which are proposed to specifically target nutrient pollution. The sampling data showed that both nitrogen and phosphorus pollution were similarly prevalent in the watershed compared to benchmark levels.

The project team has referenced multiple sources to help quantify the amount of reduction achieved by the implementation of BMPs. The actual efficiency of each BMP is difficult to estimate and is based on several variables, such as location in the watershed, soils, contribution area, and upstream uses. Due to the variation in effectiveness, no one source exists specifying expected pollutant load removal. The Geist/Fall Creek Watershed Alliance evaluated percent load reductions for BMPs based on the review of the EPA's Stormwater Menu of BMPs, EPAs National Management Measures to Control Nonpoint Source Pollution from Agriculture, The Nature Conservancy of Indiana, The Center for Watershed Protection, and the Spreadsheet Tool for Estimating Pollutant Loads (STEPL). The reported load reductions are located in Table 26. The project team suspects that these removal rates may be slightly higher than can be expected in MCCW, but they provide a means to estimate potential BMP benefits.

**Table 26.** Estimated Load Reductions per BMP

| | **Percent Removal** | | |
|---|---|---|---|
| **BMP/Action Item** | **TSS** | **TP** | **TN** |
| Alternative Water Source | 80% | 78% | 75% |
| Exclusion Fence | 70% | 60% | 65% |
| Filter Strips | 65% | 75% | 70% |
| Naturalized Stream Buffer | 75% | 45% | 40% |
| Nutrient Management | 60% | 90% | 80% |
| Rain Gardens | 80% | 20% | 20% |
| Rotational Grazing | 40% | 20% | 20% |
| Stream Restoration | 75% | 75% | 75% |
| Wetlands | 80% | 55% | 45% |

A combination of Action Items 1 - 22 should be used to achieve the target loads for nitrogen and phosphorous. Some BMPs may reduce both *E. coli* and nutrient loads, such as rotational grazing, providing an alternative water source, and livestock exclusion fences. The impact to nutrient loads and algae growth should be monitored and assessed at the end of the seven year period.

In the area immediately around Hodgenville, public education will be the most important BMP. It is suspected that many residential properties apply excess fertilizer on their lawn. Most residential property owners purchase a bag of fertilizer and then apply it all so they do not have to dispose of the excess. The soil only absorbs the nutrients that it needs and the excess fertilizer runs off to streams during rain events. Residential properties are small, so fertilization is not a large expense due to the limited quantity required, leading to over fertilization. This problem is compounded by the lack of natural riparian vegetation. Agricultural properties are much larger, requiring a large volume of fertilizer. During Watershed Council meetings, many stakeholders expressed that larger (greater than five acres) agricultural properties perform soil analysis prior to fertilizer application. Farmers want to maximize their profit by purchasing and applying the minimum amount of fertilizer required for the desired crop yield. Soil analysis will denote which nutrients are deficient so property owners do not waste money applying unnecessary expensive fertilizers.

#### 6.3.1.3. TOTAL SUSPENDED SOLIDS

Total suspended solids load reductions were required at Sites 1 & 2, 4 & 5 and 7 based on the sampling data collected. During the project team's watershed survey, degrading streambanks and active soil erosion was observed in the downstream reaches of NFNR. These visual findings align with the sampling data. It is believed that streambank and streambed erosion are the most significant contributors to total suspended solids pollution in MCCW. Site 7 is located approximately 500 ft downstream of a dam in North Fork Nolin River. This dam is used by the Hodgenville Water Plant to ensure a higher upstream volume of water to pull drinking water from. This site is also located under a small bridge which has visible bank erosion due to restriction of flow and velocity increases through the bridge culvert. These additional factors may be contributing to additional TSS pollution at Site 7. To combat this erosion, BMPs and Action Items are proposed to expand streamside riparian planting zones and stabilize degraded stream banks to reduce erosion. Livestock and construction activity around the streambanks is also a potential source of degradation and erosion, but this was not observed visually or seen in the data, so it was not prioritized for BMPs. To quantify the expected amount of pollutant reduction for sediment, the project team utilized the findings from Geist/Fall Creek Watershed Alliance which are presented in Table 26.

#### 6.3.1.4. HABITAT

Objectives 5 and 6 involve improving the habitat and riparian zone. Habitat assessment for all sites except 1 received a poor rating. It is unrealistic to expect all areas of the watershed to meet habitat rating benchmarks within the planning timeframe of seven years. The project team has set an objective of improving habitat at a rate of 1,000 linear feet per year. Improving the habitat will be considered providing a 25 foot buffer on either side of the stream (50 feet total width) by maintaining undisturbed filter strips, tree planting, constructing streamside wetlands, and allowing for no-mow natural vegetation along the channel or other similar activities. At this rate, 1.3 miles of habitat would be improved within the planning timeframe of seven years. While this is only a small portion of the noted deficiency, the project team does not believe that it is feasible for increased improvement due to limited resources and the upfront education of the community that must be completed.

#### 6.3.1.5. FLOODING

BMPs associated with Objectives 10, 11, & 12 should be implemented to reduce flooding. It is recommended to reduce flooding by using a watershed wide approach. A stormwater management plan and/or flood hazard mitigation plan should be drafted to evaluate specific priority locations of flood risk and detail options for remediation. Stream restoration, implementation of rain barrels and rain gardens, ensuring existing stormwater management measures are being properly maintained, and requiring all new developments to have proper water quantity controls should be used to help control stormwater runoff. If residential property owners installed a rain garden or rain barrel on their property, allowing for water infiltration and reuse, runoff from these properties could be reduced by approximately one-fourth. One of the most important aspects in flooding reduction will be community acceptance and participation.

Additionally, multiple community members expressed issues with beaver dams in areas throughout the watershed. These beaver dams reduce the effective flow area of North Fork Nolin River and tributaries which causes increased pooling of water upstream. The project team was unable to identify specific locations of beaver dams during the watershed visual assessment. It will be necessary to survey the watershed for beaver dam locations or request community identification.

# 7. BMP IMPLEMENTATION AND SUCCESS MONITORING

## 7.1. IMPLEMENTATION ORGANIZATION

The McDougal and Castleman Creek Watershed Management Plan is a dynamic, public document that is intended to assist in protection and enhancement of water quality within the McDougal and Castleman Creek watersheds in Hodgenville, LaRue County, Kentucky. The authors of this plan propose for the establishment of the role of MCCWMP Watershed Coordinator. The MCCWMP Watershed Coordinator will pursue BMP installation and construction; assist in securing funding through grants and other sources; ensure the MCCWMP is implemented in a manner consistent with its intent; and provide a main point of contact for volunteers and those interested in specific projects. To initially fill the role of MCCWMP Watershed Coordinator, the LaRue County Fiscal Court has engaged the community during the process of Watershed Council meetings to find a willing volunteer. To ensure that someone is available to fulfill the role of MCCWMP Watershed Coordinator for the lifetime of the plan, once the anticipated Watershed Coordinator is ready to step down, it will be their responsibility to find a qualified replacement. The MCCWMP Watershed Coordinator will begin implementation once the MCCWMP has been approved by the Kentucky Division of Water and the US EPA.

To successfully implement the BMPs selected in Section 5.1.2, a collaborative effort will be required from many individuals, officials, and agencies. The MCCWMP Watershed Coordinator cannot be solely relied on for implementation; the following groups/people must also be involved:

- Business Owners within the Watershed
- City of Hodgenville
- Community Volunteers
- Engineering Consultants
- Kentucky Division of Water
- Kentucky River Watershed Watch
- Kentucky State Nature Preserves Commission
- LaRue County Conservation District
- LaRue County Extension Office
- LaRue County Fiscal Court
- LaRue County School District
- Lincoln Trail District Health Department
- Property Owners within the Watershed

The MCCWMP Watershed Coordinator will be primarily responsible for organization and management of the above listed parties.

## 7.2. PLAN PRESENTATION AND OUTREACH

The Kentucky Division of Water has been an active partner in the process of the development of this plan. KDOW staff reviewed and provided comments on plan contents as chapter milestones were reached. These comments have been incorporated into the full version of the plan. The plan will be presented in a public meeting to political leaders, stakeholders, civic and environmental groups, and the general public in early 2024, once approval by the EPA is received. The public meeting will include a review of the plan, steps for implementation, and future monitoring efforts. The locations where the public can review the document will be announced but will be housed on the EEC website on the Green and Tradewater Rivers Basin webpage. Hard copies of the final plan will not be provided. A digital copy of the final plan will also be posted online on the LaRue County Fiscal Court website (https://laruecountyky.gov/).

## 7.3. FINANCIAL REQUIREMENTS AND BUDGETING

The estimated financial requirements for implementation of each Action Item are detailed in Section 6.1. The financial requirements for each Action Item vary greatly and may change based on the project scope once implementation begins. A number of potential funding sources have been identified to provide the financial assistance required for implementation. Potential funding sources include:

- 319(h) Nonpoint Source Water Quality Grants
- Agricultural Conservation Easement
- Bluegrass Greensource Community Grants
- City of Hodgenville
- Clean Water State Revolving Fund (CWSRF)
- Community Development Block Grant Program
- Conservation Stewardship Program
- CWSRF Kentucky Infrastructure Act Loan
- Kentucky American Water Environmental Grant Program
- Kentucky Department of Fish and Wildlife In-Lieu Fee Mitigation Funds (Stream Team)
- Kentucky Soil Erosion and Water Quality Cost Share Program
- Kentucky Soil Stewardship Program
- Landowner Payment
- LaRue County Fiscal Court
- Other Offsite Mitigation Banking (such as through Kentucky Transportation Cabinet)
- Partners for Fish and Wildlife Program
- Private Funding
- Regional Conservation Partnership Program
- USDA NRCS EQIP Cost Share Program
- Volunteer Labor

Each funding source has different requirements for approval, so the MCCWMP Watershed Coordinator should fully understand the requirements of each funding source prior to applying for financial assistance. The MCCWMP was prepared in accordance with the 319(h) funding requirements to allow for future 319(h) funding to be obtained for implementation.

Multiple of the above funding sources have recently received significant allocation. Through the Inflation Reduction Act, $8.45 billion was allocated for the USDA NRCS EQIP Cost Share Program from 2023 to 2026. The Conservation Stewardship Program also received $3.25 billion dollars of allocation from the Inflation Reduction Act, this funding will be dispersed annually from 2023 to 2026.

## 7.4. MONITORING IMPLEMENTATION

To evaluate the effectiveness of BMP implementation and the progress made toward reaching benchmark concentrations, this plan proposes additional long-term success monitoring of watershed health. It is suggested that monitoring be completed after seven years and fifteen years during spring or early summer. An initial timeline of seven years is selected to align with the timeline of Action Item prioritization and measurable milestones. Within seven years, the goal of this plan is to have 20 Category One and 14 Category Two Action Items implemented with time for the effects of each to influence water quality in the watershed. Within 15 years, the goal is for all Action Items to be implemented to the extent practical. This includes seven Category Three action items that were not anticipated to be complete within 7 years. If Action Item implementation has fallen behind schedule, the timeline to begin success monitoring will need to be evaluated to determine whether enough process has been made to provide valuable results. Monitoring should, at a minimum, include three monthly sampling events from April to June. Sites selected for monitoring may align with the sites monitored in this plan for a basis of comparison in changes to pollutant loads. It is recommended that the subwatersheds where the most Action Items have been implemented be selected for sampling. The monitoring team should perform a high-level assessment to see if the conditions of the watershed still puts these sites at risk, and if any new locations may be at risk. It is anticipated that distribution of Action Item efforts throughout the watershed should follow the prioritization rankings established in Section 6.2. If the number of Action Items implemented in a subwatershed is less than half of the value of the total Action Items expected to have been completed, multiplied by the prioritization score, it is not recommended for that subwatershed to be monitored yet. Once measurements at sites are shown to meet target loadings, they can be removed from the scope of continued monitoring. It is suggested that these monitoring events should at a minimum include:

- *E. coli* concentration
- total nitrogen concentration
- total phosphorous concentration
- specific conductivity
- discharge
- water temperature
- dissolved oxygen concentration
- pH
- photographs of stream reach;
- visual inspection for algae
- total suspended solids

All field measurements and water samples should be representative of the stream reach and collected by trained individuals by KDOW. These samplers may come from KDOW, Kentucky Watershed Watch, or a private contractor. Chain of custody forms should be utilized for sample collection and transport. Collected samples should be in accordance with KDOW approved SOP as identified in Table 9 on page 48. If Section 319(h) grant funding is used, a QAPP must be provided and approved by KDOW. Habitat assessment should be conducted using RBPs. Biological assessment should be conducted using MBI to classify the water based on benthic macroinvertebrates that are found within a stream reach. Habitat and biological assessments should be completed once during each monitoring period from April to June at each site. The collected data will be used to evaluate the success of the BMPs implemented and allow for modification to the plan to meet water quality objectives.

Additional monitoring should be performed to track progress of types of BMPs implemented and effectiveness of those BMPs. The MCC Watershed Coordinator should keep record as BMPs and associated Action Items are implemented. Each BMP or Action Item record should include a description of what was done, a list of responsible parties, technical assistance required, estimated total cost, and any funding mechanisms utilized. Following the measurable milestone criteria provided for each Action

Item, the record should quantify the contribution each individual BMP had to the total milestone completion. The record should include specific contact information for the responsible parties of each BMP so that future stakeholders can gather information on the BMPs effectiveness.

## 7.5. EVALUATION AND UPDATING OF PLAN

Evaluation of the plan should be conducted following the monitoring activities described in Section 7.4. The MCCWMP Watershed Coordinator should organize a meeting with watershed stakeholders to discuss the collected results. The effectiveness of the BMPs should be discussed. Alternative approaches should be considered in areas where BMPs are shown to not be feasible and/or effective. Each Action Item detailed in Section 6.1 should be considered. Discussion should include if the Action Item is achieving the desired objective, if it should be continued to be pursued, and if the designated outcome indicator is the most effective measure. The effectiveness of public outreach activities should be evaluated based on the number of people in attendance and the implementation of BMPs discussed at the activity (such as the number of rain barrels installed). Post-event surveys may be utilized to give all attendees an opportunity to record any feedback that wasn't shared out loud, and to serve as additional written record of their comments. These surveys can be used as a measure of the impact education and outreach activities have had on community behaviors or attitudes. As implementation progresses, the prioritization of Action Items may be altered based on a change in stakeholder involvement, project goals, or a variety of other factors. Participation surveys for events and public meetings should be prioritized to measure education and outreach success. If the evaluation process identifies a need to update the content of the plan, the Watershed Coordinator and/or the Larue County Fiscal Court could apply for 319(h) grant funding from the KDOW, similarly to how this plan was funded. The MCCWMP is intended to be a living document, so modifications should be made based on changing conditions. Any modifications should be provided to all plan holders so that updated copies can be maintained by all parties.

# 8. REFERENCES

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# APPENDIX A

## WATERSHED COUNCIL MEETING MINUTES AND SIGN IN SHEETS

# APPENDIX B

## KDOW TOTAL MAXIMUM DAILY LOAD (TMDL) MONITORING IN NORTH FORK NOLIN RIVER (USGS HUC0511000109) LARUE COUNTY 2018 & 2019 PROJECT STUDY PLANS AND PROGRAM MANAGEMENT PLANS

# APPENDIX C

## BLANK RPB HABITAT FORMS AND BIOASSESSMENT FORMS

# APPENDIX D

## KDOW TMDL MONITORING DATA FOR PHASE I AND II

# APPENDIX E

## SUBWATERSHED PRIORITIZATION CALCULATIONS

# APPENDIX A

## WATERSHED COUNCIL MEETING MINUTES AND SIGN IN SHEETS

**Meeting Agenda**
**McDougal and Castleman Creek Watershed Advisory Council**

Location: LaRue County Fiscal Court Room

Meeting Time/Date: 1:00 PM 01/24/2023

Introductions

Judge Blake Durrett introduced the plan, described how the 40% match initial investment can be returned in just one implementation project. Stephanie Blain (Palmer) detailed her past experience with watershed planning and provided introductory information on the planning process.

Contacts

| Company | Name |
|---|---|
| Biomedical specialist | Jarrod Heath |
| City of Hodgenville (Mayor) | Jim Phelps |
| Farmer | Pat Heath |
| KDOW | Nia Rivers |
| Larue Co. Schools | David Raleigh |
| Larue County Fiscal Court | Blake Durrett |
| Larue Extension office | Daniel Carpenter |
| LCCD | Paula Wood |
| Lincoln Trail Health Department | Angie Mattingly |
| LTDHD | Bryan Carroll |
| NRCS | Robert Buck Hulsey |
| NRCS | Mike Zachary |
| NRCS | Katie Smith |
| NRCS | Steve Beam |
| Palmer | John Pike |
| Palmer | Stephanie Blain |
| Palmer | Erin Remley |
| Soil Conservation District | Mark Howell |
| Stults Farms | Joe Stults |

Project Scope

- Grant introduction
- Plan objectives
    - Plan will serve as a guide, no regulations
    - All involved parties are encouraged to volunteer, no one will be forced

- Identify problem areas
    - Beaver dams in creek
    - Salem lake algal blooms damaging drinking water source
    - Inactive dairy cow waste lagoons in McDougal Watershed
- Develop indicators of success and prioritization metrics for BMPs

Project Schedule

- March stream walk to be planned
- Final plan to be finished by end of 2023
- LaRue County is investing $15,000 per year for 2 years to pay for plan production service fees

Sampling Status

- Possible need for additional samples to cover wet event
    - Could be addressed in a future stage, will need to discuss with KDOW

Stakeholder Involvement

- Watershed Details
    - Both McDougal and Castleman are flashy with high velocity and rock lined bottoms. Water floods up to the bank in downtown Hodgenville
    - Typical stream depth is around 1 ft deep
    - Large geese population
    - Stormwater basins exist in the watershed, consider opportunities for retrofit and education
    - Review area south and west of Hodgenville all the way to 222 for livestock practices with cattle in the creek
- Farmer Input
    - Streamside fencing has been one of the most common implemented BMPs in Bacon Creek
    - Pat Heath is concerned that fencing will be at risk due to high velocities and may not be economical even with the 25-75 match.
    - Farmers concerned that cattle will be totally blamed for e. coli concentrations when there are other contributing factors
        - Coordinate with KDOW on fecal source testing
- LaRue County School District
    - Interested in providing educational opportunities for students
    - Will consider combining BMP implementation with student involvement in the design and post-construction processes
- LaRue County Commercial Development
    - Explore possibility for commercial development to apply for funding to implement non-required BMP practices on site

Future Meeting Dates and Scope

Potential Goals - Avoid limiting what types of results can be obtained

- Improve water quality to promote agricultural practices, aquatic life and drinking water treatment costs
- Improve stream and riparian zone habitat to support a healthy aquatic and terrestrial ecosystem
- Increase environmental awareness in the community, and provide educational resources about improving the watershed to area residents
- Improve stormwater management, especially during large rain events to reduce flooding volume and runoff velocity
- Other ideas?

Sample Objectives

- Reduce common agricultural runoff contaminants, Phosphates, Nitrates, and sediments by XX% through agricultural BMP's
- Promote infiltration of stormwater flows to decrease velocity, reduce erosion, and remove pollutants through the installation new measures.
- Expand, maintain, and/or preserve stream riparian zone with native species to a minimum of 25 ft on 1000 linear feet of the stream banks and water bodies to filter runoff, reduce erosion, increase habitat, and promote citizen engagement.
- Stabilize stream banks to reduce erosion and sediment inputs
- Reduce fecal input from livestock to benchmark levels for bacteria
- Installation of riparian fences, cattle crossings, and alternative water sources to restrict or limit livestock access to riparian area.
- Inform the public of water quality status in McDougal and Castleman watersheds
- Proposed revisions to codes and ordinances to incorporate water quality standards and issues.
- Other ideas?

Action Items

Next meeting: April 10th 1:00 PM, LaRue County Fiscal Court

LARUE WATERSHED COUNCIL
INNAGURAL MEETING

Date: January 24, 2023
Scheduled Meeting Time: 2:00 p.m. local

| Company | Name | Phone | Fax | Email |
|---|---|---|---|---|
| NRCS | Robert Buck Hulsey | 270 765-2702 ext3 | | robert.hulsey@usda.gov |
| NRCS | MIKE Zahnder | 270-765-2273 X3 | | michael.zahner@usda.gov |
| LaRue County Fiscal Court | Blake Durrett | 270-766-9857 | | blake@laruecounty.org |
| NRCS | Katie Smith | 270-308-6626 | | katie.smith3@usda.gov |
| Palmer | John Pike | 859-321-7608 | | jpike@palmernet.com |
| City of Hodgenville | Jim Phelps | 270-358-3832 | | mayor@cityofhodgenvilleky.com |
| LTDHD | Bryan Carroll | 270-769-1601 | | bryan.carroll@ltdhd.org |
| LaRue Extension | Daniel Carpenter | 270-763-7363 | | daniel.carpenter@uky.edu |
| ~~Mark Howell~~ | ~~Mark Howell~~ | | | |
| Soil Conservation | Mark Howell | 270-766-9955 | | Mark.Howell411@Gmail.com |
| FARMER | Pat Heath | 270-735-2470 | | BHeath@windstream.net |
| Biomedical Service Specialist | Jarrod Heath | 270 207 0160 | | Jarrod.Heath@davita.com |
| NRCS | Steve Beam | 859 806 8447 | | steven.beam@usda.gov |
| LCCD | Paula Wood | 270-735-3505 | | laruecd@hotmail.com |
| Palmer | Stephanie Blain | 859-221-3897 | | sblain@palmernet.com |

LARUE WATERSHED COUNCIL
INNAGURAL MEETING

Date: January 24, 2023
Scheduled Meeting Time: 2:00 p.m. local

| Company | Name | Phone | Fax | Email |
|---|---|---|---|---|
| Stults Farms | Joe Stults | 270-735-3229 | | joestults@hotmail.com |
| Angie Mattingly | Lincoln Trail Health | 502-348-3498 | | angie.mattingly@ltdhd.org |
| KOOW | Nia Rivers | | | |
| LaRue Co. Schools | David Raleigh | 859-552-7573 | | |
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**Meeting Minutes**
**McDougal and Castleman Creek Watershed Advisory Council**

Location: LaRue County Fiscal Court Room

Meeting Time/Date: 1:00 PM   04/18/2023

Introductions

Contacts

Stream Survey Findings & Public Input

- *Kelly F testament to things he has been able to do with the Bacon Creek WMP*
  - *Fencing*
  - *Road for cattle feeding*
  - *Gutters on barns to get storm water away from barn*
  - *Storm water storage under ground*
  - *Solar system to power ground well to water cows, keeps them out of creek*
    - *This cut cattle disease, 25% uptick in cattle head sold*

Proposed Goals

- Improve water quality for aquatic life support and safe recreational use
- Increase watershed awareness and education in the community
- Improve stormwater management to reduce flooding during large rain events
- Promote measures that protect the stream and riparian zone during future development and current practices in the watershed

Proposed Objectives

- Reduce human fecal inputs
  - Identification of straight pipes or untreated flow
  - Identification of failing septic systems
  - *Decommission lagoons*
- Reduce livestock fecal inputs
- Reduce fecal inputs from native wildlife
  - *Deer population control was suggested as "there are more deer than cows"*
- Expand riparian zone to filter run off and provide habitat
- Stabilize stream bank to reduce erosion
  - *Salem Lake downstream dam restoration*

    - *Salem lake 99 year, high algal bloom presence in summer, doubling cost of water treatment. Can only pull water from the reservoir 3-4 months a year for water supply.*
- Inform the public of the water quality status of  MC & CC watershed
- Evaluation codes and ordinances for incorporation of water quality standards and issues
- Incorporate educational signage at public parks
- Develop a stormwater management plan that identifies flood prone areas
- Reduce flooding by clearing waterways of obstructions such as large debris and beaver dams
- Reduce flooding by reducing or slowing storm water runoff
    - Use of green infrastructure such as rain gardens and infiltration practices
    - Implementation of  storm water control measures such as detention basins
        - *Additionally, streamside wetlands and ponds (ephemeral streams) on private property*
- Encourage the use of green infrastructure and low impact development
- Retrofit existing development to incorporate green infrastructure
- Provide resources for environmentally friendly agricultural practices
- *Additional objectives*
    - *Dye tracing sink holes*
        - *Noted that historical attempts at dye tracing were not successful*
        - *Could still make a case to get funding to try again*
    - *Dead animal removal and other waste removal days*
        - *County already has some trash removal days but could use funding for more*
        - *Need to look into if only people in NFNR watershed can benefit from this*

Future Project Schedule

- Two stream survey visits completed (early April)
- Finalize goals and objectives (April/May)
- Calculate pollutant reductions (May)
- Identify BMPs (May/June)
- Next council meeting (June/July)
    - *June 27th 1:00 pm Fiscal Court Room*
- Full draft of watershed management plan (July/August)

Action Items

LARUE WATERSHED COUNCIL
SECOND MEETING

Date: April 18, 2023
Scheduled Meeting Time: 1:00 p.m. local

| Company/Connection | Name | Phone | Email |
|---|---|---|---|
| Palmer Engineering | John Pike | 859-321-7608 | jpike@palmernet.com |
| | Matt Howell | 270-766-9995 | Matt.Howell4160G.Mail.Com |
| Lyman Williams Family Farm | Sue Steffy | 270-268-7718 | suesteffy1023@gmail.com |
| CURLE FARMS | BILLY CURLE | 270 358-0863 | 1christis 54@gmail |
| KDOW | Brian Storz | 859-324-2875 | brian.storz@ky.gov |
| ~~Steve Berry~~ | Steve Berry | 270-735-2064 | |
| Vicki Graham | Vicki Graham | 270 401 3673 | vgraham29@windstream.net |
| Jim Phelps Mayor | Jim Phelps | 270-358-3032 | mayor@cityofhodgenvilleky.com |
| USDA-NRCS | Gage Meadows | [illegible] | Nathaniel.Meadows@usda.gov |
| | [illegible] | 270 735-6061 | |
| FARMER ~~Dennis [illegible]~~ | Dennis [illegible] | 270-735-6200 | NONE |
| LTDHD | Bryan Carroll | 270-769-1601 | bryan.carroll@ltdhd.org |
| S:B BELL FARMS | Susan Bell | 270 304 7003 | susan@SBBellFarms.com |
| " | Brian Bell | " | " |

LARUE WATERSHED COUNCIL
SECOND MEETING

Date: April 18, 2023
Scheduled Meeting Time: 1:00 p.m. local

| Company | Name | Phone | Fax | Email |
|---|---|---|---|---|
| NRCS | MIKE ZAHRNDT | 270-765-2273 | | MICHAEL.ZAHRNDT@USDA.GOV |
| | Coleman Allen | 270-235-6918 | | N- |
| LaRue Fiscal Court | Blake Durrett | 270-766-9857 | | |
| Shaw/Gray Construction | James Gray | 229-921-0005 | | Grayrooter@yahoo.com |
| Kelly Flanders | | 270-528-6272 | | |
| Angie Muttiph | Lincoln Trail Health Dept | 270-358-8665 | | angie.muttiph@ltdhd.org |
| David Raleigh | LaRue Co. Schools | 859-552-7573 | | |
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**Meeting Summary**
**McDougal and Castleman Creek Watershed Advisory Council**

Location: LaRue County Fiscal Court Room

Meeting Time/Date: 1:00 PM 06/27/2023

Introductions

- Project Team from Palmer Engineering was in attendance, as well at the Judge
- See attached sign-in sheet – Noted limited attendance potentially due to lack of reminders of the meeting. Next meeting will be advertised in the local paper

Pollutant Load Findings

- E. Coli is a critical impairment in both McDougal and / Castleman Watersheds
  - *Cattle farms noted in most critically impaired area*
  - *Decommissioning manure pits and cattle fencing, potential BMPs*
- Nitrogen is a critical impairment in Castleman Creek and is in high levels at the effluent of Hodgenville STP.
  - *Consider looking at Nitrogen and Phosphorus values in Spring specifically because this is when they spike*
  - *Consider adding dredging the lake as a BMP to remove sedimentation that is loaded with nutrients*
  - *It requires 9 g of Nitrogen per bushel of corn*
- Phosphorus is not a critical impairment in either watershed but is found in high levels at the effluent of Hodgenville STP
  - *Not much phosphorus in the LaRue County soil*
  - *Consider adding BMP to limit levels of nutrients leaving WWTP*
- TSS is a critical impairment in the southernmost part of the watershed
  - *Letting riparian buffer grow could be a BMP for this and nutrients*
  - *Hard to convince agricultural community to do this*
- *Other*
  - *Potential bench mark data from National Parks service at Lincoln Boyhood Home*
  - *Contact Robert Hulsey for possible BMPs*

Future Project Schedule

- Identify BMPs (July)
- Next council meeting (August) – Tentative Date set for August 15th at 1 PM
- Full draft of watershed management plan (August/September)

LARUE WATERSHED COUNCIL
THIRD MEETING

Date: June 27, 2023
Scheduled Meeting Time: 1:00 p.m. local

| Company/Connection | Name | Phone | Email |
|---|---|---|---|
| Palmer | John Pike | | jpike@palmernet.com |
| Palmer | Stephanie Blair | | |
| Palmer | Erin Remly | | |
| LaRue County | Blake Durrett | 270-766-9857 | blake@laruecountyky.gov |
| USDA-NRCS | Robert Buck Hulsey | 270-765-2702 ext 3 | robert.hulsey@usda.gov |
| | Mark Howell | 270-766-9955 | Mark.Howell416@G-mail.com |
| LCCD | Paula Wood | 270-358-3132 | laruecccd@hotmail.com |
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**Meeting Agenda**

**McDougal and Castleman Creek Watershed Advisory Council**

Location: LaRue County Fiscal Court Room

Meeting Time/Date: 1:00 PM 08/15/2023

Introductions

Contacts

Proposed BMPs

- Cattle Access Control
- Cattle Alternate Water Source
- Riparian Buffer Development
    - *Removal of invasive species*
        - *Virginia Creeper*
        - *Multifloral Rose*
        - *Bush Honeysuckle*
        - *Tree of Heaven*
    - *Possible control burn*
- Streambank Stabilization
- Public Education
    - *Raise Fertilizer awareness*
    - *Grant 101 webinar*
    - *KDOW will work with stakeholders to incorporate community trips to Eden Shale farm for BMP education & outreach component of 319 grants*
    - *UK Extension office offers free soil testing*
    - *Septic Care workshops*
- Failing Septic System & Sanitary Lateral Line Repair
- Cover Crops
- No-Till/ Reduced Till
- Nutrient/ Waste Management
- Rotational Grazing

- Decommission Abandoned Manure Lagoons
  - *2091 Goodin Williams Rd- Above ground slurry storage and lagoon to be decommissioned*
- WWTP Effluent Concentration Reductions
  - *Can't be specifically a BMP because it is point source but can always be mentioned in the plan to explain why loads are high and can be used in the future to make change*
- Heavy Use Area
- Lake Dredging
- Beaver Population Management
- Suggested BMPs
  - *Flooding BMPs- Hazard mitigation plans*
  - *Stream Crossings, for cattle and equipment*

Project Schedule

- Full draft of watershed management plan (September 2023)
- *All District meeting Nov. 16, 2023*

Action Items

This work was funded in part by a grant from the U.S. Environmental Protection Agency under §319(h) of the Clean Water Act.

