

WATERSHED TREND REPORT

EAST STUDY BASIN

2012 - 2019



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Introduction

Sanitation District No. 1 (SD1), a clean-water agency which serves over 30 communities in Campbell, Kenton, and Boone Counties, Kentucky, as both a wastewater and a storm water utility, is implementing an adaptive watershed management approach to cost-effectively meet numerous regulatory requirements (e.g., Combined Sewer Overflow (CSO) Program, Municipal Separate Storm Sewer System (MS4) Program, Total Maximum Daily Load (TMDL) Program, etc.) to address environmental impacts associated with sewer overflows and storm water runoff in the communities it serves. In complying with these regulatory requirements, SD1 is applying a comprehensive approach for identifying impairments. In 2009, SD1 developed Watershed Characterization Reports for 16 watersheds to relate instream conditions to watershed characteristics. The results of these Watershed Characterization Reports were used to identify impaired watersheds and prioritize them for consideration of control alternatives associated with sewer overflow mitigation¹.

SD1 is undertaking a long-term effort to collect and compile data that describes the water quality conditions of Northern Kentucky (NKY) streams. This information is compiled at a basin scale and a watershed scale to relate instream conditions to watershed characteristics. Figure 1 shows the four study basins (East, Central, North and West) that are used to group NKY watersheds into logical reporting units.

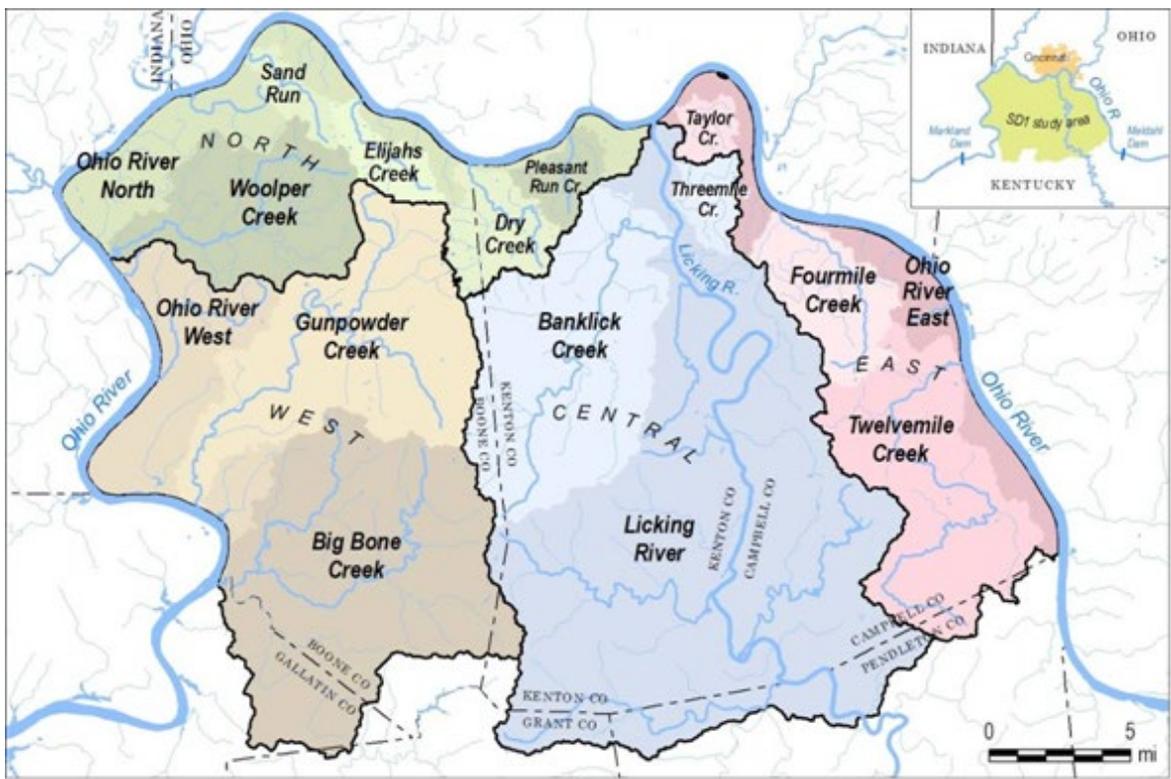


Figure 1. Study Basins and Watersheds

¹ SD1 entered into a Consent Decree with state and federal environmental regulators in 2007.

Background

The watersheds depicted in Figure 1 represent varying conditions with respect to the amount of development, as well as sources of stream pollution. The variation in the stream conditions can range from undeveloped watersheds that have been categorized as “exceptional” waters by the State, while other watersheds are more highly developed and are identified as “impaired” by the State.

As a result of the vast differences between these watersheds, SD1 initiated a comprehensive monitoring program in 2006 to collect instream water quality, biology, physical habitat, and stream stability data to establish current conditions and long-term datasets for model development and trend analysis.

This monitoring program is being implemented in a phased approach which is designed to achieve the following objectives:

- Characterize watershed conditions during baseflow/dry weather and storm flow/wet weather;
- Provide datasets for calibrating detailed watershed and water quality models;
- Provide datasets for assessment tools, such as a Stream Condition Index;
- Meet regulatory requirements for the Nine Minimum Controls as defined within the Long-term Control Plan requirements of the CSO Policy;
- Meet regulatory requirements for the Six Minimum Control Measures as defined within the Storm Water Quality Management Plan requirements of the Phase II MS4 Program;
- Characterize physical stream channel responses from urbanized storm water runoff (i.e., hydromodification);
- Establish a baseline for evaluating improvements from implementing controls; and,
- Respond to regulatory initiatives such as 305(b) assessments, 303(d) listings, TMDLs, etc.

Prior to 2006, limited water quality monitoring and biological assessments had been conducted in the watersheds of Northern Kentucky, thus the monitoring program has evolved over time based on the relative timetable associated with the objectives identified above. SD1 initiated a watershed wide monitoring program in 2006 to establish baseline conditions (base flow and storm flow) and datasets for model development - Period 1 (2006-2011). Period 2 spanned from 2012-2015 which established the basin rotation approach (e.g., 2012 - East Basin; 2013 - Central Basin; 2014 - North Basin; 2015 - West Basin). Period 3 spanned from 2016-2019 and was a continuation of the Period 2 basin rotation approach and established the ambient water quality monitoring approach to focus on spatial and temporal changes within the watersheds. After a temporary suspension of monitoring and assessment activities in 2020, Period 4 (2021-2024) data collection activities are in progress.

This report will focus on the East Basin watersheds and each of the four monitoring components of SD1’s monitoring program to assess stream condition trends for Periods 2 and 3.

Ambient Water Quality Monitoring

The objective of the ambient monitoring program is to characterize instream water quality under a wide range of environmental conditions in Northern Kentucky streams. By monitoring instream water quality, the condition of watersheds can be assessed along with the impact of land-based activities on the local waterways. Specific or emerging water quality issues may also be identified by monitoring and gathering information on the various waterbodies.



Water Quality Sampling

Although watershed wide water quality monitoring was initiated in 2006, the development of an ambient monitoring program component began in 2015 (i.e., the last year of Period 2). During Period 3, the ambient monitoring was further enhanced to meet program objectives. In 2021 (the beginning of Period 4), additional sites will be added to each watershed’s rotational basin schedule to increase spatial resolution of the monitoring.

Biological Assessments

The objective of the biological assessment program is to characterize the biological diversity and habitat quality in Northern Kentucky streams. By assessing the biological community to determine pollutant tolerant and pollutant intolerant species, the overall integrity of a waterbody can be determined along with both present and past effects of stressors of the biological integrity on the aquatic ecosystem.



Biological Assessment

Watershed wide biological assessments were conducted from 2006 through 2011 (Period 1) in order to record baseline data on the current condition of the streams and to develop subsequent monitoring and assessment strategies. With respect to the Basin Trend Reports, results and analysis of biological assessments began with the Period 2 datasets.

Stream Stability Assessments

The objective of the stream stability assessment program is to characterize the rate of streambed and streambank movement in Northern Kentucky streams. By measuring physical stream channel responses over time, that are primarily attributable to land-use conversion from undeveloped to developed, a stream site can be designated as stable or unstable. The altered flow regime associated with conventional urban development leads to hydromodification – flashier streams, larger flow, excessive stream erosion and overall channel instability. Accelerated bank erosion,



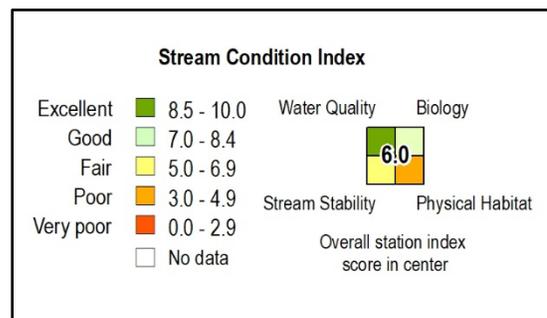
Stream Stability Assessment

channel deepening/widening, and overall enlargement pose risks to adjacent public infrastructure (i.e., sewers, roads and bridges), as well as private property losses. These same actions also cause water quality impairments (i.e., high TSS and sedimentation/siltation) and have adverse effects on aquatic biota, such as fish and macroinvertebrate populations.

Limited stream stability assessments began in 2008 after sampling crews documented significant stream erosion while conducting water quality monitoring and biological assessments. Throughout Periods 1 and 2, additional sites were added to meet program objectives. Beginning in 2019, rapid stream stability assessments were conducted at all biological assessment sites.

Stream Condition Index

To better evaluate, summarize, and communicate the results of the monitoring program, SD1 has utilized data collected from local streams and watersheds to develop a regionally based Stream Condition Index (SCI)². Appropriate indicators of stream condition were researched and selected in four key categories: water quality, biology, physical habitat, and stream stability. A scoring system for each indicator and a method to aggregate indicator scores at each site was established, creating a sub-index score for each of the four categories. At each site, the four sub-index scores are averaged to create a single Stream Condition Index (SCI) score. The SCI scores allow for a general comparison of stream conditions across the Northern Kentucky area.



Stream Condition Index

These types of environmental indices are commonly used by resource managers and scientists to summarize large amounts of complex data but are rarely calibrated to reflect conditions of such a localized area. The local focus of the SCI will allow its use in resource monitoring, potentially diagnosing problem areas, predicting relative resource condition, setting benchmarks for management targets, and (perhaps most importantly) streamlining complex data in terms that can be understood by a non-technical audience.³

The objectives for the SD1's SCI were to:

- Summarize large amounts of complex data from Northern Kentucky streams;
- Use existing monitoring programs and indices to the extent possible;
- Incorporate and reflect broader conditions beyond water quality;
- Balance scientific rigor with the timely development of an index; and,
- Communicate information on monitoring data to a lay audience.

² *A Stream Condition Index for Water Utility Resource Management in Northern Kentucky*, 2015.

³ *A Manager's Guide to Indicator Selection*. U.S. EPA, 2006.

East Basin

The East Basin study area is located mainly in Campbell County, KY (Figure 2). This basin includes (from north to south): Taylor Creek, Fourmile Creek, and Twelvemile Creek watersheds, along with smaller tributaries that discharge directly to the Ohio River (collectively depicted as Ohio River East).

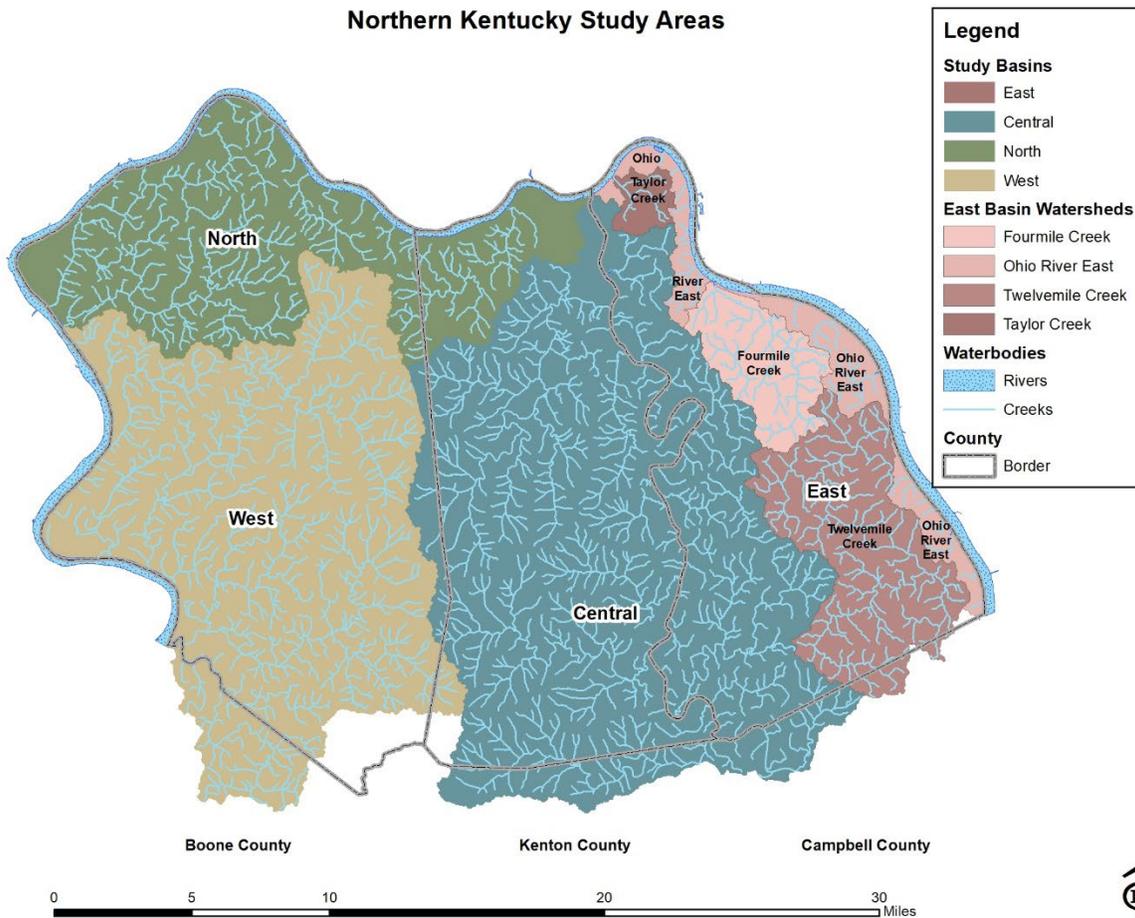


Figure 2. East Basin Study Area Map

The Basin Trend monitoring and assessment sites within the East Basin are located in three primary watersheds: Fourmile, Taylor, and Twelvemile Creek. Each watershed has multiple sites located throughout its drainage area, representing varying conditions with respect to the amount of development (i.e., impervious surface), as well as potential sources of stream pollution. Table 1 identifies the individual sites contained in each watershed.

Table 1. East Basin Site Locations

Fourmile Creek	Taylor Creek	Twelvemile Creek
FMC0.5	TYC0.6	TMC3.0
FMC6.9	TYC0.7 – CVR0.2	TMC3.9
OWC0.4	TYC0.9 – WLC1.3	BRC0.3

Sampling site locations were selected using several criteria including, but not limited to, drainage area, accessibility, stream heterogeneity, adjacent land use, past studies, and available resources.

Land cover and sewer system areas each play an important role in the quantity and quality of runoff into receiving waters. Each watershed overview section includes a series of maps that depict watershed conditions, as follows:

- 1) General watershed characteristics displayed as follows:
 - a. Waterbodies include rivers and creeks that are designated as perennial, intermittent or piped, as well as reservoirs and impoundments, such as lakes and ponds.
 - b. Constructed features include buildings, pavement, such as roads, parking lots, etc., as well as other impervious surfaces.
- 2) National Land Cover Database (NLCD) modified and displayed as follows:
 - a. Initial dataset included agriculture, barren land, developed, forest, grassland, shrubland, water and wetlands categories representing 2019 conditions.
 - b. Modified dataset to Circa 2023 with local GIS and imagery data including parcel information, buildings, pavement surfaces and waterbodies to correct and refine the agriculture, developed, grassland and water land cover categories.
- 3) SD1 service area boundaries and the active sewer overflow locations displayed as follows:
 - a. Storm Water and Wastewater Service Area boundaries depicted as of December 2019.
 - b. Modeled Sewer Overflow Locations⁴ include model predicted sanitary sewer overflows⁵ and combined sewer overflows⁶, based on 2020 sewer system conditions.

⁴ Refer to SD1’s Amended Consent Decree, Appendix A, filed 3/17/09.

⁵ Design storm modeling based on a 2-year, 6-hour rainfall event (2.29”) for the Eastern Region of KY.

⁶ Typical year modeling based on 1970 rainfall events recorded at the Cincinnati-NKY International Airport.

Fourmile Creek

Located entirely within Campbell County, the Fourmile Creek watershed originates in the city of Alexandria, KY and flows approximately 9.3 miles in a northwesterly direction to the Ohio River (Figure 3). Owl Creek and Tug Creek are two significant tributaries that contribute drainage to Fourmile Creek. The overall watershed mainly provides drainage to portions of unincorporated Campbell County, as well as portions of the cities of Alexandria, Cold Spring, Crestview, Melbourne, and Silver Grove. The Fourmile Creek watershed has a drainage area of approximately 17.7 square miles with 5.9% estimated as impervious surface. Monitoring is conducted at two sites on the main-stem of Fourmile Creek, as well as one site within the Owl Creek sub-watershed.

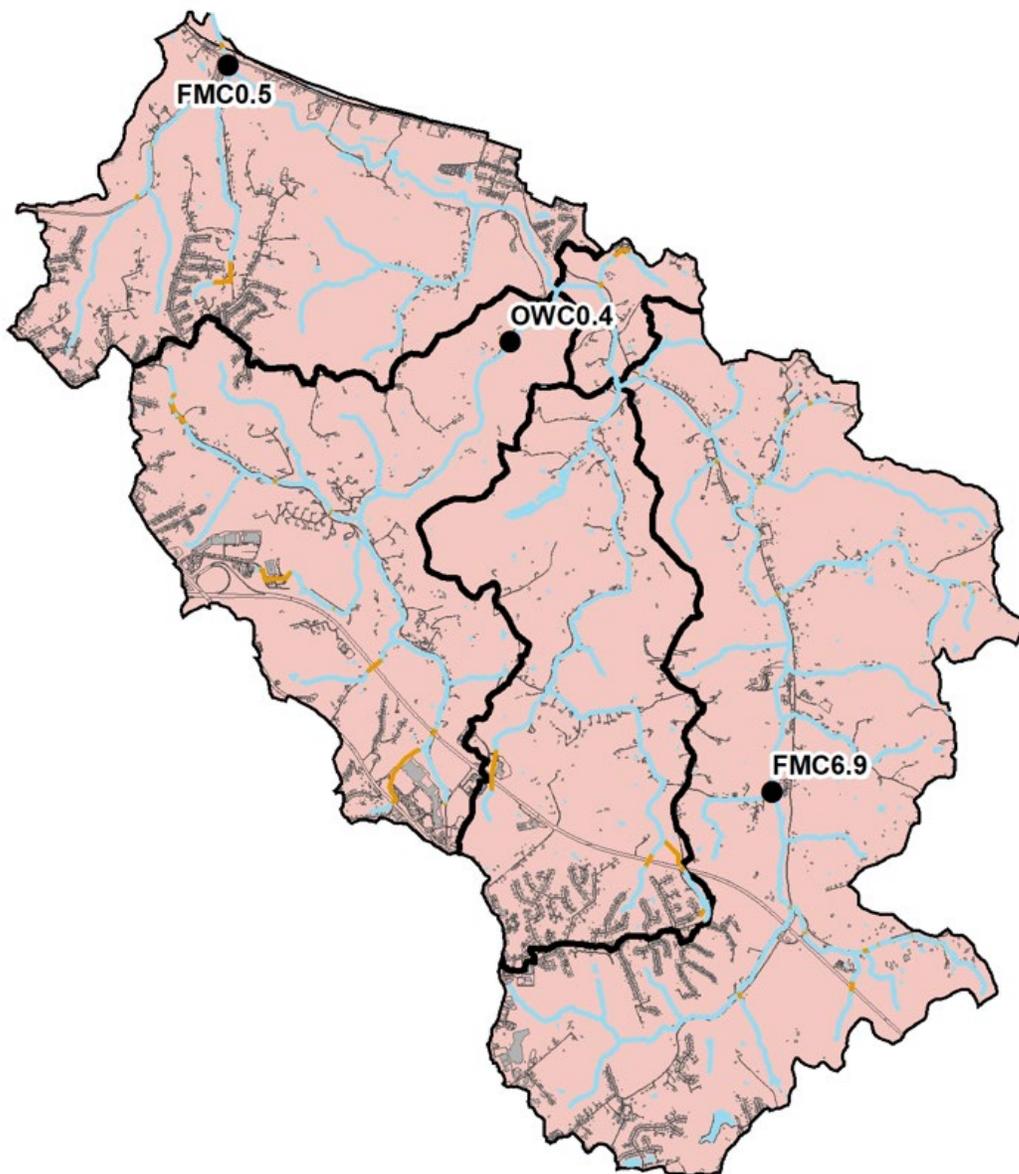


Figure 3. Fourmile Creek Watershed

Fourmile Creek watershed is mostly a mix of rural and suburban areas (Figure 4). Land cover consists of predominately forested land (~57%), with lesser amounts of developed land (~30%) and pastureland (~10%). Route 9 AA highway, a significant transportation route, traverses the upper portions of Fourmile Creek, as well as Owl Creek and Tug Creek.

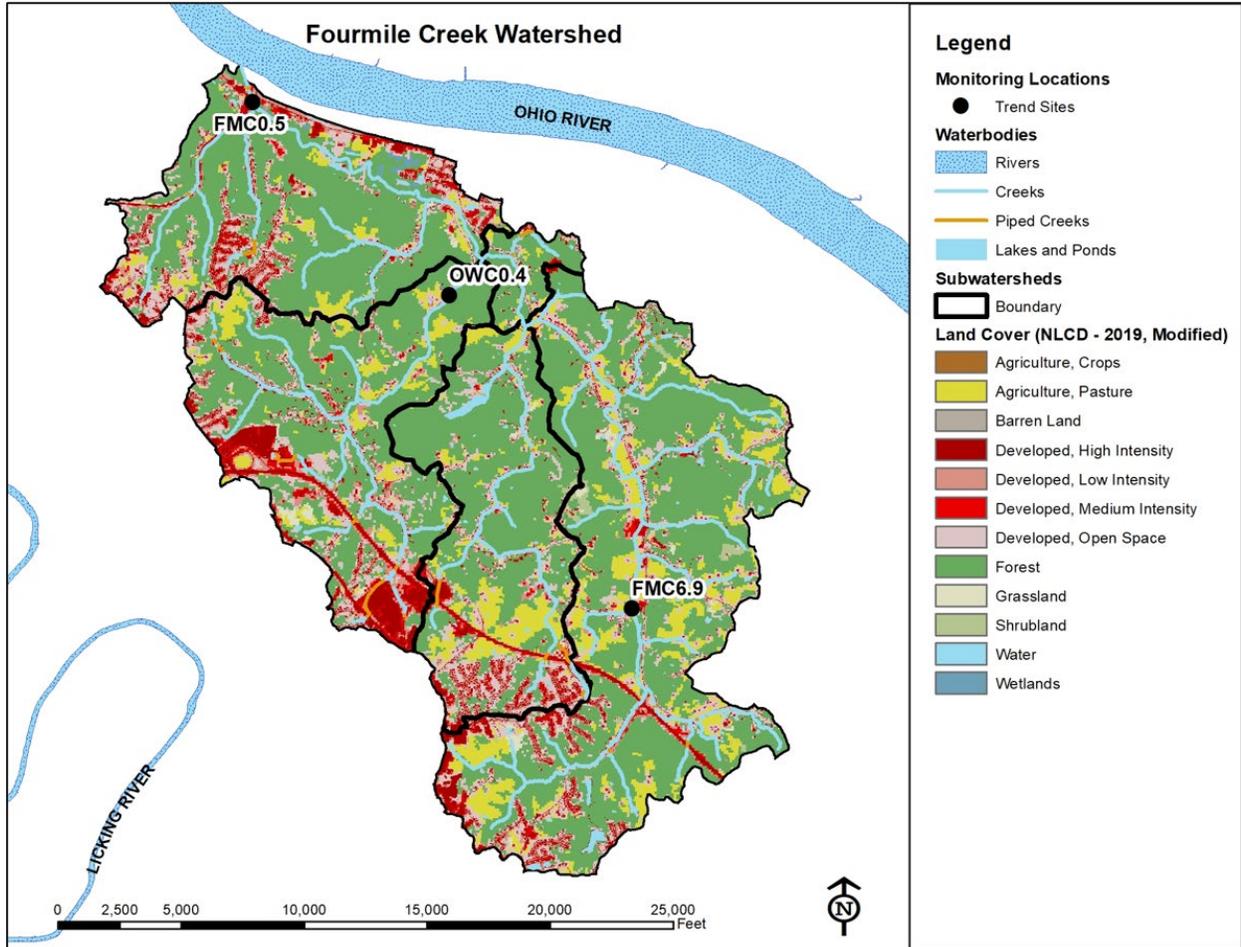


Figure 4. Fourmile Creek Land Cover

Areas within the Fourmile Creek watershed that are managed by SD1 with respect to centralized sanitary sewers and regional storm water systems, are depicted in Figure 5. Currently within the wastewater system ten modeled overflow locations, consisting of nine sanitary sewer overflows (SSOs) and one combined sewer overflow (CSO), discharge during various wet weather conditions. Most of the overflow locations occur in the lower portion of the watershed near the Ohio River. Approximately half of the watershed is subject to Kentucky's Phase II MS4 program. The majority of the MS4 program area is encompassed within SD1's storm water service area, representing the NKY Regional Storm Water Program, while area within the city limits of Cold Spring is subject to the city's storm water program. KYTC rights-of-way within the MS4 program area are subject to the Transportation Cabinet's storm water program.