LARUE WATERSHED COUNCIL
FOURTH MEETING

Date: August 15, 2023
Scheduled Meeting Time: 1:00 p.m. local

| Company/Connection | Name | Phone | Email |
|---|---|---|---|
| Soil Conservation | Billy George | (270) 358-0863 763-7325 | 1christis54@gmail.com |
| Soil Conservation | [illegible] | (270) 766-9955 | |
| Extension | Adam Thomas | (270) 358-3401 | adam.thomas@uky.edu |
| NRCS | MIKE ZAHAROS | 270-268-6379 | |
| Lincoln Trail Health | Angie Mattingly | 502-348-3698 | |
| Lincoln Trail Health | Bryan Carroll | 270-769-1601 | bryan.carroll@ltdhd.org |
| Soil Conservation | Paula Weed | 270-358-3132 | |
| NRCS | Buck Hulsey | 270-765-2702 ext3 | robert.hulsey@usda.gov |
| NRCS | Steve Beam | 859-407-0084 | steven.beam@usda.gov |
| KDOW | Haileigh Arnold | 502-396-3926 | haileigh.arnold@ky.gov |
| LCFC | Blake Durrett | 270-766-9857 | blake@laruecounty.ky.gov |
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This work was funded in part by a grant from the U.S. Environmental Protection Agency under §319(h) of the Clean Water Act.

# APPENDIX B

## KDOW TOTAL MAXIMUM DAILY LOAD (TMDL) MONITORING IN NORTH FORK NOLIN RIVER (USGS HUC0511000109) LLARUE COUNTY 2018 & 2019 PROJECT STUDY PLANS AND PROGRAM MANAGEMENT PLANS

# 2018 Total Maximum Daily Load (TMDL) Monitoring in North Fork Nolin River (USGS HUC0511000109) Larue County Project Study Plan

Jessica Schuster (Project Coordinator)
TMDL Section
Water Quality Branch
Kentucky Division of Water
300 Sower Boulevard 3rd Floor
Phone: (502) 782-7062
Email: jessica.schuster@ky.gov

Effective Date: March 01, 2018

**Project Year: 2018**

Kentucky UNBRIDLED SPIRIT

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**ACCOMPANYING DOCUMENTS**

QAPP Main Document

Program Management Plan (PMP)

## 1.0 INTRODUCTION

This study plan details sampling activities planned in the North Fork (N.F.) Nolin River watershed located in Larue County, KY (Figure 1). Biological and habitat data collected in 2006 by DOW's Probabilistic Monitoring Program were used to assess a segment of the river (river miles 3.0 to 7.05) as not supporting the warm water aquatic habitat (WAH) use designation and the cause was determined to be nutrients. The data collected for this study will be used to support 305(b) use-attainment assessments throughout the watershed and to provide data for the development of a TMDL report that addresses pollutants causing designated use impairment within the N.F. Nolin River.

The TMDL Section implements an intensive approach to monitoring watersheds prioritized for TMDL development. As a result, watershed monitoring occurs over two to three years. During the first year of sampling, March 2018 through February 2019, data collection will focus on confirming the impairments and probable sources of impairments within the mainstem and larger tributaries of the N.F. Nolin River. The second year of sampling will consist of targeted sampling for causes of impairment identified during the first year. The second year of sampling may also include data collection in smaller, un-assessed tributaries that were not sampled during the first year of monitoring. A third year of monitoring may be warranted if data gaps still exist.

This document includes the 2018 sample station locations, station details, special project-year considerations, QC requirements for monitoring activities, and the project schedule for completeness. Details on station selection procedures, methods, and all other associated QC requirements can be reviewed in the TMDL and Assessment Monitoring Program Management Plan (PMP).

## 2.0 2018 SAMPLE STATION LOCATIONS

A total of thirteen stations, 11 instream and 2 outfalls, will be monitored in the North Fork Nolin River watershed (Table 1, Figure 1). Stations are identified by the name of the stream, the location of the station based upon the nearest road, the river mile, catchment area ($mi^2$), and GPS coordinates.

## 3.0 PROJECT-YEAR SAMPLING CONSIDERATIONS

Field and laboratory methods will follow the procedures outlined in the SOPs found in Table 2.1 of the TMDL and Assessment PMP.

**Water Chemistry, *In Situ* Water Quality Measurements, and Discharge Measurements**
Water chemistry monitoring will occur at all instream stations at least once per month March 2018 thru February 2019 in order to support loading calculations for TMDL development and complete 305b assessment of warm water aquatic life use. The following chemistry parameter groups (bold) and associated parameters will be analyzed during this study:

- **Bulk:** CBOD5, bromide, chloride, fluoride, nitrate, nitrite, orthophosphorus, sulfate, turbidity, total dissolved solids, total suspended solids
- **Nutrients:** ammonia (as N), nitrate-nitrite, total kjeldahl nitrogen, total organic carbon, total phosphorus
- **Orthophosphorus:** orthophosphorus
- **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

Table 1 defines which chemistry parameter groups will be collected at each station.

An attempt will be made to achieve 12 sampling events and the following flow conditions will be targeted during each season: low flow, base flow, storm flow. Whenever water chemistry is collected, *in situ* measurements (dissolved oxygen, percent dissolved oxygen saturation, temperature, specific conductivity, and pH) will be taken, discharge will be measured, and field observation sheets will be completed.

**Outfall Sampling**
Field staff will obtain water chemistry grab samples from the outfall effluent of 2 KPDES permitted facilities in order to support nutrient loading calculations for TMDL development. These data will be used to provide nutrient speciation and help classify the source of potential nutrient loads. Grab samples will be obtained from the turbulent section of the outfall in the central part of the flow and the collector will avoid touching the bottom or the sides of the effluent conveyance. The station locations and parameters that will be collected can be found in Table 1. The following chemistry parameter groups (bold) and associated parameters will be analyzed during this study:

- **Bulk:** CBOD5, bromide, chloride, fluoride, nitrate, nitrite, orthophosphorus, sulfate, turbidity, total dissolved solids, total suspended solids
- **Nutrients:** ammonia (as N), nitrate-nitrite, total kjeldahl nitrogen, total organic carbon, total phosphorus
- **Orthophosphorus:** orthophosphorus

Each outfall will be sampled at least three times during both dry weather events and wet weather events, producing a total of at least 6 samples per outfall. Dry weather events will be characterized by 3 days without significant rainfall and wet weather events will be characterized by ≥1" of rainfall in a 48 hour period.

**Bacteria Sampling**
Five *E. coli* samples will be collected within a 30-day period in the spring (May or June) from all instream stations in order to calculate a geometric mean for 305b assessment of primary contact recreation. Additionally, monthly sampling will occur at each station during the water chemistry sampling events. *E. coli* samples will be analyzed by technical staff in KDOW's Water Quality Branch microbiology laboratory in Frankfort, KY.

**Biological Sampling**
Macroinvertebrates will be collected from the 11 instream stations in order to complete 305b assessment of the WAH designated use. During this type of sampling event, the following parameters will also be collected: *in situ* water quality parameters, stream discharge, and water chemistry.

All stations are located within the Pennyroyal bioregion and are characterized as high gradient streams therefore the collection methods for macroinvertebrates and habitat assessments will follow the high gradient procedures. An index period during which sampling will occur has been designated for each station based on the drainage area of the stream at that station. Those streams that are <5mi$^2$ are designated as headwater streams and will be sampled between March to May of 2018 and those that are >5mi$^2$ are designated as wadeable streams and will be sampled between June to September of 2018.

**Habitat Assessment**
Habitat assessments will be conducted in conjunction with biological sampling at every station in order to evaluate the quality of in-stream and riparian habitat. Assessment data will be recorded on High Gradient RBP Habitat Assessment sheets. Photographs will also be taken at each sampling station to document instream conditions.

## 4.0 PROJECT-YEAR DATA SHEETS

Data sheets required for this project include:

High-Gradient Habitat Assessment
Water Chemistry Chain of Custody
TMDL Field Observations
*E. coli* Bench Sheet

## 5.0 QC REQUIREMENT INFORMATION

QA/QC will be implemented for this project as described in the 2018 Kentucky Water Quality Monitoring Quality Assurance Project Plan (QAPP) and TMDL and Assessment PMP. All data collection, field activities, and sample analyses will follow methodologies set forth in the applicable Standard Operating Procedures, which are outlined in the PMP. Project specific QC requirements are listed in Table 2. Ideally, the stations at which duplicate, replicate, and field blank collections occur will be randomly determined prior to the sampling trip, if not, these stations will be randomly chosen in the field.

## 6.0 PROJECT COMPLETENESS

This project will be considered complete when all scheduled activities are complete (Table 3).

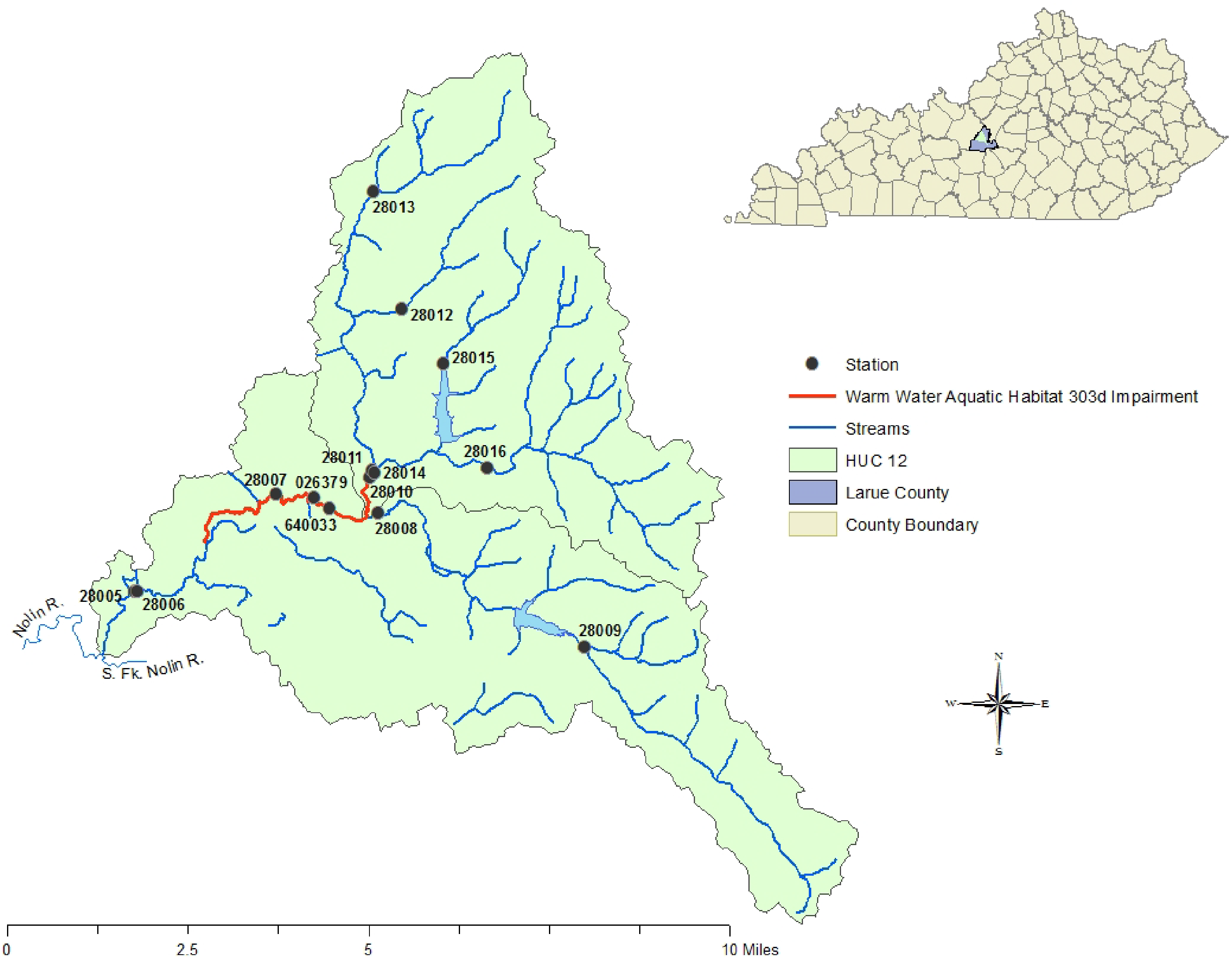


**Figure 1.** Sample station locations for TMDL monitoring activities in the North Fork Nolin River, Larue County, KY.

**Table 1.** 2018 TMDL monitoring station locations in the North Fork Nolin River watershed.

| KWADE Station ID | Locale | Location | River Mile | Catchment ($mi^2$) | Latitude | Longitude | Parameters |
|---|---|---|---|---|---|---|---|
| DOW03028005 | North Fork Nolin River | Below SR222 bridge; Below Nolynn Spring | 1.3 | 49.06 | 37.55875 | -85.78854 | *In situ,* chemistry*, *E. coli*, habitat, biology |
| DOW03028006 | North Fork Nolin River | Above SR222 bridge; Above Nolynn Spring run | 1.3 | 49.05 | 37.55894 | -85.78794 | *In situ,* chemistry*, *E. coli*, habitat, biology |
| DOW03028007 | North Fork Nolin River | Above SR61 bridge | 4.7 | 38.12 | 37.57846 | -85.75275 | *In situ,* chemistry*, *E. coli*, habitat, biology |
| DOW03028008 | McDougal Creek | Above US31E bridge | 0.3 | 12.83 | 37.57448 | -85.72702 | *In situ,* chemistry*, *E. coli*, habitat, biology |
| DOW03028009 | McDougal Creek | Above SR470 bridge off Dangerfield Rd. | 4.7 | 7.10 | 37.54749 | -85.67498 | *In situ,* chemistry*, *E. coli*, habitat, biology |
| DOW03028010 | North Fork Nolin River | Off SR2217; ~100m below Castleman Cr. confluence | 7.0 | 23.00 | 37.58165 | -85.72920 | *In situ,* chemistry*, *E. coli*, habitat, biology |
| DOW03028011 | Castleman Creek | Above SR2217 bridge | 0.1 | 9.82 | 37.58319 | -85.72865 | *In situ,* chemistry*, *E. coli*, habitat, biology |
| DOW03028012 | Castleman Creek UT 2.75 | Below Goodin Williams Rd. | 0.8 | 2.00 | 37.61569 | -85.72108 | *In situ,* chemistry*, *E. coli*, habitat, biology |
| DOW03028013 | Castleman Creek | Below SR1832 bridge | 4.8 | 3.36 | 37.63925 | -85.72821 | *In situ,* chemistry*, *E. coli*, habitat, biology |
| DOW03028014 | North Fork Nolin River | Off SR2217; above Castleman Creek confluence | 7.1 | 13.16 | 37.58276 | -85.72808 | *In situ,* chemistry*, *E. coli*, habitat, biology |
| DOW03028015 | Salem Creek | Above SR2217 bridge | 1.3 | 2.44 | 37.60453 | -85.71063 | *In situ,* chemistry*, *E. coli*, habitat, biology |
| DOW03028016 | North Fork Nolin River | Above US31E bridge | 9.0 | 7.97 | 37.58362 | -85.69958 | *In situ,* chemistry*, *E. coli*, habitat, biology |
| EFF026379 | Effluent | Hodgenville STP | 5.5 | 36.71 | 37.57763 | -85.74318 | chemistry** |
| EFF640033 | Effluent | Hodgenville Water Treatment Plant | 5.8 | 36.50 | 37.57549 | -85.73928 | chemistry** |

*Bulk, nutrients, metals, alkalinity, and orthophosphorus
**Bulk, nutrients, and orthophosphorus

**Table 2.** Required project QC activities for North Fork Nolin River TMDL Study.

| Requirement | Frequency |
|---|---|
| **Field** | |
| Water/Sediment Chemistry Field Duplicates | Minimum of 10% of samples collected distributed across the project |
| Water Chemistry Field Blanks | Minimum of 10% of samples collected distributed across the project |
| Orthophosphorus Filtering Equipment Rinsate Blanks | One for each day orthophosphorus samples are collected |
| *E. coli* Replicate (splits) | Minimum of 10% of samples collected distributed across the project |
| *E. coli* Field Blanks | One for each day *E. coli* samples are collected |
| Macroinvertebrates | Annual review of SOP and recertification in collection methods and field audits, as resources allow |
| Habitat Assessment Recertification | Annually if resources allow; at least biannually |
| Calibration of water quality probes and data sondes | At least one/week during field use |
| FlowTracker Beam Checks | At least one/week during field use |
| FlowTracker Automatic QC Check | At least one/day during field use |
| **Laboratory** | |
| Microbiology Lab QC | Varies by type; see all QC related to Microbiology in Table 2.5 in the QAPP Main Document |
| Macroinvertebrate Sorting Pan | 2 Sorting Pan Checks per staff experienced staff member. |
| Macroinvertebrate sample re-identification | 5% of all project samples, if resources allow; taxonomist maintains a verified reference collection |
| Environmental Services Branch Laboratory | see ESB LOQAM |

**Table 3.** Project schedule for North Fork Nolin River TMDL Study.

| | ***2018*** | | | | | | | | | | | | ***2019*** | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Month*** | **J** | **F** | **M** | **A** | **M** | **J** | **J** | **A** | **S** | **O** | **N** | **D** | **J** | **F** |
| Planning | X | X | | | | | | | | | | | X | X |
| Monitoring | | | X | X | X | X | X | X | X | X | X | X | | |
| Data Analysis | | | | | | | | | | X | X | X | | |

# TMDL and Assessment Monitoring Program Management Plan

Program Supervisor: Alicia Jacobs
TMDL Section
Water Quality Branch
Kentucky Division of Water
300 Sower Boulevard 3rd Floor
Phone: (502) 782-6987
Email: Alicia.Jacobs@KY.gov

Effective Date: March 1, 2018

Revision No.: 0.0

**LIST OF ACRONYMS**

*CAH – Cold Water Aquatic Habitat*
CFS - Cubic Feet per Second
COA - Certificate of Analysis
CPR – Cardiopulmonary Resuscitation
CWA – Clean Water Act
DEPS – Division of Environmental Program Support
DOW – Division of Water
DQI – Data Quality Indicator
DQO – Data Quality Objective
EDAS - Ecological Data Application System
ESB – Environmental Services Branch
GPS - Geographic Positioning System
HAZWOPER – Hazardous Waste Operations and Emergency Response
HDPE - High Density polyethylene
KDEP – Kentucky Department for Environmental Protection
KELMS - Kentucky Enterprise Learning Management System
K-WADE – Kentucky Water Assessment Data for Environmental Monitoring
LIMS – Laboratory Information Management System
LOQ – Limit of Quantitation
NPS – Nonpoint Source
PCR - Primary Contact Recreation
PTD - Percent Taxonomic Disagreement
PMP – Program Management Plan
PSP – Project Study Plan
QA – Quality Assurance
QAC – Quality Assurance Coordinator
QC – Quality Control
LOQAM - Laboratory Operations and Quality Assurance Manual
QAPP – Quality Assurance Project Plan
QAO – Quality Assurance Officer
QMP – Quality Management Plan
RPD – Relative Percent Difference
SCR – Secondary Contact Recreation
SOP – Standard Operating Procedures
STORET - Storage and Retrieval Data Warehouse
TMDL - Total Maximum Daily Loads
USEPA – United States Environmental Protection Agency
UV - Ultraviolet
WAH – Warm Water Aquatic Habitat
WQB – Water Quality Branch
WQX - Water Quality Exchange

**REVISION HISTORY**

| Date of Revision | Page(s)/Section(s) Revised | Revision Explanation |
|---|---|---|
| 28-Feb-2018 | All | Document Created |
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### ACCOMPANYING DOCUMENTS

QAPP Main Document
2018 305(b) Assessment Monitoring Lost Creek Watershed
2018 305(b) Assessment Monitoring Reassessment of Sedimentation as a Cause of WAH
2018 Total Maximum Daily Load (TMDL) Monitoring in Cypress Creek
2018 Total Maximum Daily Load (TMDL) Monitoring in North Fork Nolin River

## 1.0 PROJECT MANAGEMENT

### 1.1 Project Background and Overview

The TMDL Monitoring Program is responsible for data collection activities that support the development of Total Maximum Daily Loads (TMDL) or TMDL alternatives for 303(d) listed impairments and the assessment and/or reassessment of streams for warm water aquatic life (WAH), cold water aquatic life (CAH), primary contact recreation (PCR), and secondary contact recreation (SCR) use support. The data may also be used by other programs within KDOW for activities such as water quality standards development, water quality trend analysis, and nonpoint source pollution management projects. This PMP details monitoring activities that support the development of TMDLs and 305(b) use support decisions during February 2018 thru March 2019.

Section 303(d)(1)(C) of the Clean Water Act (CWA) and its associated policy and program requirements for water quality planning, management, and implementation (40 CFR Part 130) require the establishment of a TMDL for the achievement of state water quality standards when a waterbody is impaired for one or more designated uses. A TMDL identifies the pollutant/waterbody-specific assimilative capacity, which will allow the waterbody to meet its designated uses.

TMDLs must be calculated using existing and readily available data. The first step in developing a TMDL is to gather all existing data collected by Kentucky Division of Water (DOW). These data are often available in EPA's two databases, the Storage and Retrieval Data Warehouse (STORET) and the Water Quality Exchange (WQX), the (archived) DOW database Ecological Data Application System (EDAS) or in the Kentucky Water Assessment Data for Environmental Monitoring (K-WADE). Data generated outside of state government may be requested from the collecting agency if the data were collected under an approved quality assurance project plan (QAPP). Once existing data have been compiled, it is frequently discovered that additional water quality, biological, bacteriological, and discharge data are necessary to develop TMDLs or to confirm use support. In these cases, TMDL monitoring projects are initiated.

The TMDL section implements an intensive approach to monitoring watersheds selected for TMDL development. As a result, watershed monitoring occurs over two – three years. During the first year of sampling, March through December, data collection focuses on confirming the nature of the impairments and possible sources of those impairments. During the second year of sampling, targeted sampling for identified causes within the impaired segment(s) occurs. The second year of sampling also includes data collection in smaller, un-assessed tributaries that were not sampled during the first year of monitoring but may be contributing to the identified impairment. A third year of monitoring may be warranted if data gaps still exist.

Additionally, the TMDL Section uses data from the TMDL development studies for use-attainment assessment for sections §305(b) and §303(d) of the CWA. Stream reaches are assessed as fully-, partially-, or not supporting the aquatic life, primary contact recreation, and secondary contact recreation designated use, and are included in the 305(b) biannual report congress. These assessments are regulated by Kentucky Revised Statute Title XVIII Chapter 224 and Kentucky Administrative Regulation Title 401 Chapter 10.

### 1.2 Project/Task Organization

Each job classification below lists all of the personnel that are properly trained in the WQB for each role, and can thus complete the tasks associated with each personnel role in the program.

Program Supervisor, Water Quality Branch (WQB) – Alicia Jacobs

Project Coordinators, WQB – Rebecca Clark, Jessica Schuster

Activity Leads, WQB – Rebecca Clark, Katie McKone, James Mullins, Jessica Schuster

Technical Staff - Field Support Staff, WQB – Colin Arnold, Melanie Arnold, Keith Bowlin, Hui Chen, Rebecca Clark, Michelle Cook, David Cravens, Jacob Culp, Jeffrey Hawkins, Patrick Hoban, Alicia Jacobs, Robert Johnson, Lauren McDonald, James Mullins, Tyler Newman, Rodney Pierce, Rebecca Roberts, Lauren Schnorr, Jessica Schuster, Kacie Tackett

Technical Staff - Macroinvertebrate Biologists, WQB – Keith Bowlin, Jeffrey Hawkins, Katie McKone, Tyler Newman, Rebecca Roberts, Jessica Schuster

Technical Staff – Microbiology Laboratory Coordinator, WQB – Jessica Schuster (Frankfort), Rebecca Clark (Madisonville)

Technical Staff – TMDL Writers, WQB – Hui Chen, Lauren McDonald, Kacie Tackett

Detailed staff responsibilities can be found in Section 1.2 of the QAPP Main Document.

## 1.3 Data Quality Objectives (DQOs) Process

The data quality objective for the monitoring activities outlined in this document is to collect data of sufficient quality and quantity to achieve (1) TMDL development within 303(d) listed waterbodies and (2) 305(b) assessment of designated use attainment within waterbodies. Data will be acceptable if the following objectives are met:

a) Samples and additional field information were collected, transported, and recorded in accordance with the procedures described or referenced in this PMP.
b) Numerical values of analytes were determined by DES or DOW laboratories according to EPA or standard methods, or according to DOW SOPs and manufacturer's instructions as described in the Section 2.0 of QAPP Main Document.
c) Data were reviewed and accepted, rejected, or qualified in accordance with the procedures in Section 4.0 of QAPP Main Document.

Data quality indicators include measures of accuracy, precision, representativeness, completeness, and comparability. While specific field activity requirements may differ between project types, the projects share common parameter-specific data quality indicators, which can be found in Tables 1.2-1.5 of the QAPP Main Document. The detection limit of the data should be sufficiently low to show exceedances of water quality criteria (401 KAR 10:031. Surface water standards) or TMDL target and laboratory flags should be utilized to highlight any issues with analyses. Any data that fall outside of these criteria will be flagged in data reports. Ultimately, it will be the responsibility of the end user to determine whether or not flagged data will be used for TMDL development or 305(b) assessment.

TMDLs are required to consider seasonality and the critical period for each pollutant causing designated use impairment. Sampling frequency will be sufficient to represent the impairments under various hydrological conditions. This can vary by site and pollutant, and is addressed by sampling multiple times over a variety of flows (low flows, high flows, and storm flows) over a period of time (e.g. seasonally). The data quantity requirements for TMDL development is dependent upon the field activity type and details can be found in Section 2.1 Sampling Experimental Design. Data quantity requirements for 305(b) assessment of designated use attainment can be found in Consolidated Assessment and Listing Methodology (CALM) and are met and/or exceeded by following the requirements mentioned above.

## 1.4 Special Training Requirements

There are no program specific training requirements for this program. All general training requirements are outlined inSection 1.4 of the QAPP Main Document.

## 1.5 Documentation and Records

Documents and records generated by this program for storage can be found in Table 1.0. These documents will be stored on the KDEP servers at these locations: V:\DOWWQB\TMDL_Section\TMDL_Admin_Records or \\depdowtmdl\TMDL ADMIN RECORDS. Files for each project year will be stored in subfolders for each river basin (e.g. Kentucky, Green, etc.) or in an assessments project folder. Further details on how these documents will be handled and stored can be found in Section 1.5 andSection 2.8 of the QAPP. Data will be entered into the K-WADE database for long-term storage and curation as soon as possible after data generation. See Section 1.5.3 of the QAPP main document for further details on data management in K-WADE.

# 2.0 DATA ACQUISITION

## 2.1 Sampling Experimental Design

**TMDL Monitoring Site Selection**

Sample site locations are based on historical site locations, 2014 303(d) listed segment locations (KDOW 2015), and watershed evaluation using GIS. Sampling sites are generally placed at the following locations: at historical sites, along the impaired segment, below major impoundments, at springs, in upstream contributing areas (including upstream tributaries), at the mouth of major tributaries discharging to the impaired segment, at the downstream end of HUC 14 subwatersheds, and upstream or downstream of point and nonpoint sources. Watershed accessibility and TMDL staffing resources may also influence where sites are located and how many sites are chosen.

Permitted outfall sampling may occur in order to support the development of watershed nutrient models. These data are used to provide nutrient speciation and help classify the source of potential nutrient loads. Sample sites may be relocated or dropped due to major hydrologic changes at the site (e.g. beaver dams), major riparian changes (e.g. construction), safety concerns, accessibility issues, or changes in staffing resources.

Any site location changes will be documented and tracked throughout the life of the study. In the field, sites are identified by the name of the stream, the location of the site based upon the nearest road, the river mile, and GPS coordinates.

**Field Activities Overview**

The following subsection outlines the sampling design for all field activities performed during the course of TMDL and Assessment monitoring. Table 2.0 defines which activities are critical and which are for informational purposes only based how the data are used.

*Water Chemistry Sampling*

The parameters sampled will vary as data requirements are project dependent, therefore, PSPs should be referred to for specific project details. Water chemistry sampling will occur at every sampling site for every sampling event. The goal is to yield at least 12 samples from each site during one year of sampling. Sampling should attempt to target all seasonal flow conditions (e.g. summer low flow, summer base flow, summer storm flow, etc.).

The water chemistry sampling design for outfalls may vary as the types of outfalls and the number of outfalls samples is project dependent and details can be found in individual PSPs. Each outfall will be sampled at least three times during both dry weather events and wet weather events, producing at least 6 samples per outfall.

*Bacteria Sampling*

*E. coli* monitoring will occur at least once per month during the PCR season (May thru October). Sampling should attempt to target seasonal flow conditions (e.g. summer low flow, summer base flow, summer storm flow, etc.). Additionally, 5 (or more) samples may be collected within a 30-day period in order to calculate a geometric mean. Geometric means may be collected more than once during the PCR season. Bacteria sampling designs may vary between projects, therefore PSPs should be referred to for specific project details.

*In Situ Multi-parameter Water Quality Measurements*

Water quality measurements of pH, dissolved oxygen, specific conductivity, and water temperature will be collected using a multi-parameter water quality meter on every station visit.

*Stream Discharge*

Discharge will be measured using a flow meter at every sampling site for every sampling event if the stream is safe to wade. If the stream is deemed unsafe to wade, field staff should make note of the hydrological conditions at the time of sampling on the field observation sheet (e.g. samples were collected on the falling limb of the hydrograph), if known.

*Biological Sampling and Habitat Assessments*

Macroinvertebrates sampling will be performed at all sites where a new or updated assessment of aquatic life use is needed. Rapid habitat assessments will be completed at biology sampling sites to document habitat quality for aquatic life use assessments.

*Field Observations*

A field observation sheet will be completed at each site during each chemistry and/or E. coli sampling event. The following observations will be recorded: discharge cross section location, chemistry sampling location, flow condition, hydrologic condition, weather condition at time of sampling and in the past 24 hours and 48 hours, stream mixing, stream color, other observations such as floating woody debris, garbage, algal mats, fish kills, suds, turbidity and odor, stream shading, and biological observations. Estimates of the percent cover of nuisance algae present in a riffle, run, and pool location at the sampling site will be noted during every site visit.

*Site Photodocumentation*

Photographs will be taken at each sampling site to record site and watershed conditions. At the beginning of each project the following photographs may be taken:

- Upstream of sampling location
- Downstream of sampling location
- Stream bank and riparian condition of right and left banks
- Predominant stream substrate
- Unusual characteristics (e.g. major stream bank failures)

On subsequent sampling events, photographs may be taken to document nuisance algae and any conditions that have changed in the area potentially affecting water quality (e.g. chemical spills, near-by facilities in operation, machinery in stream channel, animals in stream channel, high or low discharge conditions, etc).

All photo numbers and descriptions will be recorded on field observation sheets with the date and time that the photo was taken. Upon return from the field, all photos will be downloaded into the electronic TMDL Administrative Record.

**Table 1.0.** Documents and records produced by the TMDL Section Monitoring Program implemented by the Kentucky Division of Water.

| Field Documents | Data Format | Required? |
|---|---|---|
| Site Photographs | JPEG or TIF | Y |
| Field Observation Forms | Paper | Y |
| Sample Chains of Custody | Paper | Y |
| **Laboratory Documents** | **Data Format** | **Required?** |
| ESB Sample Analysis Reports | PDF | Y |
| Macroinvertebrate Analysis Bench Sheets | XLSB | Y |
| Sample chains of custody | PDF | Y |
| **Quality Assurance Records and Reports** | **Data Format** | **Required?** |
| Equipment calibration and maintenance logs | XLS | Y |
| Data entry QC documentation | XLS | Y |
| Project Data Review Checklist | DOC | Y |
| Project Closeout Checklist | DOC | Y |
| Project Summary Report | DOC | Y |
| Assessment Data Report(s) | XLS | Y |

**Table 2.0.** Critical and informational measurements for TMDL and Assessment Program monitoring projects.

| | Field Activity | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Project Type | Water Chemistry | Bacteria | *In situ* | Stream Discharge | Biology | Habitat Assessments | Field Observations | Photographs |
| 305(b) CAH Assessment | critical | n/a | critical | informational | critical | critical | critical | critical |
| 305(b) WAH Assessment | critical | n/a | critical | informational | critical | critical | critical | critical |
| 305(b) PCR Assessment | informational | critical | critical | informational | n/a | n/a | critical | critical |
| 305(b) SCR Assessment | informational | critical | critical | informational | n/a | n/a | critical | critical |
| TMDL Development | critical | critical | critical | critical | critical | critical | critical | critical |

## 2.2 Sampling and Analysis Procedures and Requirements

### Field and Laboratory SOPs

Sites will be sampled for chemistry, *E.* coli, multi-parameter water quality measurements, discharge, macroinvertebrates, and for habitat assessment according to the schedule outlined in the TMDL PSPs. Field and laboratory methods will follow the procedures outlined in the SOPs and manuals found in Table 2.1. Details for sample requirements such as holding time, preservatives and sample volumes can be found in Appendix L of the ESB Laboratory and Operational Quality Assurance Manual (LOQAM). Any special sampling considerations within a given project year will be explained in the PSPs.

**Table 2.1.** Standard operating procedures (SOP) detailing field sampling and analysis methods used in the Kentucky Division of Water's TMDL Section Monitoring Program[1].

| Task | SOP Titles with Links |
|---|---|
| Water chemistry samples | Sampling Surface Water Quality in Lotic Systems<br>Sample Control and Management<br>ESB Laboratory SOPs available upon request |
| Bacteria samples | Sampling Surface Water Quality in Lotic Systems<br>Enzyme Substrate Test Method for the Detection of Total Coliforms and *Escherichia coli* |
| Multi-parameter water quality measurements | In-situ Water Quality Measurements and Meter Calibration |
| Discharge measurements | Measuring Stream Discharge |
| Macroinvertebrates | Benthic Macroinvertebrates Collection Methods in Wadeable Streams<br>Benthic Macroinvertebrates Processing and Identification |
| Habitat Assessment | Methods for Assessing Habitat in Wadeable Waters |

[1] The most current versions of DOW SOPs are be located at: http://water.ky.gov/Pages/SurfaceWaterSOP.aspx

**Sampling Equipment and Supplies**

A list of field and laboratory supplies and equipment can be found in Table 2.2. This table is not all inclusive, as certain projects may require additional, unforeseen equipment.

**Table 2.2.** List of common equipment and supplies needed to complete field sampling and laboratory analysis for samples collected by the TMDL Section Monitoring Program. In rare circumstances, other equipment and/or supplies might be needed.

| ***In situ* and Discharge Measurements** | **Water Chemistry Sampling** | **Macroinvertebrate Sampling** |
|---|---|---|
| Multi-parameter water quality meter | Sample bottles (HDPE) | 16 oz. sample jars (macroinvertebrates) |
| Flow Meter | Latex or nitrile gloves | 90% ethanol |
| 100' Tape Measure | Preservative acid | Dipnets |
| Clipboard | Cooler(s) with ice | D-Frame dip net (600µm) |
| Waterproof pens and paper | 0.45 µm filters | Modified Kicknet (600µm) |
| Camera | Ehrlenmeyer filter flask | Sieve bucket |
| GPS | Filter funnel with tubing | #10 mesh sieve |
| | Hand Pump | #30 mesh sieve |
| | Deionized Water | Forceps |
| | Weighted bottle sampler | Plastic sorting pans |
| ***In situ* Meter Calibration** | **E. coli Analysis** | **Macroinvertebrate Analysis** |
| Yellow DO Membranes | IDEXX Sealer | Stereomicroscope |
| Blue DO Membranes | Autoclave | Compound microscope |
| pH 4 standard | Incubator | Plastic sorting pans |
| pH 7 standard | Thermometers | Forceps |
| pH 10 standard | UV Lamps | 70% ethanol |
| 1000µS conductivity standard | Quanti-tray 2000 | Shell vials |
| Plastic tub/bucket | Colilert media | Labels |
| | Mixing vessels | |
| | Freezer | |

## 2.3 Sample Handling and Custody Requirements

A sample is in "custody" if it is in the actual possession of a sampler or in a secured area that is restricted to authorized personnel. Once a sample is in the custody of DOW staff, guidelines for sample handling, storage and transport from the QAPP (Section 2.3) will be followed.

## 2.4 Analytical Methods Requirements

Analytical requirements for all water chemistry samples collected in this program can be found in Section 2.4 of the QAPP. In this program, analytes and bottles collected are project dependent and are thus detailed in project-specific PSPs.

## 2.5 Quality Control (QC) Requirements

Table 2.2 lists the QC requirements for this program. QC samples (duplicates, blanks, rinsate blanks, field blanks, and replicates) will be collected randomly throughout the course of each project. Project-specific QC requirements are detailed in individual PSPs. For details regarding the associated corrective action, responsible personnel, DQO's addressed by QC, and measurement performance criteria for specific QC, see Table 2.4 and Table 2.5 of the QAPP main document.

**Table 2.2.** TMDL Section Monitoring Program Quality Control Requirements.

| Requirement | Frequency |
|---|---|
| **Field** | |
| Water/Sediment Chemistry Field Duplicates | Minimum of 10% of samples collected distributed across the project |
| Water Chemistry Field Blanks | Minimum of 10% of samples collected distributed across the project |
| Orthophosphorus Filtering Equipment Rinsate Blanks | One for each day orthophosphorus samples are collected |
| *E. coli* Replicate (splits) | Minimum of 10% of samples collected distributed across the project |
| *E. coli* Field Blanks | One for each day *E. coli* samples are collected |
| Macroinvertebrates | Annual review of SOP and recertification in collection methods and field audits, as resources allow |
| Habitat Assessment Recertification | Annually if resources allow; at least biannually |
| Calibration of water quality probes and data sondes | At least one/week during field use |
| FlowTracker Beam Checks | At least one/week during field use |
| FlowTracker Automatic QC Check | At least one/day during field use |
| **Laboratory** | |
| Microbiology Lab QC | Varies by type; see all QC related to Microbiology in Table 2.5 in QAPP Main Document |
| Macroinvertebrate Sorting Pan | 2 Sorting Pan Checks per staff experienced staff member. |
| Macroinvertebrate sample re-identification | 5% of all project samples, if resources allow; taxonomist maintains a verified reference collection |
| Environmental Services Branch Laboratory | see ESB LOQAM |

## 2.6 Testing, Calibration and Maintenance Requirements for Equipment and Supplies

This program uses the following equipment: Multi-parameter Water Quality Probes, SonTek Flow Trackers, Biological Sampling Equipment, WQB Microbiology Lab Equipment, and WQB Taxonomy Laboratory Equipment.

There are no project specific testing, calibration and maintenance requirements for this program. Project staff should review Section 2.6 of the QAPP Main Document for details on testing, calibration and maintenance requirements. The activity lead will be responsible for calibration of YSI multi-parameter probes used to collect temperature, pH, dissolved oxygen and specific conductivity. Calibration will follow guidelines in Section 2.6.1 of the QAPP main document and the *In-situ* Water Quality Measurements SOP. Other consumable supplies (i.e. sample bottles, preservatives, etc.) will follow QAQC guidelines in section 2.6.2 of the QAPP Main Document.

## 2.7 Data Acquisition Requirements for Non-direct Measurements

Non-direct measurements collected in this program include ArcGIS analysis of watershed characteristics, and weather/climatic data. Section 2.7 of the QAPP details the requirements and limitations of these data.

## 2.8 Data Management Requirements

Documents specific to this program (Table 1.2) are stored on the KDEP servers at the following locations: \\depdowtmdl\TMDL\TMDL ADMIN RECORDS and V:\DOWWQB\TMDL_Section\TMDL_Admin_Records . Project files are organized by basin and then by watershed (e.g. Tennessee River - Cypress Creek, Kentucky River – Benson Creek, etc.). Files for each data type in Section 1.5 will be organized into individual subfolders. Further details on how these documents will be handled and stored can be found in Section 1.5 and Section 2.8 of the QAPP Main Document. Data will be entered into the K-WADE database for long-term storage and curation as soon as possible after data generation.

# 3.0 ASSESSMENTS AND OVERSIGHT

## 3.1 Project-Level Assessments and Response Actions

Refer to Section 3.1 of the QAPP main document for guidelines for project-level assessment and response actions.

## 3.2 Program-Wide Assessments and Response Actions

Refer to Section 3.2 of the QAPP main document for guidelines for project-level assessment and response actions.

# 4.0 DATA VERIFICATION, VALIDATION AND USABILITY

## 4.1 Data Review, Validation, and Verification Criteria and Documentation

There are no data review, validation, and verification criteria and documentation details specific to this program. Please see Section 4.1 of the QAPP for guidelines on project-level assessment and response actions.

## 4.2 Validation and Verification Methods

- Initial data review will be completed as soon as possible after data generation (Section 4.2.1 of the QAPP).
- Field activity QA will include the Sample Collection, Measurement Observation, Bioassessment and Biological Metrics and Indices QA checklists (Section 4.2.2 of the QAPP).
- The station visit checklist will be completed (Section 4.2.3 of the QAPP).
- The project closeout checklist will be completed (Section 4.2.4 of the QAPP).

## 4.3 Reconciliation with Project Requirements

Reconciliation with project requirements will follow section 4.3 of the QAPP. It is the responsibility of the Project Coordinators to ensure that all data related to each monitoring project, including flagged and non-compliant data, is included in the final data reports. All flagged and non-compliant data (data that do not meet QAPP DQOs) will be highlighted and an explanation provided as to why those data are questionable. Final data reports for each monitoring project will contain documentation for all data assessment and verification activities. The final reports will also contain documentation regarding limitations to the final data set.

After project closeout, the program manager and project coordinator will work with the TMDL writing staff and/or the 305(b) assessment coordinator to determine if the data collected are appropriate for use in TMDL development and/or 305(b) assessment. The following guidelines are used may be used to make this determination:

i. Analytical data are from the appropriate timeframe. For example, if the pollutant of concern is *E. coli*, which affects the PCR use, then by definition the PCR use only applies from May through October. Data from outside this range cannot be used to determine compliance with the standard.
ii. The detection limit of the data is sufficiently low to show exceedances of any water quality criteria or TMDL target, as appropriate
iii. Laboratory QA flags show the data are of acceptable quality
iv. Analytical data were validated by the TMDL Supervisor, and
v. The TMDL Supervisor has signed off on the data assessment procedure

During the assessment and verification procedure, data may be rejected and removed from the final data reports. This may be done under the following circumstances:

- Chemistry and/or *E. coli* samples were collected from pooled sites
- *In situ* field measurements were collected in pooled sites
- Laboratory results contain excessive data quality flags
- Calibration records are incomplete

If, during the data review process, it is deemed that there are insufficient data for TMDL development or 305(b) assessment, the TMDL Supervisor may require that the monitoring project be extended until adequate data are collected.

# 2019 Total Maximum Daily Load (TMDL) Monitoring in North Fork Nolin River (USGS HUC0511000109) Larue County Project Study Plan

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Effective Date: March 01, 2019

**Project Year: 2019**

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**ACCOMPANYING DOCUMENTS**

QAPP Main Document
Program Management Plan (PMP)

## 1.0 INTRODUCTION

This study plan details sampling activities planned in the North Fork (N.F.) Nolin River watershed located in Larue County, KY (Figure 1). Biological and habitat data collected in 2006 by DOW's Probabilistic Monitoring Program were used to assess a segment of the river (river miles 3.0 to 7.05) as not supporting the warm water aquatic habitat (WAH) use designation and the cause was determined to be nutrients. The data collected for this study will be used to support 305(b) use-attainment assessments throughout the watershed and to provide data for the development of a TMDL report that addresses pollutants causing designated use impairment within the N.F. Nolin River.

The Intensive Survey and Wetlands Section implements an intensive approach to monitoring watersheds prioritized for TMDL development. As a result, watershed monitoring occurs over two to three years. During the first year of sampling, March 2018 through February 2019, data collection focused on confirming the impairments and probable sources of impairments within the mainstem and larger tributaries of the N.F. Nolin River. The second year of sampling, March 2019 through February 2020, will focus on characterizing the conditions above and below Nolynn Spring, Nolynn Spring proper, above the Waste Water Treatment Plant (WWTP), and above the Water Treatment Plant (WTP). The second year of sampling will also include an attempt to capture water quality conditions in N.F. Nolin mainstem above and below where it sinks and loses flow to the spring drainage area, as well as, biology sampling at site DOW03028006. Sampling at this site was not able to be completed during the first year of sampling due to low flow conditions. A third year of monitoring may be warranted if data gaps still exist.

This document includes the 2019 sample station locations, station details, special project-year considerations, QC requirements for monitoring activities, and the project schedule for completeness. Details on station selection procedures, methods, and all other associated QC requirements can be reviewed in the TMDL and Assessment Monitoring Program Management Plan (PMP).

## 2.0 2019 SAMPLE STATION LOCATIONS

A total of eight stations, 6 instream, 1 spring, and 1 outfall, will be monitored in the North Fork Nolin River watershed (Table 1, Figure 1). Stations are identified by the name of the stream, the location of the station based upon the nearest road, the river mile, catchment area ($mi^2$), and GPS coordinates.

## 3.0 PROJECT-YEAR SAMPLING CONSIDERATIONS

Field and laboratory methods will follow the procedures outlined in the SOPs found in Table 2.1 of the TMDL and Assessment PMP.

**Water Chemistry, *In Situ* Water Quality Measurements, and Discharge Measurements**
Water chemistry monitoring will occur at all instream stations at least once per month March 2019 through February 2020 in order to support loading calculations for TMDL development and complete 305b assessment of warm water aquatic life use. The following chemistry parameter groups (bold) and associated parameters will be analyzed during this study:

- **Bulk:** CBOD5, bromide, chloride, fluoride, nitrate, nitrite, orthophosphorus, sulfate, turbidity, total dissolved solids, total suspended solids
- **Nutrients:** ammonia (as N), nitrate-nitrite, total kjeldahl nitrogen, total organic carbon, total phosphorus
- **Orthophosphorus:** orthophosphorus
- **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

Table 1 defines which chemistry parameter groups will be collected at each station.

An attempt will be made to achieve 12 sampling events and the following flow conditions will be targeted during each season: low flow, base flow, storm flow. Whenever water chemistry is collected, *in situ* measurements (dissolved oxygen, percent dissolved oxygen saturation, temperature, specific conductivity, and pH) will be taken, discharge will be measured, and field observation sheets will be completed.

**Outfall Sampling**
Field staff will obtain water chemistry grab samples from the outfall effluent of 1 KPDES permitted facility in order to support nutrient loading calculations for TMDL development. These data will be used to provide nutrient speciation and help classify the source of potential nutrient loads. Grab samples will be obtained from the turbulent section of the outfall in the central part of the flow and the collector will avoid touching the bottom or the sides of the effluent conveyance. The station locations and parameters that will be collected can be found in Table 1. The following chemistry parameter groups (bold) and associated parameters will be analyzed during this study:

- **Bulk:** CBOD5, bromide, chloride, fluoride, nitrate, nitrite, orthophosphorus, sulfate, turbidity, total dissolved solids, total suspended solids
- **Nutrients:** ammonia (as N), nitrate-nitrite, total kjeldahl nitrogen, total organic carbon, total phosphorus
- **Orthophosphorus:** orthophosphorus

**Biological Sampling**
Macroinvertebrates will be collected from three instream stations in order to complete 305b assessment of the WAH designated use. During this type of sampling event, the following parameters will also be collected: *in situ* water quality parameters, stream discharge, and water chemistry.

The stations are located within the Pennyroyal bioregion and are characterized as high gradient streams therefore the collection methods for macroinvertebrates and habitat assessments will follow the high gradient procedures. An index period during which sampling will occur has been designated for each station based on the drainage area of the stream at that station. The stations >5mi$^2$ are designated as wadeable streams and will be sampled June through September of 2019.

**Habitat Assessment**
Habitat assessments will be conducted in conjunction with biological sampling at every station in order to evaluate the quality of instream and riparian habitat. Assessment data will be recorded on High Gradient RBP Habitat Assessment sheets. Photographs will also be taken at each sampling station to document instream conditions.

## 4.0 PROJECT-YEAR DATA SHEETS

Data sheets required for this project include:

High-Gradient Habitat Assessment
Water Chemistry Chain of Custody
TMDL Field Observations

## 5.0 QC REQUIREMENT INFORMATION

QA/QC will be implemented for this project as described in the 2018 Kentucky Water Quality Monitoring Quality Assurance Project Plan (QAPP) and TMDL and Assessment PMP. All data collection, field activities, and sample analyses will follow methodologies set forth in the applicable Standard Operating Procedures, which are outlined in the PMP. Project specific QC requirements are listed in Table 2. Ideally, the stations at which duplicate, replicate, and field blank collections occur will be randomly determined prior to the sampling trip, if not, these stations will be randomly chosen in the field.

## 6.0 PROJECT COMPLETENESS

This project will be considered complete when all scheduled activities are complete (Table 3).