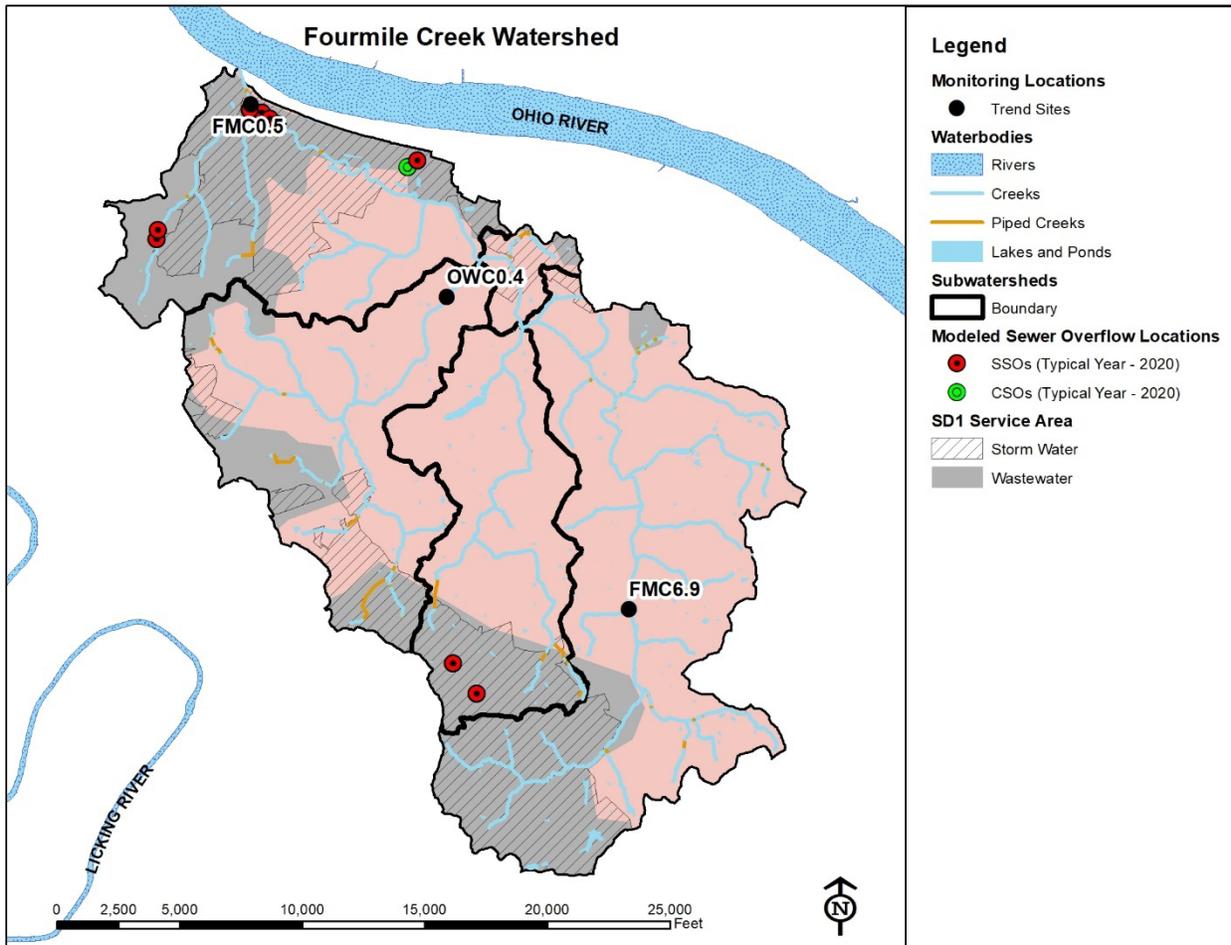


Figure 5. Fourmile Creek Modeled Sewer Overflows and Service Areas

Taylor Creek

Located entirely within Campbell County, the Taylor Creek watershed originates in the cities of Newport and Southgate, KY and flows approximately 1.7 miles in a northerly direction to the Ohio River (Figure 6). Covert Run Creek and Woodlawn Creek are two significant tributaries that contribute drainage to Taylor Creek. Covert Run, with headwaters to the east in Fort Thomas, also provides drainage to portions of two cities - Dayton and Bellevue. Woodlawn Creek, with headwaters to the south in Fort Thomas, also provides drainage to the city of Woodlawn. The Taylor Creek watershed has a drainage area of approximately 4.2 square miles with 26.1% estimated as impervious surface. Monitoring is conducted at one site on the main-stem of Taylor Creek, as well as two tributary sites - Covert Run and Woodlawn Creek.

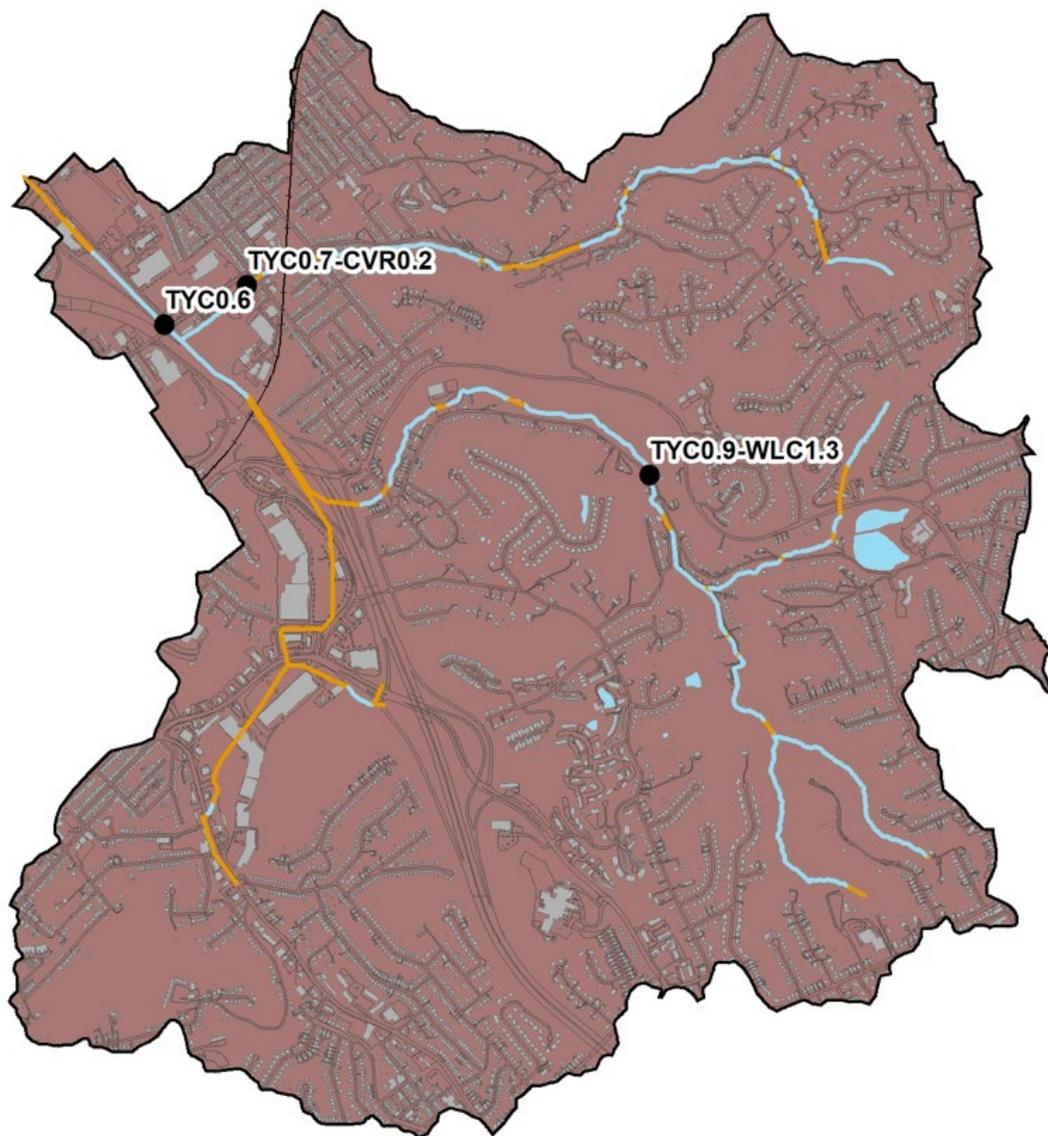


Figure 6. Taylor Creek Watershed

Taylor Creek watershed is highly urbanized (e.g., much of the drainage area is piped) and is the most developed watershed in the East Basin (Figure 7). Land cover consists of predominately developed land (~78%), followed by forested land (~21%). Interstate highway I-471, a significant transportation route, traverses the watershed along the lower mainstem of Taylor Creek.

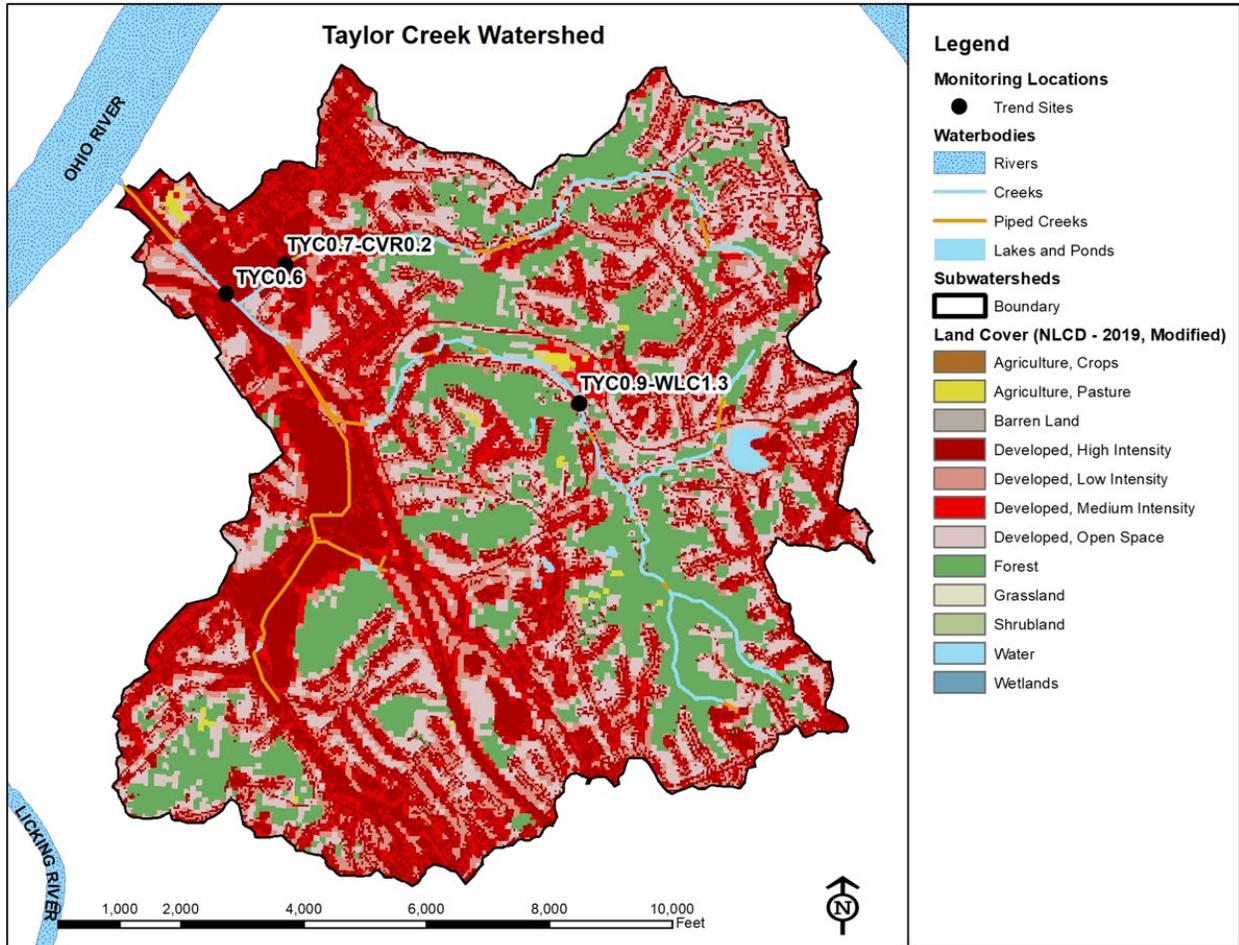


Figure 7. Taylor Creek Land Cover

Areas within the Taylor Creek watershed that are managed by SD1 with respect to centralized sanitary sewers and regional storm water systems are depicted in Figure 8. Currently within the wastewater system 28 modeled overflow locations, consisting of 17 sanitary sewer overflows (SSOs) and 11 combined sewer overflows (CSO), discharge during various wet weather conditions. CSO locations occur in the lower portion of the watershed near the Ohio River, while SSO locations occur in the upper portions of the watershed. The entire watershed is subject to Kentucky's Phase II MS4 program and is encompassed within SD1's storm water service area, representing the NKY Regional Storm Water Program, while area within KYTC rights-of-way is subject to the Transportation Cabinet's storm water program.

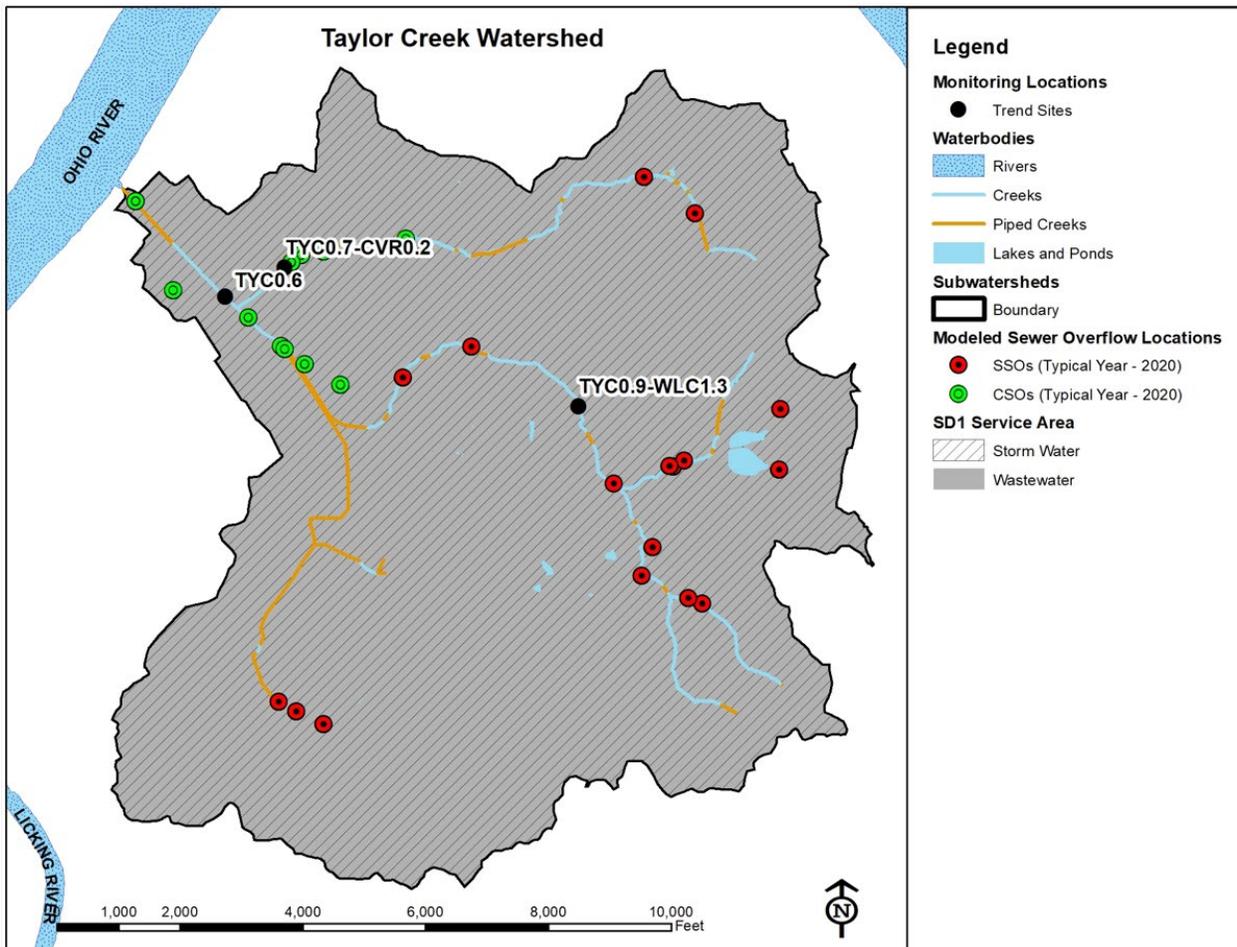


Figure 8. Taylor Creek Modeled Sewer Overflows and Service Areas

Twelvemile Creek

Located mostly in Campbell County, the Twelvemile Creek watershed originates in unincorporated Pendleton County, KY and flows approximately 22.2 miles in a north easterly direction to the Ohio River (Figure 9). Brush Creek (northwest), Flagg Spring Creek (southeast), and Lick Branch (north) are three significant tributaries that contribute drainage to Twelvemile Creek. The overall watershed mainly provides drainage to portions of unincorporated Campbell County, as well as portions of the city of Alexandria and unincorporated Pendleton County. The Twelvemile Creek watershed has a drainage area of approximately 46.2 square miles with 2.2% estimated as impervious surface. Monitoring is conducted at two sites on the main-stem of Twelvemile Creek, as well as one site within the Brush Creek sub-watershed.

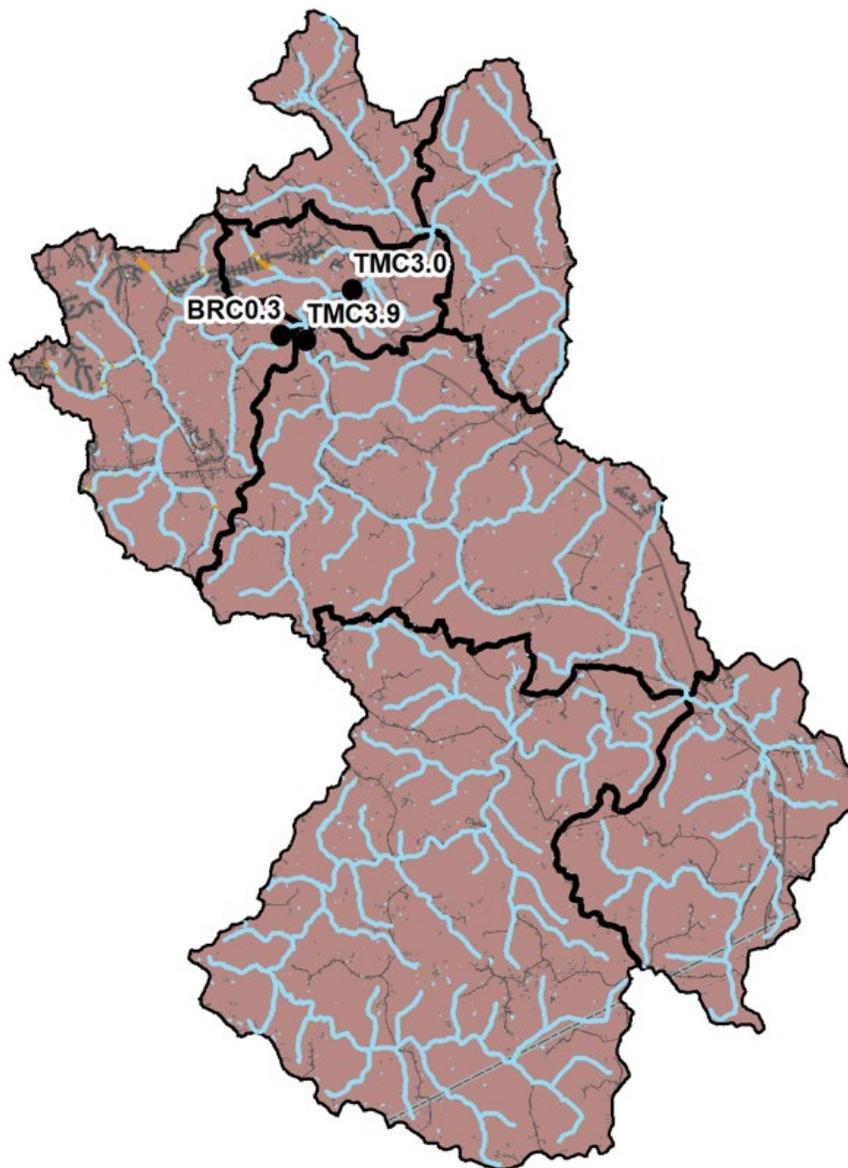


Figure 9. Twelvemile Creek Watershed

Twelvemile Creek watershed is primarily rural and has the highest density of livestock in the East Basin (Figure 10). Land cover consists of predominately forested land (~55%), with lesser amounts of pastureland (~27%) and developed land (~16%). Route 9 AA highway, a significant transportation route, traverses the extent of the watershed.

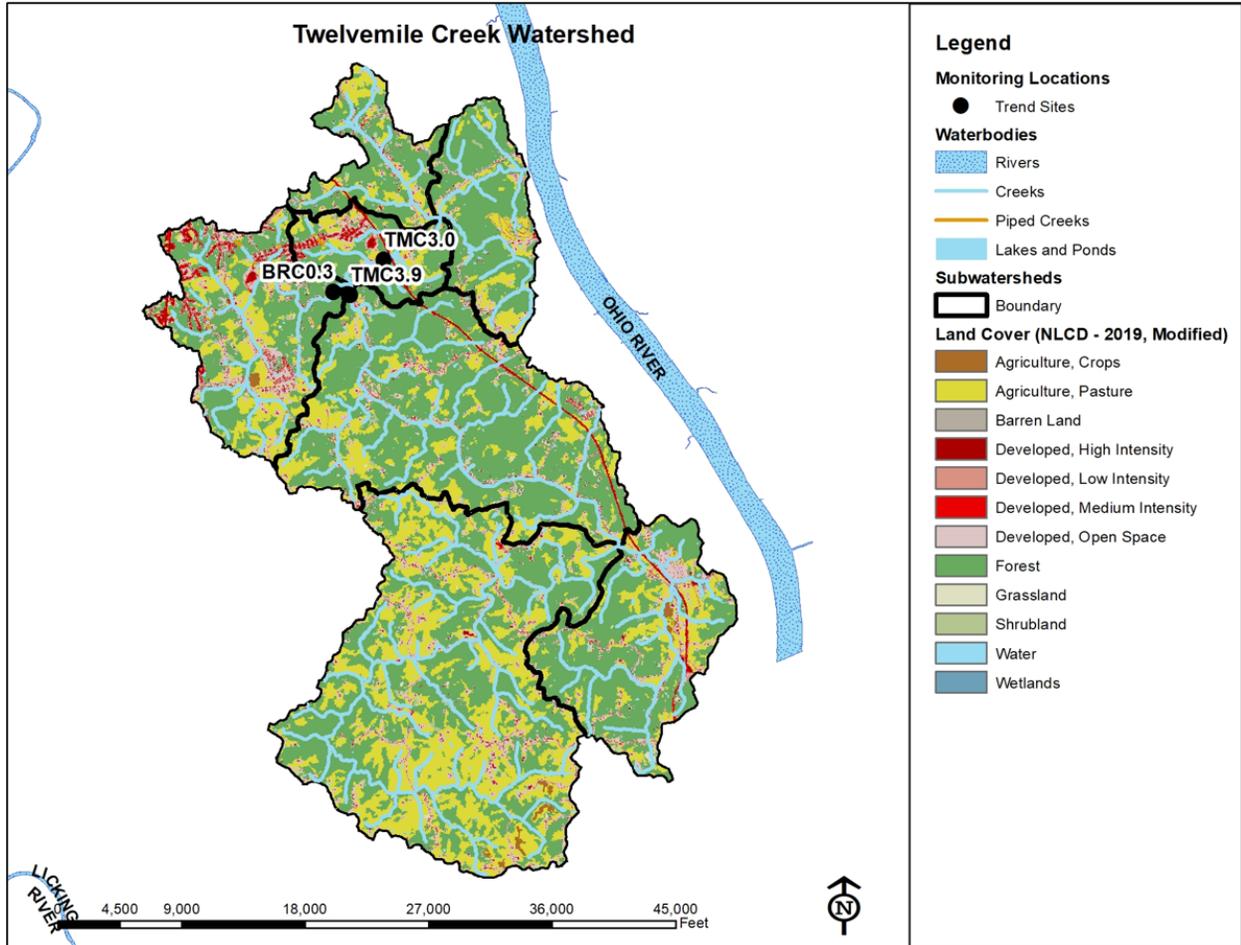


Figure 10. Twelvemile Creek Land Cover

Areas within the Twelvemile Creek watershed that are managed by SD1 with respect to centralized sanitary sewers and regional storm water systems are depicted in Figure 11. While there are no modeled overflow locations within the watershed, SD1's Eastern Regional Water Reclamation Facility, located near Alexandria, discharges to Brush Creek, a tributary of Twelvemile Creek. Only a small portion of the watershed is subject to Kentucky's Phase II MS4 program, which is encompassed within SD1's storm water service area, representing the NKY Regional Storm Water Program. KYTC rights-of-way within the MS4 program area are subject to the Transportation Cabinet's storm water program.

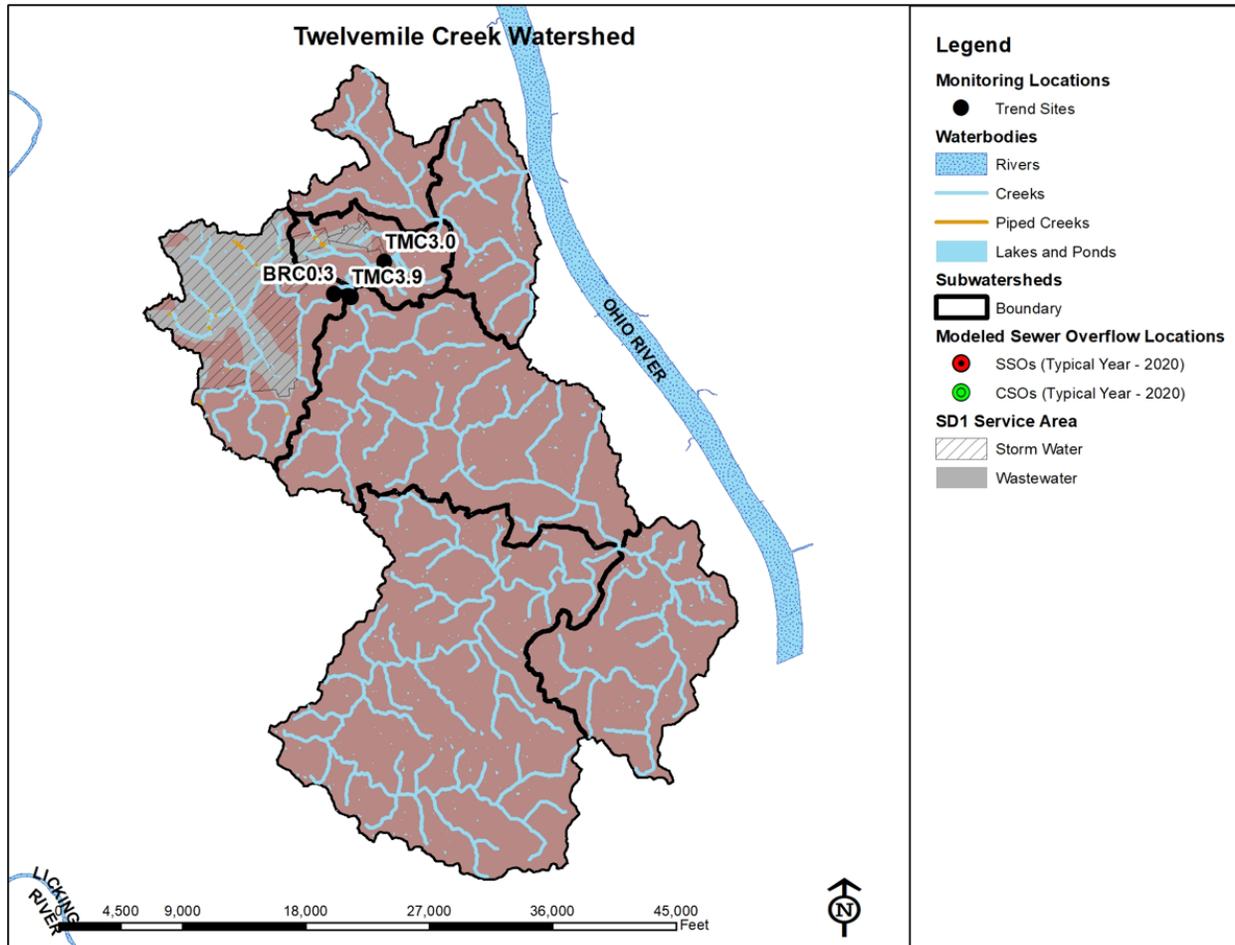


Figure 11. Twelvemile Creek Modeled Sewer Overflows and Service Areas

Further detailed characteristics of each watershed can be found on the SD1 website, <https://www.sd1.org/233/Watershed-Characterization-Reports>.

Ambient Water Quality Monitoring Results

SD1’s ambient water quality monitoring consists of surface water grab samples collected from March through November on a set schedule (10 – 16 events per year) to “capture” varying flow regimes during the spring, summer and fall seasons. All sampling events were conducted following the appropriate Field Monitoring and Sampling Plan (FMSP) and the associated Quality Assurance Program Plan (QAPP) utilizing approved sampling protocols⁷. The FMSP and QAPP were designed to ensure that all monitoring activities undertaken result in representative data necessary to support the characterization of the watershed being sampled. Samples collected were analyzed in a laboratory for bacteria (*Escherichia coli* - *E. coli*), solids (total suspended solids - TSS), and nutrients (total phosphorus - TP and total nitrogen - TN) per the associated QAPP following approved analytical protocols⁸.

- Bacteria are utilized as pathogen indicators and can range widely based on failing or undersized infrastructure and host source (e.g., human, livestock, pets, wildlife).
- TSS can rise significantly during and immediately after rainfall events due to land surface erosion and/or streambank erosion caused by runoff.
- Background phosphorus is typically higher in NKY area watersheds, primarily due to creek beds composed of limestone bedrock, however excess values are often attributed to point source and nonpoint source pollution.
- Nitrogen is found naturally in the environment; however excess values are often attributed to point source and nonpoint source pollution.

Ambient results for each site were compiled by parameter and represented in Box-and-Whisker plots. The whiskers for each plot represent the minimum and maximum values, while the box represents the 25th and 75th percentile range of the data. The “heavy” short black line represents the median value of the data. These plots are used to compare time periods within the watershed by site for each parameter. Additionally, either the water quality criteria or benchmark values are also shown in the figures. The water quality standard was derived from Section 401 of the Kentucky Administrative Regulations *401 KAR 10:031. Surface water standards*. The benchmarks were developed by Kentucky Division of Water as a guideline since there are no current standards developed for those parameters yet.

Table 2. Water Quality Criteria Type

Parameter	Water Quality Criteria Type	Value	Units	Applies
<i>E. coli</i>	KDOW Standard - Max	240	mpn/100 mL	May-Oct
TSS	KDOW Benchmark	7.25	mg/L	Apr-Oct
TP	KDOW Benchmark	0.08	mg/L	Jan-Dec
TN	KDOW Benchmark	0.6	mg/L	Jan-Dec

Refer to Appendix A for results from individual sites within the East Basin study area.

⁷EPA Guidance for Quality Assurance Project Plans, 2002.

⁸ Standard Methods for the Examination of Water and Wastewater, 2017.

Fourmile Creek

Fourmile Creek watershed monitoring site FMC6.9 was sampled during Period 2 and all four years of Period 3, while monitoring site FMC0.5 was only sampled during Period 2 and the first two years of Period 3. Monitoring site OWC0.4 was added to the ambient monitoring program in 2021, with all three sites scheduled for sampling during Period 4 per the basin rotation cycle.

Table 3. Fourmile Creek Number of Samples Collected

Fourmile Creek Site	Period 2 No. of Samples	Period 3 No. of Samples			
	2015	2016	2017	2018	2019
FMC0.5	10	16	6	NS	NS
FMC6.9	10	16	13	12	12
OWC0.4	NS	NS	NS	NS	NS

Columns displaying “NS” do not currently have results available but will in subsequent years (i.e., Period 4).



Photo 1. Fourmile Creek 0.5

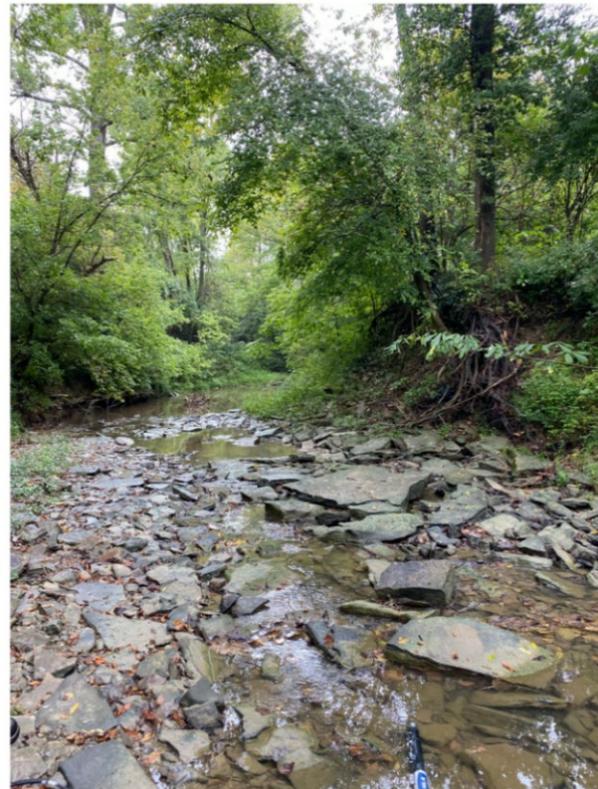


Photo 2. Owl Creek 0.4

Fourmile Creek *E. coli*

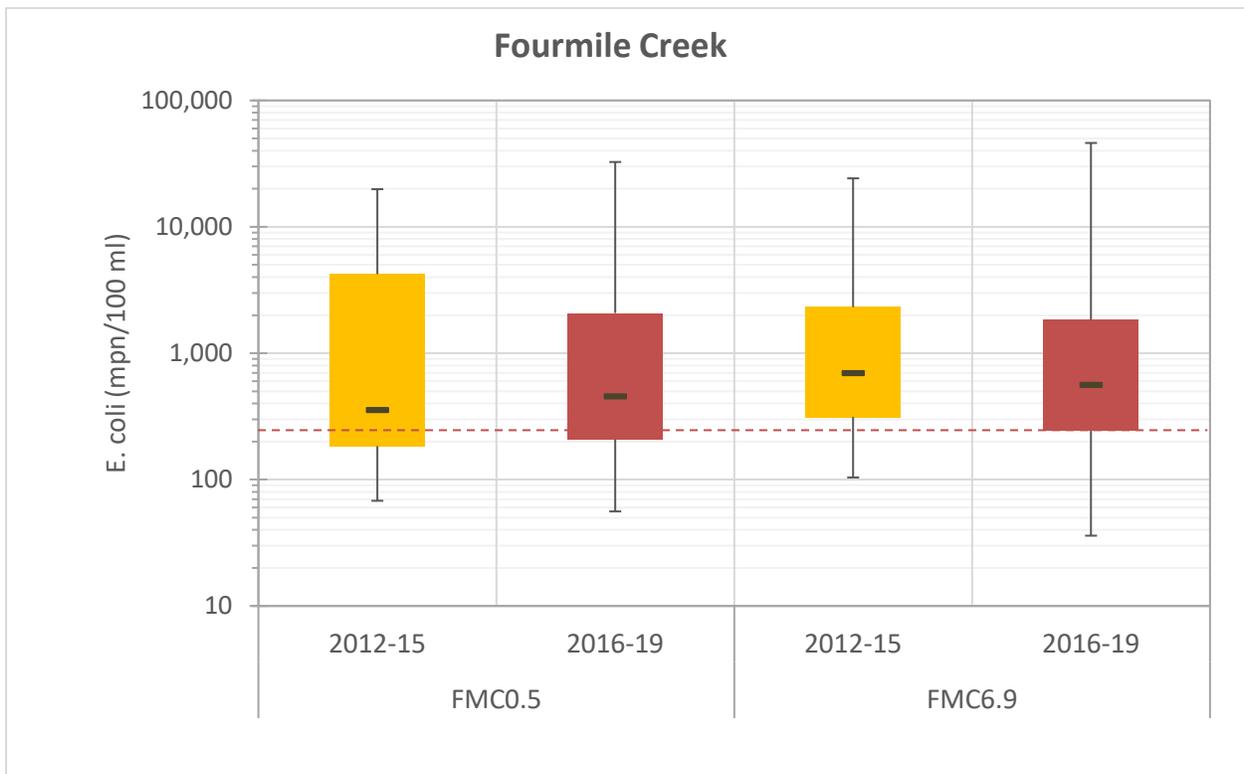
E. coli values ranged from 68 mpn/100ml to 19,860 mpn/100ml during Period 2 and ranged from 56 mpn/100ml to 32,600 mpn/100ml during Period 3 at FMC0.5. The median values during both periods were above the 240 mpn/100ml criteria, 354 mpn/100ml and 454 mpn/100ml.

E. coli values ranged from 104 mpn/100ml to 24,200 mpn/100ml during Period 2 and ranged from 36 mpn/100ml to 46,100 mpn/100ml during Period 3 at FMC6.9. The median values during both periods were above the 240 mpn/100ml criteria, 696 mpn/100ml and 560 mpn/100ml.

Suspected sources of elevated *E. coli* values within the Fourmile Creek watershed primarily includes sewer overflows, failing septic systems and storm water runoff.



Photo 3. Fourmile Creek 6.9



The dashed line in the graph represents the single sample maximum criteria of 240 mpn/100ml.

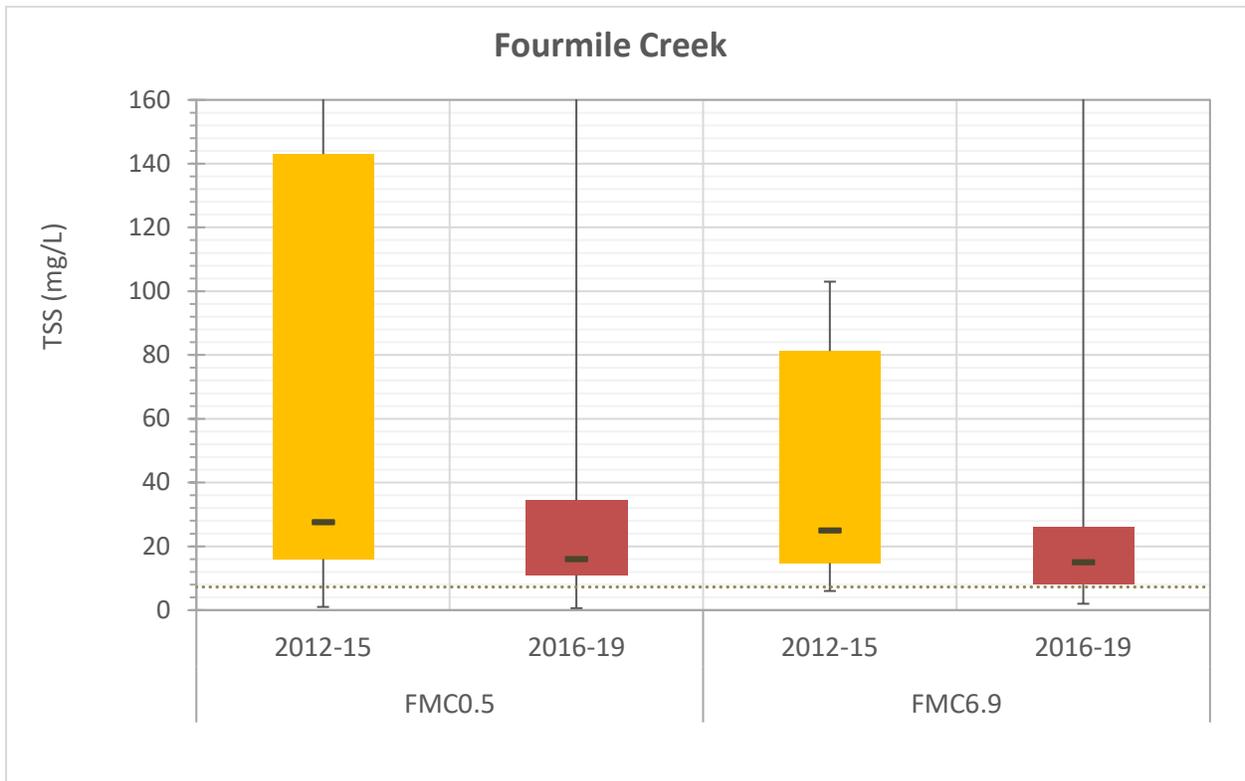
Figure 12. Fourmile Creek *E. coli* Results

Fourmile Creek Total Suspended Solids

TSS values ranged from <2 mg/L to 296 mg/L during Period 2 and ranged from <1.2 mg/L to 1,800 mg/L during Period 3 at FMC0.5. The median values during both periods were above the 7.25 mg/L benchmark, 27.5 mg/L and 16 mg/L.

TSS values ranged from 6 mg/L to 103 mg/L during Period 2 and ranged from 2 mg/L to 1,250 mg/L during Period 3 at FMC6.9. The median values during both periods were above the 7.25 mg/L benchmark, 25 mg/L and 15 mg/L.

The median TSS value for each reporting period was highest within the Fourmile Creek watershed when compared to the other two East Basin watersheds. Suspected sources of elevated TSS values within the Fourmile Creek watershed primarily includes storm water runoff and streambank erosion due to hydromodification.



The dashed line in the graph represents the benchmark value established by KDOW of 7.25 mg/L.

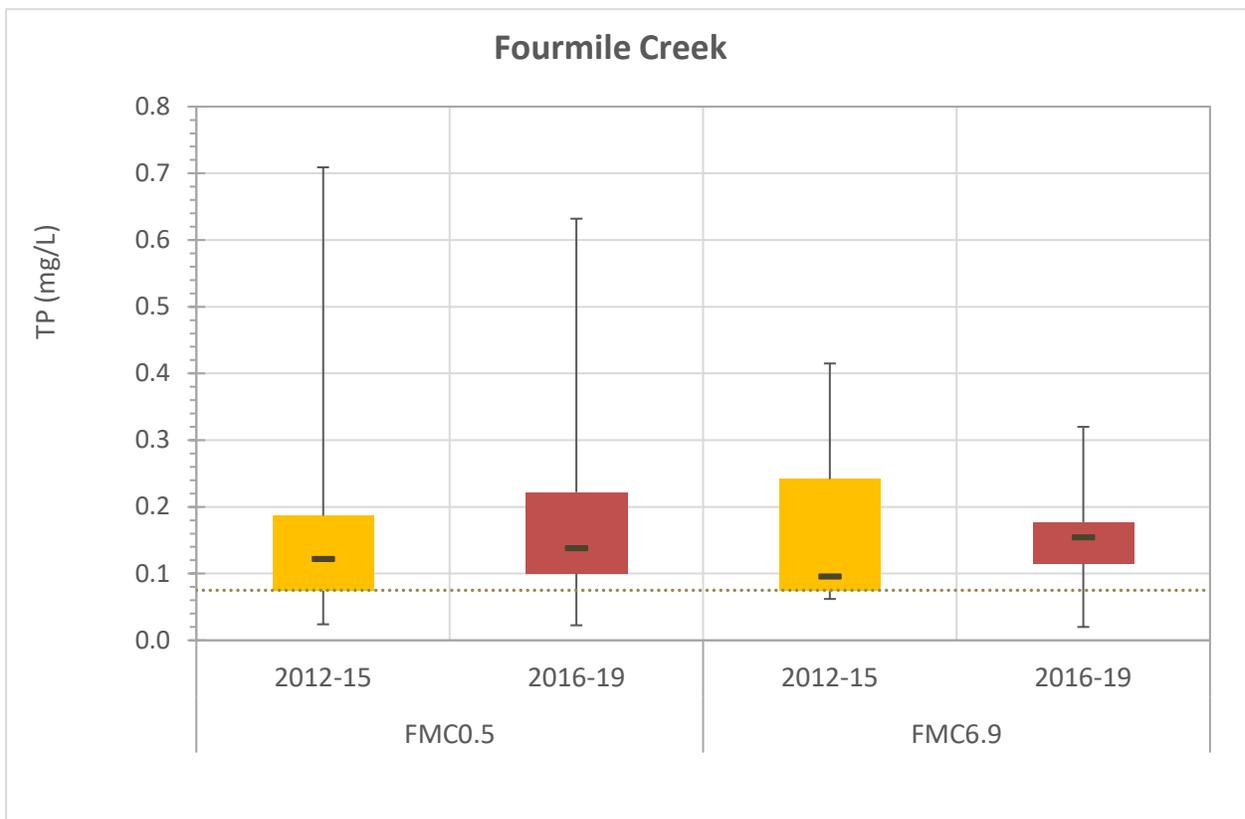
Figure 13. Fourmile Creek TSS Results

Fourmile Creek Total Phosphorous

TP values ranged from 0.024 mg/L to 0.709 mg/L during Period 2 and ranged from <0.045 mg/L to 0.632 mg/L during Period 3 at FMC0.5. The median values during both periods were above the 0.08 mg/L benchmark, 0.122 mg/L and 0.138 mg/L.

TP values ranged from 0.062 mg/L to 0.415 mg/L during Period 2 and ranged from <0.045 mg/L to 0.320 mg/L during Period 3 at FMC6.9. The median values during both periods were above the 0.08 mg/L benchmark, 0.096 mg/L and 0.154 mg/L.

Suspected sources of excess phosphorus values within the Fourmile Creek watershed primarily include storm water runoff.



The dashed line in the graph represents the benchmark value established by KDOW of 0.08 mg/L.