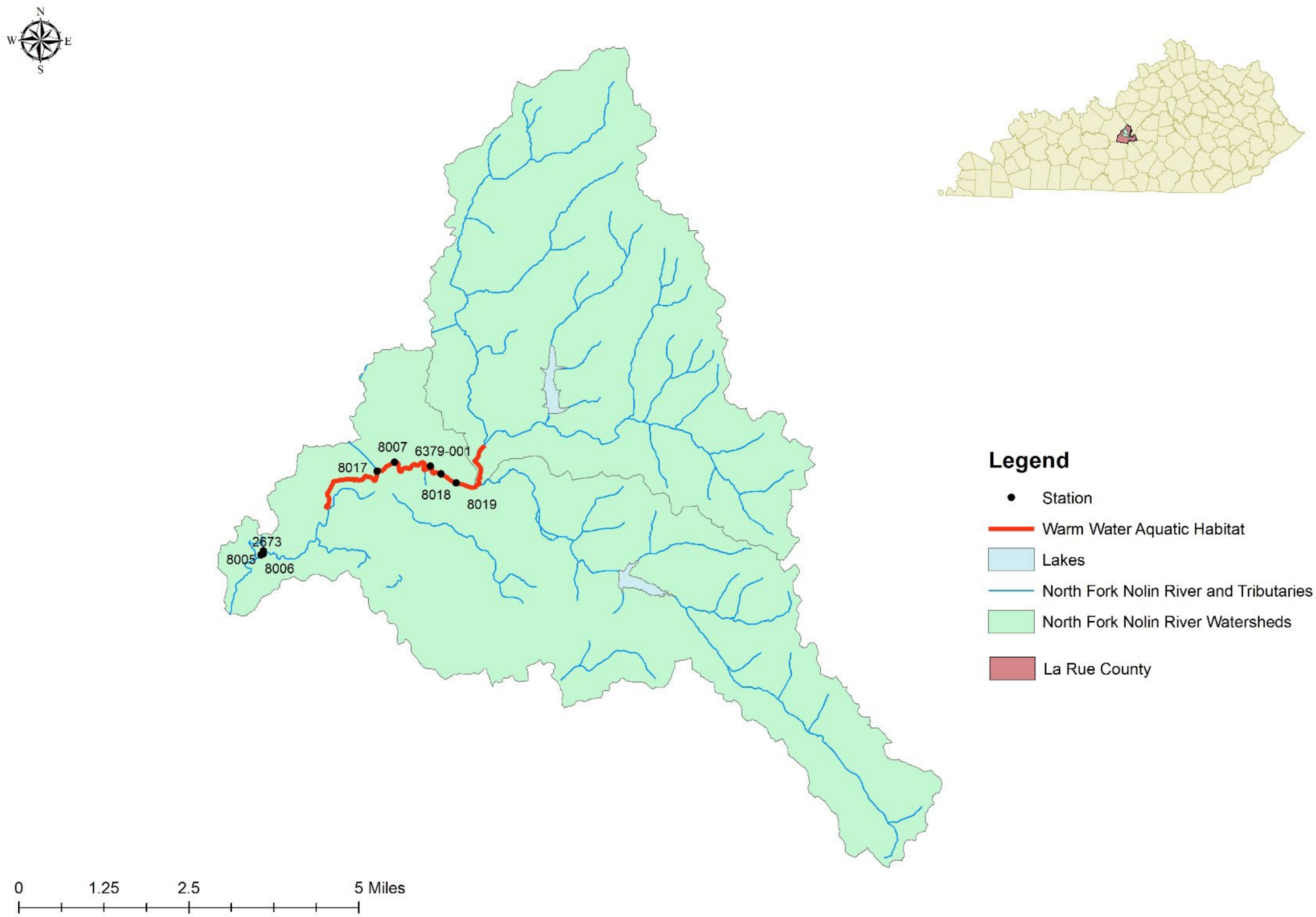


**Figure 1.** Sample station locations for TMDL monitoring activities in the North Fork Nolin River, Larue County, KY.

**Table 1.** 2019 TMDL monitoring station locations in the North Fork Nolin River watershed.

| KWADE Station ID | Locale | Location | River Mile | Catchment ($mi^2$) | Latitude | Longitude | Parameters |
|---|---|---|---|---|---|---|---|
| DOW03028005 | North Fork Nolin River | Below SR222 bridge; Below Nolynn Spring | 1.3 | 49.06 | 37.55875 | -85.78854 | *In situ,* chemistry* |
| DOW03028006 | North Fork Nolin River | Above SR222 bridge; Above Nolynn Spring run | 1.3 | 49.05 | 37.55894 | -85.78794 | *In situ,* chemistry*, habitat, biology |
| DOW03028007 | North Fork Nolin River | Above SR61 bridge | 4.7 | 38.12 | 37.57846 | -85.75275 | *In situ,* chemistry* |
| DOW03028017 | North Fork Nolin River | ~0.25mi below SR61 bridge; below stream sink | 4.3 | 39 | 37.57596 | -85.75744 | *In situ,* chemistry*, habitat, biology |
| DOW03028018 | North Fork Nolin River | Below SR210 | 5.7 | 36.50 | 37.575956 | -85.74033 | *In situ,* chemistry***, habitat, biology |
| DOW03028019 | North Fork Nolin River | Above Water treatment plant; behind Fisher Autoparts of US31 | 6.0 | 36.37 | 37.574046 | -85.736315 | *In situ,* chemistry* |
| KY0026379-001 | Effluent | Hodgenville STP | 5.5 | 36.71 | 37.57763 | -85.74318 | chemistry** |
| GW90002673 | Nolynn Spring | Above SR222 | 1.3 | 56 | 37.559583 | -85.78794 | *In situ,* chemistry*** |

*Bulk, nutrients, alkalinity, and orthophosphorus
**Bulk, nutrients, and orthophosphorus
***Bulk, nutrients, metals, alkalinity, and orthophosphorus

**Table 2.** Required project QC activities for North Fork Nolin River TMDL Study.

| Requirement | Frequency |
|---|---|
| **Field** | |
| Water/Sediment Chemistry Field Duplicates | Minimum of 10% of samples collected distributed across the project |
| Water Chemistry Field Blanks | Minimum of 10% of samples collected distributed across the project |
| Orthophosphorus Filtering Equipment Rinsate Blanks | One for each day orthophosphorus samples are collected |
| *E. coli* Replicate (splits) | Minimum of 10% of samples collected distributed across the project |
| *E. coli* Field Blanks | One for each day *E. coli* samples are collected |
| Macroinvertebrates | Annual review of SOP and recertification in collection methods and field audits, as resources allow |
| Habitat Assessment Recertification | Annually if resources allow; at least biannually |
| Calibration of water quality probes and data sondes | At least one/week during field use |
| FlowTracker Beam Checks | At least one/week during field use |
| FlowTracker Automatic QC Check | At least one/day during field use |
| **Laboratory** | |
| Microbiology Lab QC | Varies by type; see all QC related to Microbiology in Table 2.5 in the QAPP Main Document |
| Macroinvertebrate Sorting Pan | 2 Sorting Pan Checks per staff experienced staff member. |
| Macroinvertebrate sample re-identification | 5% of all project samples, if resources allow; taxonomist maintains a verified reference collection |
| Environmental Services Branch Laboratory | see ESB LOQAM |

**Table 3.** Project schedule for North Fork Nolin River TMDL Study.

| | ***2019*** | | | | | | | | | | | | ***2020*** | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Month*** | **J** | **F** | **M** | **A** | **M** | **J** | **J** | **A** | **S** | **O** | **N** | **D** | **J** | **F** | **M** | **A** | **M** |
| Planning | X | X | | | | | | | | | | | | | | | |
| Monitoring | | | X | X | X | X | X | X | X | X | X | X | X | X | | | |
| Data Analysis | | | | | | | | | | X | X | X | | | X | X | X |

# TMDL and Assessment Monitoring Program Management Plan

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**LIST OF ACRONYMS**

CAH – Cold Water Aquatic Habitat
CWA – Clean Water Act
DEPS – Division of Environmental Program Support
DO – Dissolved Oxygen
DOW – Division of Water
DQO – Data Quality Objective
EDAS – Ecological Data Application System
ESB – Environmental Services Branch
GPS – Geographic Positioning System
HDPE – High Density polyethylene
KDEP – Kentucky Department for Environmental Protection
K-WADE – Kentucky Water Assessment Data for Environmental Monitoring
LOQ – Limit of Quantitation
PCR – Primary Contact Recreation
PMP – Program Management Plan
PSP – Project Study Plan
QA – Quality Assurance
QC – Quality Control
LOQAM – Laboratory Operations and Quality Assurance Manual
QAPP – Quality Assurance Project Plan
SCR – Secondary Contact Recreation
SOP – Standard Operating Procedures
STORET – Storage and Retrieval Data Warehouse
TMDL – Total Maximum Daily Loads
UV – Ultraviolet
WAH – Warm Water Aquatic Habitat
WQB – Water Quality Branch
WQX – Water Quality Exchange

**REVISION HISTORY**

| Date of Revision | Page(s)/Section(s) Revised | Revision Explanation |
|---|---|---|
| 02/18/2019 | Entire document | Updated and made basic editorial changes to the 2018/Version 0.0 PMP |
| 02/18/2019 | List of Acronyms | Updated list |
| 02/18/2019 | Section 4.3 | Deleted bullet v. The TMDL Supervisor has signed off on the data assessment procedure; statement was not accurate |
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**ACCOMPANYING DOCUMENTS**

QAPP Main Document
North Fork Nolin River Project Study Plan
305(b) Assessment Monitoring Reassessment of Sedimentation
305(b) Assessment Monitoring Lost Creek

## 1.0 PROJECT MANAGEMENT

### 1.1 Project Background and Overview

The TMDL Monitoring Program is responsible for data collection activities that support the development of Total Maximum Daily Loads (TMDL) or TMDL alternatives for 303(d) listed impairments and the assessment and/or reassessment of streams for warm water aquatic life (WAH), cold water aquatic life (CAH), primary contact recreation (PCR), and secondary contact recreation (SCR) use support. The data may also be used by other programs within KDOW for activities such as water quality standards development, water quality trend analysis, and nonpoint source pollution management projects. This PMP details monitoring activities that support the development of TMDLs and 305(b) use support decisions during March 2019 thru February 2020.

Section 303(d)(1)(C) of the Clean Water Act (CWA) and its associated policy and program requirements for water quality planning, management, and implementation (40 CFR Part 130) require the establishment of a TMDL for the achievement of state water quality standards when a waterbody is impaired for one or more designated uses. A TMDL identifies the pollutant/waterbody-specific assimilative capacity, which will allow the waterbody to meet its designated uses.

TMDLs must be calculated using existing and readily available data. The first step in developing a TMDL is to gather all existing data collected by Kentucky Division of Water (DOW). These data are often available in EPA's two databases, the Storage and Retrieval Data Warehouse (STORET) and the Water Quality Exchange (WQX), the (archived) DOW database Ecological Data Application System (EDAS) or in the Kentucky Water Assessment Data for Environmental Monitoring (K-WADE) database. Data generated outside of state government may be requested from the collecting agency if the data were collected under an approved quality assurance project plan (QAPP). Once existing data have been compiled, it is frequently discovered that additional water quality, biological, bacteriological, and discharge data are necessary to develop TMDLs or to confirm use support. In these cases, TMDL monitoring projects are initiated.

The TMDL section implements an intensive approach to monitoring watersheds selected for TMDL development. As a result, watershed monitoring occurs over two – three years. During the first year of sampling, March through December, data collection focuses on confirming the nature of the impairments and possible sources of those impairments. During the second year of sampling, targeted sampling for identified causes within the impaired segment(s) occurs. The second year of sampling also includes data collection in smaller, un-assessed tributaries that were not sampled during the first year of monitoring but may be contributing to the identified impairment. A third year of monitoring may be warranted if data gaps still exist.

Additionally, the TMDL Section uses data from the TMDL development studies for use-attainment assessment for sections §305(b) and §303(d) of the CWA. Stream reaches are assessed as fully-, partially-, or not supporting the aquatic life, primary contact recreation, and secondary contact recreation designated uses, and are included in the 305(b) biannual to report congress. These assessments are regulated by Kentucky Revised Statute Title XVIII Chapter 224 and Kentucky Administrative Regulation Title 401 Chapter 10.

### 1.2 Project/Task Organization

Each job classification below lists all of the personnel that are properly trained in the WQB for each role, and can thus complete the tasks associated with each personnel role in the program.

Program Supervisor, Water Quality Branch (WQB) – Alicia Jacobs, Acting

Project Coordinators, WQB – Becky Clark, Jessica Schuster

Activity Leads, WQB – Becky Clark, Katie McKone, James Mullins, Jessica Schuster, Lesley Sneed

Technical Staff - Field Support Staff, WQB – Colin Arnold, Melanie Arnold, Kristin Berger, Keith Bowlin, Hui Chen, Becky Clark, Michelle Cook, David Cravens, Jacob Culp, Jeffrey Hawkins, Patrick Hoban, Alicia Jacobs, Robert Johnson, Lauren McDonald, Katie McKone, James Mullins, Lara Panayotoff, Logan Phelps, Rodney Pierce, Mary Rockey, Lauren Schnorr, Jessica Schuster, Lesley Sneed, Kacie Prather

Technical Staff - Macroinvertebrate Biologists, WQB – Keith Bowlin, Jeffrey Hawkins, Robert Johnson, Jessica Schuster

Technical Staff – Microbiology Laboratory Coordinator, WQB – Jessica Schuster (Frankfort), Becky Clark (Madisonville)

Technical Staff – TMDL Writers, WQB – Hui Chen, Lauren McDonald, Kacie Prather

Technical Staff – 305(b) Assessment Coordinator, WQB – Katie McKone

Detailed staff responsibilities can be found in Section 1.2 of the QAPP Main Document.

## 1.3 Data Quality Objectives (DQOs) Process

The data quality objective for the monitoring activities outlined in this document is to collect data of sufficient quality and quantity to achieve (1) TMDL development within 303(d) listed waterbodies and (2) 305(b) assessment of designated use attainment within waterbodies. Data will be acceptable if the following objectives are met:

a) Samples and additional field information were collected, transported, and recorded in accordance with the procedures described or referenced in this PMP.
b) Numerical values of analytes were determined by DES or DOW laboratories according to EPA or standard methods, or according to DOW SOPs and manufacturer's instructions as described in the Section 2.0 of QAPP Main Document.
c) Data were reviewed and accepted, rejected, or qualified in accordance with the procedures in Section 4.0 of QAPP Main Document.

Data quality indicators include measures of accuracy, precision, representativeness, completeness, and comparability. While specific field activity requirements may differ between project types, the projects share common parameter-specific data quality indicators, which can be found in Tables 1.2-1.5 of the QAPP Main Document. The detection limit of the data should be sufficiently low to show exceedances of water quality criteria (401 KAR 10:031. Surface water standards) or TMDL target and laboratory flags should be utilized to highlight any issues with analyses. Any data that fall outside of these criteria will be flagged in data reports. Ultimately, it will be the responsibility of the end user to determine whether or not flagged data will be used for TMDL development or 305(b) assessment.

TMDLs are required to consider seasonality and the critical period for each pollutant causing designated use impairment. Sampling frequency will be sufficient to represent the impairments under various hydrological conditions. This can vary by site and pollutant, and is addressed by sampling multiple times over a variety of flows (low flows, high flows, and storm flows) over a period of time (e.g. seasonally). The data quantity requirements for TMDL development is dependent upon the field activity type and details can be found in Section 2.1 Sampling Experimental Design. Data quantity requirements for 305(b) assessment of designated use attainment can be found in Consolidated Assessment and Listing Methodology (CALM) and are met and/or exceeded by following the requirements mentioned above.

## 1.4 Special Training Requirements

There are no program specific training requirements for this program. All general training requirements are outlined in Section 1.4 of the QAPP Main Document.

## 1.5 Documentation and Records

Documents and records generated by this program for storage can be found in Table 1.0. These documents will be stored on the KDEP servers at these locations: V:\DOWWQB\TMDL_Section\TMDL_Admin_Records or \\depdowtmdl\TMDL ADMIN RECORDS. Files for each project year will be stored in subfolders for each river basin (e.g. Kentucky, Green, etc.) or in an assessments project folder. Further details on how these documents will be handled and stored can be found in Section 1.5 and Section 2.8 of the QAPP. Data will be entered into the K-WADE database for long-term storage and curation as soon as possible after data generation. See Section 1.5.3 of the QAPP main document for further details on data management in K-WADE.

**Table 1.0.** Documents and records produced by the TMDL and Assessment Program implemented by the Kentucky Division of Water.

| Field Documents | Format | Required? |
|---|---|---|
| Field Reconnaissance Documents | Paper & PDF | N |
| Station Photographs | JPEG or TIF | Y |
| Habitat Assessment Datasheets | Paper or XLS & PDF | Y |
| Visit Observations Datasheets | Paper or XLS and PDF | Y |
| Fish Sampling Field Books / Forms | Paper or book & PDF | N |
| Sample Chains of Custody | PDF | Y |
| **Laboratory Documents** | **Format** | **Required?** |
| DEPS Sample Analysis Reports | PDF | Y |
| DOW Frankfort Lab *E. coli* Analysis Bench Sheets | Paper & PDF | Y |
| DOW Field Office *E. coli* Analysis Bench Sheets/Logs | PDF | Y |
| Contract Lab *E. coli* Analysis Reports | PDF | Y |
| Macroinvertebrate Analysis Bench Sheets | XLSB & PDF | Y |
| Macroinvertebrate Data Entry Application | XLSB | Y |
| Fish Sample Analysis Bench Sheets | XLSB & PDF | N |
| Fish Data Entry Application | XLSB | N |
| MBI Index Templates | XLSB & PDF | N |
| KIBI Index Templates | XLS | N |
| **QAQC Records and Reports** | **Format** | **Required?** |
| Equipment Calibration and Maintenance Logs | Paper or XLS & PDF | Y |
| Microbiology Lab QC Documentation | XLSX & PDF | Y |
| Biology (Taxonomic) QC Documentation | XLSB & PDF | Y |
| Project Data Review Checklists | XLSX & PDF | Y |
| Project QA Tracking Sheet | XLSX/B & PDF | Y |
| Project QA Summary | XLSB & PDF | Y |
| Project Final Data Report | DOCX or XLSB & PDF | Y |
| Assessment Data Report(s) | XLSB | Y |

## 2.0 DATA ACQUISITION

## 2.1 Sampling Experimental Design

**Site Selection**

Sample site locations are based on historical site locations, 2016 303(d) listed segment locations (KDOW 2018), and watershed evaluation using GIS. Sampling sites are generally placed at the following locations: at historical sites, along the impaired segment, below major impoundments, at springs, in upstream contributing areas (including upstream tributaries), at the mouth of major tributaries discharging to the impaired segment, at the downstream end of HUC 14 subwatersheds, and upstream or downstream of point and nonpoint sources. Watershed accessibility and TMDL staffing resources may also influence where sites are located and how many sites are chosen.

Permitted outfall sampling may occur in order to support the development of watershed nutrient models. These data are used to provide nutrient speciation and help classify the source of potential nutrient loads. Sample sites may be relocated or dropped due to major hydrologic changes at the site (e.g. beaver dams), major riparian changes (e.g. construction), safety concerns, accessibility issues, or changes in staffing resources.

Any site location changes will be documented and tracked throughout the life of the study. In the field, sites are identified by the name of the stream, the location of the site based upon the nearest road, the river mile, and GPS coordinates.

### 2.2 Sampling and Analysis Procedures and Requirements

**Field and Laboratory SOPs**

Sites will be sampled for chemistry, *E.* coli, multi-parameter water quality measurements, discharge, macroinvertebrates, and for habitat assessment according to the schedule outlined in the TMDL PSPs. Field and laboratory methods will follow the procedures outlined in the SOPs and manuals found in Table 2.0. Details for sample requirements such as holding time, preservatives and sample volumes can be found in Appendix L of the ESB Laboratory and Operational Quality Assurance Manual (LOQAM). Any special sampling considerations within a given project year will be explained in the PSPs.

**Table 2.0.** Standard operating procedures (SOP) detailing field sampling and analysis methods used in the Kentucky Division of Water's TMDL and Assessment Program[1].

| Task | SOP Titles with Links |
|---|---|
| Water chemistry samples | Sampling Surface Water Quality in Lotic Systems<br>Sample Control and Management<br>DEPS Laboratory SOPs available upon request |
| Bacteria samples | Sampling Surface Water Quality in Lotic Systems<br>Enzyme Substrate Test Method for the Detection of Total Coliforms and *Escherichia coli* |
| Multi-parameter water quality measurements | In-situ Water Quality Measurements and Meter Calibration |
| Discharge measurements | Measuring Stream Discharge |
| Macroinvertebrates | Benthic Macroinvertebrates Collection Methods in Wadeable Streams<br>Benthic Macroinvertebrates Processing and Identification |
| Habitat Assessment | Methods for Assessing Habitat in Wadeable Waters |

[1] The most current versions of DOW SOPs are be located at: https://eec.ky.gov/Environmental-Protection/Water/QA/Pages/default.aspx

**Field Activities Overview**

The following subsection outlines the sampling design for all field activities performed during the course of TMDL and Assessment monitoring. Table 2.1 defines which activities are critical and which are for informational purposes only based how the data are used.

*Water Chemistry Sampling*

The parameters sampled will vary as data requirements are project dependent, therefore, PSPs should be referred to for specific project details. Water chemistry sampling will occur at every sampling site for every sampling event. The goal is to yield at least 12 samples from each site during one year of sampling. Sampling should attempt to target all seasonal flow conditions (e.g. summer low flow, summer base flow, summer storm flow, etc.).

The water chemistry sampling design for outfalls may vary as the types of outfalls and the number of outfalls samples is project dependent and details can be found in individual PSPs. Each outfall will be sampled at least three times during both dry weather events and wet weather events, producing at least 6 samples per outfall.

*Bacteria Sampling*

*E. coli* monitoring will occur at least once per month during the PCR season (May thru October). Sampling should attempt to target seasonal flow conditions (e.g. summer low flow, summer base flow, summer storm flow, etc.). Additionally, 5 (or more) samples may be collected within a 30-day period in order to calculate a geometric mean. Geometric means may be collected more than once during the PCR season. Bacteria sampling designs may vary between projects, therefore PSPs should be referred to for specific project details.

*In Situ Multi-parameter Water Quality Measurements*

Water quality measurements of pH, dissolved oxygen, specific conductivity, and water temperature will be collected using a multi-parameter water quality meter on every station visit.

*Stream Discharge*

Discharge will be measured using a flow meter at every sampling site for every sampling event if the stream is safe to wade. If the stream is deemed unsafe to wade, field staff should make note of the hydrological conditions at the time of sampling on the field observation sheet (e.g. samples were collected on the falling limb of the hydrograph), if known.

*Biological Sampling and Habitat Assessments*

Macroinvertebrates sampling will be performed at all sites where a new or updated assessment of aquatic life use is needed. Rapid habitat assessments will be completed at biology sampling sites to document habitat quality for aquatic life use assessments.

*Field Observations*

A field observation sheet will be completed at each site during each chemistry and/or E. coli sampling event. The following observations will be recorded: discharge cross section location, chemistry sampling location, flow condition, hydrologic condition, weather condition at time of sampling and in the past 24 hours and 48 hours, stream mixing, stream color, other observations such as floating woody debris, garbage, algal mats, fish kills, suds, turbidity and odor, stream shading, and biological observations. Estimates of the percent cover of nuisance algae present in a riffle, run, and pool location at the sampling site will be noted during every site visit.

*Site Photodocumentation*

Photographs will be taken at each sampling site to record site and watershed conditions. At the beginning of each project the following photographs may be taken:

- Upstream of sampling location
- Downstream of sampling location
- Stream bank and riparian condition of right and left banks
- Predominant stream substrate
- Unusual characteristics (e.g. major stream bank failures)

On subsequent sampling events, photographs may be taken to document nuisance algae and any conditions that have changed in the area potentially affecting water quality (e.g. chemical spills, near-by facilities in operation, machinery in stream channel, animals in stream channel, high or low discharge conditions, etc).

All photo numbers and descriptions will be recorded on field observation sheets with the date and time that the photo was taken. Upon return from the field, all photos will be downloaded into the electronic TMDL Administrative Record.

**Table 2.1.** Critical and informational measurements for TMDL and Assessment Program monitoring projects.

| | Field Activity | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Project Type** | **Water Chemistry** | **Bacteria** | ***In situ*** | **Stream Discharge** | **Biology** | **Habitat Assessments** | **Field Observations** | **Photographs** |
| 305(b) CAH Assessment | critical | n/a | critical | informational | critical | critical | critical | critical |
| 305(b) WAH Assessment | critical | n/a | critical | informational | critical | critical | critical | critical |
| 305(b) PCR Assessment | informational | critical | critical | informational | n/a | n/a | critical | critical |
| 305(b) SCR Assessment | informational | critical | critical | informational | n/a | n/a | critical | critical |
| TMDL Development | critical | critical | critical | critical | critical | critical | critical | critical |

**Sampling Equipment and Supplies**

A list of field and laboratory supplies and equipment can be found in Table 2.2. This table is not all inclusive, as certain projects may require additional, unforeseen equipment.

**Table 2.2.** List of common equipment and supplies needed to complete field sampling and laboratory analysis for samples collected by the TMDL and Assessment Program. In rare circumstances, other equipment and/or supplies might be needed.

| ***In situ* and Discharge Measurements** | **Water Chemistry Sampling** | **Macroinvertebrate Sampling** |
|---|---|---|
| Multi-parameter water quality meter | Sample bottles (HDPE) | 16 oz. sample jars (macroinvertebrates) |
| Flow Meter | Latex or nitrile gloves | 90% ethanol |
| 100' Tape Measure | Preservative acid | Dipnets |
| Clipboard | Cooler(s) with ice | D-Frame dip net (600µm) |
| Waterproof pens and paper | 0.45 µm filters | Modified Kicknet (600µm) |
| Camera | Ehrlenmeyer filter flask | Sieve bucket |
| GPS | Filter funnel with tubing | #10 mesh sieve |
| | Hand Pump | #30 mesh sieve |
| | Deionized Water | Forceps |
| | Weighted bottle sampler | Plastic sorting pans |
| ***In situ* Meter Calibration** | **E. coli Analysis** | **Macroinvertebrate Analysis** |
| Yellow DO Membranes | IDEXX Sealer | Stereomicroscope |
| Blue DO Membranes | Autoclave | Compound microscope |
| pH 4 standard | Incubator | Plastic sorting pans |
| pH 7 standard | Thermometers | Forceps |
| pH 10 standard | UV Lamps | 70% ethanol |
| 1000µS conductivity standard | Quanti-tray 2000 | Shell vials |
| Plastic tub/bucket | Colilert media | Labels |
| | Mixing vessels | |
| | Freezer | |

## 2.3 Sample Handling and Custody Requirements

A sample is in "custody" if it is in the actual possession of a sampler or in a secured area that is restricted to authorized personnel. Once a sample is in the custody of DOW staff, guidelines for sample handling, storage and transport from the QAPP (Section 2.3) will be followed.

## 2.4 Analytical Methods Requirements

Analytical requirements for all water chemistry samples collected in this program can be found in Section 2.4 of the QAPP Main Document. In this program, analytes and bottles collected are project dependent and are thus detailed in project-specific PSPs.

## 2.5 Quality Control (QC) Requirements

Table 2.3 lists the QC requirements for this program. QC samples (duplicates, blanks, rinsate blanks, field blanks, and replicates) will be collected randomly throughout the course of each project. Project-specific QC requirements are detailed in individual PSPs. For details regarding the associated corrective action, responsible personnel, DQOs addressed by QC, and measurement performance criteria for specific QC, see Table 2.4 and Table 2.5 of the QAPP Main Document.

**Table 2.3.** TMDL Section Monitoring Program Quality Control Requirements.

| Requirement | Frequency |
|---|---|
| **Field** | |
| Water/Sediment Chemistry Field Duplicates | Minimum of 10% of samples collected distributed across the project |
| Water Chemistry Field Blanks | Minimum of 10% of samples collected distributed across the project |
| Orthophosphorus Filtering Equipment Rinsate Blanks | One for each day orthophosphorus samples are collected |
| *E. coli* Replicate (splits) | Minimum of 10% of samples collected distributed across the project |
| *E. coli* Field Blanks | One for each day *E. coli* samples are collected |
| Macroinvertebrates | Annual review of SOP and recertification in collection methods and field audits, as resources allow |
| Habitat Assessment Recertification | Annually if resources allow; at least biannually |
| Calibration of water quality probes and data sondes | At least one/week during field use |
| FlowTracker Beam Checks | At least one/week during field use |
| FlowTracker Automatic QC Check | At least one/day during field use |
| **Laboratory** | |
| Microbiology Lab QC | Varies by type; see all QC related to Microbiology in Table 2.5 in QAPP Main Document |
| Macroinvertebrate Sorting Pan | 2 Sorting Pan Checks per experienced staff member. |
| Macroinvertebrate sample re-identification | 5% of all project samples, if resources allow; taxonomist maintains a verified reference collection |
| Department of Environmental Services Laboratory | see ESB LOQAM |

## 2.6 Testing, Calibration and Maintenance Requirements for Equipment and Supplies

This program uses the following equipment: Multi-parameter Water Quality Probes, SonTek Flow Trackers, Biological Sampling Equipment, WQB Microbiology Lab Equipment, and WQB Taxonomy Laboratory Equipment.