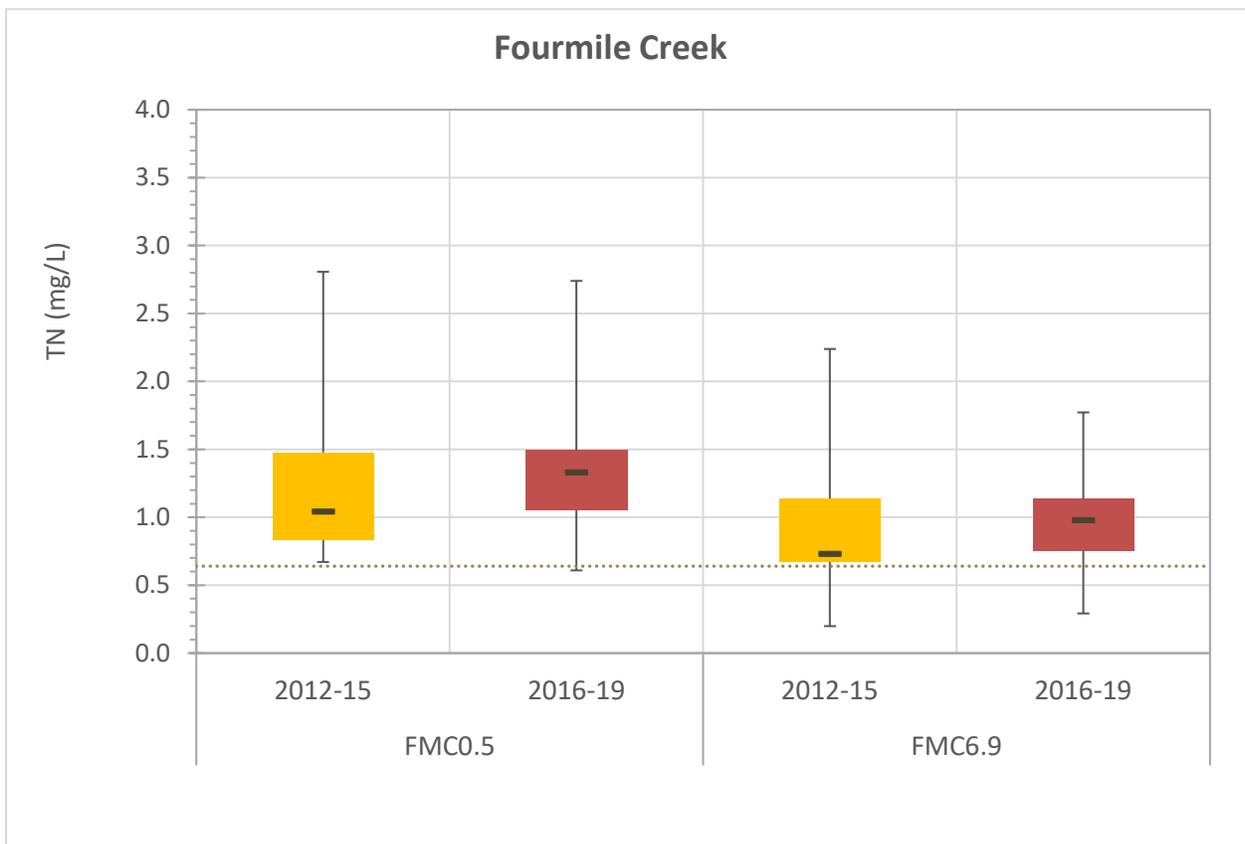
Figure 14. Fourmile Creek TP Results

Fourmile Creek Total Nitrogen

TN values ranged from 0.67 mg/L to 2.81 mg/L during Period 2 and 0.61 mg/L to 2.74 mg/L during Period 3 at FMC0.5. The median values during both periods were above the 0.6 mg/L benchmark, 1.04 mg/L and 1.33 mg/L.

TN values ranged from 0.20 mg/L to 2.24 mg/L during Period 2 and 0.29 and 1.77 mg/L during Period 3 at FMC6.9. The median values during both periods were above the 0.6 mg/L benchmark, 0.64 mg/L and 0.98 mg/L.

Suspected sources of excess nitrogen values within the Fourmile Creek watershed primarily include storm water runoff.



The dashed line in the graph represents the benchmark value established by KDOW of 0.6 mg/L.

Figure 15. Fourmile Creek TN Results

Taylor Creek

Taylor Creek watershed monitoring site TYC 0.6 was sampled during Period 2 and four years of Period 3. Monitoring sites TYC0.7 – CVR0.2 and TYC0.9 – WLC1.3 were added to the ambient monitoring program in 2021, with all three sites scheduled for sampling during Period 4 per the basin rotation cycle.

Table 4. Taylor Creek Number of Samples Collected

Taylor Creek Site	Period 2 No. of Samples	Period 3 No. of Samples			
	2015	2016	2017	2018	2019
TYC0.6	10	16	13	12	12
TYC0.7 – CVR0.2	NS	NS	NS	NS	NS
TYC0.9 – WLC1.3	NS	NS	NS	NS	NS

Columns displaying “NS” do not currently have results available but will in subsequent years (i.e., Period 4).



Photo 4. Taylor Creek 0.6

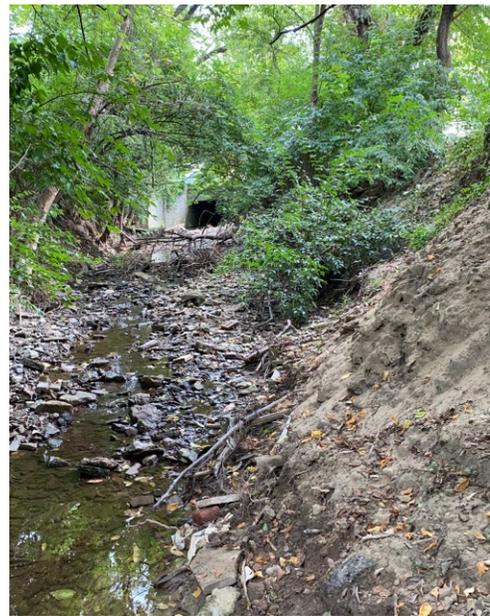


Photo 5. Covert Run 0.2

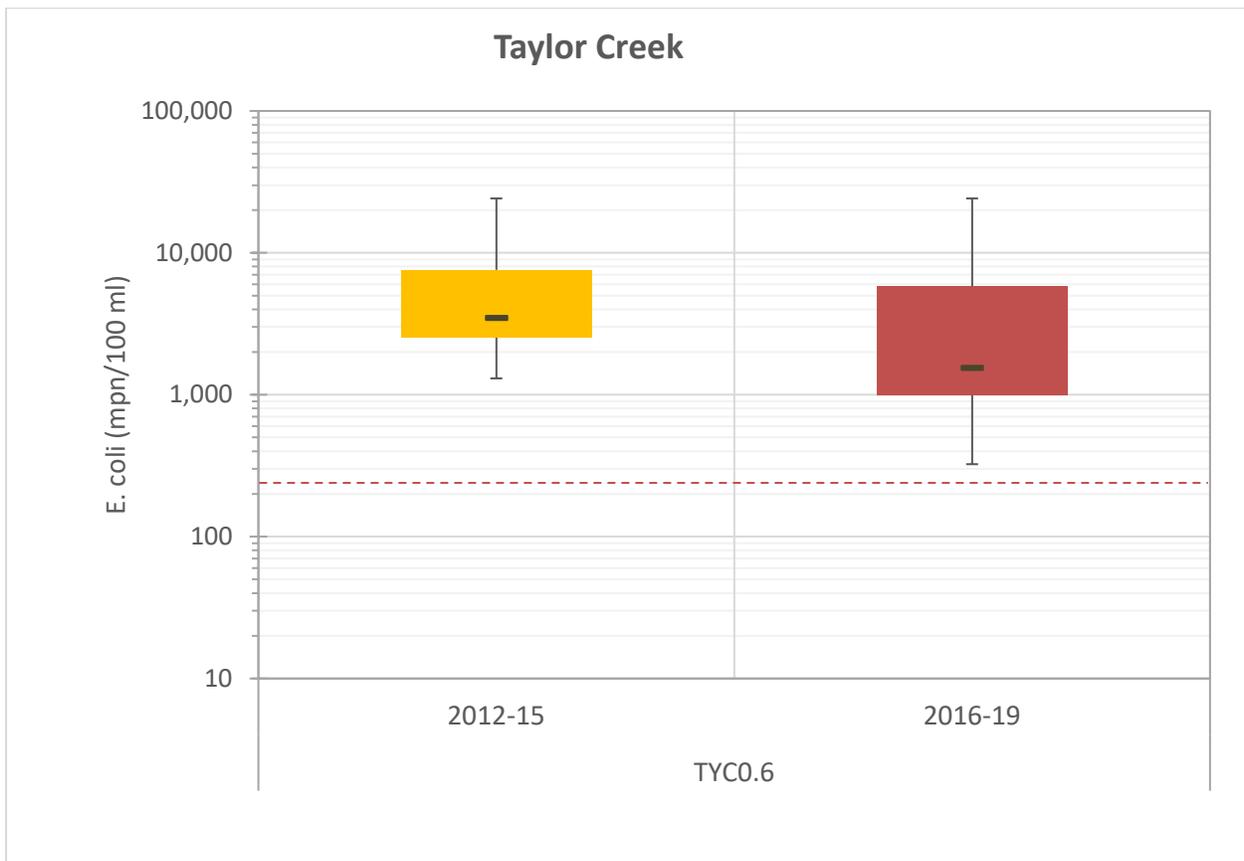
Taylor Creek *E. coli*

E. coli values ranged from 1,304 mpn/100ml to 24,200 mpn/100ml during Period 2 and ranged from 432 mpn/100ml to 24,200 mpn/100ml during Period 3 at TYC0.6. The median values during both periods were above the 240 mpn/100ml criteria, 3,475 mpn/100ml and 1,548 mpn/100ml.

The median bacteria value for each reporting period was highest within the Taylor Creek watershed when compared to the other two East Basin watersheds. Suspected sources of elevated *E. coli* values within the Taylor Creek watershed primarily includes sewer overflows and storm water runoff.



Photo 6. Woodlawn Creek 1.3



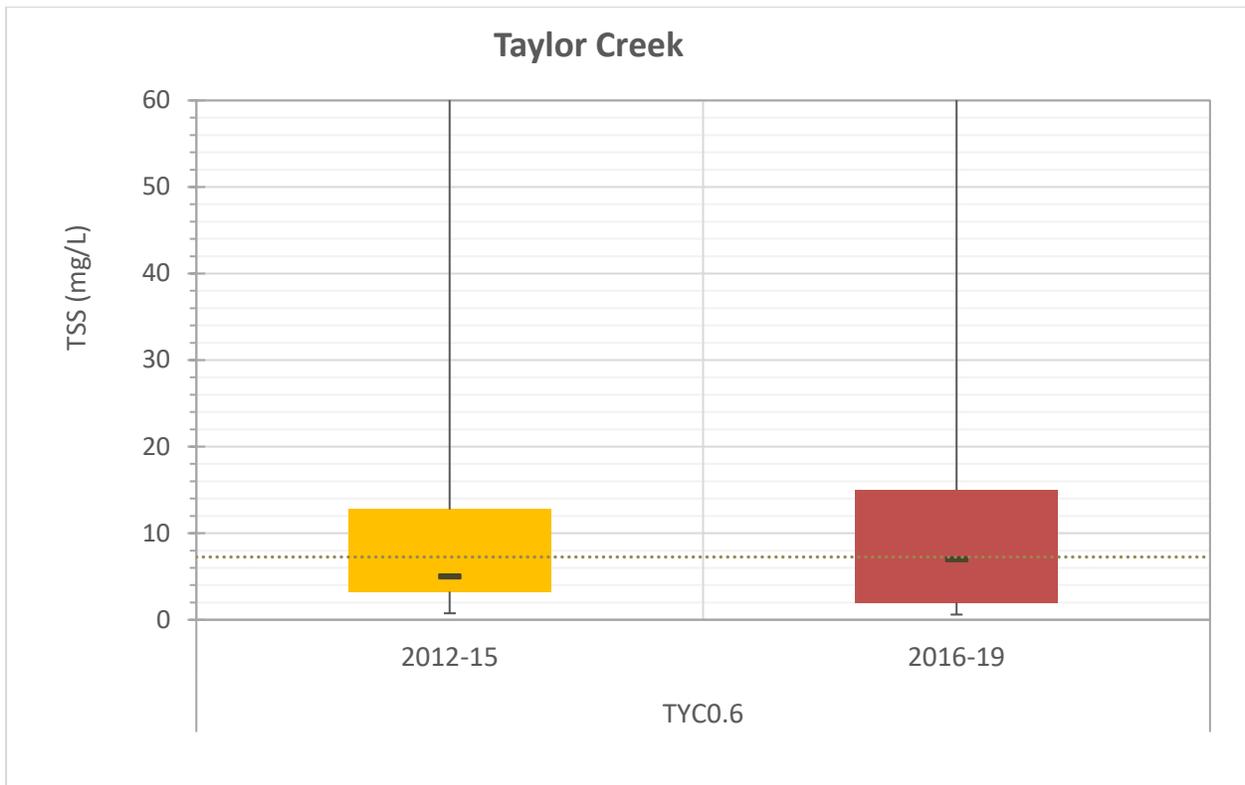
The dashed line in the graph represents the single sample maximum criteria of 240 mpn/100ml.

Figure 16. Taylor Creek *E. coli* Results

Taylor Creek Total Suspended Solids

TSS values ranged from <1.5 mg/L to 130 mg/L during Period 2 and ranged from <1.2 mg/L to 149 mg/L during Period 3 at TYC0.6. The median values during both periods were below the 7.25 mg/L benchmark, 5 mg/L and 7 mg/L.

The median TSS value for each reporting period was lowest within the Taylor Creek watershed when compared to the other two East Basin watersheds. Suspected sources of elevated TSS values within the Taylor Creek watershed primarily includes sewer overflows, storm water runoff and streambank erosion due to hydromodification.



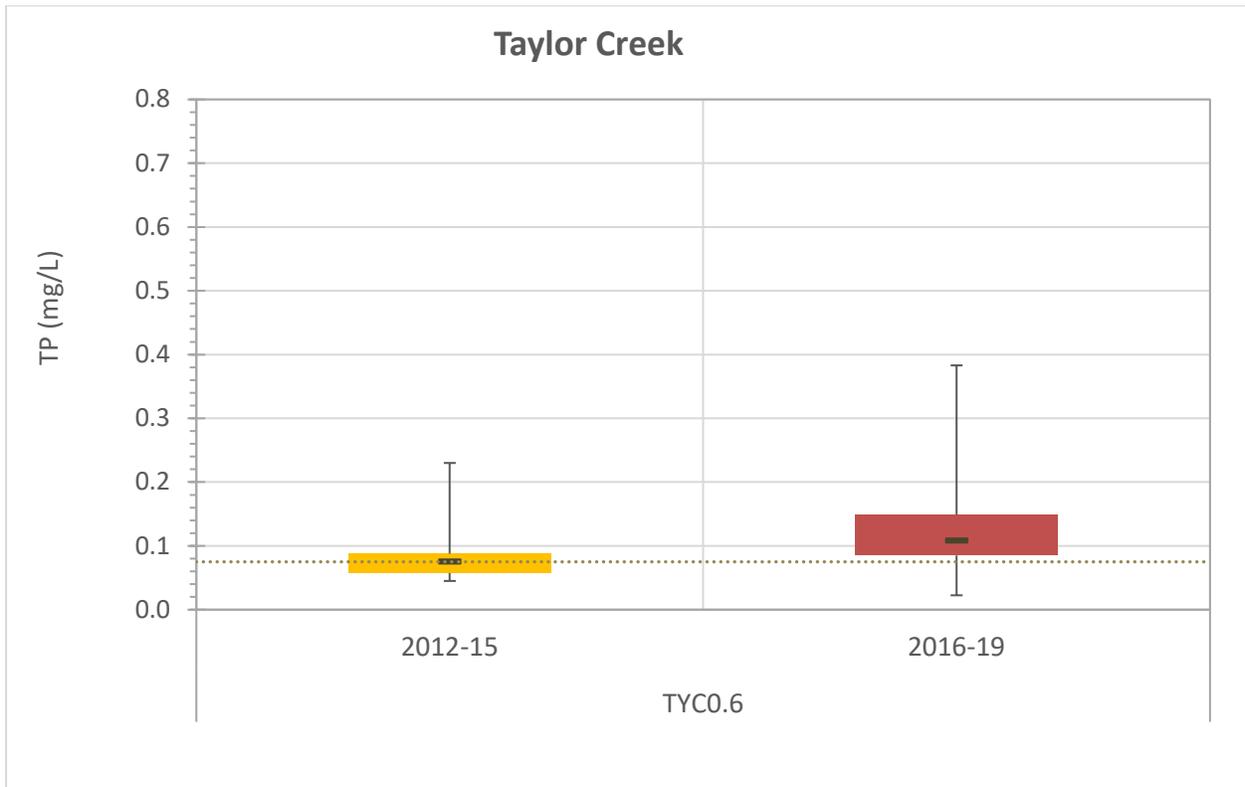
The dashed line in the graph represents the benchmark value established by KDOW of 7.25 mg/L.

Figure 17. Taylor Creek TSS Results

Taylor Creek Total Phosphorous

TP values ranged from 0.045 mg/L to 0.230 mg/L during Period 2 and ranged from <0.045 mg/L to 0.383 mg/L during Period 3 at TYC0.6. The median value during Period 2 was below the benchmark (0.08 mg/L) and the median value was above the benchmark during Period 3 (0.108 mg/L).

The median phosphorus value for each reporting period was lowest within the Taylor Creek watershed when compared to the other two East Basin watersheds. The suspected sources of elevated phosphorus values within the Taylor Creek watershed primarily includes sewer overflows and storm water runoff.



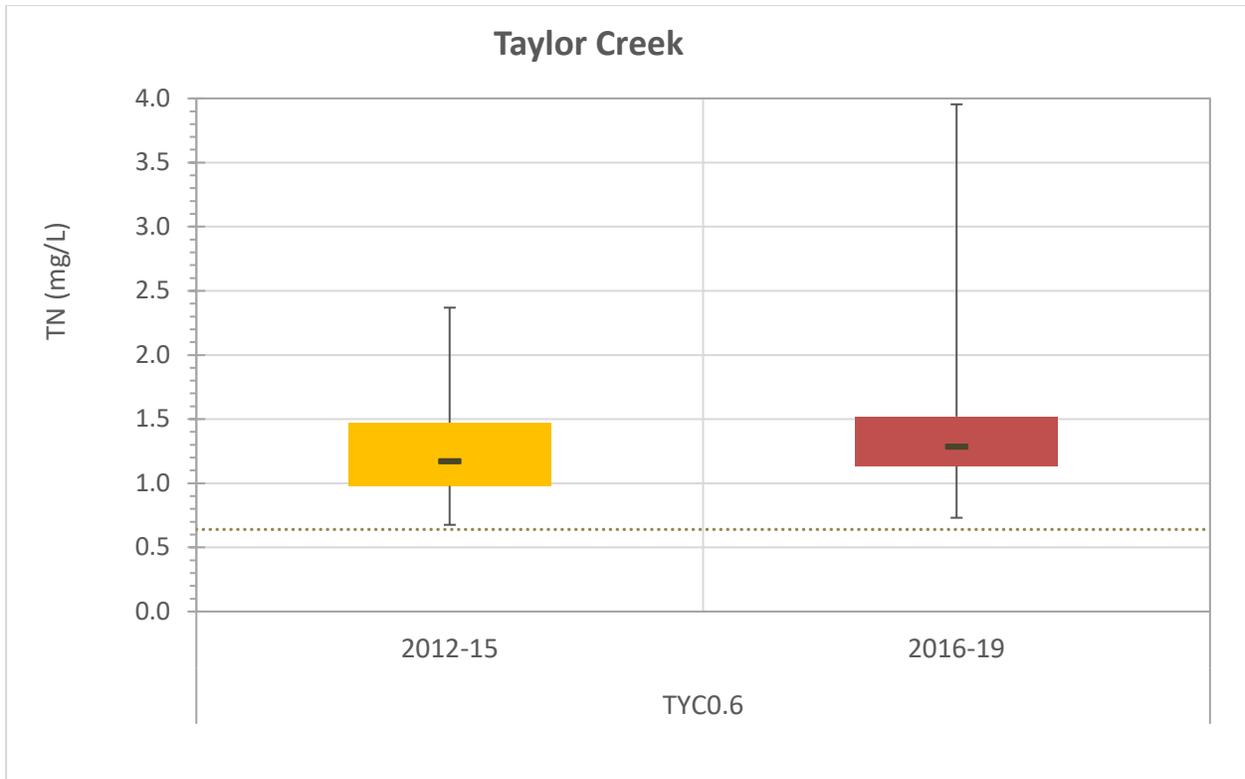
The dashed line in the graph represents the benchmark value established by KDOW of 0.08 mg/L.

Figure 18. Taylor Creek TP Results

Taylor Creek Total Nitrogen

TN values ranged from 0.68 mg/L to 2.37 mg/L during Period 2 and 0.73 mg/L to 3.95 mg/L during Period 3 at TYC0.6. The median values during both periods were above the 0.6 mg/L benchmark, 1.17 mg/L and 1.28 mg/L.

Suspected sources of excess nitrogen values within the Taylor Creek watershed primarily includes sewer overflows and storm water runoff.



The dashed line in the graph represents the benchmark value established by KDOW of 0.6 mg/L.

Figure 19. Taylor Creek TN Results

Twelvemile Creek

Twelvemile Creek watershed monitoring site TMC3.0 was sampled during Period 2 and four years of Period 3. Monitoring sites TMC3.9 and BRC0.3 had limited data collected in 2016 and were added to the ambient monitoring program in 2021, with all three sites scheduled for sampling during Period 4 per the basin rotation cycle.

Table 5. Twelvemile Creek Number of Samples Collected

Twelvemile Creek Site	Period 2	Period 3			
	No. of Samples	No. of Samples			
	2015	2016	2017	2018	2019
TMC3.0	10	16	13	12	12
TMC3.9	NS	5	NS	NS	NS
BRC0.3	NS	5	NS	NS	NS

Columns displaying “NS” do not currently have results available but will in subsequent years (i.e., Period 4).



Photo 7. Twelvemile Creek 3.0



Photo 8. Twelvemile Creek 3.9

Twelvemile Creek *E. coli*

E. coli values ranged from 168 mpn/100ml to 1,600 mpn/100ml at TMC3.9 during Period 3. The median value was above the 240 mpn/100ml criteria, 292 mpn/100ml.

E. coli values ranged from 64 mpn/100ml to 24,200 mpn/100ml during Period 2 and ranged from 48 mpn/100ml to 30,800 mpn/100ml during Period 3 at TMC3.0. The median values during both periods were above the 240 mpn/100ml criteria, 250 mpn/100ml and 300 mpn/100ml.

E. coli values ranged from 76 mpn/100ml to 43,500 mpn/100ml during Period 3 at BRC0.3. The median value was just below the 240 mpn/100ml criteria, 236 mpn/100ml.

The median bacteria value for each reporting period was lowest within the Twelvemile Creek watershed when compared to the other two East Basin watersheds. Suspected sources of elevated *E. coli* values within the Twelvemile Creek watershed primarily includes failing septic systems and storm water runoff.