There are no project specific testing, calibration and maintenance requirements for this program. Project staff should review Section 2.6 of the QAPP Main Document for details on testing, calibration and maintenance requirements. The activity lead will be responsible for calibration of YSI multi-parameter probes used to collect temperature, pH, dissolved oxygen and specific conductivity. Calibration will follow guidelines in Section 2.6.1 of the QAPP Main Document and the *In-situ* Water Quality Measurements SOP. Other consumable supplies (i.e. sample bottles, preservatives, etc.) will follow QAQC guidelines in section 2.6.2 of the QAPP Main Document.

## 2.7 Data Acquisition Requirements for Non-direct Measurements

Non-direct measurements collected in this program include ArcGIS analysis of watershed characteristics, and weather/climatic data. Section 2.7 of the QAPP Main Document details the requirements and limitations of these data.

## 2.8 Data Management Requirements

Documents specific to this program (Table 1.2) are stored on the KDEP servers at the following locations: \\depdowtmdl\TMDL\TMDL ADMIN RECORDS and V:\DOWWQB\TMDL_Section\TMDL_Admin_Records . Project files are organized by basin and then by watershed (e.g. Tennessee River - Cypress Creek, Kentucky River – Benson Creek, etc.). Files for each data type in Section 1.5 will be organized into individual subfolders. Further details on how these documents will be handled and stored can be found in Section 1.5

and Section 2.8 of the QAPP Main Document. Data will be entered into the K-WADE database for long-term storage and curation as soon as possible after data generation.

## 3.0 ASSESSMENTS AND OVERSIGHT

### 3.1 Project-Level Assessments and Response Actions

Refer to Section 3.1 of the QAPP Main Document for guidelines for project-level assessment and response actions.

### 3.2 Program-Wide Assessments and Response Actions

Refer to Section 3.2 of the QAPP Main Document for guidelines for project-level assessment and response actions.

## 4.0 DATA VERIFICATION, VALIDATION AND USABILITY

### 4.1 Data Review, Validation, and Verification Criteria and Documentation

There are no data review, validation, and verification criteria and documentation details specific to this program. Please see Section 4.1 of the QAPP for guidelines on project-level assessment and response actions.

### 4.2 Validation and Verification Methods

- Initial data review will be completed as soon as possible after data generation (Section 4.2.1 of the QAPP).
- Field activity QA will include the Sample Collection, Measurement Observation, Bioassessment and Biological Metrics and Indices QA checklists (Section 4.2.2 of the QAPP Main Document).
- The station visit checklist will be completed (Section 4.2.3 of the QAPP Main Document).
- The project closeout checklist will be completed (Section 4.2.4 of the QAPP Main Document).

### 4.3 Reconciliation with Project Requirements

Reconciliation with project requirements will follow section 4.3 of the QAPP Main Document. It is the responsibility of the Project Coordinators to ensure that all data related to each monitoring project, including flagged and non-compliant data, is included in the final data reports. All flagged and non-compliant data (data that do not meet QAPP DQOs) will be highlighted and an explanation provided as to why those data are questionable. Final data reports for each monitoring project will contain documentation for all data assessment and verification activities. The final reports will also contain documentation regarding limitations to the final data set.

After project closeout, the program supervisor and project coordinator will work with the TMDL writing staff and/or the 305(b) assessment coordinator to determine if the data collected are appropriate for use in TMDL development and/or 305(b) assessment. The following guidelines are used may be used to make this determination:

i. Analytical data are from the appropriate timeframe. For example, if the pollutant of concern is *E. coli*, which affects the PCR use, then by definition the PCR use only applies from May through October. Data from outside this range cannot be used to determine compliance with the standard.

ii. The detection limit of the data is sufficiently low to show exceedances of any water quality criteria or TMDL target, as appropriate

iii. Laboratory QA flags show the data are of acceptable quality

iv. Analytical data were validated by the Program Supervisor, and

During the assessment and verification procedure, data may be rejected and removed from the final data reports. This may be done under the following circumstances:

- Chemistry and/or *E. coli* samples were collected from pooled sites
- *In situ* field measurements were collected in pooled sites
- Laboratory results contain excessive data quality flags
- Calibration records are incomplete

If, during the data review process, it is deemed that there are insufficient data for TMDL development or 305(b) assessment, the Program Supervisor may require that the monitoring project be extended until adequate data are collected.

# APPENDIX C

## BLANK RPB HABITAT FORMS AND BIOASSESSMENT FORMS

# High Gradient Bioassessment Stream Visit Sheet

| | | | |
|---|---|---|---|
| **STREAM NAME:** | **LOCATION:** | | |
| **STATION #:** | **COUNTY:** | | **PROGRAM:**<br>**PROJECT:** |
| **INVESTIGATORS:**<br>Verify Site LAT/LONG vs GPS ☐YES ☐NO ☐N/A | **DATE:** | **TIME (24hr)** | **Start:**<br>**Finish:** |

| | Station | Reach Downstream | Reach Upstream |
|---|---|---|---|
| **LAT** | | | |
| **LONG** | | | |

**CANOPY COVER::**
☐ Fully Exposed (0-25%)
☐ Partially Exposed (25-50%)
☐ Partially Shaded (50-75%)
☐ Fully Shaded (75-100%)

**STREAM TYPE:**
☐ Perennial
☐ Ephemeral
☐ Intermittent

**WEATHER**
Has there been a scouring rain in the last 14 days?
☐ Yes ☐ No

| Now | Past 24 hours | |
|---|---|---|
| ☐ | ☐ | Heavy rain |
| ☐ | ☐ | Steady rain |
| ☐ | ☐ | Intermittent showers |
| ☐ | ☐ | Clear/sunny |
| ☐ | ☐ | Cloudy |

**LOCAL WATERSHED FEATUREES** (Predominant Surrounding Land Use):
☐ Surface Mining
☐ Deep Mining
☐ Oil Wells
☐ Land Disposal
☐ Residential
☐ Construction
☐ Commercial
☐ Industrial
☐ Row Crops
☐ Forest
☐ Pasture/Grazing
☐ Silviculture
☐ Urban Runoff/Storm Sewers

**INSTREAM FEATURES**
Stream Width ________ ft
Maximum Depth ________ ft
Reach Length ________m

Riffle/Run/Pool Sequence
(No. Sampled in Reach)
_____Riffle _____Run _____Pool

**HYDRAULIC STRUCTURES**
☐ Dams
☐ Bridge Abutments
☐ Island
☐ Waterfalls
☐ Other:

**STREAM FLOW**
☐ Dry
☐ Pooled
☐ Low
☐ High
☐ Normal

**RIPARIAN VEGETATION**
Dominate Type:
☐ Trees ☐ Herbaceous
☐ Grasses ☐ Shrubs
Number of strata ____ Dom. Tree/Shrub Taxa

**CHANNEL ALTERATIONS**
☐ Dredging
☐ Channelization
(☐Full ☐Partial)

**P-CHEM** Instrument Used: ______________________ Date Calibrated: ____________________

Temp(°C)__________ D.O. (mg/l)___________ %Saturation___________ pH(S.U.)___________ Cond.___________ Turb.___________

## Sample Collection Verification

| | | |
|---|---|---|
| **Algae** | Sample: ☐ QualMHC ☐ Other ☐ Visual Assessment | Lead Collector: |
| **Fish** | ☐BPEF ☐ Seine ☐ Other Time: BPEF__________ Seine__________ | Lead Collector: |
| **Habitat** | ☐ RBP ☐ Substrate ☐ Other: | Lead Collector: |
| **Invertebrates** | ☐ $1m^2$ ☐ Qual ☐ Other:<br>☐ 20 Jab (#Jabs: Cobble_____ Snags_____ Veg. Banks_____ Sand_____ Macrophytes_____ Other ______) | Lead Collector: |
| **Tissue:** | No. of Samples collected________ Sp: | Lead Collector: |
| **Water Chem** | ☐ Acid/Alk ☐ Bulk ☐ Nutrients ☐ Metals ☐ Low Hg<br>☐ Herbicides ☐ Pesticides ☐ Ortho P ☐ Other: | Lead Collector: |

**Duplicate Samples Taken:**

## Substrate Characterization

| Substrate ☐Est. ☐P.C. | **Riffle_______%** | **Run_______%** | **Pool_______%** | **Reach Total** |
|---|---|---|---|---|
| Silt/Clay (<0.06 mm) | | | | |
| Sand (0.06 – 2 mm) | | | | |
| Gravel (2-64 mm) | | | | |
| Cobble (64 – 256 mm) | | | | |
| Boulders (>256 mm) | | | | |
| Bedrock | | | | |

**NOTES/COMMENTS:**

**SITE NOT SAMPLED:**
☐ Land owner denial ☐ Dry ☐Too deep/Impounded
☐ Site not found/Secluded ☐Unsafe
☐ Other (indicate under comments)

# RBP High Gradient Habitat

| Habitat Parameter | Condition Category | | | |
|---|---|---|---|---|
| | Optimal | Suboptimal | Marginal | Poor |
| SCORE | 20 19 18 17 16 | 15 14 13 12 11 | 10 9 8 7 6 | 5 4 3 2 1 0 |
| **1.Epifaunal Substrate/ Available Cover** Score | Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are <u>not</u> new fall and <u>not</u> transient). | 40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of new fall, but not yet prepared for colonization (may rate at high end of scale). | 20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed. | Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking. |
| **2.Embeddedness** Score | 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** Score | All four velocity/depth regimes present (slow-deep, slow-shallow, fast-deep, fast-shallow). (Sow 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** Score | 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. |
| **5.Channel Flow Status** Score | Water reaches base of both lower banks, and minimal amount of channel substrate is exposed. | Water fills >75% of the available channel; or <25% of channel substrate is exposed. | Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed. | Very little water in channel and mostly present as standing pools. |
| **6.Channel Alteration** Score | 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 yr.) 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. |
| **7.Frequency of Riffles (or bends)** Score | 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. In streams where riffles are continuous, placement of boulders or other large, natural obstruction is important. | 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. |
| Left/Right Bank | 10 9 | 8 7 6 | 5 4 3 | 2 1 0 |
| **8.Bank Stability** LB RB | 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. |
| **9. Vegetative Protection** LB RB | More than 90% of the stream bank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally. | 70-90% of the stream bank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining. | 50-70% of the stream bank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining. | Less than 50% of the stream bank surfaces covered by vegetation; disruption of stream bank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height. |
| **10. Riparian Vegetative Zone Width** LB RB | Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone. | Width of riparian zone 12-18 meters; human activities have impacted zone only minimally. | Width of riparian zone 6-12 meters; human activities have impacted zone a great deal. | Width of riparian zone <6 meters: little or no riparian vegetation due to human activities. |

**Total Score**

**NOTES/COMMENTS:**

# Low Gradient Bioassessment Stream Visit Sheet

| | |
|---|---|
| **STREAM NAME:** | **LOCATION:** |
| **STATION #:** | **COUNTY:** / **PROGRAM:** **PROJECT:** |
| **INVESTIGATORS:** | **DATE:** / **TIME (24hr)** **Start:** **Finish:** |
| Verify Site LAT/LONG vs GPS ☐YES ☐NO ☐N/A | |

| | Station | Reach Downstream | Reach Upstream |
|---|---|---|---|
| **LAT** | | | |
| **LONG** | | | |

**CANOPY COVER:**:
☐ Fully Exposed (0-25%)
☐ Partially Exposed (25-50%)
☐ Partially Shaded (50-75%)
☐ Fully Shaded (75-100%)

**STREAM TYPE:**
☐ Perennial
☐ Ephemeral
☐ Intermittent

**WEATHER**
Has there been a scouring rain in the last 14 days?
☐ Yes ☐ No

| Now | Past 24 hours | |
|---|---|---|
| ☐ | ☐ | Heavy rain |
| ☐ | ☐ | Steady rain |
| ☐ | ☐ | Intermittent showers |
| ☐ | ☐ | Clear/sunny |
| ☐ | ☐ | Cloudy |

**LOCAL WATERSHED FEATUREES** (Predominant Surrounding Land Use):

☐ Surface Mining
☐ Deep Mining
☐ Oil Wells
☐ Land Disposal
☐ Residential
☐ Construction
☐ Commercial
☐ Industrial
☐ Row Crops
☐ Forest
☐ Pasture/Grazing
☐ Silviculture
☐ Urban Runoff/Storm Sewers

**INSTREAM FEATURES**
Stream Width ________ ft
Maximum Depth ________ ft
Reach Length ________m

Riffle/Run/Pool Sequence
(No. Sampled in Reach)

_____Riffle _____Run _____Pool

**HYDRAULIC STRUCTURES**
☐ Dams
☐ Bridge Abutments
☐ Island
☐ Waterfalls
☐ Other:

**STREAM FLOW**
☐ Dry
☐ Pooled
☐ Low
☐ High
☐ Normal

**RIPARIAN VEGETATION**
Dominate Type:
☐ Trees ☐ Herbaceous
☐ Grasses ☐ Shrubs
Number of strata ____ Dom. Tree/Shrub Taxa

**CHANNEL ALTERATIONS**
☐ Dredging
☐ Channelization
(☐Full ☐Partial)

**P-CHEM** Instrument Used: ______________________ Date Calibrated: __________________

Temp(°C)__________ D.O. (mg/l)___________ %Saturation___________ pH(S.U.)___________ Cond.___________ Turb.___________

## Sample Collection Verification

| | | |
|---|---|---|
| **Algae** | Sample: ☐ QualMHC ☐ Other ☐ Visual Assessment | Lead Collector: |
| **Fish** | ☐BPEF ☐ Seine ☐ Other Time: BPEF__________ Seine__________ | Lead Collector: |
| **Habitat** | ☐ RBP ☐ Substrate ☐ Other: | Lead Collector: |
| **Invertebrates** | ☐ $1m^2$ ☐ Qual ☐ Other: | Lead Collector: |
| | ☐ 20 Jab (#Jabs: Cobble_____ Snags_____ Veg. Banks_____ Sand_____ Macrophytes_____ Other ______) | |
| **Tissue:** | No. of Samples collected________ Sp: | Lead Collector: |
| **Water Chem** | ☐ Acid/Alk ☐ Bulk ☐ Nutrients ☐ Metals ☐ Low Hg | Lead Collector: |
| | ☐ Herbicides ☐ Pesticides ☐ Ortho P ☐ Other: | |

**Duplicate Samples Taken:**

## Substrate Characterization

| Substrate ☐Est. ☐P.C. | **Riffle_______%** | **Run_______%** | **Pool_______%** | **Reach Total** |
|---|---|---|---|---|
| Silt/Clay (<0.06 mm) | | | | |
| Sand (0.06 – 2 mm) | | | | |
| Gravel (2-64 mm) | | | | |
| Cobble (64 – 256 mm) | | | | |
| Boulders (>256 mm) | | | | |
| Bedrock | | | | |

**NOTES/COMMENTS:**

## SITE NOT SAMPLED:

☐ Land owner denial ☐ Dry ☐ Too deep/Impounded

☐ Site not found/Secluded ☐ Unsafe

☐ Other (indicate under comments)

# RBP Low Gradient Habitat

| Habitat Parameter | Condition Category | | | |
|---|---|---|---|---|
| | **Optimal** | **Suboptimal** | **Marginal** | **Poor** |
| **SCORE** | 20 19 18 17 16 | 15 14 13 12 11 | 10 9 8 7 6 | 5 4 3 2 1 0 |
| **1. Epifaunal Substrate/ Available Cover** <br> **Score** | Greater than 50% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new and transient). | 30-50% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale). | 10-30% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed. | Less than 10% stable habitat; lack of habitat is obvious; substrate unstable or lacking. |
| **2. Pool Substrate Characterization** <br> **Score** | Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common. | Mixture of soft sand, mud, or clay; mud may be dominant; some root mats and submerged vegetation present. | All mud or clay or sand bottom; little or no root mat; no submerged vegetation. | Hard-pan clay or bedrock; no root mat or vegetation. |
| **3. Pool Variability** | Even mix of large-shallow, large-deep, small-shallow, small-deep pools present. | Majority of pools large-deep; very few shallow. | Shallow pools much more prevalent than deep pools. | Majority of pools small-shallow or pools absent. |
| **4. Sediment Deposition** <br> **Score** | Little or no enlargement of islands or point bars and less than 20% of the bottom affected by sediment deposition. | Some new increase in bar formation, mostly from gravel, sand or fine sediment; 20-50% of the bottom affected; slight deposition in pools. | Moderate deposition of new gravel, sand or fine sediment on old and new bars; 50-80% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent. | Heavy deposits of fine material, increased bar development; 80% of the bottom changing frequently; pools almost absent due to substantial sediment deposition. |
| **5. Channel Flow Status** <br> **Score** | Water reaches base of both lower banks, and minimal amount of channel substrate is exposed. | Water fills >75% of the available channel; or <25% of channel substrate is exposed. | Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed. | Very little water in channel and mostly present as standing pools. |
| **6. Channel Alteration** <br> **Score** | 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, (>20 yr.) 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. In stream habitat greatly altered or removed entirely. |
| **7. Channel Sinuosity** <br> **Score** | The bends in the stream increase the stream length 3 to 4 times longer than if it was in a straight line. (Note - channel braiding is considered normal in coastal plains and other low-lying areas. This parameter is not easily rated in these areas. | The bends in the stream increase the stream length 2 to 3 times longer than if it was in a straight line. | The bends in the stream increase the stream length 2 to 1 times longer than if it was in a straight line. | Channel straight; waterway has been channelized for a long distance. |
| Left/Right Bank | 10 9 | 8 7 6 | 5 4 3 | 2 1 0 |
| **8. Bank Stability** <br> LB <br> RB | 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. |
| **9. Vegetative Protection** <br> LB <br> RB | More than 90% of the stream bank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally. | 70-90% of the stream bank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining. | 50-70% of the stream bank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining. | Less than 50% of the stream bank surfaces covered by vegetation; disruption of stream bank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height. |
| **10. Riparian Vegetative Zone Width** <br> LB <br> RB | Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone. | Width of riparian zone 12-18 meters; human activities have impacted zone only minimally. | Width of riparian zone 6-12 meters; human activities have impacted zone a great deal. | Width of riparian zone <6 meters: little or no riparian vegetation due to human activities. |

**Total Score**

**NOTES/COMMENTS:**

# APPENDIX D

## KDOW TMDL MONITORING DATA FOR PHASE I AND II

| Stream Site ID | Date | Conductivity µS/cm @ 25C | Dissolved Oxygen (mg/L) | Dissolved Oxygen (% Sat) | Flow (ADV/EMV) cfs | PH (S.U.) | Temperature (C) | Ammonia (as N) mg/L | Un-ionized Ammonia (mg/L) | CBOD-5 mg/L | Chloride mg/L | Flouride mg/L | Nitrate & Nitrite (as N) mg/L | Nitrate (as N) mg/L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3/22/18 9:50 | 296.00 | 9.92 | 85.40 | 68.23 | 7.43 | 8.74 | | | | 9.2 | 0.08 | 2.31 | 2.16 |
| 1 | 4/19/18 9:50 | 301.00 | 8.93 | 84.50 | 70.59 | 7.31 | 12.81 | | | 3.710 | 6.46 | 0.10 | 2.1 | 2.28 |
| 1 | 5/1/18 10:30 | 310.00 | 8.13 | 78.90 | 23.38 | 7.23 | 13.97 | | | | | | | |
| 1 | 5/8/18 9:45 | 301.00 | 7.29 | 74.00 | 39.74 | 7.20 | 16.03 | | | | | | | |
| 1 | 5/15/18 10:00 | 370.00 | 5.91 | 61.90 | 10.70 | 7.15 | 17.54 | | | | | | | |
| 1 | 5/22/18 9:45 | 371.00 | 5.59 | 58.60 | 9.10 | 7.15 | 17.61 | | | | 8.03 | | 2.48 | 2.5 |
| 1 | 5/29/18 10:00 | 371.00 | 5.68 | 60.00 | 11.22 | 7.10 | 17.94 | | | | | 0.16 | | |
| 1 | 6/19/18 10:20 | 381.00 | 5.68 | 60.80 | 2.11 | 6.88 | 18.61 | | | | 8.09 | 0.12 | 2.94 | 2.96 |
| 1 | 7/17/18 10:25 | 384.00 | 5.53 | 59.20 | 0.62 | 6.78 | 18.62 | | | | | 0.15 | | |
| 1 | 8/9/18 10:00 | 228.00 | 4.96 | 53.50 | 23.30 | 6.64 | 19.04 | 0.035 | 0.000 | 2.840 | 3.91 | 0.12 | 1.82 | 1.76 |
| 1 | 10/18/18 10:30 | 354.00 | 9.81 | 95.50 | 25.51 | 7.19 | 14.10 | 0.047 | 0.000 | | 8.43 | 0.10 | 3.08 | 3.13 |
| 1 | 11/29/18 10:15 | 314.00 | 9.46 | 82.40 | 25.29 | 7.36 | 9.20 | | | | 7.64 | 0.12 | 2.9 | 2.99 |
| 1 | 1/17/19 9:45 | 315.60 | 11.15 | 96.80 | 45.46 | 7.27 | 9.10 | | | | 7.17 | 0.09 | 2.75 | 2.83 |
| 1 | 2/21/19 9:45 | 172.40 | 11.41 | 94.00 | 634.56 | 7.03 | 7.10 | 0.04 | 0.000 | | 3.93 | 0.06 | 1.65 | 1.62 |
| 1 | 4/24/19 10:35 | 305.50 | 7.83 | 77.90 | | 7.39 | 14.80 | | | | 6.07 | 0.07 | 2.8 | 2.62 |
| 1 | 5/20/19 11:00 | 360.30 | 6.15 | 63.40 | 7.05 | 7.29 | 16.70 | | | | 7.49 | 0.12 | 2.62 | 2.6 |
| 1 | 6/19/19 10:45 | 752.10 | 6.19 | 63.30 | | 6.94 | 16.80 | | | | 5.39 | 0.09 | 3.43 | 3.45 |
| 1 | 6/26/19 12:15 | 312.10 | 7.02 | 72.40 | | 7.05 | 17.00 | | | | 5.96 | 0.08 | 2.71 | |
| 1 | 7/23/19 12:10 | 365.10 | 5.36 | 57.70 | 33.80 | 7.11 | 18.90 | | | | 7.27 | 0.13 | 2.81 | 2.74 |
| 1 | 8/28/19 12:00 | 370.60 | 5.20 | 55.10 | 16.79 | 6.87 | 18.00 | 0.025 | 0.000 | | 7.28 | 0.13 | 2 | |
| 1 | 9/26/19 12:30 | 354.40 | 4.72 | 50.20 | | 6.99 | 18.30 | | | | 7.86 | 0.16 | 2.05 | 2.16 |
| 1 | 10/29/19 12:20 | 396.60 | 5.31 | 52.30 | | 7.03 | 14.70 | | | | 9.76 | 0.15 | 1.85 | 2.08 |
| 1 | 11/21/19 12:10 | 421.30 | 7.62 | 70.10 | | 7.43 | 11.60 | | | | 9.61 | 0.13 | 2.89 | |
| 1 | 12/11/19 12:50 | 312.10 | 9.45 | 83.10 | 102.6226 | 7.53 | 9.70 | 0.03 | 0.000 | | 6.23 | 0.09 | 2.53 | |
| 1 | 3/5/20 13:00 | 317.30 | 8.71 | 81.40 | 126.7831 | 7.29 | 12.30 | | | | 5.57 | 0.08 | 2.95 | |
| 2 | 3/22/18 10:30 | 277.00 | 10.83 | 90.30 | 68.23 | 7.68 | 7.48 | 0.029 | 0.000 | | 9.6 | 0.08 | 1.86 | 1.71 |
| 2 | 4/19/18 10:25 | 285.00 | 9.47 | 89.50 | 70.59 | 7.54 | 12.78 | | | | 6.67 | 0.09 | 1.75 | 1.82 |
| 2 | 5/1/18 10:50 | 292.00 | 8.93 | 87.00 | 23.38 | 7.35 | 14.12 | | | | | | | |
| 2 | 5/8/18 10:10 | 274.00 | 7.61 | 78.10 | 39.74 | 7.33 | 16.59 | | | | | | | |
| 2 | 5/15/18 10:20 | 356.00 | 6.00 | 63.70 | 10.70 | 7.22 | 18.20 | | | | | | | |
| 2 | 5/22/18 10:10 | 364.00 | 5.91 | 61.50 | 9.10 | 7.23 | 17.29 | 0.044 | 0.000 | | 9.42 | 0.11 | 2.64 | 2.58 |
| 2 | 5/29/18 10:20 | 360.00 | 6.11 | 63.80 | 11.22 | 7.14 | 17.42 | | | | | | | |
| 2 | 6/19/18 10:50 | 363.00 | 5.80 | 66.30 | 2.11 | 7.26 | 22.08 | 0.06 | 0.001 | | 9 | 0.11 | 2.59 | 2.64 |
| 2 | 7/17/18 11:00 | 377.00 | 6.00 | 69.90 | 0.62 | 7.35 | 22.89 | 0.06 | 0.001 | | 9.01 | 0.13 | 2.57 | 2.54 |
| 2 | 8/9/18 10:30 | 211.00 | 6.05 | 68.10 | 23.30 | 6.97 | 21.12 | 0.081 | 0.000 | 2.600 | 4.36 | 0.12 | 1.44 | 1.36 |
| 2 | 10/18/18 11:00 | 324.00 | 10.99 | 104.60 | 25.51 | 7.32 | 13.08 | 0.043 | 0.000 | | 8.62 | 0.12 | 2.5 | 2.46 |
| 2 | 11/29/18 10:40 | 289.80 | 10.03 | 83.00 | 25.29 | 7.35 | 7.50 | | | | 8.49 | 0.09 | | 2.73 |
| 2 | 1/17/19 10:10 | 301.30 | 11.23 | 93.90 | 45.46 | 7.21 | 7.80 | | | | 7.51 | 0.08 | 2.29 | 2.43 |
| 2 | 2/21/19 10:00 | 172.40 | 11.33 | 93.60 | 639.2741 | 7.13 | 7.10 | 0.039 | 0.000 | | 3.94 | 0.08 | 1.52 | 1.63 |
| 2 | 4/24/19 10:50 | 275.50 | 9.07 | 92.10 | | 7.66 | 16.00 | | | | 6.02 | 0.07 | 2.15 | 2.06 |
| 2 | 5/20/19 11:30 | 342.50 | 5.69 | 60.10 | 7.05 | 7.48 | 17.80 | 0.047 | 0.001 | | 7.96 | 0.09 | 2.15 | 2.11 |
| 2 | 6/19/19 11:10 | 751.90 | 7.66 | 82.90 | | 7.22 | 19.20 | 0.047 | 0.000 | | 6.95 | 0.08 | 3.03 | 3.02 |
| 2 | 6/26/19 12:25 | 277.00 | 7.98 | 86.60 | | 7.38 | 19.50 | 0.033 | 0.000 | | 6.16 | 0.09 | 2.4 | |

| Stream Site ID | Date | Conductivity µS/cm @ 25C | Dissolved Oxygen (mg/L) | Dissolved Oxygen (% Sat) | Flow (ADV/EMV) cfs | PH (S.U.) | Temperature (C) | Ammonia (as N) mg/L | Un-ionized Ammonia (mg/L) | CBOD-5 mg/L | Chloride mg/L | Flouride mg/L | Nitrate & Nitrite (as N) mg/L | Nitrate (as N) mg/L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 7/23/19 12:30 | 346.90 | 6.86 | 74.00 | 8.43 | 7.35 | 19.00 | 0.039 | 0.000 | | 7.7 | 0.12 | 2.22 | 2.26 |
| 2 | 12/11/19 13:25 | 279.50 | 10.15 | 86.00 | 103.35866 | 7.58 | 8.10 | 0.046 | 0.000 | | 6.19 | 0.10 | 2.09 | |
| 2 | 3/5/20 13:15 | 246.10 | 11.41 | 102.30 | 129.34994 | 7.68 | 10.50 | | | | 5.27 | 0.07 | 2.04 | |
| 3 | 4/24/19 11:10 | 342.40 | 6.92 | 66.70 | | 7.22 | 13.60 | | | | 6.08 | 0.08 | 3.9 | |
| 3 | 5/20/19 11:20 | 360.80 | 5.91 | 60.30 | | 7.25 | 16.40 | 0.031 | 0.000 | | 7.3 | 0.10 | 2.77 | 2.75 |
| 3 | 6/19/19 10:55 | 273.70 | 5.46 | 55.00 | | 6.76 | 15.60 | | | | 4.44 | 0.08 | 3.82 | 3.67 |
| 3 | 6/26/19 12:30 | 341.30 | 5.88 | 58.30 | | 6.97 | 14.90 | | | | 5.36 | 0.09 | 3.88 | |
| 3 | 7/23/19 12:20 | 372.00 | 4.59 | 49.40 | | 7.04 | 18.90 | | | | 0.374 | | | |
| 3 | 8/28/19 12:20 | 371.20 | 5.13 | | | 6.83 | 17.90 | | | | 7.29 | 0.14 | 2.06 | |
| 3 | 9/26/19 12:50 | | 4.66 | 49.30 | | 6.94 | 18.20 | | | | | 0.16 | 2.02 | 2.17 |
| 3 | 10/29/19 12:00 | 396.10 | 5.24 | 51.40 | | 7.13 | 14.80 | | | | 9.75 | 0.15 | 1.81 | 2.09 |
| 3 | 11/21/19 11:50 | 425.60 | 7.69 | 71.20 | | 7.63 | 11.90 | | | | 9.55 | 0.13 | 2.99 | |
| 3 | 12/11/19 13:15 | 371.10 | 7.98 | 75.30 | | 7.29 | 12.70 | | | | 6.43 | 0.11 | 3.48 | |
| 3 | 3/5/20 13:30 | 334.20 | 7.94 | 74.90 | | 7.18 | 12.70 | | | | 5.81 | 0.09 | 3.83 | |
| 4 | 5/20/19 17:00 | 303.30 | 5.24 | 60.40 | 2.63 | 7.84 | 21.10 | 0.26 | 0.009 | | 7.35 | 0.09 | 1.45 | 1.49 |
| 4 | 6/26/19 13:50 | 268.80 | 8.52 | 94.50 | 82.39 | 7.49 | 20.50 | 0.034 | 0.001 | | 5.87 | 0.09 | 2.06 | |
| 4 | 7/23/19 14:30 | 301.10 | 7.19 | 84.40 | 0.58 | 7.68 | 23.30 | 0.099 | 0.003 | | 6.74 | 0.13 | 1.61 | 1.58 |
| 5 | 3/22/18 11:45 | 255.00 | 12.75 | 104.00 | 53.28 | 8.02 | 6.61 | 0.038 | 0.001 | | 7.09 | 0.08 | 1.57 | 1.44 |
| 5 | 4/19/18 11:15 | 282.00 | 10.29 | 96.10 | 51.37 | 7.57 | 12.24 | 0.028 | 0.000 | | 5.52 | 0.09 | 1.32 | 1.36 |
| 5 | 5/1/18 11:10 | 266.00 | 10.73 | 108.10 | 19.58 | 7.83 | 15.68 | | | | | | | |
| 5 | 5/8/18 10:40 | 252.00 | 8.74 | 91.80 | 34.57 | 7.64 | 17.70 | | | | | | | |
| 5 | 5/15/18 11:10 | 308.00 | 6.30 | 71.80 | 13.44 | 7.49 | 21.78 | | | | | | | |
| 5 | 5/22/18 10:45 | 317.00 | 5.77 | 65.70 | 10.70 | 7.56 | 21.77 | 0.284 | 0.005 | | 7.4 | 0.12 | 0.972 | 0.926 |
| 5 | 5/29/18 10:45 | 313.00 | 5.78 | 66.30 | 11.59 | 7.50 | 22.07 | | | | | | | |
| 5 | 6/19/18 11:25 | 310.00 | 5.85 | 70.70 | 6.84 | 7.51 | 24.85 | | | | 7.96 | 0.12 | 1.66 | 1.67 |
| 5 | 7/17/18 11:40 | 300.00 | 6.26 | 74.20 | 6.92 | 7.42 | 23.84 | 0.05 | 0.001 | | 7.55 | 0.12 | 2.03 | 1.97 |
| 5 | 8/9/18 11:30 | 209.00 | 6.30 | 73.60 | 16.20 | 7.30 | 23.20 | 0.115 | 0.001 | 2.660 | 4.88 | 0.13 | 1.55 | 1.46 |
| 5 | 9/11/18 10:30 | 307.90 | 6.23 | 68.50 | 6.25 | 7.56 | 19.90 | 0.056 | 0.001 | | | 0.17 | 2.18 | |
| 5 | 10/18/18 11:50 | 304.00 | 11.49 | 111.40 | 24.21 | 7.53 | 13.94 | 0.064 | 0.001 | | 7.33 | 0.12 | 1.67 | 1.72 |
| 5 | 11/29/18 11:10 | 273.30 | 12.79 | 102.00 | 25.76 | 7.54 | 5.70 | 0.057 | 0.000 | | 7.14 | 0.11 | 2.12 | 2.22 |
| 5 | 1/17/19 11:10 | 279.50 | 11.96 | 97.60 | 39.24 | 7.50 | 6.60 | | | | | 0.07 | 1.84 | 1.99 |
| 5 | 2/21/19 10:45 | 185.70 | 11.25 | 94.10 | 463 | 6.98 | 7.70 | 0.03 | 0.000 | | 5.01 | 0.07 | 3.18 | 2.9 |
| 5 | 4/24/19 12:20 | 265.40 | 9.81 | 99.40 | | 7.82 | 16.00 | | | | 6.57 | 0.09 | | |
| 5 | 5/20/19 13:00 | 303.00 | 6.89 | 75.80 | 10.44 | 7.72 | 19.90 | 0.272 | 0.007 | | 7.2 | 0.09 | 1.39 | 1.44 |
| 5 | 6/26/19 14:10 | 261.40 | 8.17 | 92.80 | | 7.58 | 20.90 | 0.039 | 0.001 | | 5.74 | 0.08 | 1.99 | |
| 5 | 7/23/19 14:00 | 297.50 | 7.21 | 84.70 | 0.20 | 7.69 | 23.10 | 0.061 | 0.002 | | 6.67 | 0.13 | 1.51 | 1.53 |
| 5 | 8/28/19 14:00 | 276.00 | 6.42 | 74.20 | 4.11 | 7.51 | 22.50 | 0.091 | 0.002 | | 7.7 | 0.14 | 1.33 | |
| 5 | 9/26/19 14:30 | 225.60 | 6.94 | 78.00 | 4.88 | 7.55 | 21.00 | 0.044 | 0.001 | | 7.9 | 0.15 | 1.42 | 1.55 |
| 5 | 10/29/19 13:30 | 283.60 | 6.69 | 64.90 | 4.07 | 7.42 | 14.00 | 0.121 | 0.001 | | | 0.15 | 1.13 | 1.26 |
| 6 | 5/1/18 14:20 | | | | 17.97 | | | 0.056 | 0.000 | 2.340 | 37.2 | 0.51 | 19.2 | |
| 6 | 5/8/18 13:30 | | | | 30.33 | | | 0.028 | 0.000 | 2.540 | 29.3 | 0.44 | 6.08 | 6.06 |
| 6 | 5/22/18 11:20 | | | | 8.61 | | | 0.056 | 0.000 | | | 0.59 | 1.95 | |
| 6 | 6/19/18 11:55 | | | | 4.10 | | | 0.055 | 0.000 | | 47.1 | 0.76 | 15.8 | 15.3 |
| 6 | 7/17/18 12:20 | | | | 3.45 | | | 0.047 | 0.000 | | 48 | 0.70 | 22.7 | 23.1 |

| Stream Site ID | Date | Conductivity µS/cm @ 25C | Dissolved Oxygen (mg/L) | Dissolved Oxygen (% Sat) | Flow (ADV/EMV) cfs | PH (S.U.) | Temperature (C) | Ammonia (as N) mg/L | Un-ionized Ammonia (mg/L) | CBOD-5 mg/L | Chloride mg/L | Flouride mg/L | Nitrate & Nitrite (as N) mg/L | Nitrate (as N) mg/L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6 | 8/9/18 12:35 | | | | 16.53 | | | 0.035 | 0.000 | | 36.1 | 0.60 | 17 | 16.6 |
| 6 | 9/11/18 12:15 | | | | 6.17 | | | | | | 47.1 | 0.64 | 17.2 | |
| 6 | 10/18/18 12:30 | | | | 20.19 | | | 0.04 | 0.000 | | 34.8 | 0.57 | 13.5 | 13.1 |
| 6 | 11/29/18 11:45 | | | | 21.18 | | | 0.046 | 0.000 | | 36.2 | 0.44 | 14.3 | 14.2 |
| 6 | 1/17/19 11:45 | | | | 34.99 | | | | | 2.420 | 34.8 | 0.45 | 17.2 | 15.3 |
| 6 | 5/20/19 14:20 | | | | 12.20 | | | 0.063 | 0.000 | 2.090 | 45.3 | 0.68 | 15.4 | 15.3 |
| 6 | 7/23/19 10:20 | | | | 10.79 | | | 0.03 | 0.000 | | 34.3 | 0.58 | 6.32 | |
| 6 | 8/28/19 10:00 | | | | 5.35 | | | 0.039 | 0.000 | | 33.9 | 0.62 | 10.6 | |
| 6 | 9/26/19 11:00 | | | | 6.14 | | | 0.149 | 0.000 | | 55.3 | 0.79 | 21.7 | 22.9 |
| 6 | 10/29/19 10:35 | | | | 4.58 | | | 0.027 | 0.000 | | 41.8 | 0.67 | 4.14 | 12.1 |
| 6 | 11/21/19 10:30 | | | | 35.50 | | | | | 2.500 | 46.4 | 0.67 | | |
| 7 | 4/24/19 13:15 | 256.40 | 9.38 | 95.60 | | 7.86 | 16.00 | 0.025 | 0.001 | | 5.04 | 0.08 | 1.57 | |
| 7 | 5/20/19 14:40 | 292.30 | 7.57 | 82.50 | 12.20 | 7.77 | 19.70 | 0.066 | 0.002 | | 5.4 | 0.08 | 0.962 | 1 |
| 7 | 6/26/19 10:20 | 247.30 | 8.53 | 94.40 | 48.22 | 7.51 | 20.20 | 0.05 | 0.001 | | 5.27 | 0.08 | 1.58 | |
| 7 | 7/23/19 10:45 | 287.90 | 7.35 | 84.60 | 10.79 | 7.57 | 22.30 | 0.085 | 0.002 | | 5.56 | 0.11 | 1.23 | 1.32 |
| 7 | 8/20/19 12:30 | 239.10 | 6.64 | 81.30 | 3.61 | 7.52 | 25.60 | 0.317 | 0.007 | | 5.1 | 0.10 | 0.48 | 0.483 |
| 7 | 8/28/19 10:30 | 276.70 | 6.79 | 76.80 | 5.35 | 7.36 | 21.40 | 0.087 | 0.001 | | 5.45 | 0.11 | 0.711 | |
| 7 | 9/26/19 11:30 | 201.80 | 7.40 | 82.70 | 6.14 | 7.58 | 20.80 | 0.048 | 0.001 | | 5 | 0.11 | 0.25 | 0.287 |
| 7 | 10/29/19 10:45 | 303.90 | 7.80 | 75.40 | 4.58 | 7.21 | 13.80 | 0.059 | 0.000 | | 6.36 | 0.10 | 0.4 | 0.43 |
| 7 | 11/21/19 10:35 | 363.10 | 9.48 | 79.70 | 3.31 | 7.90 | 7.80 | 0.082 | 0.001 | | 7.9 | 0.10 | 0.977 | |
| 7 | 12/11/19 11:15 | 241.10 | 11.83 | 95.50 | 35.50 | 7.77 | 6.10 | 0.078 | 0.001 | | 4.89 | 0.08 | 1.43 | |
| 7 | 3/5/20 11:15 | 229.80 | 11.46 | 99.30 | | 7.72 | 9.10 | | | | 4.48 | 0.08 | 1.69 | |
| 9 | 4/24/19 13:55 | 256.00 | 8.06 | 81.90 | | 7.83 | 16.40 | 0.033 | 0.001 | | 4.93 | 0.06 | 1.51 | |
| 9 | 5/20/19 15:55 | 289.20 | 6.64 | 71.90 | 12.20 | 7.48 | 19.20 | 0.125 | 0.002 | | 5.2 | 0.09 | 0.893 | 0.929 |
| 9 | 6/26/19 11:20 | 247.60 | 6.85 | 75.50 | 48.22 | 7.37 | 20.40 | 0.043 | 0.000 | | | 0.08 | 1.63 | |
| 9 | 7/23/19 11:30 | 281.50 | 4.94 | 56.70 | 10.79 | 7.41 | 22.00 | 0.121 | 0.002 | | 5.02 | 0.11 | 1.24 | 1.24 |
| 9 | 8/28/19 11:15 | 262.90 | 4.23 | 48.10 | 5.35 | 7.25 | 21.70 | 0.131 | 0.001 | | 4.73 | 0.11 | 0.696 | |
| 9 | 3/5/20 11:45 | 230.00 | 11.49 | 100.00 | | 7.80 | 9.20 | | | | 4.45 | 0.07 | 1.71 | |
| 10 | 3/23/18 13:00 | 210.00 | 12.56 | 107.40 | 21.68 | 7.86 | 8.46 | | | | 6.02 | | 0.896 | |
| 10 | 4/19/18 12:10 | 213.00 | 11.21 | 101.20 | 21.65 | 7.62 | 10.81 | | | 2.130 | 4.23 | 0.07 | 0.831 | 0.845 |
| 10 | 5/1/18 12:00 | 226.00 | 10.14 | 100.80 | 8.63 | 7.63 | 15.06 | | | | | | | |
| 10 | 5/8/18 11:30 | 215.00 | 9.10 | 96.40 | 18.64 | 7.50 | 18.13 | | | | | | | |
| 10 | 5/15/18 12:10 | 258.00 | 7.15 | 80.60 | 6.85 | 7.39 | 21.21 | | | | | | | |
| 10 | 5/22/18 11:45 | 262.00 | 6.06 | 68.80 | 6.02 | 7.45 | 21.64 | 0.077 | 0.001 | | 4.89 | 0.08 | 0.728 | 0.691 |
| 10 | 5/29/18 11:30 | 265.00 | 5.72 | 64.80 | 4.15 | 7.34 | 21.49 | | | | | | | |
| 10 | 6/19/18 12:25 | 267.00 | 6.09 | 73.50 | 3.94 | 7.35 | 24.81 | 0.078 | 0.001 | | 5.45 | 0.10 | 1.32 | 1.29 |
| 10 | 7/11/18 10:30 | 249.00 | 5.39 | 63.30 | 7.35 | 7.19 | 23.38 | 0.106 | 0.001 | | 5.42 | 0.08 | 1.04 | 1.65 |
| 10 | 7/17/18 12:35 | 256.00 | 5.85 | 68.90 | 3.82 | 7.22 | 23.54 | 0.093 | 0.001 | | 5.42 | 0.09 | 1.76 | 1.66 |
| 10 | 8/9/18 12:30 | 252.00 | | | 5.79 | 7.23 | 23.67 | 0.148 | 0.002 | | 5.07 | 0.09 | 1.51 | 1.42 |
| 10 | 9/11/18 11:20 | 266.20 | 4.97 | 53.20 | 2.74 | 7.30 | 18.60 | 0.142 | 0.001 | | 5.39 | 0.10 | 1.68 | 1.68 |
| 10 | 10/18/18 12:50 | 239.00 | 11.52 | 111.00 | 11.63 | 7.54 | 13.62 | 0.063 | 0.001 | | 5.86 | 0.10 | 0.81 | 0.788 |
| 10 | 11/29/18 12:00 | 214.00 | 12.00 | 96.50 | 9.72 | 7.57 | 6.00 | 0.038 | 0.000 | | 5.46 | 0.06 | 1.42 | 1.48 |
| 10 | 1/17/19 12:00 | 221.00 | 12.24 | 99.30 | 16.84 | 7.37 | 6.40 | | | | 5.03 | 0.05 | 1.36 | 1.43 |
| 10 | 2/21/19 11:20 | 113.60 | 11.63 | 94.10 | 150.0568 | 6.87 | 6.20 | 0.033 | 0.000 | | 2.64 | 0.07 | | 0.817 |

| Stream Site ID | Date | Conductivity µS/cm @ 25C | Dissolved Oxygen (mg/L) | Dissolved Oxygen (% Sat) | Flow (ADV/EMV) cfs | PH (S.U.) | Temperature (C) | Ammonia (as N) mg/L | Un-ionized Ammonia (mg/L) | CBOD-5 mg/L | Chloride mg/L | Flouride mg/L | Nitrate & Nitrite (as N) mg/L | Nitrate (as N) mg/L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 11 | 3/23/18 13:50 | 209.00 | 13.47 | 116.00 | 13.13 | 8.23 | 8.81 | | | | 6.29 | | 1.16 | 1.22 |
| 11 | 4/19/18 14:30 | 192.00 | 13.15 | 119.00 | 93.15 | 8.52 | 10.90 | | | | 4.7 | 0.05 | 1 | 1.02 |
| 11 | 5/1/18 14:00 | 229.10 | 11.28 | 116.00 | 4.33 | 8.19 | 16.80 | | | | | | | |
| 11 | 5/8/18 13:30 | 201.40 | 9.85 | 102.80 | 8.32 | 7.97 | 16.90 | | | | | | | |
| 11 | 5/15/18 13:25 | 262.50 | 8.30 | 92.50 | 3.30 | 7.86 | 21.10 | | | | | | | |
| 11 | 5/22/18 14:30 | 265.30 | 7.55 | 84.40 | 2.79 | 7.88 | 20.30 | 0.038 | 0.001 | | 5.11 | 0.08 | 0.961 | 0.931 |
| 11 | 5/29/18 13:50 | 257.40 | 7.52 | 83.10 | 4.54 | 7.87 | 21.20 | | | | | | | |
| 11 | 6/19/18 14:10 | 275.60 | 7.67 | 92.70 | 1.55 | 7.82 | 24.90 | | | | | 0.09 | 0.907 | 0.938 |
| 11 | 7/10/18 14:00 | 258.00 | 8.26 | 96.90 | 1.90 | 7.82 | 23.52 | 0.027 | 0.001 | | 5.46 | 0.08 | 1.14 | 1.17 |
| 11 | 7/17/18 14:30 | 292.90 | 7.61 | 90.50 | 1.52 | 7.80 | 24.40 | 0.043 | 0.002 | | 4.58 | 0.08 | 0.729 | 0.749 |
| 11 | 8/9/18 14:10 | 255.10 | 6.55 | 76.40 | 1.63 | 7.88 | 23.30 | | | | 3.92 | 0.09 | 0.645 | 0.614 |
| 11 | 9/11/18 13:40 | 314.30 | 8.68 | 91.80 | 1.37 | 7.89 | 18.10 | | | | 5.14 | 0.10 | 0.456 | 0.486 |
| 11 | 10/18/18 14:00 | 246.40 | 9.94 | 92.40 | 5.45 | 8.16 | 12.70 | 0.037 | 0.001 | | 7.46 | 0.06 | 1.79 | 1.78 |
| 11 | 11/29/18 13:35 | 237.70 | 11.22 | 90.40 | 4.77 | 8.21 | 5.90 | | | | 6.68 | 0.06 | 1.74 | 1.77 |
| 11 | 1/17/19 13:40 | 194.40 | 15.29 | 126.60 | 8.86 | 8.04 | 7.20 | | | | 6.08 | 0.05 | 1.83 | 1.86 |
| 11 | 2/21/19 12:30 | 163.00 | 10.94 | 96.10 | 86.7748 | 7.55 | 9.70 | | | | 3.13 | 0.07 | 0.967 | 0.886 |
| 12 | 3/22/18 13:25 | 281.00 | 13.28 | 116.00 | 30.00 | 8.15 | 7.56 | | | | 7.16 | 0.08 | 1.56 | 1.46 |
| 12 | 4/19/18 13:00 | 286.00 | 12.37 | 113.00 | 26.90 | 7.99 | 11.29 | | | 2.160 | | 0.09 | 1.33 | 1.38 |
| 12 | 5/1/18 13:20 | 286.00 | 9.98 | 100.50 | 10.10 | 7.77 | 15.66 | | | | | | | |
| 12 | 5/8/18 12:25 | 303.00 | 9.50 | 98.10 | 12.66 | 7.67 | 16.86 | | | | | | | |
| 12 | 5/15/18 13:05 | 340.00 | 6.27 | 71.90 | 7.54 | 7.47 | 22.08 | | | | | | | |
| 12 | 5/22/18 12:45 | 316.00 | 5.77 | 65.50 | 5.90 | 7.59 | 21.57 | 0.106 | 0.002 | 2.340 | 5.09 | 0.09 | 0.596 | 0.586 |
| 12 | 5/29/18 12:30 | 325.00 | 5.97 | 68.60 | 7.84 | 7.49 | 22.22 | | | | | | | |
| 12 | 6/19/18 13:15 | 301.00 | 5.64 | 69.40 | 4.30 | 7.39 | 25.84 | 0.129 | 0.002 | | 5.49 | 0.12 | 0.496 | 0.476 |
| 12 | 7/12/18 10:30 | 298.00 | 5.78 | 67.50 | 4.58 | 7.41 | 23.08 | 0.144 | 0.002 | | 5.46 | 0.10 | 0.882 | 0.803 |
| 12 | 7/17/18 13:15 | 297.00 | 5.89 | 71.20 | 3.71 | 7.31 | 24.89 | 0.12 | 0.002 | | 5.39 | 0.10 | 0.715 | 0.646 |
| 12 | 8/9/18 13:35 | 251.00 | 6.10 | 72.10 | 10.63 | 7.27 | 23.68 | 0.118 | 0.001 | 2.510 | 4.56 | 0.11 | 1.5 | 1.8 |
| 12 | 9/11/18 12:45 | 290.80 | 6.33 | 69.30 | 3.59 | 7.61 | 19.80 | 0.085 | 0.002 | | 5.88 | 0.11 | 0.435 | 0.45 |
| 12 | 10/18/18 13:50 | 358.00 | 11.69 | 112.00 | 9.20 | 7.55 | 13.37 | 0.032 | 0.000 | | 6.7 | 0.10 | 1.86 | 1.95 |
| 12 | 11/29/18 13:00 | 305.20 | 12.70 | 101.20 | 12.50 | 7.64 | 5.70 | 0.087 | 0.001 | | 6.31 | 0.09 | 1.98 | 2.02 |
| 12 | 1/17/19 12:50 | 318.20 | 12.71 | 104.60 | 17.60 | 7.60 | 6.90 | | | | 5.87 | 0.09 | 1.9 | 1.96 |
| 12 | 2/21/19 12:15 | 227.40 | 11.21 | 95.80 | 226.3591 | 7.28 | 8.60 | 0.028 | 0.000 | | 4.65 | 0.07 | 2.07 | 2.22 |
| 13 | 3/22/18 15:00 | 267.00 | 13.65 | 118.20 | 24.20 | 8.36 | 8.96 | | | | 6.22 | 0.07 | 1.08 | 0.98 |
| 13 | 4/19/18 13:35 | 272.00 | 12.60 | 114.90 | 21.70 | 8.12 | 11.22 | | | 2.090 | 4.41 | 0.08 | 0.895 | 0.955 |
| 13 | 5/1/18 13:30 | 275.00 | 9.95 | 100.40 | 8.74 | 7.83 | 15.77 | | | | | | | |
| 13 | 5/8/18 12:40 | 288.00 | 10.00 | 103.50 | 11.39 | 7.73 | 16.94 | | | | | | | |
| 13 | 5/15/18 13:10 | 320.00 | 6.23 | 71.30 | 6.05 | 7.53 | 21.96 | | | | | | | |
| 13 | 5/22/18 13:20 | 307.00 | 5.33 | 60.50 | 6.02 | 7.64 | 21.59 | 0.172 | 0.004 | 2.370 | 4.78 | 0.10 | 0.606 | 0.568 |
| 13 | 5/29/18 12:45 | 317.00 | 5.88 | 67.60 | 7.16 | 7.56 | 22.21 | | | | | | | |
| 13 | 6/19/18 14:15 | 284.00 | 5.30 | 65.50 | 3.47 | 7.36 | 26.03 | 0.116 | 0.002 | | 5.28 | 0.10 | 0.483 | 0.473 |
| 13 | 7/12/18 11:45 | 281.00 | 5.24 | 61.50 | 4.02 | 7.43 | 23.37 | 0.152 | 0.002 | | 5.15 | 0.10 | 0.765 | 0.712 |
| 13 | 7/17/18 13:25 | 274.00 | 5.29 | 63.80 | 3.70 | 7.28 | 24.76 | 0.123 | 0.002 | | 5.07 | 0.10 | 0.684 | 0.599 |
| 13 | 8/9/18 14:15 | 255.00 | 5.95 | 66.80 | 5.21 | 7.28 | 24.26 | 0.136 | 0.002 | | 4.7 | 0.11 | 0.643 | 0.608 |
| 13 | 9/11/18 13:10 | 282.60 | 6.19 | 68.00 | 3.56 | 7.58 | 19.80 | 0.092 | 0.002 | | 5.78 | 0.11 | 0.448 | 0.453 |