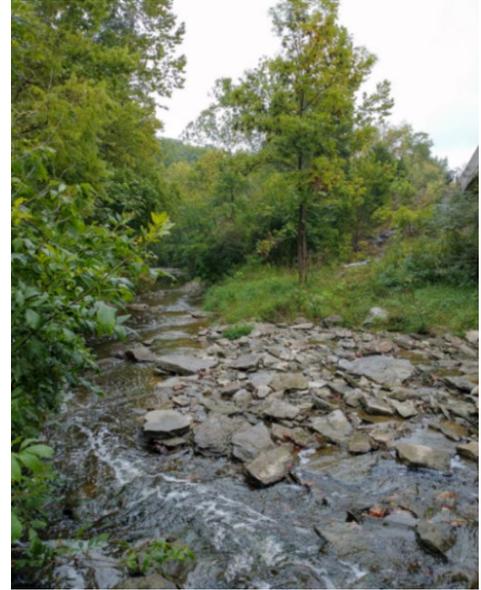
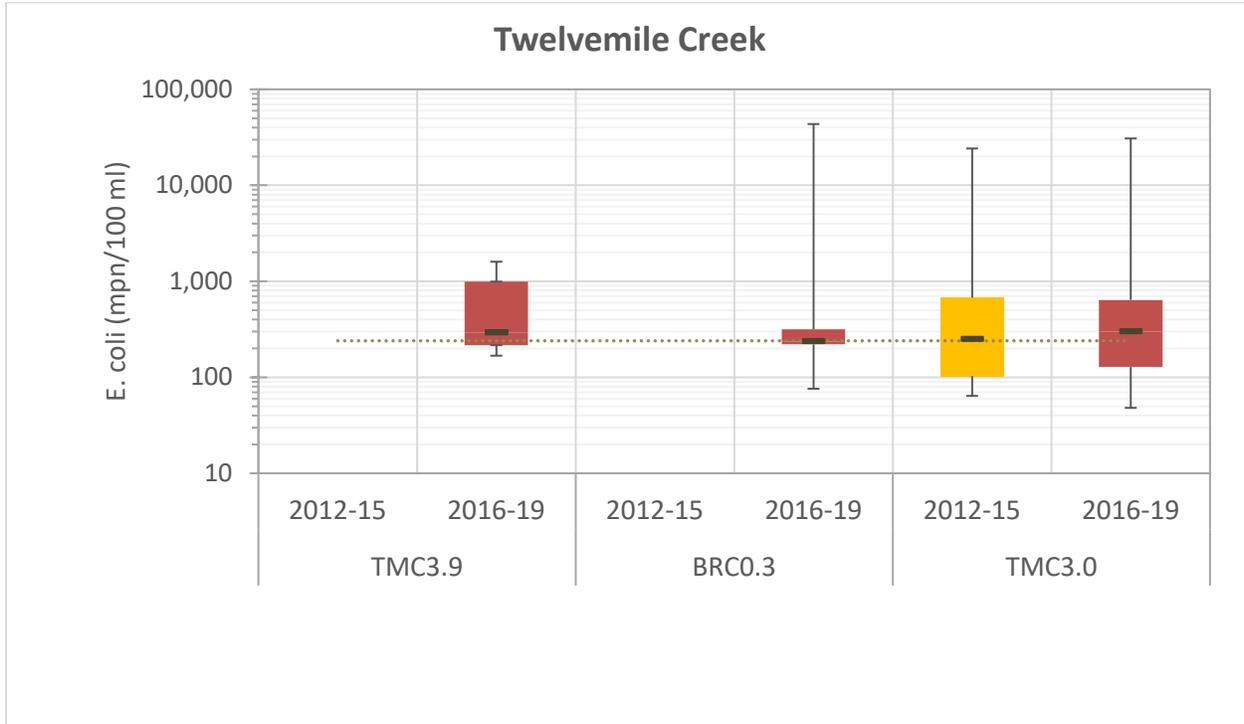


Photo 9. Brush Creek 0.3



The dashed line in the graph represents the single sample maximum criteria of 240 mpn/100ml.

Figure 20. Twelvemile Creek *E. coli* Results

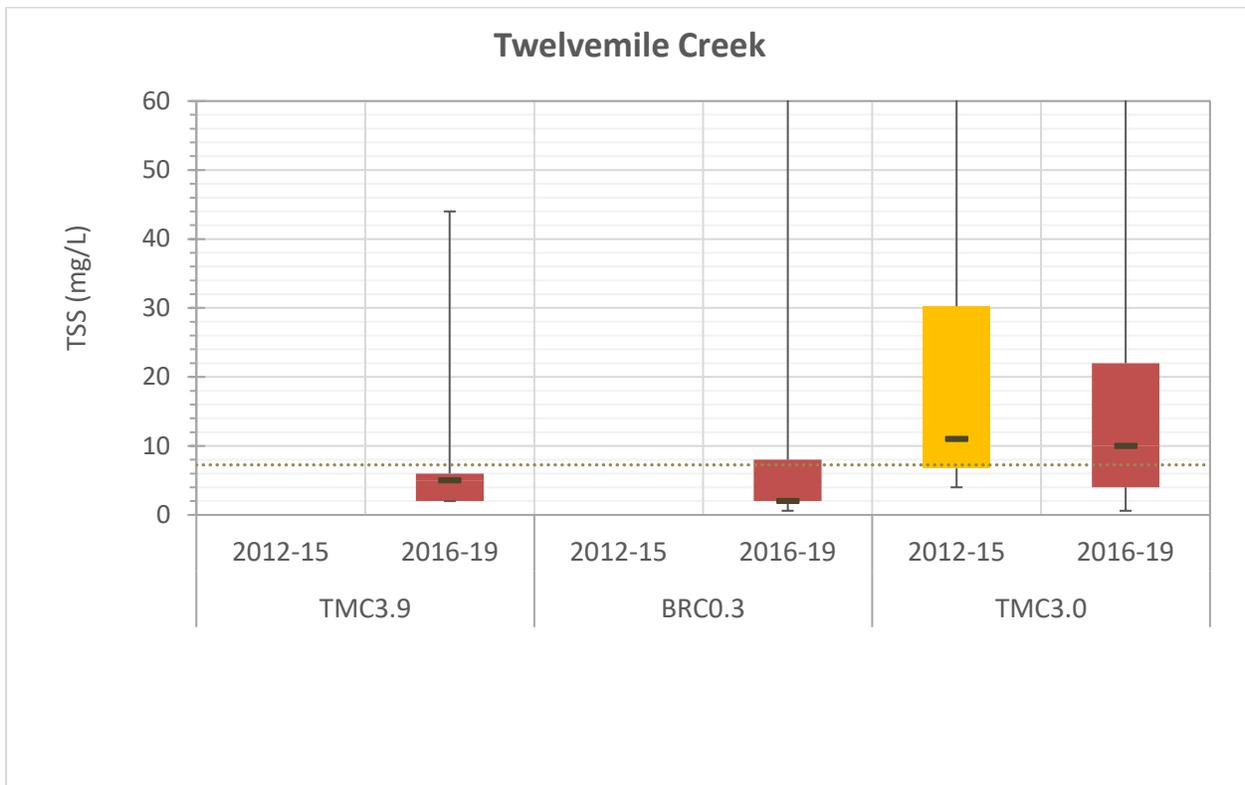
Twelvemile Creek Total Suspended Solids

TSS values ranged from 2 mg/L to 44 mg/L at TMC3.9 during Period 3. The median value was below the 7.25 mg/L benchmark, 5 mg/L.

TSS values ranged from <1.2 mg/L to 1,230 mg/L at BRC0.3 during Period 3. The median value was below the 7.25 mg/L benchmark, 2 mg/L.

TSS values ranged from 4 mg/L to 136 mg/L during Period 2 and ranged from <1.2 mg/L to 385 mg/L during Period 3 at TMC3.0. The median values were above the 7.25 mg/L benchmark during Period 2 and 3 at TMC3.0, 11 mg/L and 10 mg/L.

The suspected source of elevated TSS values within the Twelvemile Creek watershed primarily includes storm water runoff and streambank erosion due to hydromodification.



The dashed line in the graph represents the benchmark value established by KDOW of 7.25 mg/L.

Figure 21. Twelvemile Creek TSS Results

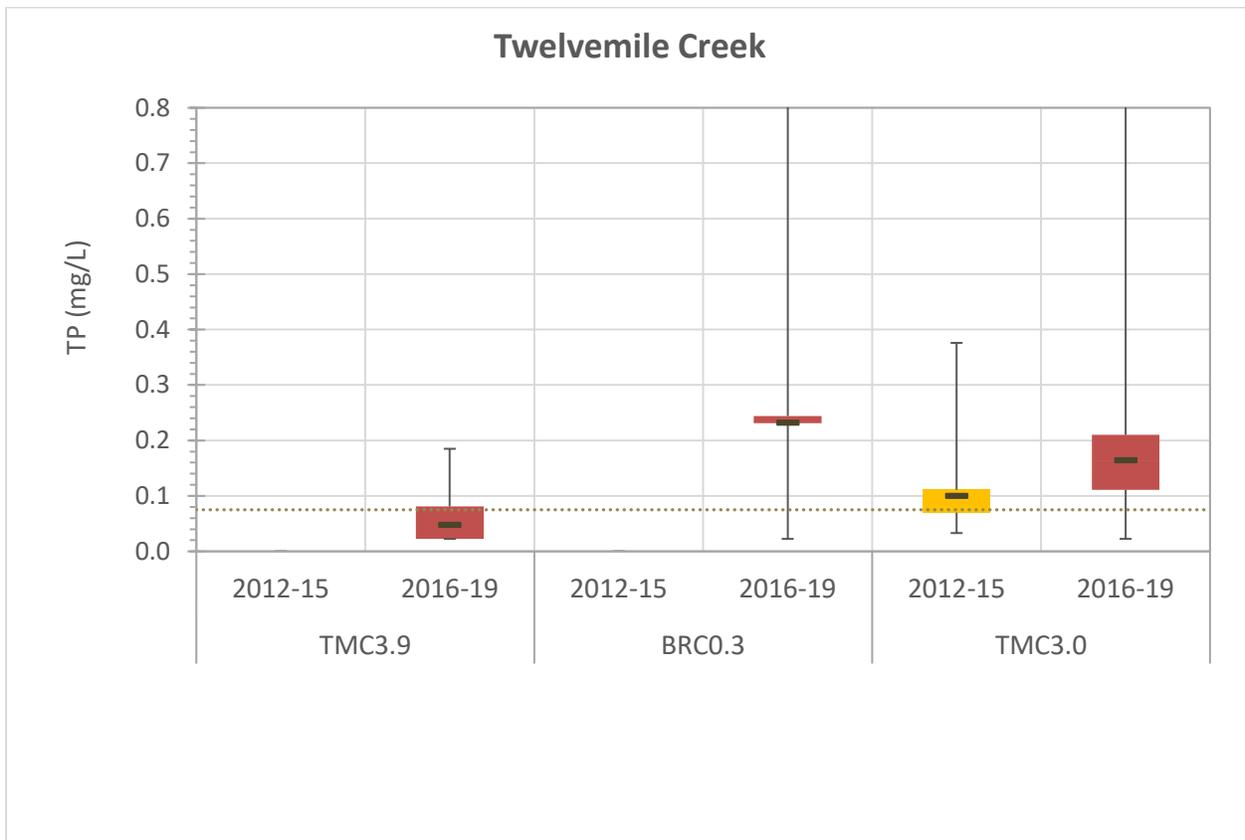
Twelvemile Creek Total Phosphorous

TP values ranged from <0.045 mg/L to 0.185 mg/L during Period 3 at TMC3.9. The median value was below the 0.08 mg/L benchmark, 0.048 mg/L.

TP values ranged from <0.045 mg/L to 1.91 mg/L during Period 3 at BRC0.3. The median value was above the 0.08 mg/L benchmark, 0.232 mg/L.

TP values ranged from 0.033 mg/L to 0.376 mg/L during Period 2 and ranged from <0.045 mg/L to 4.01 mg/L during Period 3 at TMC3.0. The median values during both periods were above the 0.08 mg/L benchmark 0.1 mg/L and 0.164 mg/L.

The suspected source of elevated phosphorus values within the Twelvemile Creek watershed primarily includes point source discharges and storm water runoff.



The dashed line in the graph represents the benchmark value established by KDOW of 0.08 mg/L.

Figure 22. Twelvemile Creek TP Results

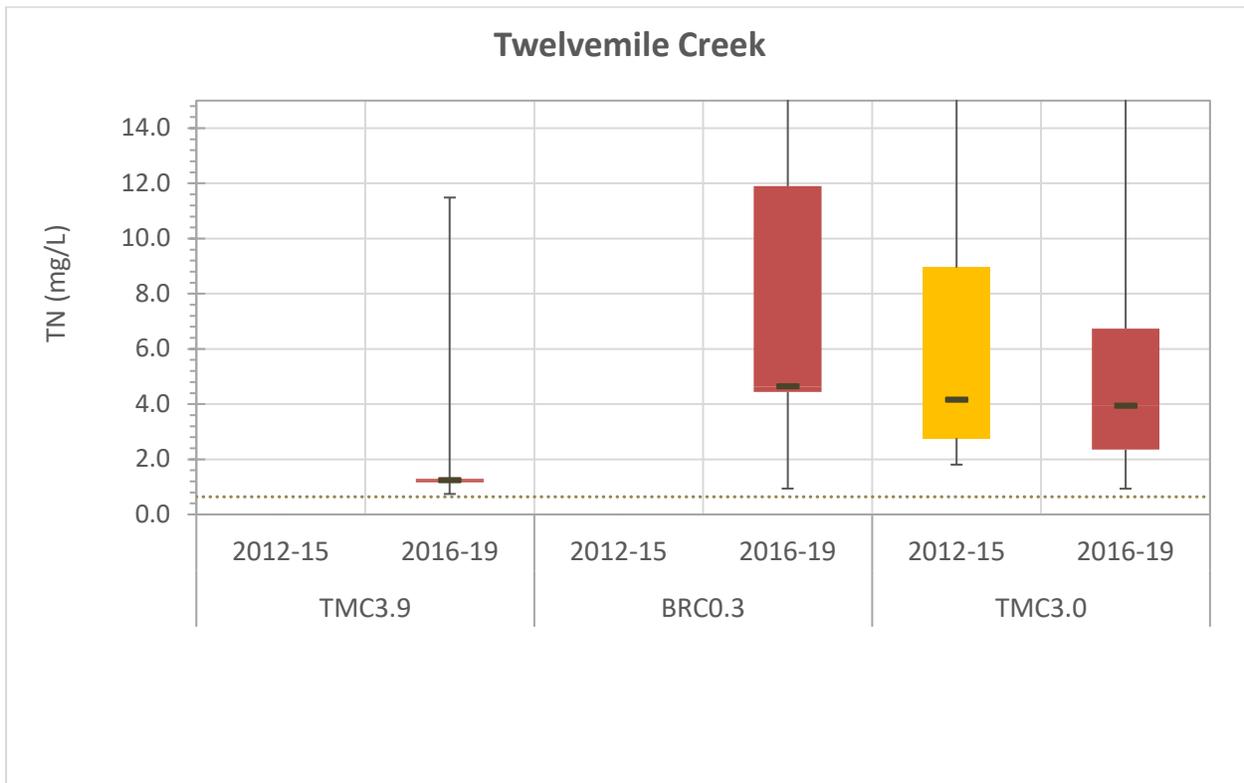
Twelvemile Creek Total Nitrogen

TN values ranged from 0.74 mg/L to 11.49 mg/L at TMC3.9 during Period 3. The median value was above the 0.6 mg/L benchmark, 1.24 mg/L.

TN values ranged from 0.94 mg/L to 16.75 mg/L at BRC0.3 during Period 3. The median value was 4.64 mg/L which is above the 0.6 mg/L benchmark.

TN values ranged from 1.81 mg/L to 15.81 mg/L during Period 2 and 0.93 mg/L to 18.08 mg/L during Period 3 at TMC3.0. The median values during both periods were above the 0.6 mg/L benchmark, 4.15 mg/L and 3.93 mg/L.

The median TN value for each reporting period was highest within the Twelvemile Creek watershed when compared to the other two East Basin watersheds. Suspected sources of excess nitrogen values within the Twelvemile watershed primarily include point source discharges and storm water runoff.



The dashed line in the graph represents the benchmark value established by KDOW of 0.6 mg/L.

Figure 23. Twelvemile Creek TN Results

Biological Assessment Results

SD1's biological assessments consist of macroinvertebrate specimen collection and habitat characterization conducted at multiple sites in each watershed. During the Period 2 basin rotation, East Basin sites were collected in 2012; during Period 3 basin rotation, East Basin sites were collected in 2016. All assessments were conducted following the appropriate Field Monitoring and Sampling Plan (FMSP) and the associated Quality Assurance Program Plan (QAPP) utilizing approved bioassessment protocols⁹.

Macroinvertebrate specimen samples were analyzed using the Kentucky Division of Water Macroinvertebrate Biologic Index (MBI), as well as statistical analyses that examine community structure. The MBI is a multi-metric index that uses various attributes to assign a score (0-100, scaled temporally and spatially) and a rating (Excellent, Good, Fair, Poor, Very Poor) to a given stream reach, with higher scores corresponding to higher quality streams. Key metrics that affect overall index scores (refer to Appendix B1 for additional details) are as follows:

- Abundance of genera (i.e., taxa richness) - increasing total number of genera generally indicates improving water quality and habitat conditions (see example photos below).



Photo 10. Hellgrammite Larvae (Megaloptera)



Photo 11. Crane Fly Larvae (Diptera)

- Abundance of pollution sensitive organisms (specifically insect orders of Ephemeroptera, Plecoptera and Trichoptera) - increasing total pollutant sensitive organisms generally indicate improving water quality and habitat conditions (see example photos below).



Photo 12. Mayfly Nymph (Ephemeroptera)



Photo 13. Stonefly (Plecoptera)

⁹ Kentucky Division of Water/U.S. Environmental Protection Agency criteria (Barbour et al. 1999, KDOW 2001)

- Abundance of pollution tolerant organisms - increasing total pollutant tolerant organisms generally indicate declining water quality conditions (see example photos below).

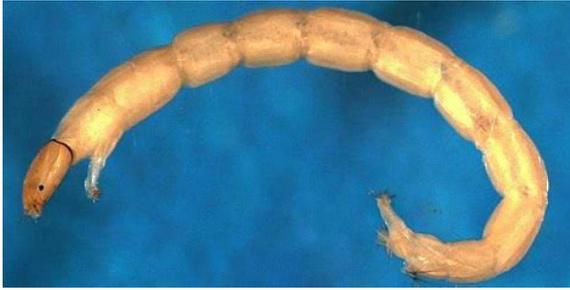


Photo 14. Chironomid Larvae (Chironomidae)¹⁰ Photo 15. Aquatic Worm (Oligochaete)

Habitat assessments were determined using Rapid Bioassessment Protocols (RBP). This protocol evaluates instream metrics – such as embeddedness, and velocity, as well as the surrounding riparian buffer metrics – such as bank stability, vegetative protection, and channel alteration. In combination, these metrics give an overall evaluation of the stream reach. In total there are ten metrics that are evaluated (refer to Appendix B2 for additional details). Each metric is assigned a score (0-20) by the field crew for each site. A final score is calculated, and a rating (Good, Fair, Poor) is given to the stream reach, with higher scores corresponding to higher quality streams.

Habitat and macroinvertebrate data were collected at sampling sites as defined in the FMSP. Sites were separated into two types and categorized as either headwater or wadeable. Headwater sites have 5 miles² or less drainage area, while wadeable sites have greater than 5 miles² of drainage area.

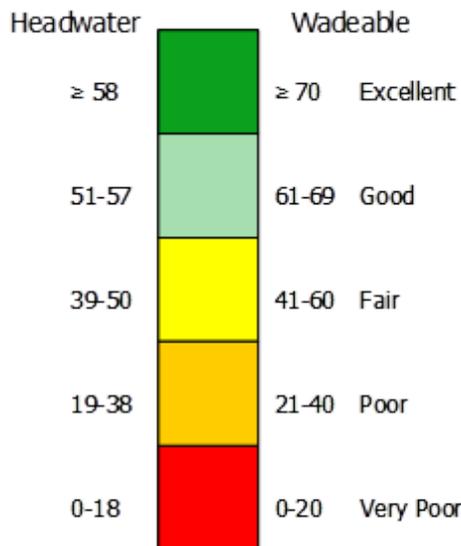


Table 6. RBP Ratings

Headwater		Wadeable	
Good	>156	Good	>130
Fair	142-155	Fair	114-129
Poor	<141	Poor	<113

Figure 24. MBI Ratings

Refer to Appendices B1 and B2 for results from individual sites within the East Basin study area.

¹⁰ Photo taken from the North Carolina Department of Environmental Quality website.

Fourmile Creek

Fourmile Creek streams within the watershed are typically moderate to steep gradient, with streambeds usually dominated by cobble/boulder/bedrock substrates. Riparian zone habitat varies throughout the stream length, dependent primarily on the surrounding land use. The current state of development has resulted in a watershed total impervious surface area of 5.9%. Assessments were performed at all three monitoring sites during Period 2 and Period 3.

Table 7. Fourmile Creek MBI Scores

Fourmile Creek	Site Type	Period 2 MBI Scores	Period 3 MBI Scores
Site	Category	2012	2016
FMC0.5	Wadeable	57.80 (Fair)	49.95 (Fair)
FMC6.9	Headwater	31.61 (Poor)	41.09 (Fair)
OWC0.4	Headwater	48.90 (Fair)	34.87 (Poor)

The Fourmile Creek MBI scores ranged from fair to poor at all three sites. At sites FMC0.5 and OWC0.4 the scores decreased from 2012 to 2016. While pollutant sensitive organism metrics stayed relatively the same, the percentage of pollutant tolerant organisms increased greatly. The MBI score at site FMC6.9 increased from poor in 2012 to fair in 2016, due to significant increases in pollutant sensitive organism metrics, and a decrease in pollutant tolerant organisms.

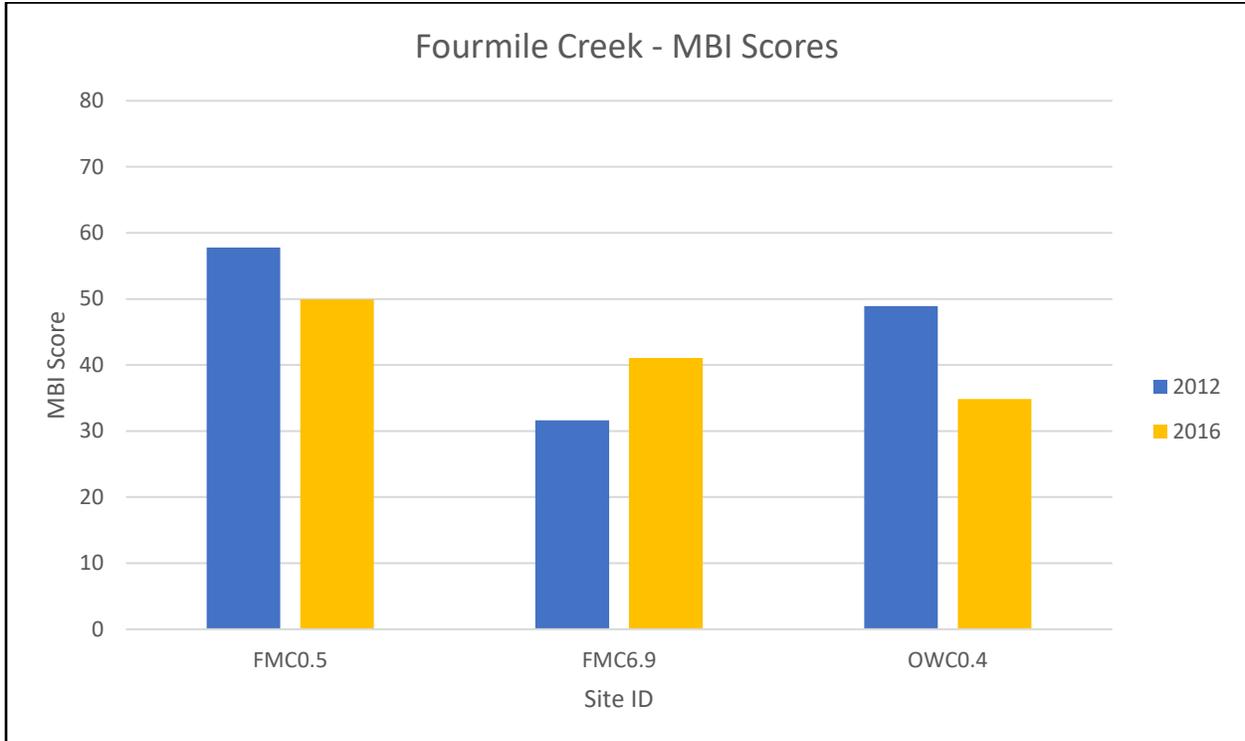


Figure 25. Fourmile Creek MBI Scores

Table 8. Fourmile Creek RBP Scores

Fourmile Creek	Site Type	Period 2 RBP Scores	Period 3 RBP Scores
Site	Category	2012	2016
FMC0.5	Wadeable	102 (Poor)	82 (Poor)
FMC6.9	Headwater	114 (Fair)	130 (Good)
OWC0.4	Headwater	137 (Poor)	137 (Poor)

The Fourmile Creek habitat scores ranged from poor to good at all three sites. Site FMC0.5 scores decreased from 2012 to 2016, remaining with a poor rating. FMC0.5 is greatly affected by Ohio River backwater and flooding, as well as a reduction in vegetation and riparian buffers. Site FMC6.9 scores increased from fair in 2012 to good in 2016 due to many habitat metric improvements, such as riffle frequency and bank stability. While individual metrics fluctuated, site OWC0.4 scores remained the same for both 2012 and 2016.