| Stream Site ID | Date | Conductivity µS/cm @ 25C | Dissolved Oxygen (mg/L) | Dissolved Oxygen (% Sat) | Flow (ADV/EMV) cfs | PH (S.U.) | Temperature (C) | Ammonia (as N) mg/L | Un-ionized Ammonia (mg/L) | CBOD-5 mg/L | Chloride mg/L | Flouride mg/L | Nitrate & Nitrite (as N) mg/L | Nitrate (as N) mg/L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 13 | 10/18/18 14:00 | 348.00 | 11.26 | 108.10 | 7.63 | 7.62 | 13.51 | 0.094 | 0.001 | | 6.23 | 0.11 | 1.42 | 1.44 |
| 13 | 11/29/18 13:15 | 288.50 | 12.84 | 101.90 | 8.96 | 7.70 | 5.50 | 0.079 | 0.001 | | 5.26 | 0.09 | 1.29 | 1.3 |
| 13 | 1/17/19 13:10 | 305.90 | 12.47 | 102.30 | 14.92 | 7.71 | 6.80 | | | | 4.89 | 0.09 | 1.22 | 1.33 |
| 13 | 2/21/19 12:35 | 211.70 | 11.47 | 97.90 | 181.8693 | 7.38 | 8.50 | | | | 3.72 | 0.07 | 1.26 | 1.28 |
| 14 | 3/22/18 14:00 | 314.00 | 12.92 | 110.90 | 6.66 | 7.90 | 8.68 | | | | 9.46 | 0.07 | 3.33 | 3.04 |
| 14 | 4/19/18 14:10 | 327.00 | 12.61 | 116.60 | 6.30 | 7.82 | 11.82 | | | | 7.74 | 0.09 | 2.91 | 2.94 |
| 14 | 5/1/18 13:45 | 375.00 | 9.02 | 90.70 | 1.02 | 7.48 | 15.60 | | | | | | | |
| 14 | 5/8/18 13:00 | 374.00 | 6.95 | 71.60 | 1.22 | 7.32 | 16.73 | | | | | | | |
| 14 | 5/15/18 13:30 | 426.00 | 4.35 | 49.40 | 0.71 | 7.31 | 21.54 | | | | | | | |
| 14 | 5/22/18 13:00 | 413.00 | 3.72 | 41.80 | 0.38 | 7.37 | 21.10 | 0.143 | 0.002 | | 7.53 | 0.11 | 0.709 | 0.677 |
| 14 | 5/29/18 12:55 | 408.00 | 3.50 | 39.70 | 0.50 | 7.28 | 21.69 | | | | | | | |
| 14 | 6/19/18 13:45 | 420.00 | 4.12 | 49.80 | 0.29 | 7.34 | 24.90 | 0.123 | 0.002 | | 8.41 | 0.14 | 0.499 | 0.495 |
| 14 | 7/10/18 10:30 | 422.00 | 4.21 | 48.30 | 0.64 | 7.32 | 22.19 | 0.056 | 0.001 | | 7.81 | 0.12 | 1.91 | 1.89 |
| 14 | 7/17/18 13:55 | 421.00 | 4.58 | 54.40 | 0.37 | 7.26 | 23.86 | 0.059 | 0.001 | | 7.85 | 0.12 | 1.04 | 1.02 |
| 14 | 8/9/18 14:35 | 247.00 | 6.35 | 74.80 | 3.70 | 7.25 | 23.49 | 0.052 | 0.001 | | 4.74 | 0.11 | 2.04 | 2.05 |
| 14 | 9/11/18 13:25 | 408.80 | 4.53 | 48.80 | 0.14 | 7.38 | 19.00 | 0.057 | 0.001 | | 7.56 | 0.14 | 0.361 | 0.382 |
| 14 | 10/18/18 14:15 | 388.00 | 10.39 | 97.30 | 1.57 | 7.32 | 12.74 | 0.04 | 0.000 | | 8.32 | 0.11 | 3.56 | 3.57 |
| 14 | 11/29/18 13:40 | 347.20 | 11.96 | 96.80 | 5.03 | 7.59 | 6.30 | | | | 8.9 | 0.09 | 3.6 | 3.72 |
| 14 | 1/17/19 13:35 | 353.10 | 12.54 | 104.30 | 4.40 | 7.65 | 7.40 | | | | 8.74 | 0.08 | 3.49 | 3.69 |
| 14 | 2/21/19 12:55 | 249.40 | 10.28 | 89.70 | 61.4773 | 7.29 | 9.40 | 0.057 | 0.000 | | 5.98 | 0.08 | 3.4 | 3.52 |
| 15 | 3/22/18 18:30 | 267.00 | 13.35 | 121.80 | 16.29 | 8.67 | 11.28 | | | | 6.4 | 0.08 | 0.977 | 0.925 |
| 15 | 4/19/18 14:40 | 280.00 | 15.29 | 137.20 | 11.54 | 8.57 | 10.50 | | | | 4.48 | 0.08 | 0.817 | 0.837 |
| 15 | 5/1/18 12:40 | 305.40 | 13.53 | 136.30 | 5.19 | 8.40 | 15.80 | | | | | | | |
| 15 | 5/8/18 12:30 | 309.30 | 11.87 | 120.70 | 7.91 | 8.34 | 16.10 | | | | | | | |
| 15 | 5/15/18 12:05 | 356.30 | 9.54 | 108.10 | 3.07 | 8.08 | 22.30 | | | | | | | |
| 15 | 5/22/18 13:15 | 352.80 | 6.75 | 75.00 | 2.76 | 7.95 | 20.80 | 0.055 | 0.002 | | 5.46 | 0.11 | 0.886 | 0.897 |
| 15 | 5/29/18 12:35 | 333.20 | 9.51 | 108.80 | 4.23 | 8.03 | 22.00 | | | | | | | |
| 15 | 6/19/18 13:00 | 345.80 | 8.37 | 107.60 | 1.02 | 8.26 | 28.30 | 0.027 | 0.004 | | 7.11 | 0.12 | 1.04 | 1.05 |
| 15 | 7/11/18 13:30 | 346.00 | 11.21 | 141.80 | 1.93 | 8.14 | 27.42 | 0.035 | 0.004 | | 6.47 | 0.12 | 1.73 | 1.04 |
| 15 | 7/17/18 13:30 | 328.20 | 10.37 | 130.20 | 1.04 | 8.14 | 27.00 | 0.029 | 0.003 | | 6.6 | 0.13 | 0.776 | 0.781 |
| 15 | 8/9/18 13:10 | 313.90 | 9.32 | 109.50 | 2.32 | 8.08 | 23.80 | | | | | 0.11 | 0.812 | |
| 15 | 9/11/18 12:50 | 388.70 | 10.28 | 112.90 | 0.97 | 8.11 | 18.80 | | | | 8.36 | 0.17 | 0.511 | 0.537 |
| 15 | 10/18/18 13:00 | 398.50 | 10.57 | 98.00 | 3.96 | 7.98 | 11.90 | 0.07 | 0.002 | | | 0.10 | 1.69 | 1.77 |
| 15 | 11/29/18 12:45 | 340.80 | 13.02 | 102.90 | 4.28 | 8.12 | 5.40 | | | | 5.66 | 0.10 | 1.27 | 1.3 |
| 15 | 1/17/19 12:50 | 287.30 | 10.73 | 140.10 | 8.86 | 8.12 | 7.40 | | | | 4.9 | 0.08 | 1.25 | 1.28 |
| 15 | 2/21/19 12:00 | 219.90 | 11.08 | 97.70 | 121.3702 | 7.60 | 9.70 | | | | 3.64 | 0.07 | 1.32 | 1.3 |
| 16 | 3/22/18 17:45 | 261.00 | 12.58 | 114.40 | 6.69 | 8.50 | 11.15 | | | | 6.8 | 0.08 | 1.6 | 1.45 |
| 16 | 4/19/18 13:15 | 272.30 | 14.32 | 127.30 | 3.50 | 8.31 | 10.00 | | | 3.630 | 4.84 | 0.08 | 1.15 | 1.17 |
| 16 | 5/1/18 11:40 | 311.30 | 11.47 | 111.10 | 2.38 | 7.92 | 14.00 | | | | | | | |
| 16 | 5/3/18 10:30 | 309.00 | | | 1.22 | 7.80 | 17.86 | 0.053 | 0.001 | | 5.28 | 0.10 | 0.998 | 1.02 |
| 16 | 5/8/18 11:45 | 326.90 | 8.78 | 88.00 | 1.71 | 7.82 | 15.60 | | | | | | | |
| 16 | 5/15/18 11:20 | 361.40 | 5.23 | 58.30 | 1.03 | 7.63 | 20.50 | | | | | | | |
| 16 | 5/22/18 12:15 | 352.10 | 7.31 | 81.40 | 0.89 | 7.66 | 20.60 | 0.027 | 0.001 | | 6.6 | 0.11 | 1.19 | 1.2 |
| 16 | 5/29/18 12:00 | 337.50 | 7.04 | 78.90 | 1.52 | 7.62 | 20.60 | | | | | | | |

| Stream Site ID | Date | Conductivity µS/cm @ 25C | Dissolved Oxygen (mg/L) | Dissolved Oxygen (% Sat) | Flow (ADV/EMV) cfs | PH (S.U.) | Temperature (C) | Ammonia (as N) mg/L | Un-ionized Ammonia (mg/L) | CBOD-5 mg/L | Chloride mg/L | Flouride mg/L | Nitrate & Nitrite (as N) mg/L | Nitrate (as N) mg/L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 16 | 6/19/18 12:00 | 377.90 | 5.81 | 69.50 | 0.22 | 7.60 | 24.40 | | | | 6.78 | 0.12 | 1.27 | 1.3 |
| 16 | 7/17/18 12:50 | 364.00 | 6.10 | 71.90 | 0.21 | 7.53 | 23.60 | | | | 6.22 | 0.12 | 1.13 | 1.13 |
| 16 | 8/9/18 12:20 | 294.30 | 7.46 | 85.10 | 1.73 | 7.65 | 21.80 | | | | 5.46 | 0.11 | 1.61 | 1.67 |
| 16 | 9/11/18 11:55 | 388.00 | 7.98 | 84.80 | 0.18 | 7.70 | 18.30 | | | | 6.52 | 0.13 | 0.667 | 0.683 |
| 16 | 10/18/18 12:10 | 361.70 | 8.76 | 82.30 | 1.31 | 7.90 | 12.60 | 0.03 | 0.001 | | 7.34 | 0.11 | 2.31 | 2.42 |
| 16 | 11/29/18 11:45 | 333.40 | 12.28 | 96.20 | 1.81 | 7.99 | 5.60 | | | | 6.03 | 0.09 | 1.71 | 1.73 |
| 16 | 1/17/19 11:50 | 310.20 | 13.98 | 115.40 | 2.40 | 7.87 | 7.00 | | | | 5.58 | 0.08 | 1.63 | 1.7 |
| 16 | 2/21/19 11:25 | 206.80 | 11.11 | 96.10 | 46.085 | 7.53 | 8.90 | | | | 3.97 | 0.08 | 1.63 | 1.61 |
| 17 | 3/22/18 17:00 | 266.00 | 13.12 | 126.90 | 5.66 | 8.79 | 13.81 | | | | 9.24 | 0.07 | 4.438 | 4.12 |
| 17 | 4/19/18 11:55 | 292.20 | 14.77 | 129.70 | 2.89 | 8.61 | 9.60 | | | 4.540 | 8.04 | 0.07 | 3.77 | 3.76 |
| 17 | 5/1/18 11:00 | 346.30 | 12.15 | 122.60 | 0.92 | 8.20 | 15.80 | | | | | | | |
| 17 | 5/3/18 13:45 | 316.00 | 10.68 | 124.60 | 0.88 | 8.13 | 23.27 | 0.147 | 0.011 | | 9.04 | 0.09 | 3.29 | 3.41 |
| 17 | 5/8/18 10:50 | 361.40 | 10.40 | 109.90 | 0.97 | 8.11 | 17.90 | | | | | | | |
| 17 | 5/15/18 10:45 | 412.20 | 9.49 | 110.00 | 0.42 | 7.99 | 22.50 | | | | | | | |
| 17 | 5/22/18 11:25 | 357.30 | 8.04 | 93.10 | 0.49 | 7.85 | 22.60 | 0.789 | 0.031 | 2.750 | 9.67 | 0.11 | 3.44 | 3.08 |
| 17 | 5/29/18 11:00 | 331.40 | 7.44 | 86.10 | 1.60 | 7.67 | 22.50 | | | | | | | |
| 17 | 6/19/18 11:10 | 408.80 | 7.75 | 95.10 | 0.25 | 7.77 | 25.90 | 0.161 | 0.007 | 2.270 | 12.2 | 0.11 | 2.99 | 2.86 |
| 17 | 7/17/18 11:20 | 360.80 | 9.26 | 113.10 | 0.24 | 7.77 | 25.50 | 0.033 | 0.001 | | 9.94 | 0.11 | 3.03 | 3.04 |
| 17 | 8/9/18 11:10 | 321.90 | 8.42 | 95.50 | 3.25 | 7.76 | 21.80 | 0.037 | 0.001 | 2.830 | 6.35 | 0.09 | 4.61 | 4.72 |
| 17 | 9/11/18 10:55 | 421.70 | 9.13 | 96.30 | 0.22 | 7.83 | 17.10 | 0.049 | 0.001 | | 9.95 | 0.12 | 2.85 | 2.75 |
| 17 | 10/18/18 11:20 | 359.10 | 11.65 | 109.30 | 1.81 | 7.93 | 12.50 | 0.037 | 0.001 | | 9.14 | 0.10 | 4.15 | 4.3 |
| 17 | 11/29/18 11:00 | 340.30 | 12.87 | 102.50 | 1.27 | 8.19 | 6.00 | | | | | 0.08 | 4.1 | 4.18 |
| 17 | 1/17/19 10:00 | 325.10 | 17.60 | 145.60 | 1.61 | 8.05 | 7.20 | | | | 8.88 | 0.08 | 4.26 | 4.23 |
| 17 | 2/21/19 10:45 | 233.00 | 11.45 | 100.80 | 39.2077 | 7.51 | 9.70 | | | | 6.27 | 0.07 | 3.83 | 3.94 |
| 18 | 3/22/18 16:15 | 213.00 | 11.40 | 105.20 | 6.99 | 7.83 | 11.97 | | | | 10.3 | 0.06 | 3.41 | 3.14 |
| 18 | 4/19/18 11:00 | 269.20 | 13.30 | 115.90 | 4.44 | 8.32 | 9.20 | | | 3.870 | 8.61 | 0.06 | 3.07 | 3.11 |
| 18 | 4/24/18 10:30 | 280.00 | 12.87 | 121.40 | 3.67 | 8.10 | 12.69 | | | | 9.04 | 0.09 | 2.78 | |
| 18 | 5/1/18 10:20 | 320.90 | 11.99 | 114.90 | 2.07 | 8.22 | 13.40 | | | | | | | |
| 18 | 5/8/18 10:10 | 330.00 | 10.49 | 104.90 | 2.22 | 8.06 | 15.30 | | | | | | | |
| 18 | 5/15/18 10:05 | 377.60 | 9.45 | 103.70 | 1.33 | 7.97 | 19.80 | | | | | | | |
| 18 | 5/22/18 10:15 | 312.40 | 8.66 | 95.00 | 1.78 | 7.80 | 19.80 | 0.309 | 0.009 | 2.940 | | 0.11 | | |
| 18 | 5/29/18 10:10 | 294.00 | 9.07 | 97.90 | 3.09 | 7.56 | 19.00 | | | | | | | |
| 18 | 6/19/18 10:15 | 371.50 | 7.83 | 91.60 | 0.77 | 7.97 | 23.10 | 0.072 | 0.004 | | 8.16 | 0.10 | 2.65 | 2.54 |
| 18 | 7/17/18 10:20 | 352.00 | 9.36 | 109.00 | 0.71 | 8.11 | 23.20 | | | | 7.62 | 0.09 | 2.37 | 2.37 |
| 18 | 8/9/18 10:20 | 297.40 | 8.82 | 98.50 | 2.37 | 7.61 | 20.90 | 0.034 | 0.001 | | 6.56 | 0.09 | 2.07 | 2.17 |
| 18 | 9/11/18 9:55 | 382.50 | 10.16 | 105.60 | 0.53 | 7.94 | 16.80 | | | | 7.6 | 0.12 | 1.94 | 2 |
| 18 | 10/18/18 10:20 | 324.40 | 10.44 | 94.70 | 2.14 | 8.08 | 10.90 | | | | 11.1 | 0.09 | 4.16 | 4.16 |
| 18 | 11/29/18 10:05 | | 12.10 | 98.40 | 2.93 | 8.24 | 6.20 | | | | 10.3 | 0.06 | 3.93 | 3.96 |
| 18 | 1/17/19 9:00 | 282.80 | 11.74 | 98.30 | 3.80 | 8.02 | 7.60 | | | | 10.1 | 0.07 | 3.92 | 4.09 |
| 18 | 2/21/19 10:15 | 195.20 | 11.74 | 99.00 | 46.7173 | 7.47 | 7.90 | 0.114 | 0.001 | | 7 | 0.06 | 3.4 | 3.38 |

| Stream Site ID | Date | Nitrite (as N) mg/L | Organic Carbon, Total (TOC) mg/L | Orthophosphate Lab (as P) mg/L | Orthophosphate Field (as P) mg/L | Phosphorus, Total (as P) mg/L | Solids, Total Dissolved mg/L | Solids, Total Suspended mg/L | Total Kjeldhal Nitrogen (as N) mg/L | Turbidity NTU | E. coli MPN/100mL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3/22/18 9:50 | | 1.49 | | 0.02 | | 179 | 11 | 0.247 | 11.1 | |
| 1 | 4/19/18 9:50 | 0.015 | 1.36 | | | 0.014 | 174 | 12 | 0.288 | 13.4 | |
| 1 | 5/1/18 10:30 | | | | | | | | | | 102.00 |
| 1 | 5/8/18 9:45 | | | | | | | | | | 687.00 |
| 1 | 5/15/18 10:00 | | | | | | | | | | 8.00 |
| 1 | 5/22/18 9:45 | 0.018 | 1.4 | 0.036 | 0.028 | | 213 | 15.5 | 0.258 | 10.7 | 155.00 |
| 1 | 5/29/18 10:00 | | | | | | | | | | 488.00 |
| 1 | 6/19/18 10:20 | | 1.23 | 0.05 | 0.019 | 0.075 | 233 | 14.5 | | 9.24 | 99.00 |
| 1 | 7/17/18 10:25 | | | | | | | | | | 152.00 |
| 1 | 8/9/18 10:00 | | 5.87 | 0.181 | 0.18 | 0.326 | 156 | 72 | 0.842 | 60.3 | 7,270.00 |
| 1 | 10/18/18 10:30 | 0.015 | 1.96 | 0.037 | 0.037 | 0.053 | 203 | 12.5 | | 11.5 | 299.00 |
| 1 | 11/29/18 10:15 | 0.019 | 0.9 | 0.028 | 0.026 | 0.021 | 202 | 10 | 0.338 | 7.66 | |
| 1 | 1/17/19 9:45 | 0.019 | 1.09 | 0.018 | | 0.04 | 177 | | | 7.8 | |
| 1 | 2/21/19 9:45 | | 2.32 | | 0.014 | 0.14 | 131 | 82 | 0.666 | 67.5 | |
| 1 | 4/24/19 10:35 | | 1.22 | 0.035 | 0.03 | 0.034 | 202 | 51 | | 13.6 | |
| 1 | 5/20/19 11:00 | 0.044 | 1.36 | 0.011 | 0.031 | 0.08 | 201 | 22 | | 10.5 | |
| 1 | 6/19/19 10:45 | 0.033 | 2.37 | 0.045 | 0.031 | 0.188 | 174 | 79.5 | 0.326 | 44.3 | |
| 1 | 6/26/19 12:15 | | 1.91 | | | 0.071 | 187 | 30.5 | 0.358 | 15.7 | |
| 1 | 7/23/19 12:10 | | 1.52 | 0.069 | 0.077 | | 214 | 22 | | 12 | |
| 1 | 8/28/19 12:00 | | 1.77 | | 0.017 | 0.067 | 216 | 6 | | 6.56 | |
| 1 | 9/26/19 12:30 | | 3 | 0.083 | 0.051 | 0.12 | 199 | 11 | 0.292 | 5.54 | |
| 1 | 10/29/19 12:20 | | 2.43 | 0.069 | 0.131 | 0.132 | 234 | | | 3.35 | |
| 1 | 11/21/19 12:10 | | 1.23 | 0.01 | | 0.059 | 241 | 7 | | 5.69 | |
| 1 | 12/11/19 12:50 | | 1.6 | | 0.013 | 0.056 | 182 | 18 | 0.249 | 12.3 | |
| 1 | 3/5/20 13:00 | | 1.11 | | 0.012 | 0.062 | 182 | 34 | 0.627 | 20.4 | |
| 2 | 3/22/18 10:30 | | 1.74 | | | | 168 | 5 | 0.37 | 6.7 | |
| 2 | 4/19/18 10:25 | 0.016 | 1.6 | | | 0.015 | 163 | 7 | | 6.94 | |
| 2 | 5/1/18 10:50 | | | | | | | | | | 130.00 |
| 2 | 5/8/18 10:10 | | | | | | | | | | 345.00 |
| 2 | 5/15/18 10:20 | | | | | | | | | | 167.00 |
| 2 | 5/22/18 10:10 | 0.027 | 1.55 | 0.018 | 0.025 | 0.069 | 208 | 8.5 | 0.389 | 4.77 | 261.00 |
| 2 | 5/29/18 10:20 | | | | | | | | | | 261.00 |
| 2 | 6/19/18 10:50 | 0.028 | 1.66 | | 0.015 | 0.035 | 229 | 4 | 0.236 | 4.22 | 411.00 |
| 2 | 7/17/18 11:00 | 0.024 | 1.42 | | 0.02 | 0.014 | 218 | 2.5 | 0.862 | 1.93 | 980.00 |
| 2 | 8/9/18 10:30 | 0.016 | 6.23 | 0.203 | 0.205 | 0.246 | 145 | 35 | 0.749 | 105 | 3,968.00 |
| 2 | 10/18/18 11:00 | 0.018 | 2.59 | 0.033 | 0.023 | 0.051 | 190 | 7.5 | 0.241 | 7.44 | 687.00 |
| 2 | 11/29/18 10:40 | 0.024 | 1.3 | | 0.017 | 0.019 | 187 | 2 | | 3.83 | |
| 2 | 1/17/19 10:10 | 0.02 | 1.28 | | 0.01 | 0.038 | 157 | 3.5 | | 4.7 | |
| 2 | 2/21/19 10:00 | | 2.31 | 0.027 | 0.016 | 0.152 | 121 | 74 | 0.886 | 65.6 | |
| 2 | 4/24/19 10:50 | 0.026 | 1.43 | | 0.027 | 0.033 | 168 | 14.5 | | 8.48 | |
| 2 | 5/20/19 11:30 | 0.041 | 1.68 | 0.017 | 0.025 | 0.067 | 194 | 3.5 | 0.207 | 3.03 | |
| 2 | 6/19/19 11:10 | 0.056 | 2.62 | 0.028 | | 0.122 | 168 | 34.5 | | 13.6 | |
| 2 | 6/26/19 12:25 | | 2.17 | | | 0.077 | 177 | 25.5 | 0.336 | 15.3 | |

| Stream Site ID | Date | Nitrite (as N) mg/L | Organic Carbon, Total (TOC) mg/L | Orthophosphate Lab (as P) mg/L | Orthophosphate Field (as P) mg/L | Phosphorus, Total (as P) mg/L | Solids, Total Dissolved mg/L | Solids, Total Suspended mg/L | Total Kjeldhal Nitrogen (as N) mg/L | Turbidity NTU | E. coli MPN/100mL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 7/23/19 12:30 | 0.018 | 1.67 | 0.034 | | | 213 | 3.5 | | 2.59 | |
| 2 | 12/11/19 13:25 | | 2.04 | 0.012 | | 0.052 | 161 | 4 | 0.236 | 7.39 | |
| 2 | 3/5/20 13:15 | | 1.41 | | 0.011 | 0.06 | 283 | 13 | 0.789 | 14 | |
| 3 | 4/24/19 11:10 | | 0.815 | | 0.042 | 0.043 | 242 | 42 | | 22.7 | |
| 3 | 5/20/19 11:20 | | 1.06 | 0.047 | 0.015 | 0.081 | 210 | 42 | | 13.5 | |
| 3 | 6/19/19 10:55 | 0.021 | 2.32 | 0.056 | | 0.158 | 167 | 94 | | 57.1 | |
| 3 | 6/26/19 12:30 | | 1.03 | | 0.014 | 0.075 | 216 | 47 | | 26.4 | |
| 3 | 7/23/19 12:20 | | 0.115 | | | | | | | | |
| 3 | 8/28/19 12:20 | | 1.84 | | 0.017 | 0.064 | 129 | 6 | | 6.21 | |
| 3 | 9/26/19 12:50 | | | 0.082 | 0.042 | 0.096 | 204 | 9 | | | |
| 3 | 10/29/19 12:00 | | 2.49 | 0.13 | 0.079 | 0.13 | 237 | 3 | 0.393 | 3.43 | |
| 3 | 11/21/19 11:50 | | 1.03 | | 0.01 | 0.059 | 246 | 2 | | 5.87 | |
| 3 | 12/11/19 13:15 | | 1 | | 0.013 | 0.066 | 212 | 37 | | 20.2 | |
| 3 | 3/5/20 13:30 | | 0.686 | | 0.02 | 0.071 | 220 | 32 | 0.469 | 21.6 | |
| 4 | 5/20/19 17:00 | 0.081 | 2.22 | 0.15 | 0.061 | 0.19 | 163 | 33 | 0.634 | 12.6 | |
| 4 | 6/26/19 13:50 | | 2.35 | | | 0.07 | 164 | 17.5 | 1.04 | 11.5 | |
| 4 | 7/23/19 14:30 | 0.033 | 2.47 | 0.076 | | 0.091 | 176 | 6 | 0.259 | 5.21 | |
| 5 | 3/22/18 11:45 | | 1.9 | | 0.073 | | 152 | 4 | 0.274 | 5.74 | |
| 5 | 4/19/18 11:15 | 0.017 | 1.82 | | | 0.012 | 144 | 5.5 | 0.296 | 7.21 | |
| 5 | 5/1/18 11:10 | | | | | | | | | | 461.00 |
| 5 | 5/8/18 10:40 | | | | | | | | | | 548.00 |
| 5 | 5/15/18 11:10 | | | | | | | | | | 548.00 |
| 5 | 5/22/18 10:45 | 0.071 | 2.63 | 0.13 | 0.11 | 0.146 | 180 | | 1.02 | 7.43 | 488.00 |
| 5 | 5/29/18 10:45 | | | | | | | | | | 770.00 |
| 5 | 6/19/18 11:25 | 0.046 | 2.54 | 0.222 | 0.118 | 0.154 | 187 | 6.5 | 0.332 | 5.03 | 225.00 |
| 5 | 7/17/18 11:40 | 0.035 | 2.9 | 0.098 | 0.094 | 0.131 | 173 | 8.5 | 0.371 | 7.19 | 345.00 |
| 5 | 8/9/18 11:30 | 0.021 | 6 | 0.175 | 0.18 | 0.176 | 139 | 21 | 0.842 | 32.4 | 2,064.00 |
| 5 | 9/11/18 10:30 | 0.034 | | 0.207 | 0.185 | 0.217 | 184 | 11.5 | 0.382 | | 276.00 |
| 5 | 10/18/18 11:50 | 0.022 | 3 | 0.03 | 0.021 | 0.059 | 175 | 6.5 | 0.418 | 8.11 | 461.00 |
| 5 | 11/29/18 11:10 | 0.024 | 1.43 | | 0.02 | 0.024 | 176 | 2 | | 5.23 | |
| 5 | 1/17/19 11:10 | 0.023 | | 0.013 | | 0.041 | 136 | 3.5 | | 5.56 | |
| 5 | 2/21/19 10:45 | | 1.43 | 0.047 | 0.011 | 0.118 | 173 | 54.5 | 0.318 | 48.3 | |
| 5 | 4/24/19 12:20 | | | | 0.025 | | 193 | 11 | | 8.02 | |
| 5 | 5/20/19 13:00 | 0.079 | 2.22 | 0.133 | 0.045 | 0.189 | 167 | 9.5 | 0.618 | 5.25 | |
| 5 | 6/26/19 14:10 | | 2.43 | | | 0.069 | 159 | 18 | 0.45 | 12.8 | |
| 5 | 7/23/19 14:00 | 0.035 | 2.51 | 0.071 | | 0.099 | 179 | 17 | 0.257 | 9.33 | |
| 5 | 8/28/19 14:00 | | 3.32 | | 0.041 | 0.193 | 157 | 38 | | 16.3 | |
| 5 | 9/26/19 14:30 | 0.016 | 5.57 | 0.078 | 0.146 | 0.289 | 131 | 14 | 0.828 | 10.2 | |
| 5 | 10/29/19 13:30 | 0.035 | | 0.115 | 0.091 | 0.139 | 176 | 6 | 0.422 | | |
| 6 | 5/1/18 14:20 | | 4.42 | | 1.65 | 2.87 | 321 | 7 | | 4.07 | |
| 6 | 5/8/18 13:30 | 0.02 | 3.86 | 1.43 | | 1.46 | 228 | 4 | 0.693 | 3.72 | |
| 6 | 5/22/18 11:20 | 0.042 | | 2.49 | 2.3 | 2.5 | 264 | 2 | 1.04 | | |
| 6 | 6/19/18 11:55 | 0.091 | 4.63 | 3.48 | 3.44 | 3.4 | 322 | 2.5 | 0.33 | 2.04 | |
| 6 | 7/17/18 12:20 | 0.048 | 4.44 | 3.16 | 3.02 | 3.09 | 556 | | | 1.39 | |

| Stream Site ID | Date | Nitrite (as N) mg/L | Organic Carbon, Total (TOC) mg/L | Orthophosphate Lab (as P) mg/L | Orthophosphate Field (as P) mg/L | Phosphorus, Total (as P) mg/L | Solids, Total Dissolved mg/L | Solids, Total Suspended mg/L | Total Kjeldhal Nitrogen (as N) mg/L | Turbidity NTU | E. coli MPN/100mL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 6 | 8/9/18 12:35 | 0.018 | 4.55 | 3.2 | 2.25 | 3.04 | 302 | 3.5 | | 2.84 | |
| 6 | 9/11/18 12:15 | 0.031 | 3.88 | 1.85 | 2.61 | 2.64 | 324 | 3.5 | | 1.9 | |
| 6 | 10/18/18 12:30 | 0.023 | 3.76 | 1.54 | 1.42 | 1.49 | 169 | 4.5 | 0.496 | 1.94 | |
| 6 | 11/29/18 11:45 | | 2.7 | 1.22 | 1.07 | 1.4 | 288 | 14 | 0.612 | 6.97 | |
| 6 | 1/17/19 11:45 | 0.042 | 3.77 | 1.42 | 1.36 | 1.85 | 229 | 22 | 0.974 | 10.6 | |
| 6 | 5/20/19 14:20 | | 4.22 | 2.01 | 3.17 | 3.36 | 291 | 2 | | 0.996 | |
| 6 | 7/23/19 10:20 | | 3.46 | | 1.44 | 1.62 | 255 | | | 1.33 | |
| 6 | 8/28/19 10:00 | | 3.69 | | 1.15 | 1.81 | 254 | 3.5 | | 1.22 | |
| 6 | 9/26/19 11:00 | 0.036 | 4.91 | 4.17 | 3.28 | 4.23 | 357 | 6 | | 3.15 | |
| 6 | 10/29/19 10:35 | 0.017 | 4.03 | 1.87 | 1.29 | 1.71 | 301 | 5 | 0.234 | 2.56 | |
| 6 | 11/21/19 10:30 | | 3.69 | 1.95 | | | 356 | 19 | | 8.07 | |
| 7 | 4/24/19 13:15 | | 1.61 | | | | 161 | 5.5 | | 6.31 | |
| 7 | 5/20/19 14:40 | 0.035 | 2.07 | | | 0.052 | 161 | 9.5 | 0.339 | 6.98 | |
| 7 | 6/26/19 10:20 | | 2.69 | | | 0.057 | 154 | 21 | 0.454 | 12.5 | |
| 7 | 7/23/19 10:45 | 0.039 | 2.47 | 0.026 | | 0.051 | 169 | 14.5 | 0.218 | 11.7 | |
| 7 | 8/20/19 12:30 | 0.016 | 4.19 | | | 0.05 | 135 | 9 | 1.04 | 9.68 | |
| 7 | 8/28/19 10:30 | | 3.62 | | | 0.038 | 164 | 2.5 | | 10.7 | |
| 7 | 9/26/19 11:30 | | 5.68 | | | 0.084 | 122 | 10 | 0.702 | 13.9 | |
| 7 | 10/29/19 10:45 | 0.019 | 4.47 | | | 0.044 | 180 | 10 | 0.256 | 6.96 | |
| 7 | 11/21/19 10:35 | | 2.88 | | | 0.029 | 213 | | 0.216 | 5.23 | |
| 7 | 12/11/19 11:15 | | 2.39 | | | 0.033 | 137 | | | 9.47 | |
| 7 | 3/5/20 11:15 | | 1.51 | | | 0.047 | 147 | 10 | 1.14 | 14.1 | |
| 9 | 4/24/19 13:55 | | 1.66 | | | 0.011 | 94 | 8 | | 6.96 | |
| 9 | 5/20/19 15:55 | 0.059 | 2.1 | | 0.019 | 0.049 | 162 | 5 | 0.315 | 5.76 | |
| 9 | 6/26/19 11:20 | | | | | 0.054 | 164 | | 0.506 | | |
| 9 | 7/23/19 11:30 | 0.061 | 2.72 | 0.026 | | 0.049 | 164 | 12 | | 10.4 | |
| 9 | 8/28/19 11:15 | | 4.08 | | | 0.051 | 153 | 8 | | 9.05 | |
| 9 | 3/5/20 11:45 | | 1.46 | | | 0.042 | 144 | 10 | 0.842 | 13.8 | |
| 10 | 3/23/18 13:00 | | 1.92 | | 0.022 | 0.01 | 123 | 5 | 0.379 | | |
| 10 | 4/19/18 12:10 | 0.018 | 2.3 | | | | 120 | 4 | 0.238 | 7.43 | |
| 10 | 5/1/18 12:00 | | | | | | | | | | 167.00 |
| 10 | 5/8/18 11:30 | | | | | | | | | | 345.00 |
| 10 | 5/15/18 12:10 | | | | | | | | | | 225.00 |
| 10 | 5/22/18 11:45 | 0.056 | 3 | | 0.01 | 0.024 | 149 | 7.5 | 0.617 | 6.64 | 435.00 |
| 10 | 5/29/18 11:30 | | | | | | | | | | 816.00 |
| 10 | 6/19/18 12:25 | 0.063 | 3.2 | | | 0.039 | 256 | 5.5 | 0.367 | 4.88 | 866.00 |
| 10 | 7/11/18 10:30 | 0.098 | 3.66 | | | 0.063 | 151 | 12 | 0.506 | 7.7 | |
| 10 | 7/17/18 12:35 | 0.074 | 3.77 | | 0.016 | 0.067 | 161 | 5 | 0.391 | 6.8 | 1,046.00 |
| 10 | 8/9/18 12:30 | 0.046 | 3.95 | | 0.01 | 0.067 | 154 | 7 | | 9.22 | 426.00 |
| 10 | 9/11/18 11:20 | 0.085 | 3.7 | | | 0.043 | 165 | 9 | 0.522 | 8 | 579.00 |
| 10 | 10/18/18 12:50 | 0.023 | 3.75 | | | 0.036 | 257 | 8 | 0.574 | 8.1 | 461.00 |
| 10 | 11/29/18 12:00 | 0.023 | 1.67 | 0.01 | | | 137 | | | 5.13 | |
| 10 | 1/17/19 12:00 | 0.021 | 1.69 | | | 0.027 | 106 | | | 6.62 | |
| 10 | 2/21/19 11:20 | | 2.64 | | 0.015 | 0.137 | 103 | 71.5 | 0.654 | 79.7 | |

| Stream Site ID | Date | Nitrite (as N) mg/L | Organic Carbon, Total (TOC) mg/L | Orthophosphate Lab (as P) mg/L | Orthophosphate Field (as P) mg/L | Phosphorus, Total (as P) mg/L | Solids, Total Dissolved mg/L | Solids, Total Suspended mg/L | Total Kjeldhal Nitrogen (as N) mg/L | Turbidity NTU | E. coli MPN/100mL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 11 | 3/23/18 13:50 | | | | | | 122 | 2 | 0.201 | | |
| 11 | 4/19/18 14:30 | 0.015 | 1.11 | | | | 112 | | | 2.59 | |
| 11 | 5/1/18 14:00 | | | | | | | | | | 109.00 |
| 11 | 5/8/18 13:30 | | | | | | | | | | 248.00 |
| 11 | 5/15/18 13:25 | | | | | | | | | | 185.00 |
| 11 | 5/22/18 14:30 | 0.024 | 1.59 | | | 0.021 | 155 | 7 | 0.514 | 2.55 | 261.00 |
| 11 | 5/29/18 13:50 | | | | | | | | | | 770.00 |
| 11 | 6/19/18 14:10 | 0.017 | | | 0.028 | 0.028 | 170 | | | 2 | 238.00 |
| 11 | 7/10/18 14:00 | 0.02 | 1.19 | | | 0.014 | 162 | | 0.215 | 1.47 | |
| 11 | 7/17/18 14:30 | 0.018 | 1.69 | | 0.01 | | 172 | | 0.302 | 3.47 | 435.00 |
| 11 | 8/9/18 14:10 | | 2.83 | | 0.01 | 0.015 | 158 | 2.5 | | 4.79 | 450.00 |
| 11 | 9/11/18 13:40 | | 1.76 | | | 0.013 | 188 | | | 1.35 | 157.00 |
| 11 | 10/18/18 14:00 | 0.015 | 1.48 | | | | 143 | | | 1.78 | 613.00 |
| 11 | 11/29/18 13:35 | | 0.651 | | | 0.026 | 131 | | | 1.97 | |
| 11 | 1/17/19 13:40 | | 0.829 | | | 0.058 | 98 | 7.5 | | 3.46 | |
| 11 | 2/21/19 12:30 | | 1.26 | | | 0.022 | 120 | 9.5 | 0.249 | 15.5 | |
| 12 | 3/22/18 13:25 | | 1.88 | | 0.013 | | 163 | 3.5 | | 7.82 | |
| 12 | 4/19/18 13:00 | 0.012 | | | | | 156 | 4 | | 5.31 | |
| 12 | 5/1/18 13:20 | | | | | | | | | | 291.00 |
| 12 | 5/8/18 12:25 | | | | | | | | | | 579.00 |
| 12 | 5/15/18 13:05 | | | | | | | | | | 517.00 |
| 12 | 5/22/18 12:45 | 0.051 | 2.82 | | | 0.034 | 175 | 9 | 0.682 | 8.95 | 1,120.00 |
| 12 | 5/29/18 12:30 | | | | | | | | | | 2,420.00 |
| 12 | 6/19/18 13:15 | 0.038 | 2.39 | | | 0.023 | 210 | 6.5 | 0.334 | 5.11 | 488.00 |
| 12 | 7/12/18 10:30 | 0.062 | 2.57 | | | 0.023 | 172 | 6 | 0.277 | 6.7 | |
| 12 | 7/17/18 13:15 | 0.057 | 2.74 | | | 0.012 | 168 | | 0.311 | 5.77 | 727.00 |
| 12 | 8/9/18 13:35 | 0.016 | 5.3 | 0.086 | 0.089 | 0.121 | 153 | 24 | 0.871 | 28.1 | 1,918.00 |
| 12 | 9/11/18 12:45 | 0.034 | 3.82 | | | 0.017 | 172 | 7 | 0.387 | 6.11 | 186.00 |
| 12 | 10/18/18 13:50 | 0.023 | 2.15 | | 0.024 | | 323 | 2 | | 2.96 | 172.00 |
| 12 | 11/29/18 13:00 | 0.026 | 1.15 | | 0.011 | | 197 | 3 | | 3.26 | |
| 12 | 1/17/19 12:50 | 0.023 | 1.13 | | | 0.013 | 166 | | | 2.93 | |
| 12 | 2/21/19 12:15 | | 1.66 | 0.031 | 0.01 | 0.064 | 157 | 29.5 | 0.242 | 25.3 | |
| 13 | 3/22/18 15:00 | | 1.73 | | | | 154 | 3.5 | 0.278 | 7.19 | |
| 13 | 4/19/18 13:35 | 0.016 | 1.56 | | | 0.058 | 151 | 5 | | 6.7 | |
| 13 | 5/1/18 13:30 | | | | | | | | | | 435.00 |
| 13 | 5/8/18 12:40 | | | | | | | | | | 770.00 |
| 13 | 5/15/18 13:10 | | | | | | | | | | 461.00 |
| 13 | 5/22/18 13:20 | 0.04 | 2.94 | | | 0.029 | 165 | 13 | 0.76 | 10.3 | 980.00 |
| 13 | 5/29/18 12:45 | | | | | | | | | | 2,420.00 |
| 13 | 6/19/18 14:15 | 0.04 | 2.46 | | | 0.025 | 176 | 5.5 | 0.318 | 4.9 | 461.00 |
| 13 | 7/12/18 11:45 | 0.069 | 2.68 | | | 0.024 | 163 | 9 | 0.364 | 7.27 | |
| 13 | 7/17/18 13:25 | 0.062 | 2.86 | | | 0.013 | 316 | 6.5 | 0.308 | 5.77 | 435.00 |
| 13 | 8/9/18 14:15 | 0.027 | 5 | | | 0.049 | 154 | 12 | 0.546 | 15 | 193.00 |
| 13 | 9/11/18 13:10 | 0.029 | 3.79 | | | | 172 | 5 | 0.482 | 6.71 | 157.00 |

| Stream Site ID | Date | Nitrite (as N) mg/L | Organic Carbon, Total (TOC) mg/L | Orthophosphate Lab (as P) mg/L | Orthophosphate Field (as P) mg/L | Phosphorus, Total (as P) mg/L | Solids, Total Dissolved mg/L | Solids, Total Suspended mg/L | Total Kjeldhal Nitrogen (as N) mg/L | Turbidity NTU | E. coli MPN/100mL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 13 | 10/18/18 14:00 | 0.027 | 2.24 | | | | 379 | 2 | 0.388 | 2.8 | 179.00 |
| 13 | 11/29/18 13:15 | 0.025 | 1.38 | | 0.011 | | 181 | 2 | 0.214 | 3.97 | |
| 13 | 1/17/19 13:10 | 0.021 | 1.2 | | | 0.018 | 159 | 2 | | 4.03 | |
| 13 | 2/21/19 12:35 | | 1.71 | | | 0.049 | 151 | 27 | | 23.4 | |
| 14 | 3/22/18 14:00 | 0.018 | 2.21 | 0.011 | | | 192 | | 0.404 | 9.56 | |
| 14 | 4/19/18 14:10 | 0.024 | 1.24 | | | 0.016 | 185 | 2.5 | | 3.57 | |
| 14 | 5/1/18 13:45 | | | | | | | | | | 57.00 |
| 14 | 5/8/18 13:00 | | | | | | | | | | 61.00 |
| 14 | 5/15/18 13:30 | | | | | | | | | | 119.00 |
| 14 | 5/22/18 13:00 | 0.047 | 1.68 | | | 0.026 | 235 | 2.5 | 0.482 | 3.6 | 488.00 |
| 14 | 5/29/18 12:55 | | | | | | | | | | 1,046.00 |
| 14 | 6/19/18 13:45 | 0.036 | 1.75 | | | 0.043 | 261 | 4 | 0.329 | 3.85 | 921.00 |
| 14 | 7/10/18 10:30 | 0.036 | 1.25 | | | 0.027 | 234 | 2.5 | 0.256 | 3.55 | |
| 14 | 7/17/18 13:55 | 0.032 | 1.5 | | | 0.02 | 389 | 3 | | 3.07 | 727.00 |
| 14 | 8/9/18 14:35 | 0.016 | 5.42 | 0.104 | 0.064 | 0.156 | 162 | 16 | 0.795 | 27.3 | 3,448.00 |
| 14 | 9/11/18 13:25 | 0.026 | 2.2 | | | 0.038 | 238 | 3 | 0.206 | 3.74 | 72.00 |
| 14 | 10/18/18 14:15 | 0.017 | 1.58 | 0.032 | 0.016 | 0.018 | 379 | 3 | | 3.41 | 236.00 |
| 14 | 11/29/18 13:40 | 0.02 | 0.585 | | | | 215 | | | 1.75 | |
| 14 | 1/17/19 13:35 | 0.022 | 0.786 | | 0.01 | 0.011 | 182 | | | 2.35 | |
| 14 | 2/21/19 12:55 | 0.017 | 1.45 | 0.045 | 0.01 | 0.089 | 178 | 21 | 0.234 | 21.8 | |
| 15 | 3/22/18 18:30 | | 1.26 | | | | 156 | 2 | | 4.57 | |
| 15 | 4/19/18 14:40 | | 1.07 | | | | | | | 3.41 | |
| 15 | 5/1/18 12:40 | | | | | | | | | | 133.00 |
| 15 | 5/8/18 12:30 | | | | | | | | | | 387.00 |
| 15 | 5/15/18 12:05 | | | | | | | | | | 816.00 |
| 15 | 5/22/18 13:15 | 0.027 | 2.08 | | | 0.015 | 207 | 3.5 | 0.364 | 3.95 | 579.00 |
| 15 | 5/29/18 12:35 | | | | | | | | | | 2,420.00 |
| 15 | 6/19/18 13:00 | 0.018 | 1.56 | | | 0.01 | 214 | 3.5 | | 2.38 | 980.00 |
| 15 | 7/11/18 13:30 | 0.019 | 1.65 | | | 0.028 | 200 | | | 2.23 | |
| 15 | 7/17/18 13:30 | 0.018 | 1.61 | | | | 191 | | | 2.21 | 1,046.00 |
| 15 | 8/9/18 13:10 | | | | | 0.029 | 196 | 4 | 0.231 | | 780.00 |
| 15 | 9/11/18 12:50 | | 1.82 | | | | 239 | 2 | | 2.35 | 488.00 |
| 15 | 10/18/18 13:00 | 0.016 | | | | | 235 | | | 1.15 | 365.00 |
| 15 | 11/29/18 12:45 | | 0.635 | | 0.011 | | | | | 1.32 | |
| 15 | 1/17/19 12:50 | | 0.866 | | | 0.01 | 176 | 2 | | 2.64 | |
| 15 | 2/21/19 12:00 | | 1.24 | | | 0.029 | 151 | 10 | | 16.2 | |
| 16 | 3/22/18 17:45 | | 1.25 | | | | 157 | 2.5 | | 5.96 | |
| 16 | 4/19/18 13:15 | | 1.03 | | 0.036 | | 159 | | | 3.98 | |
| 16 | 5/1/18 11:40 | | | | | | | | | | 91.00 |
| 16 | 5/3/18 10:30 | | 1.45 | | | | 183 | 2.5 | 0.325 | 2.9 | |
| 16 | 5/8/18 11:45 | | | | | | | | | | 1,046.00 |
| 16 | 5/15/18 11:20 | | | | | | | | | | 461.00 |
| 16 | 5/22/18 12:15 | 0.029 | 1.94 | | | 0.013 | 201 | 1.5 | 0.32 | 2.84 | 770.00 |
| 16 | 5/29/18 12:00 | | | | | | | | | | 2,420.00 |

| Stream Site ID | Date | Nitrite (as N) mg/L | Organic Carbon, Total (TOC) mg/L | Orthophosphate Lab (as P) mg/L | Orthophosphate Field (as P) mg/L | Phosphorus, Total (as P) mg/L | Solids, Total Dissolved mg/L | Solids, Total Suspended mg/L | Total Kjeldhal Nitrogen (as N) mg/L | Turbidity NTU | E. coli MPN/100mL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 16 | 6/19/18 12:00 | 0.015 | 1.37 | | | 0.023 | 230 | | | 1.93 | 186.00 |
| 16 | 7/17/18 12:50 | 0.016 | 1.5 | | | 0.057 | 216 | 2 | 0.355 | 4.36 | 1,120.00 |
| 16 | 8/9/18 12:20 | | 4.45 | 0.047 | 0.171 | 0.132 | 183 | 2.5 | 1.72 | 9.7 | 3,255.00 |
| 16 | 9/11/18 11:55 | | 1.83 | 0.025 | 0.011 | 0.011 | 233 | | | 1.15 | 96.00 |
| 16 | 10/18/18 12:10 | | 1.26 | | 0.014 | | 218 | | | 1.71 | 153.00 |
| 16 | 11/29/18 11:45 | | 0.562 | | | 0.057 | 189 | | | 1.97 | |
| 16 | 1/17/19 11:50 | | 0.777 | | | | 170 | | | 1.67 | |
| 16 | 2/21/19 11:25 | | 1.42 | | | 0.033 | 151 | 6 | 0.218 | 14.4 | |
| 17 | 3/22/18 17:00 | 0.018 | 2.1 | | | | 168 | 2.5 | 0.218 | 9.52 | |
| 17 | 4/19/18 11:55 | 0.018 | 1.1 | | | | 181 | | | 3 | |
| 17 | 5/1/18 11:00 | | | | | | | | | | 411.00 |
| 17 | 5/3/18 13:45 | 0.085 | 5.02 | 0.033 | | 0.086 | 196 | | 2.49 | 5.54 | |
| 17 | 5/8/18 10:50 | | | | | | | | | | 1,300.00 |
| 17 | 5/15/18 10:45 | | | | | | | | | | 2,420.00 |
| 17 | 5/22/18 11:25 | 0.357 | 5.51 | | 0.013 | 0.086 | 214 | 12.5 | 2.47 | 16.1 | 6,131.00 |
| 17 | 5/29/18 11:00 | | | | | | | | | | 19,860.00 |
| 17 | 6/19/18 11:10 | 0.235 | 3.75 | | 0.029 | 0.088 | 247 | 5 | 1.09 | 6.09 | 2,420.00 |
| 17 | 7/17/18 11:20 | 0.065 | 2.01 | | 0.018 | | 215 | | 0.218 | 1.51 | 261.00 |
| 17 | 8/9/18 11:10 | 0.017 | 3.49 | 0.036 | 0.043 | 0.108 | 205 | 14.5 | 0.77 | 18.8 | 1,450.00 |
| 17 | 9/11/18 10:55 | 0.061 | 1.98 | 0.046 | 0.024 | 0.053 | 250 | | 0.288 | 2.62 | 1,300.00 |
| 17 | 10/18/18 11:20 | 0.018 | 1.16 | | 0.012 | 0.014 | 216 | 1.5 | | 3.09 | 1,203.00 |
| 17 | 11/29/18 11:00 | 0.022 | 0.51 | | 0.01 | 0.012 | 206 | | | 1.9 | |
| 17 | 1/17/19 10:00 | 0.023 | 0.73 | | | | 179 | | | 1.98 | |
| 17 | 2/21/19 10:45 | | | | | 0.049 | 173 | 5 | 0.262 | 18.8 | |
| 18 | 3/22/18 16:15 | 0.015 | 2.17 | | 0.038 | | 151 | 2.5 | 0.269 | 6.76 | |
| 18 | 4/19/18 11:00 | 0.019 | 1.13 | | 0.014 | 0.01 | 166 | | | 4.41 | |
| 18 | 4/24/18 10:30 | | 2.23 | | | | 174 | 2 | 0.314 | | |
| 18 | 5/1/18 10:20 | | | | | | | | | | 326.00 |
| 18 | 5/8/18 10:10 | | | | | | | | | | 1,414.00 |
| 18 | 5/15/18 10:05 | | | | | | | | | | 1,203.00 |
| 18 | 5/22/18 10:15 | 0.249 | | 0.262 | 0.245 | 0.319 | 203 | 10.5 | 1.42 | 26.2 | 10,462.00 |
| 18 | 5/29/18 10:10 | | | | | | | | | | 24,190.00 |
| 18 | 6/19/18 10:15 | 0.12 | 1.72 | 0.075 | 0.029 | 0.092 | 232 | 4 | | 3.35 | 1,046.00 |
| 18 | 7/17/18 10:20 | 0.023 | 1.42 | | 0.03 | 0.018 | 207 | 1.5 | | 1.68 | 457.00 |
| 18 | 8/9/18 10:20 | | 2.93 | 0.045 | 0.044 | 0.102 | 185 | 8 | 0.598 | 13.2 | 1,725.00 |
| 18 | 9/11/18 9:55 | 0.019 | 1.41 | 0.056 | 0.025 | 0.048 | 227 | | | 1.49 | 345.00 |
| 18 | 10/18/18 10:20 | 0.035 | 1.71 | 0.043 | 0.027 | 0.035 | 203 | 2 | | 3.09 | 345.00 |
| 18 | 11/29/18 10:05 | 0.019 | 0.659 | | | 0.04 | 186 | | | 2.09 | |
| 18 | 1/17/19 9:00 | 0.027 | 0.883 | | | | 158 | | | 3.77 | |
| 18 | 2/21/19 10:15 | 0.023 | 1.76 | 0.023 | 0.064 | 0.124 | 151 | 27.5 | 0.409 | 22.5 | |

# APPENDIX E

## SUBWATERSHED PRIORITIZATION CALCULATIONS

| Site ID | E. Coli Exceedance % | E. Coli Reduction % | Nitrogen Exceedance % | Nitrogen Reduction % | Phosphorus Exceedance % | Phosphorus Reduction % | TSS Exceedance % | TSS Reduction % | Raw Score | Normalized Score |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.44 | 0.80 | 0.80 | 0.00 | 0.35 | 0.32 | 0.82 | 0.46 | 3.39 | 0.86 |
| 2 | 0.78 | 0.80 | 0.75 | 0.00 | 0.27 | 0.32 | 0.40 | 0.46 | 3.31 | 0.84 |
| 4 | 0.90 | 0.64 | 0.33 | 0.22 | 0.67 | 0.27 | 0.67 | 0.20 | 3.43 | 0.87 |
| 5 | 0.90 | 0.64 | 0.24 | 0.22 | 0.69 | 0.27 | 0.42 | 0.20 | 3.19 | 0.81 |
| 7 | 0.76 | 0.65 | 0.00 | 0.00 | 0.10 | 0.00 | 0.25 | 0.24 | 1.84 | 0.47 |
| 9 | 0.76 | 0.65 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.41 | 0.36 |
| 10 | 0.80 | 0.46 | 0.00 | 0.00 | 0.10 | 0.26 | 0.00 | 0.00 | 1.58 | 0.40 |
| 11 | 0.60 | 0.34 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.94 | 0.24 |
| 13 | 0.70 | 0.66 | 0.00 | 0.00 | 0.00 | 0.00 | 0.14 | 0.00 | 1.46 | 0.37 |
| 14 | 0.50 | 0.84 | 0.58 | 0.39 | 0.20 | 0.05 | 0.14 | 0.00 | 2.44 | 0.62 |
| 15 | 0.90 | 0.67 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.57 | 0.40 |
| 16 | 0.60 | 0.79 | 0.08 | 0.00 | 0.14 | 0.00 | 0.00 | 0.00 | 1.59 | 0.40 |
| 17 | 1.00 | 0.95 | 1.00 | 0.49 | 0.50 | 0.00 | 0.50 | 0.00 | 3.94 | 1.00 |
| 18 | 1.00 | 0.96 | 0.91 | 0.40 | 0.44 | 0.33 | 0.00 | 0.00 | 3.70 | 0.94 |