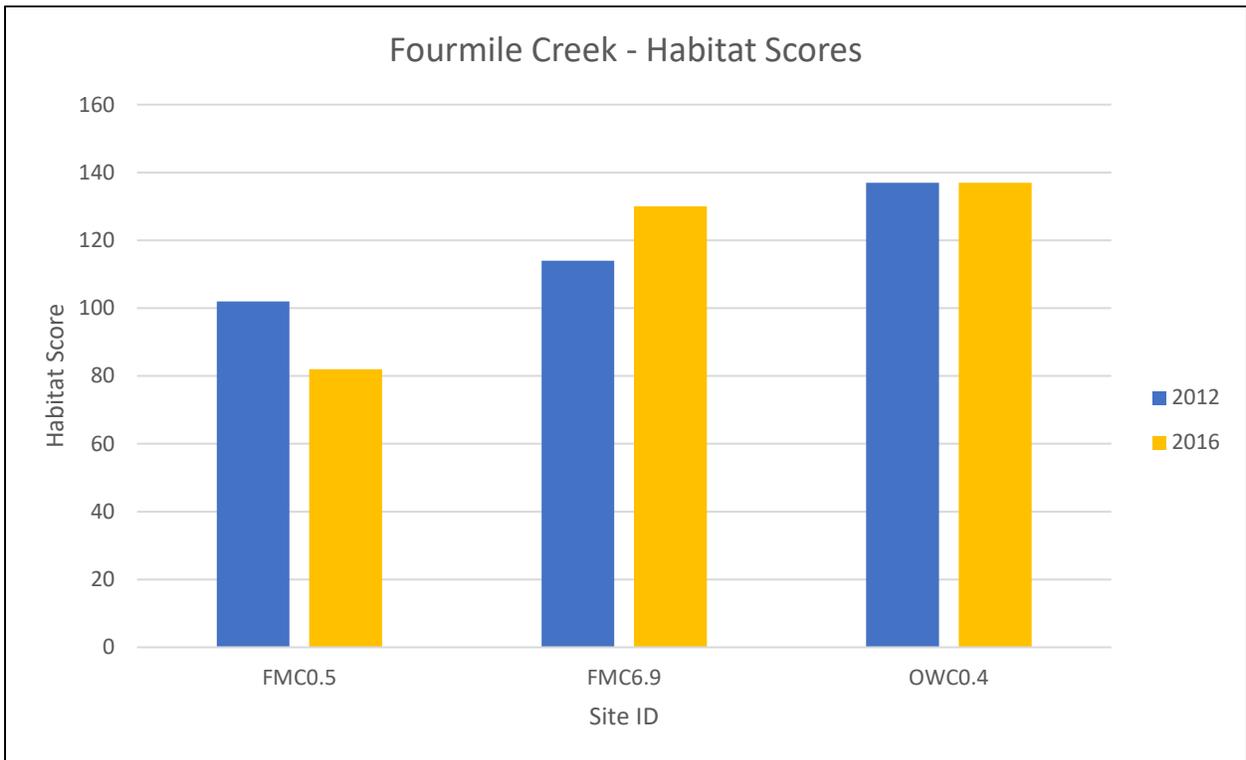


Figure 26. Fourmile Creek Habitat Scores

Taylor Creek

Taylor Creek streams within the watershed are typically low gradient, with streambeds usually dominated by gravel substrates. Riparian zone habitat has been highly modified and subject to flow modifications from channelization. The current state of development has resulted in a watershed total impervious surface area of 26.1%. Assessments were performed at all three monitoring sites during Period 2 and Period 3.

Table 9. Taylor Creek MBI Scores

Taylor Creek	Site Type	Period 2 MBI Scores	Period 3 MBI Scores
Site	Category	2012	2016
TYC0.6	Headwater	32.82 (Poor)	19.43 (Poor)
TYC0.7 – CVR0.2	Headwater	36.05 (Poor)	19.56 (Poor)
TYC0.9 – WLC1.3	Headwater	45.15 (Fair)	30.02 (Poor)

The Taylor Creek MBI scores decreased at all three sites from 2012 to 2016, remaining with a poor rating. While metrics associated with pollutant sensitive organisms did not change, the pollutant tolerant organisms increased at each site. The Taylor Creek scores were the lowest among the other East Basin watersheds.

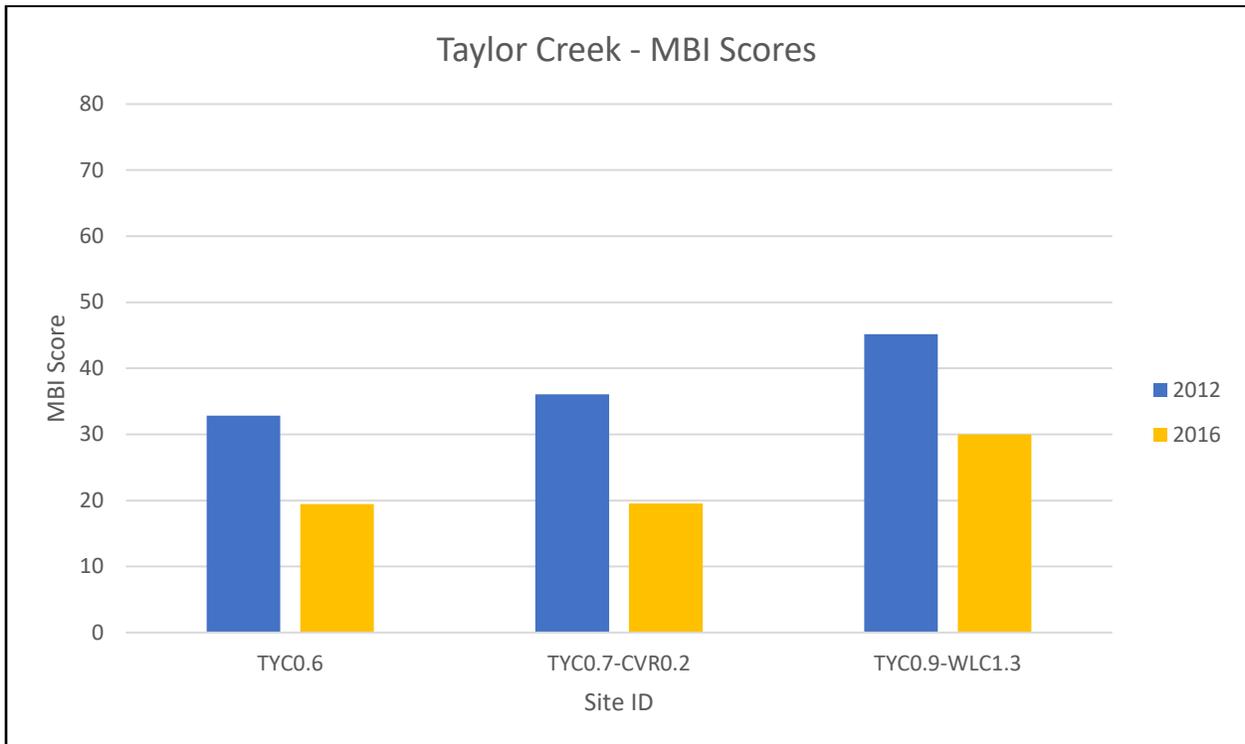


Figure 27. Taylor Creek MBI Scores

Table 10. Taylor Creek RBP Scores

Taylor Creek	Site Type	Period 2 RBP Scores	Period 3 RBP Scores
Site	Category	2012	2016
TYC0.6	Headwater	76 (Poor)	90 (Poor)
TYC0.7 – CVR0.2	Headwater	66 (Poor)	99 (Poor)
TYC0.9 – WLC1.3	Headwater	55 (Poor)	84 (Poor)

The Taylor Creek habitat scores increased at all three sites from 2012 to 2016, however scores remained with a poor rating. Frequency of riffles and embeddedness metrics increased, while many of the other metrics stayed the same or decreased.

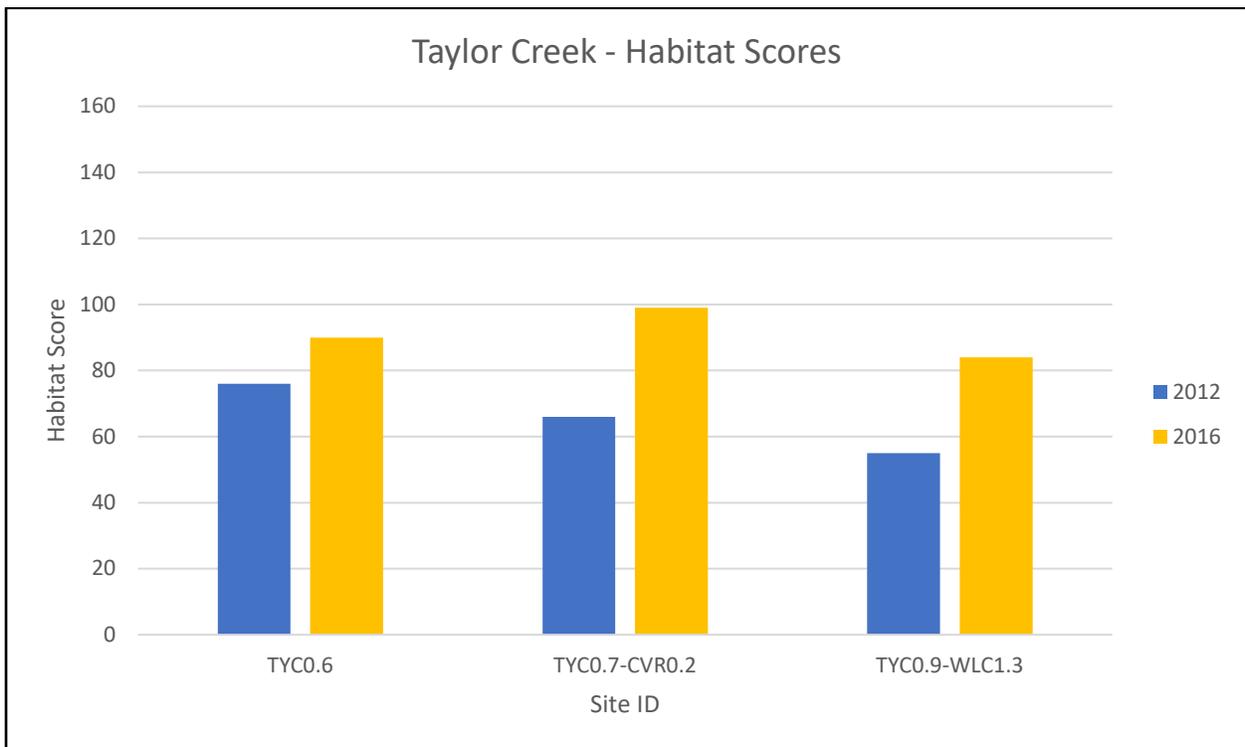


Figure 28. Taylor Creek Habitat Scores

Twelvemile Creek

Twelvemile Creek streams within the watershed are typically moderate to high gradient, with streambeds usually dominated by cobble/boulder/bedrock substrates. Riparian zone habitat varies throughout the stream length, dependent primarily on the surrounding land use. The current state of development has resulted in a watershed total impervious surface area of 2.2%. Assessments were performed at two of the three monitoring sites during Period 2 (TMC3.9 was not assessed in 2012 as a result of low flow conditions) and all three sites during Period 3.

Table 11. Twelvemile Creek MBI Scores

Twelvemile Creek	Site Type	Period 2 MBI Scores	Period 3 MBI Scores
Site	Category	2012	2016
TMC3.0	Wadeable	60.60 (Good)	63.70 (Good)
TMC3.9	Wadeable	NA	61.59 (Good)
BRC0.3	Wadeable	55.86 (Fair)	69.63 (Excellent)

Columns displaying "NA" were not assessed during the monitoring period.

The Twelvemile Creek MBI scores were rated as good or excellent at all three sites. At sites TMC3.0 and BRC0.3 the scores increased from 2012 to 2016, with TMC 3.0 remaining with a good rating and BRC0.3 improving from fair to excellent, due to increases in taxa richness at both sites. The Twelvemile Creek scores were the highest among the other East Basin watersheds.

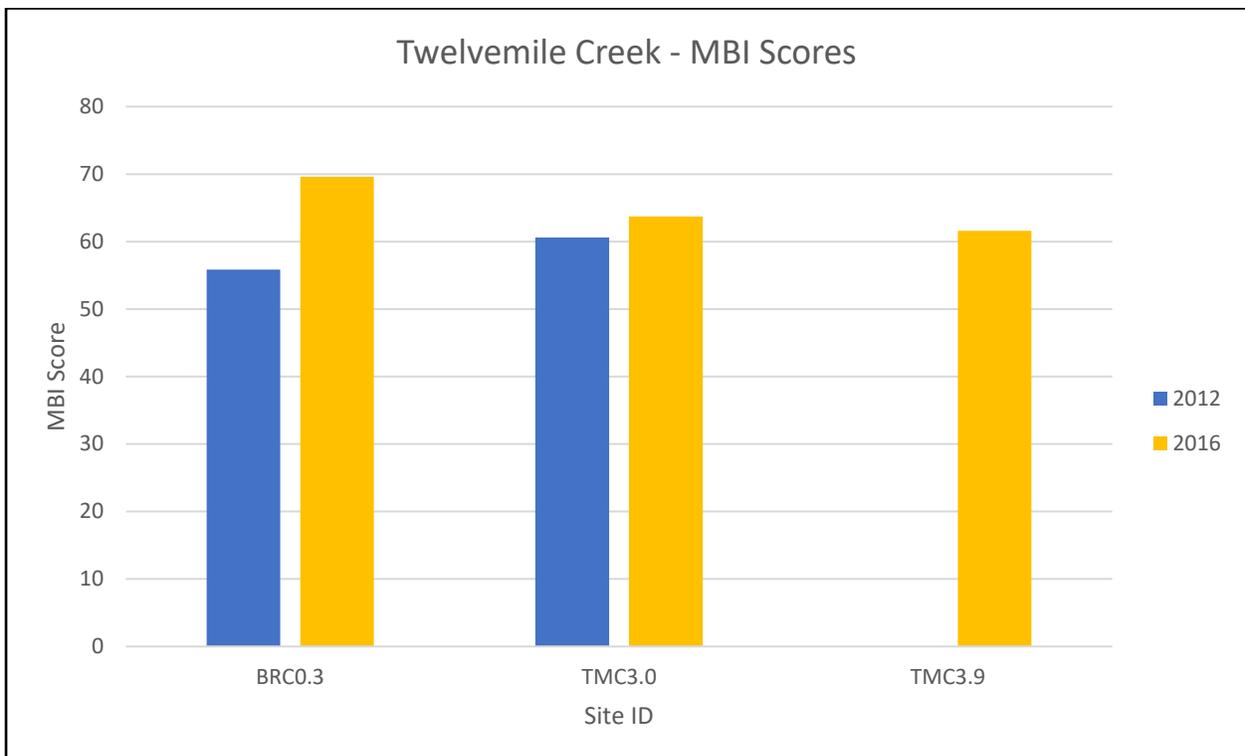


Figure 29. Twelvemile Creek MBI Scores

Table 12. Twelvemile Creek RBP Scores

Twelvemile Creek	Site Type	Period 2 RBP Scores	Period 3 RBP Scores
Site	Category	2012	2016
TMC3.0	Wadeable	127 (Fair)	142 (Good)
TMC3.9	Wadeable	NA	128 (Fair)
BRC0.3	Wadeable	130 (Good)	102 (Poor)

Columns displaying “NA” were not assessed during the monitoring period.

The Twelvemile Creek habitat scores ranged from poor to good at all three sites. Site TMC3.0 scores increased from fair in 2012 to good in 2016, with improvements to embeddedness, as well as bank stability and riparian buffer metrics. Whereas site BRC0.3 scores decreased from good in 2012 to poor in 2016, with a decline due to embeddedness and other metrics.

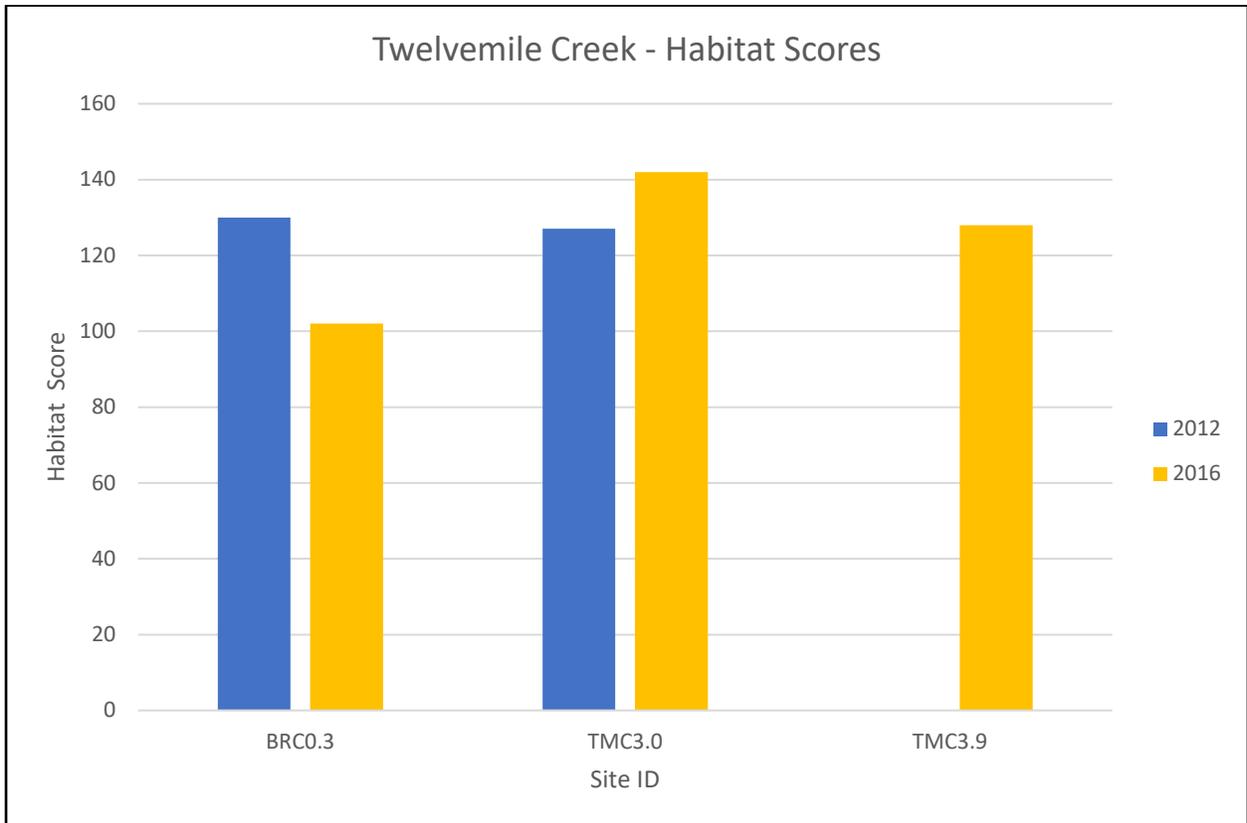


Figure 30. Twelvemile Creek Habitat Scores

Stream Stability Assessment Results

The stream stability monitoring program collects dimensions of stream geomorphology across NKY to develop a regional stream stability index, which consists of full surveys (i.e., channel cross-sections and longitudinal profiles, along with bed material particle counts), as well as rapid stability assessments¹¹ (i.e., bank height/angle, channel shape, bedrock, and pool depth indexes). The rapid stability assessment was developed to supplement the labor-intensive data collection of full surveys to enable the generation of a numerical score immediately upon data collection. For efficient data collection, rapid stream stability assessments were conducted during the biological assessments.

Rapid Stability Scores measure rates of channel change, as seen in Figure 31 (figure shows the channel evolution model – illustration of how a stream can deepen, then widen, and reestablish new banks, over time), in conjunction with field indicators, failure mechanisms, and sediment transport analyses to develop a regionally calibrated channel stability index. The index scale (i.e., 0 – 10 scale) is designed to have built-in flexibility to score sites without detailed stream stability surveys on the same scale as those with multiple years of data using simple but significant metrics. There is not a definitive separation between scores, as in the MBI, however, as a guideline, Table 13 shows stability rankings (i.e., Stable, Transition and Unstable) with respect to assessment scores.

Table 13. Rapid Stability Scores

Rapid Stability Scores	
Stable (relative equilibrium)	>7
Transition (intermediate)	>4 to <7
Unstable (actively adjusting in multiple dimensions)	<4

Refer to Appendix C for results from individual sites within the East Basin study area.

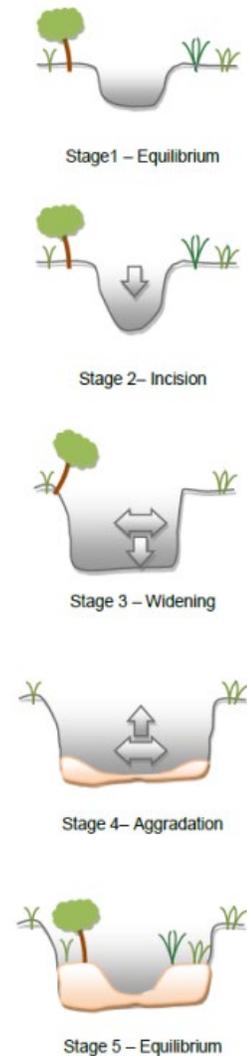


Figure 31. Channel Evolution Model¹²

¹¹ Regionally-Calibrated Channel Stability Index for Northern Kentucky Streams, July 2012 Memorandum

¹² Incised Channels: Morphology Dynamics and Control, Schumm et al. 1984

Fourmile Creek

Fourmile Creek watershed monitoring sites were assessed during Period 2 (FMC0.5 in 2012 and OWC0.4 and FMC6.9 in 2015). Although none of the sites were assessed during Period 3, all three sites are scheduled for assessment during Period 4, per the basin rotation cycle.

Table 14. Fourmile Creek Rapid Stability Scores

Fourmile Creek		Period 2		Period 3
Site	2012	2015	2016	
FMC0.5	0.50	NA	NA	
OWC0.4	NA	1.35	NA	
FMC6.9	NA	4.80	NA	

Columns displaying “NA” do not currently have results available but will in subsequent years (i.e., Period 4).

The monitoring sites in the Fourmile Creek watershed were all below the stable threshold score of 7, with only one site (FMC6.9) within the transition zone, as represented by the area between the solid and dashed blue lines in Figure 32. Evidence of erosion and undercut banks can be seen in the site photos that follow.

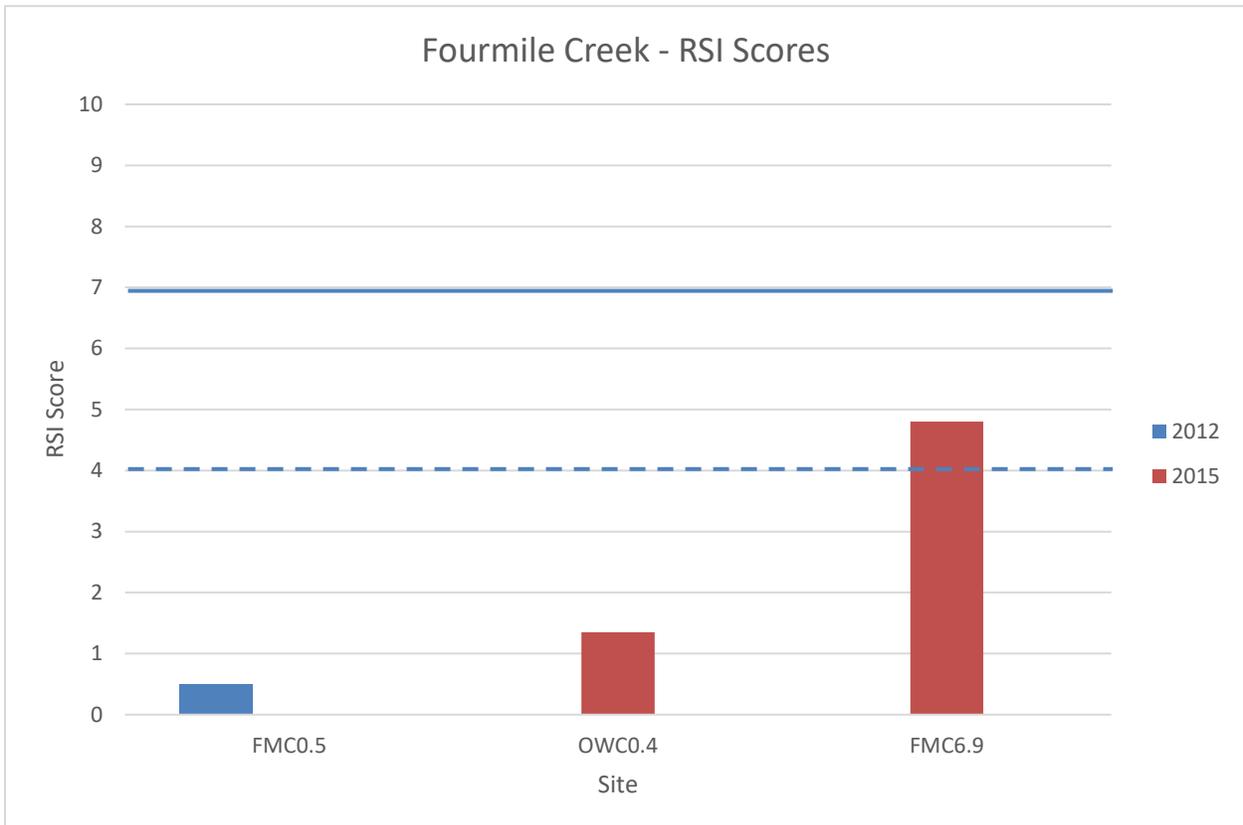


Figure 32. Fourmile Creek Rapid Stability Scores



Photo 16. Owl Creek 0.4



Photo 17. Fourmile Creek 6.9

Taylor Creek

Taylor Creek watershed monitoring sites were assessed in 2012 during Period 2. Although none of the sites were assessed during Period 3, all three sites are scheduled for assessment during Period 4, per the basin rotation cycle.

Table 15. Taylor Creek Rapid Stability Scores

Taylor Creek	Period 2	Period 3
Site	2012	2016
TYC0.6	1.80	NA
TYC0.7 – CVR0.2	3.55	NA
TYC0.9 – WLC1.3	3.60	NA

Columns displaying “NA” do not currently have results available but will in subsequent years (i.e., Period 4).

The monitoring sites in the Taylor Creek watershed were all below the unstable threshold score of 4, as represented by the dashed blue line in Figure 33. The site photo of TYC0.6 illustrates the unstable bank at the time of monitoring, while the site photo of TYC0.9-WLC1.3, is an example of a highly urbanized stream.

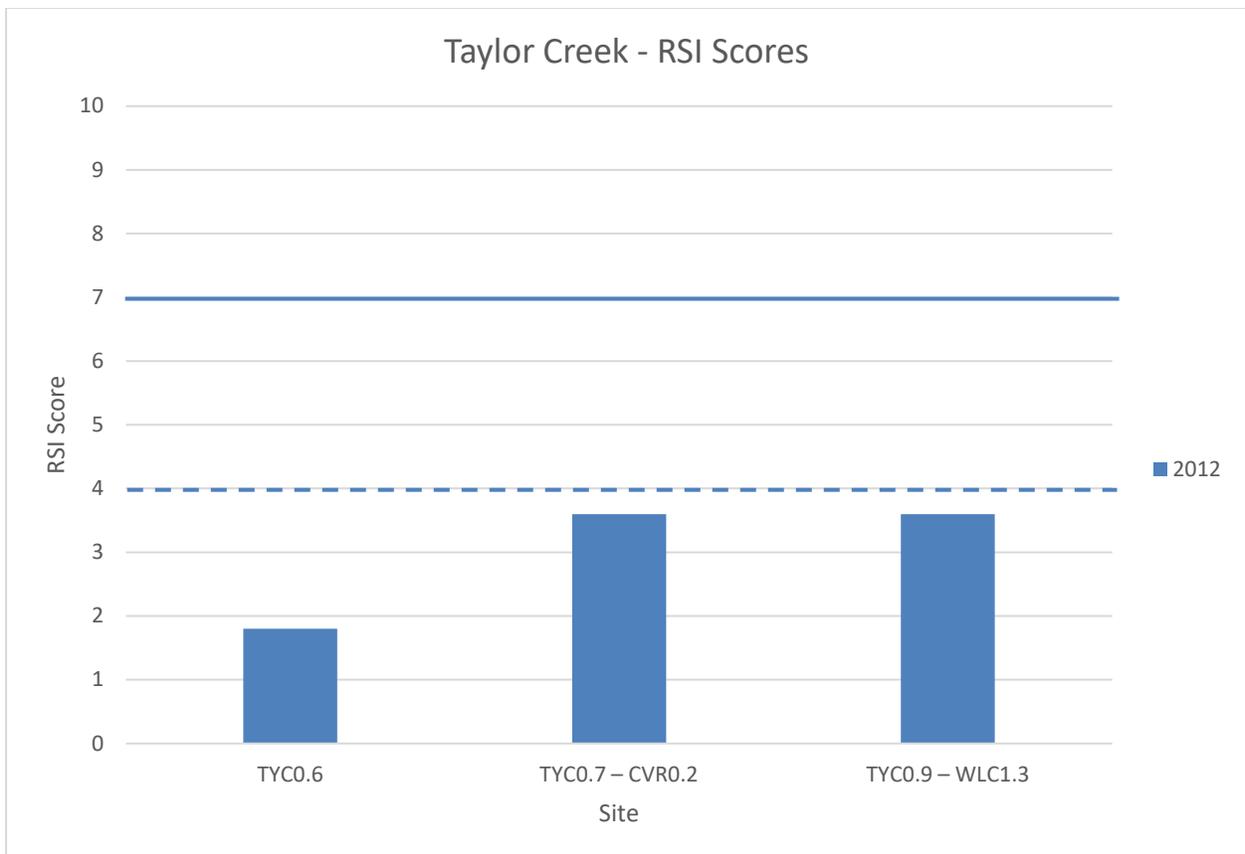


Figure 33. Taylor Creek Rapid Stability Scores



Photo 18. Taylor Creek 0.6



Photo 19. Woodlawn Creek 1.3

Twelvemile Creek

Twelvemile Creek watershed monitoring site TMC3.0 was assessed twice during Period 2 (2012 and 2015), Brush Creek only in 2015. Monitoring sites TMC3.9 and BRC0.3 were added to the stream stability monitoring program in 2021, with all three sites scheduled for assessment during Period 4, per the basin rotation cycle.

Table 16. Twelvemile Creek Rapid Stability Scores

Twelvemile Creek	Period 2		Period 3
Site	2012	2015	2016
TMC3.0	6.10	6.60	NA
TMC3.9	NA	NA	NA
BRC0.3	NA	4.2	NA

Columns displaying “NA” do not currently have results available but will in subsequent years (i.e., Period 4).

Monitoring site TMC3.0 was assessed twice, producing scores within the transition zone (i.e., a score between 4 and 7), as represented by the area between the solid and dashed blue lines in Figure 34. The site photo of TMC3.0 depicts the setup of a stream stability survey.

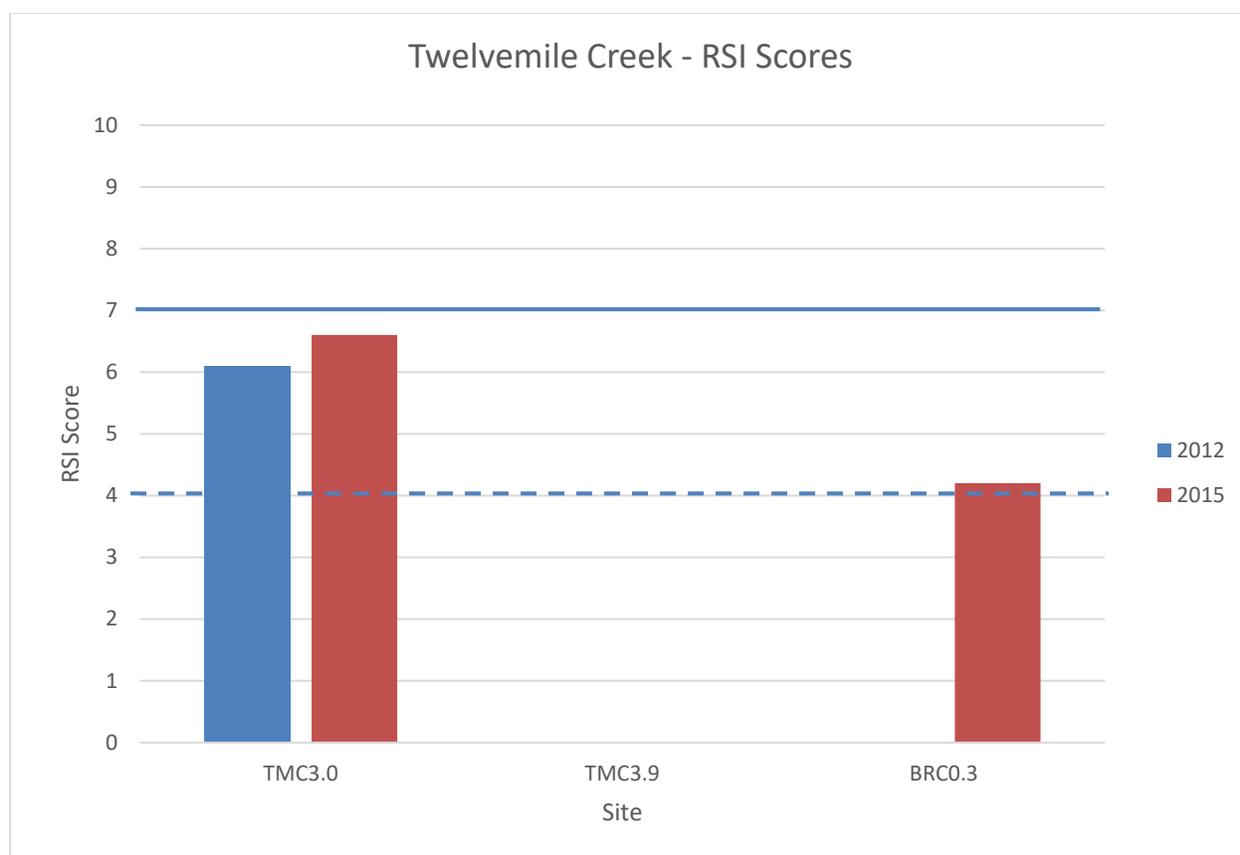


Figure 34. Twelvemile Creek Rapid Stability Scores



Photo 20. Twelvemile Creek 3.0

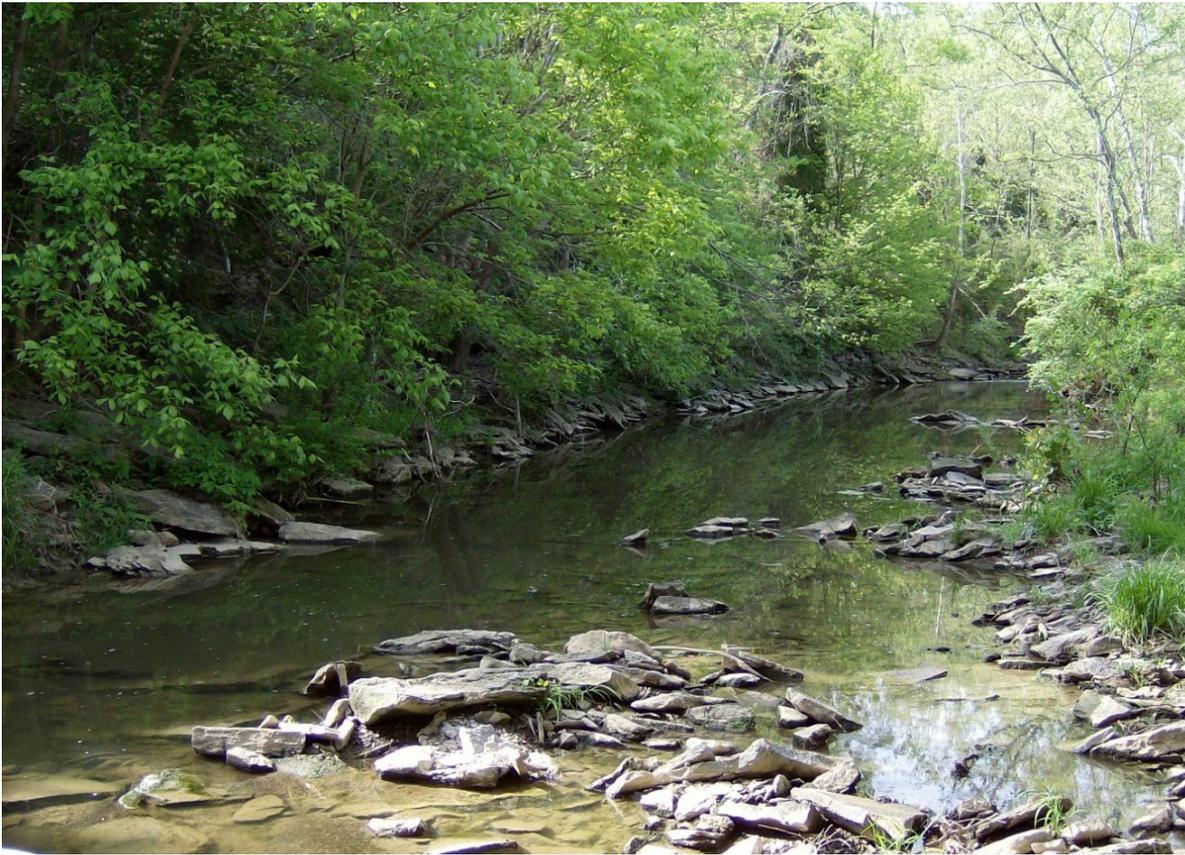


Photo 21. Brush Creek 0.3

Stream Condition Index Basin Trends

The Stream Condition Index (SCI) is a visual representation (Figure 35) of four key components of SD1’s watershed assessment program: water quality, biology, physical habitat, and stream stability¹³. Originally developed for a tool to summarize large amounts of complex information that can be easily understood by the general public, the SCI was updated in 2020 for trend analysis¹⁴. Each of these four components is essential to fully understand the ecological functions and relative health of the individual streams. Relying on a single parameter could be problematic since some streams may rate well in one category, but poor in others. Each of the four indicators used in the Stream Condition Index are given sub-scores. The four sub-scores are then averaged to generate a single overall Stream Condition Index score. These scores are updated as additional data is collected and as the characterization of the watersheds are refined. The overall score for a monitoring site is only calculated if 3 out of the 4 indicators are populated with a sub-score.

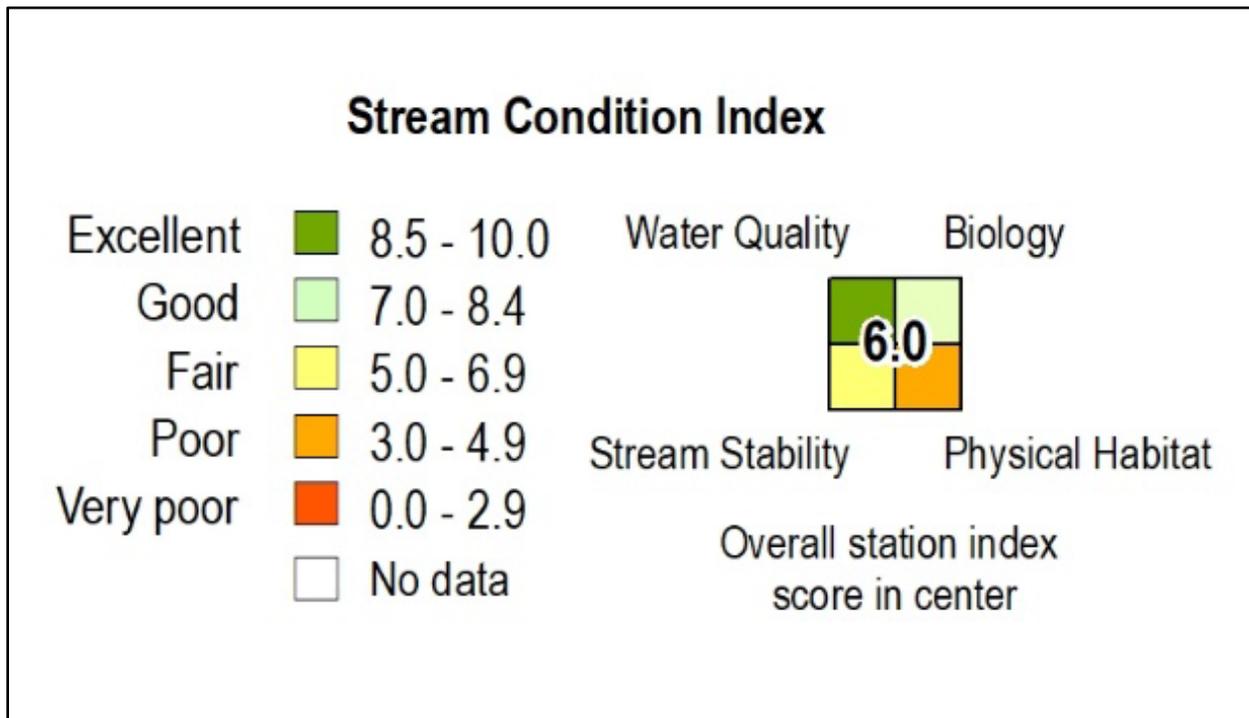


Figure 35. Stream Condition Index Visual Representation

An overall watershed SCI score is calculated if at least 50% of the monitoring sites within the watershed contain data and, if at minimum, sub-scores are calculated for water quality, biology and physical habitat. Watershed scores for Periods 2 and 3 are displayed in the preceding graphs and tables. These scores are out of a total rating of 10, which would be the highest score possible. Appendix D contains tables for Individual site scores for Periods 2 and 3.

¹³ A Stream Condition Index for Water Utility Resource Management in Northern Kentucky Document, June 2013

¹⁴ Basin Trend Stream Condition Index Water Quality Sub-Indices Development, October 2020 Memorandum

The overall SCI scores for the East Basin watersheds from 2012 - 2015 range from 3.63 to 6.89. Twelvemile Creek had the highest score of 6.89 (Fair), with Fourmile and Taylor having lower scores of 4.68 (Poor) and 3.63 (Poor), respectively (Table 17 and Figure 36).

Table 17. Stream Condition Index Basin Trend Scores by Watershed for Period 2 (2012 - 2015)

Watershed	Water Quality Score	Biology Score	Habitat Score	Stream Stability Score	Score
Fourmile Creek	5.89	6.14	4.46	2.22	4.68
Taylor Creek	4.15	5.06	2.33	2.98	3.63
Twelvemile Creek	6.00	6.79	9.48	5.28	6.89

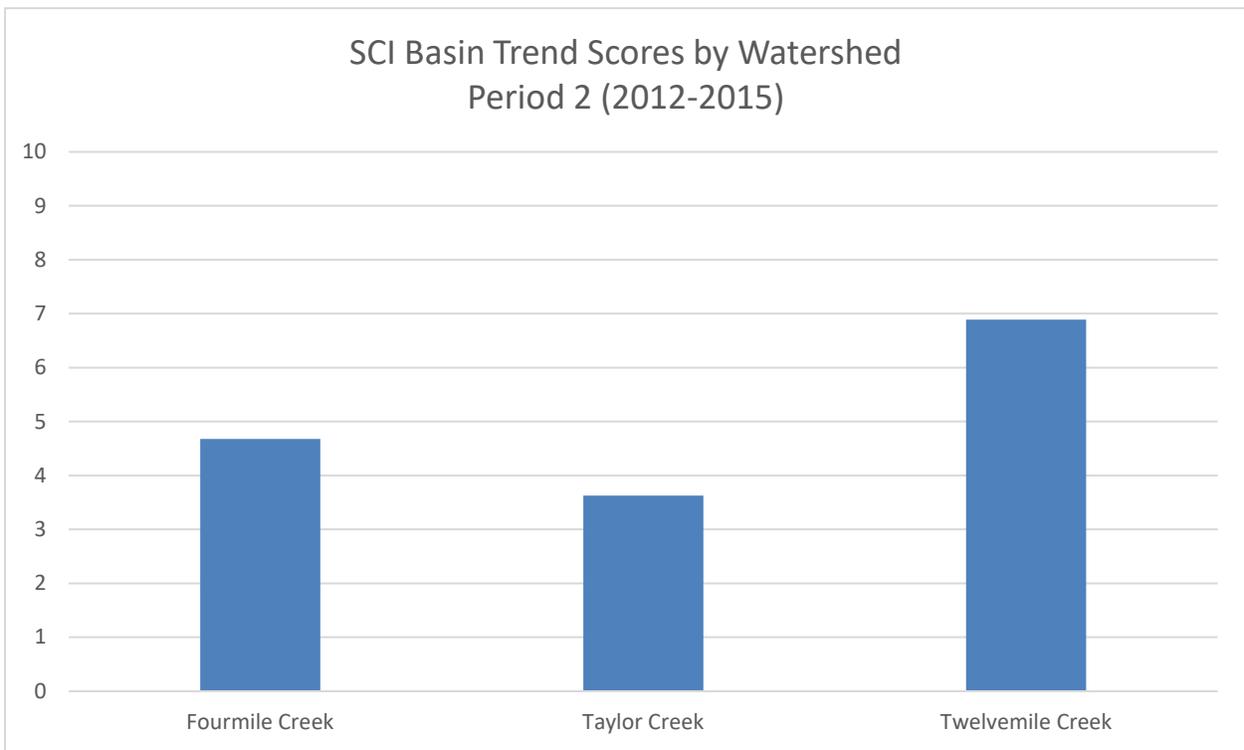


Figure 36. Stream Condition Index Basin Trend Scores by Watershed for Period 2

The overall SCI scores for the East Basin watersheds from 2016 - 2019 range from 3.79 to 7.52. Twelvemile Creek had the highest score of 7.52 (Good), with Fourmile and Taylor having lower scores of 5.29 (Fair) and 3.79 (Poor), respectively (Table 18 and Figure 37).

Table 18. Stream Condition Index Basin Trend Scores by Watershed for Period 3 (2016 - 2019)

Watershed	Water Quality Score	Biology Score	Habitat Score	Stream Stability Score	Score
Fourmile Creek	6.12	5.40	4.35	NA	5.29
Taylor Creek	5.05	3.10	3.23	NA	3.79
Twelvemile Creek	5.86	8.74	7.95	NA	7.52

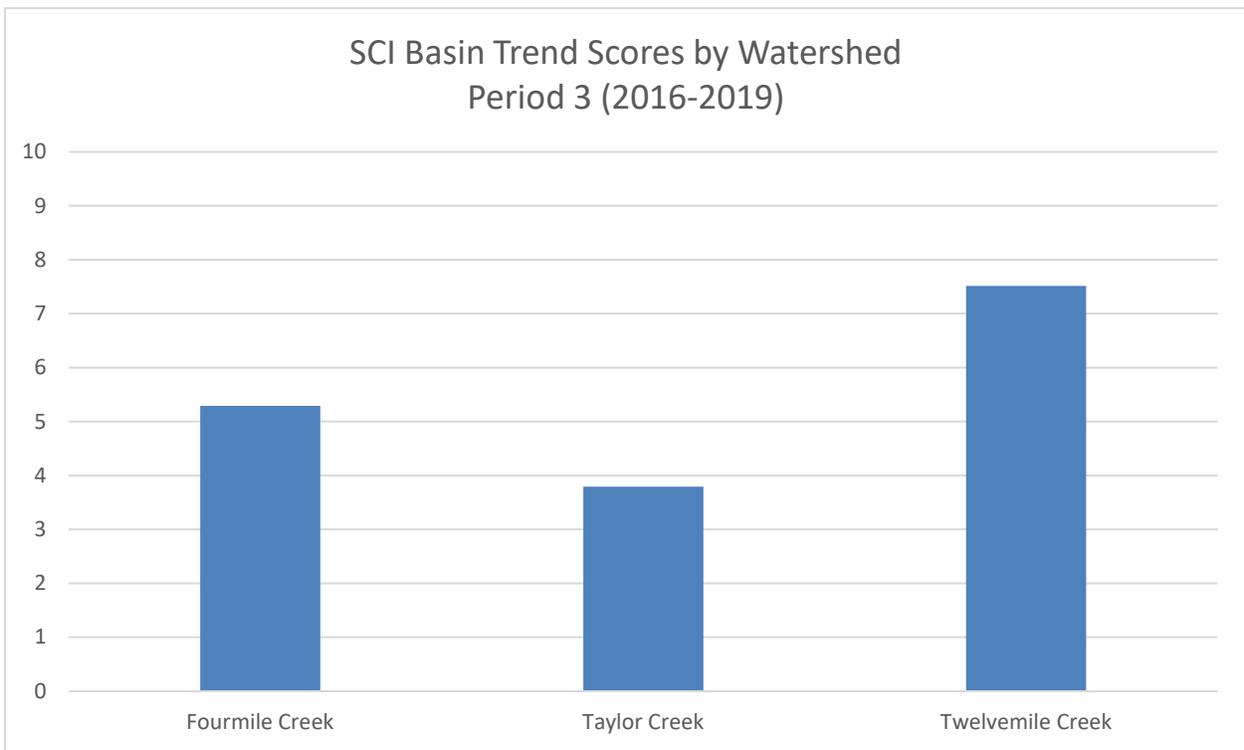


Figure 37. Stream Condition Index Basin Trend Scores by Watershed for Period 3

Conclusion

Table 19 and Figure 38 depict the initial points of a trend line representing SD1's Stream Condition Index for the three watersheds in the East Basin. Although data was limited at some monitoring sites within the watersheds during Periods 2 and 3, a more complete dataset starting with Period 4 will increase the accuracy of the analysis.

Over time as the watersheds are sampled and assessed, the trend line representing each watershed's rating will extend. Currently, the lines between periods for all three watersheds are trending upward (i.e., positive improvement).

Table 19. Stream Condition Index Basin Trend Scores

Watershed	Period 2 (2012-2015)	Period 3 (2016-2019)
Fourmile Creek	4.68	5.29
Taylor Creek	3.63	3.79
Twelvemile Creek	6.89	7.52

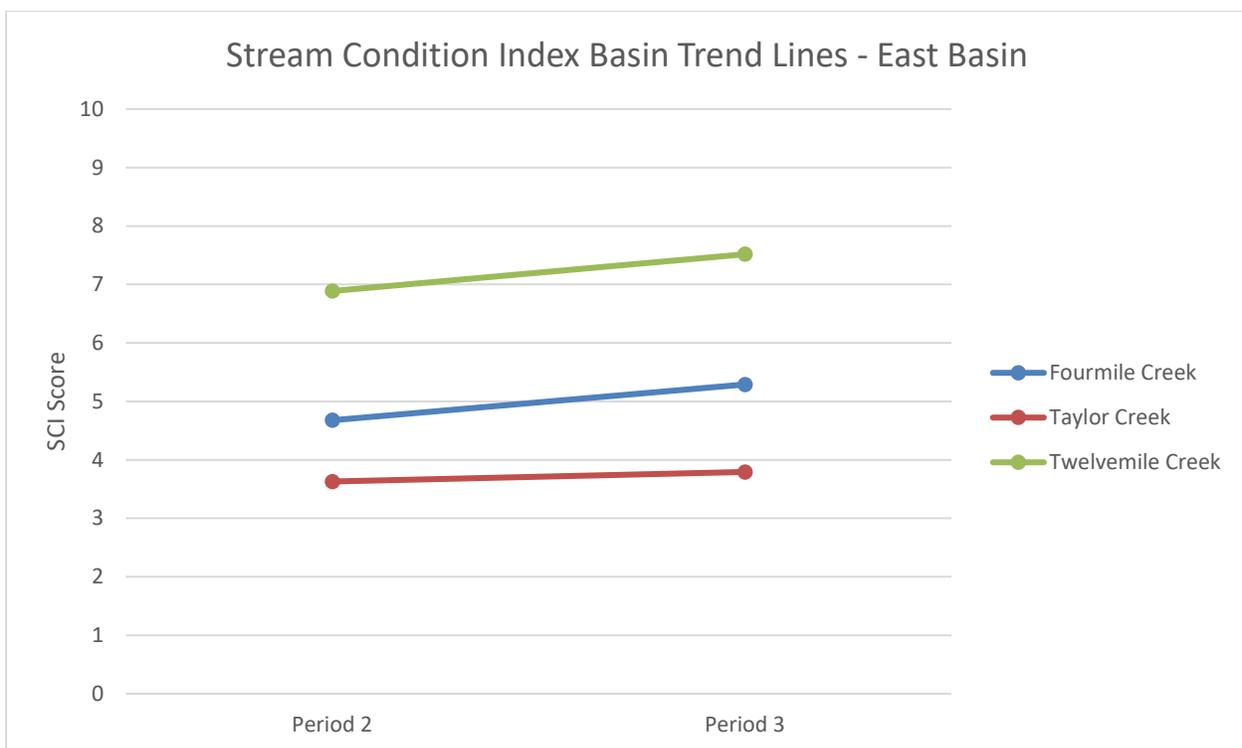


Figure 38. Stream Condition Index Basin Trend Scores

As stated in the beginning objectives, there are numerous reasons why SD1 continues to collect instream water quality, biology, physical habitat, and stream stability data. These monitoring program components together not only characterize the state of Northern Kentucky watersheds, but they also provide locally relevant data as to how to better manage the impacts to the watersheds by implementing effective regulatory requirements and improvement projects.

This data has been used to inform local storm water management policies and regulations that are effective in protecting the region's water quality. Additionally, the monitoring data collected by SD1 has been used by local partners (e.g., conservation districts and citizen watershed groups) to obtain 319 (h) grants from Kentucky to inform additional watershed plans and implementation projects that compliment SD1 initiatives.

SD1 is committed to balance the need to keep local waterways clean and safe with the need to provide affordable wastewater and storm water services in Northern Kentucky. Clean H₂O40 is SD1's commitment to increasing our capacity to better manage the flow of wastewater and storm water in Northern Kentucky. Through a number of strategic projects specifically designed to address sewer overflows, SD1 will meet the requirements of Northern Kentucky's consent decree and improve the quality of life in our community. By the year 2040, SD1 will completely eliminate typical-year sanitary sewer overflows and recapture at least 85 percent of all typical-year combined sewer overflows.

Additional information on SD1's monitoring programs and Clean H₂O40 initiative can be found at <https://www.sd1.org>.

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Appendix A – Water Quality Data

Instream water quality results are listed in tables beginning with the Fourmile Creek watershed, followed by the Taylor Creek and Twelvemile Creek watersheds. Along with the individual parameter results, the precipitation condition in which the samples were collected is also included in the tables as follows:

- Baseflow (Dry) – flow in the stream is comprised primarily of groundwater and/or the hydrograph is stable (typical example: no precipitation within 72 hours prior to sampling).
- Storm Flow (Wet) – flow in the stream is dominated by runoff and/or the hydrograph is rising or falling (typical example: greater than 0.25” of precipitation within 24 hours prior to sampling).

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Fourmile Creek Water Quality Data

Watershed	Stream	RM	LocID	Period	Precip Condition	Date	E. coli (mpn/100 ml)	TSS (mg/L)	TP (mg/L)	TN (mg/L)	TKN (mg/L)	N/N (mg/L)
Fourmile Creek	Fourmile Creek	0.5	FMC0.5	2	Dry	7/22/15 12:15	5,790	246	0.370	1.299	0.891	0.408
Fourmile Creek	Fourmile Creek	0.5	FMC0.5	2	Dry	8/5/15 11:20	3,080	160	0.153	1.537	1.040	0.497
Fourmile Creek	Fourmile Creek	0.5	FMC0.5	2	Dry	8/19/15 11:40	176	19	0.090	1.204	0.681	0.523
Fourmile Creek	Fourmile Creek	0.5	FMC0.5	2	Dry	9/2/15 11:20	68	21	0.050	0.848	0.725	0.123
Fourmile Creek	Fourmile Creek	0.5	FMC0.5	2	Dry	9/16/15 11:30	208	<2	0.069	0.781	0.526	0.255
Fourmile Creek	Fourmile Creek	0.5	FMC0.5	2	Dry	9/30/15 12:20	4,610	92	0.198	0.875	0.667	0.208
Fourmile Creek	Fourmile Creek	0.5	FMC0.5	2	Dry	10/14/15 12:00	300	34	0.101	0.671	0.579	0.092
Fourmile Creek	Fourmile Creek	0.5	FMC0.5	2	Wet	7/8/15 12:00	176	12	0.142	2.015	1.670	0.345
Fourmile Creek	Fourmile Creek	0.5	FMC0.5	2	Wet	10/28/15 12:10	19,860	296	0.709	2.807	2.270	0.537
Fourmile Creek	Fourmile Creek	0.5	FMC0.5	2	Wet	11/11/15 11:45	408	15	0.024	0.827	0.677	0.150
Fourmile Creek	Fourmile Creek	0.5	FMC0.5	3	Dry	5/25/16 13:20	196	9	0.113	1.056	0.567	0.489
Fourmile Creek	Fourmile Creek	0.5	FMC0.5	3	Dry	6/8/16 11:20	156	17	0.129	1.050	0.812	0.238
Fourmile Creek	Fourmile Creek	0.5	FMC0.5	3	Dry	7/20/16 11:35	488	21	0.159	1.397	1.090	0.307
Fourmile Creek	Fourmile Creek	0.5	FMC0.5	3	Dry	8/3/16 12:30	316	14	0.136	1.509	1.240	0.269
Fourmile Creek	Fourmile Creek	0.5	FMC0.5	3	Dry	8/31/16 12:40	404	17	<0.045	1.452	1.160	0.292
Fourmile Creek	Fourmile Creek	0.5	FMC0.5	3	Dry	9/14/16 13:00	244	15	0.138	1.019	0.805	0.214
Fourmile Creek	Fourmile Creek	0.5	FMC0.5	3	Dry	10/12/16 13:10	56	<1.2	0.058	0.609	0.550	0.059
Fourmile Creek	Fourmile Creek	0.5	FMC0.5	3	Dry	10/26/16 11:15	416	10	0.190	1.343	1.160	0.183
Fourmile Creek	Fourmile Creek	0.5	FMC0.5	3	Dry	11/9/16 12:05	144	5	0.242	1.415	1.410	<0.01
Fourmile Creek	Fourmile Creek	0.5	FMC0.5	3	Dry	4/12/17 12:00	1,740	61	0.225	1.363	1.270	0.093
Fourmile Creek	Fourmile Creek	0.5	FMC0.5	3	Dry	4/26/17 11:55	152	12	0.096	1.187	0.626	0.561
Fourmile Creek	Fourmile Creek	0.5	FMC0.5	3	Dry	5/10/17 11:40	2,748	33	0.213	1.992	1.660	0.332
Fourmile Creek	Fourmile Creek	0.5	FMC0.5	3	Dry	6/7/17 11:45	420	30	0.092	0.844	0.662	0.182
Fourmile Creek	Fourmile Creek	0.5	FMC0.5	3	Dry	6/21/17 12:20	2,192	11	0.135	1.314	0.798	0.516

Watershed	Stream	RM	LocID	Period	Precip Condition	Date	E. coli (mpn/100 ml)	TSS (mg/L)	TP (mg/L)	TN (mg/L)	TKN (mg/L)	N/N (mg/L)
Fourmile Creek	Fourmile Creek	0.5	FMC0.5	3	Wet	4/13/16 12:30	592	35	0.138	0.826	0.730	0.096
Fourmile Creek	Fourmile Creek	0.5	FMC0.5	3	Wet	4/27/16 11:25	9,800	70	0.227	1.704	1.450	0.254
Fourmile Creek	Fourmile Creek	0.5	FMC0.5	3	Wet	5/11/16 11:55	6,870	129	0.298	1.802	1.610	0.192
Fourmile Creek	Fourmile Creek	0.5	FMC0.5	3	Wet	6/22/16 11:15	1,232	11	0.145	0.973	0.812	0.161
Fourmile Creek	Fourmile Creek	0.5	FMC0.5	3	Wet	7/6/16 11:05	4,610	121	0.310	1.706	1.360	0.346
Fourmile Creek	Fourmile Creek	0.5	FMC0.5	3	Wet	8/17/16 12:35	32,600	1,800	0.632	2.740	2.490	0.250
Fourmile Creek	Fourmile Creek	0.5	FMC0.5	3	Wet	9/28/16 12:50	80	2	<0.045	1.149	1.100	0.049
Fourmile Creek	Fourmile Creek	0.5	FMC0.5	3	Wet	5/24/17 11:55	664	13	0.095	1.227	0.930	0.297
Fourmile Creek	Fourmile Creek	6.9	FMC6.9	2	Dry	7/22/15 11:50	3,333	135	0.225	0.983	0.621	0.362
Fourmile Creek	Fourmile Creek	6.9	FMC6.9	2	Dry	8/5/15 10:55	2,498	115	0.123	1.361	0.915	0.446
Fourmile Creek	Fourmile Creek	6.9	FMC6.9	2	Dry	8/19/15 11:15	140	13	0.094	1.104	0.598	0.506
Fourmile Creek	Fourmile Creek	6.9	FMC6.9	2	Dry	9/2/15 10:52	86	19	0.084	0.783	0.685	0.098
Fourmile Creek	Fourmile Creek	6.9	FMC6.9	2	Dry	9/16/15 11:00	280	14	0.071	0.490	<0.139	0.192
Fourmile Creek	Fourmile Creek	6.9	FMC6.9	2	Dry	9/30/15 11:55	14,405	98	0.241	1.121	0.803	0.318
Fourmile Creek	Fourmile Creek	6.9	FMC6.9	2	Dry	10/14/15 11:30	1,376	60	0.218	0.679	0.565	0.114
Fourmile Creek	Fourmile Creek	6.9	FMC6.9	2	Wet	7/8/15 11:30	346	10	0.105	1.379	1.124	0.255
Fourmile Creek	Fourmile Creek	6.9	FMC6.9	2	Wet	10/28/15 11:35	19,860	192	0.562	2.523	2.015	0.508
Fourmile Creek	Fourmile Creek	6.9	FMC6.9	2	Wet	11/11/15 11:15	354	15	0.043	0.700	0.591	0.109
Fourmile Creek	Fourmile Creek	6.9	FMC6.9	3	Dry	5/25/16 13:00	378	12	0.122	1.003	0.628	0.375
Fourmile Creek	Fourmile Creek	6.9	FMC6.9	3	Dry	6/8/16 11:10	362	22	0.146	1.071	0.846	0.225
Fourmile Creek	Fourmile Creek	6.9	FMC6.9	3	Dry	7/20/16 11:15	590	17	0.160	1.215	0.937	0.278
Fourmile Creek	Fourmile Creek	6.9	FMC6.9	3	Dry	8/3/16 11:55	1,134	43	0.157	1.256	1.030	0.227
Fourmile Creek	Fourmile Creek	6.9	FMC6.9	3	Dry	8/31/16 12:15	482	13	<0.045	1.330	1.050	0.280
Fourmile Creek	Fourmile Creek	6.9	FMC6.9	3	Dry	9/14/16 12:40	194	10	0.102	1.038	0.877	0.161
Fourmile Creek	Fourmile Creek	6.9	FMC6.9	3	Dry	10/12/16 13:40	150	1	0.116	0.607	0.575	<0.01

Watershed	Stream	RM	LocID	Period	Precip Condition	Date	E. coli (mpn/100 ml)	TSS (mg/L)	TP (mg/L)	TN (mg/L)	TKN (mg/L)	N/N (mg/L)
Fourmile Creek	Fourmile Creek	6.9	FMC6.9	3	Dry	10/26/16 10:50	352	8	0.178	1.177	1.027	0.151
Fourmile Creek	Fourmile Creek	6.9	FMC6.9	3	Dry	11/9/16 11:45	172	5	0.183	1.275	1.270	<0.01
Fourmile Creek	Fourmile Creek	6.9	FMC6.9	3	Dry	4/12/17 11:40	1,240	41	0.215	1.102	0.995	0.107
Fourmile Creek	Fourmile Creek	6.9	FMC6.9	3	Dry	4/26/17 11:30	170	10	0.095	0.896	0.598	0.298
Fourmile Creek	Fourmile Creek	6.9	FMC6.9	3	Dry	5/10/17 11:10	1,944	31	0.185	1.616	1.307	0.309
Fourmile Creek	Fourmile Creek	6.9	FMC6.9	3	Dry	6/7/17 11:25	424	26	0.115	1.213	0.981	0.232
Fourmile Creek	Fourmile Creek	6.9	FMC6.9	3	Dry	6/21/17 12:00	1,748	16	0.151	1.193	0.831	0.362
Fourmile Creek	Fourmile Creek	6.9	FMC6.9	3	Dry	7/12/17 11:30	1,952	15	0.139	0.972	0.653	0.319
Fourmile Creek	Fourmile Creek	6.9	FMC6.9	3	Dry	7/26/17 11:30	1,844	29	0.126	1.030	0.917	0.113
Fourmile Creek	Fourmile Creek	6.9	FMC6.9	3	Dry	8/16/17 12:35	80	5	0.115	0.606	0.554	0.052
Fourmile Creek	Fourmile Creek	6.9	FMC6.9	3	Dry	9/6/17 12:00	372	19	0.154	0.852	0.572	0.280
Fourmile Creek	Fourmile Creek	6.9	FMC6.9	3	Dry	9/20/17 12:05	2,192	11	0.169	0.781	0.745	0.036
Fourmile Creek	Fourmile Creek	6.9	FMC6.9	3	Dry	10/18/17 11:50	396	12	0.168	0.641	0.636	<0.01
Fourmile Creek	Fourmile Creek	6.9	FMC6.9	3	Dry	4/18/18 11:05	204	4	0.070	0.553	0.531	0.022
Fourmile Creek	Fourmile Creek	6.9	FMC6.9	3	Dry	5/9/18 11:20	260	7	0.052	0.292	0.270	0.022
Fourmile Creek	Fourmile Creek	6.9	FMC6.9	3	Dry	6/13/18 11:20	9,800	96	0.312	1.510	0.986	0.524
Fourmile Creek	Fourmile Creek	6.9	FMC6.9	3	Dry	7/11/18 12:00	1,104	27	0.169	1.052	0.868	0.184
Fourmile Creek	Fourmile Creek	6.9	FMC6.9	3	Dry	7/25/18 11:40	716	22	0.161	0.876	0.697	0.179
Fourmile Creek	Fourmile Creek	6.9	FMC6.9	3	Dry	9/12/18 11:55	316	17	0.150	0.978	0.587	0.391
Fourmile Creek	Fourmile Creek	6.9	FMC6.9	3	Dry	10/17/18 11:35	272	3	0.127	0.678	0.427	0.251
Fourmile Creek	Fourmile Creek	6.9	FMC6.9	3	Dry	11/14/18 11:25	80	3	0.067	0.758	0.393	0.365
Fourmile Creek	Fourmile Creek	6.9	FMC6.9	3	Dry	3/20/19 12:15	36	9	0.086	0.748	0.609	0.139
Fourmile Creek	Fourmile Creek	6.9	FMC6.9	3	Dry	4/24/19 12:55	612	12	0.083	0.742	0.734	<0.016
Fourmile Creek	Fourmile Creek	6.9	FMC6.9	3	Dry	5/8/19 11:40	244	17	0.107	0.717	0.415	0.302
Fourmile Creek	Fourmile Creek	6.9	FMC6.9	3	Dry	5/22/19 13:40	216	13	0.110	0.833	0.583	0.250
Fourmile Creek	Fourmile Creek	6.9	FMC6.9	3	Dry	6/12/19 11:55	992	23	0.131	1.013	0.752	0.261

Watershed	Stream	RM	LocID	Period	Precip Condition	Date	E. coli (mpn/100 ml)	TSS (mg/L)	TP (mg/L)	TN (mg/L)	TKN (mg/L)	N/N (mg/L)
Fourmile Creek	Fourmile Creek	6.9	FMC6.9	3	Dry	7/10/19 12:15	7,700	14	0.112	0.906	0.520	0.386
Fourmile Creek	Fourmile Creek	6.9	FMC6.9	3	Dry	7/24/19 11:15	1,196	31	0.130	0.891	0.652	0.239
Fourmile Creek	Fourmile Creek	6.9	FMC6.9	3	Dry	8/14/19 12:40	24,200	51	0.257	1.445	1.130	0.315
Fourmile Creek	Fourmile Creek	6.9	FMC6.9	3	Dry	9/11/19 11:55	48	11	0.168	1.057	0.919	0.138
Fourmile Creek	Fourmile Creek	6.9	FMC6.9	3	Dry	9/25/19 12:25	148	4	0.245	0.682	0.640	0.042
Fourmile Creek	Fourmile Creek	6.9	FMC6.9	3	Dry	10/23/19 11:20	144	5	0.020	0.716	0.678	0.038
Fourmile Creek	Fourmile Creek	6.9	FMC6.9	3	Dry	11/13/19 11:45	476	3	0.117	0.754	0.585	0.169
Fourmile Creek	Fourmile Creek	6.9	FMC6.9	3	Wet	4/13/16 12:00	478	23	0.127	0.778	0.706	0.072
Fourmile Creek	Fourmile Creek	6.9	FMC6.9	3	Wet	4/27/16 11:05	7,640	71	0.224	1.541	1.315	0.226
Fourmile Creek	Fourmile Creek	6.9	FMC6.9	3	Wet	5/11/16 11:30	6,330	91	0.253	1.648	1.450	0.198
Fourmile Creek	Fourmile Creek	6.9	FMC6.9	3	Wet	6/22/16 11:00	10,546	16	0.163	1.085	0.902	0.183
Fourmile Creek	Fourmile Creek	6.9	FMC6.9	3	Wet	7/6/16 10:40	5,045	87	0.272	1.508	1.210	0.298
Fourmile Creek	Fourmile Creek	6.9	FMC6.9	3	Wet	8/17/16 10:00	39,350	1,525	0.436	2.256	1.970	0.286
Fourmile Creek	Fourmile Creek	6.9	FMC6.9	3	Wet	9/28/16 12:30	140	3	0.117	1.039	1.005	0.034
Fourmile Creek	Fourmile Creek	6.9	FMC6.9	3	Wet	5/24/17 11:30	592	16	0.083	1.146	0.874	0.272
Fourmile Creek	Fourmile Creek	6.9	FMC6.9	3	Wet	11/15/17 11:30	136	8	0.123	1.187	1.050	0.137
Fourmile Creek	Fourmile Creek	6.9	FMC6.9	3	Wet	3/28/18 11:00	1,844	75	0.320	1.646	1.440	0.206
Fourmile Creek	Fourmile Creek	6.9	FMC6.9	3	Wet	5/23/18 13:15	3,650	69	0.244	1.400	1.120	0.280
Fourmile Creek	Fourmile Creek	6.9	FMC6.9	3	Wet	8/22/18 10:55	856	23	0.189	0.966	0.791	0.175
Fourmile Creek	Fourmile Creek	6.9	FMC6.9	3	Wet	9/26/18 11:55	1,380	19	0.167	1.056	0.752	0.304

Taylor Creek Water Quality Data

Watershed	Stream	RM	LocID	Period	Precip Condition	Date	E. coli (mpn/100 ml)	TSS (mg/L)	TP (mg/L)	TN (mg/L)	TKN (mg/L)	N/N (mg/L)
Taylor Creek	Taylor Creek	0.6	TYC0.6	2	Dry	7/23/15 11:05	1,460	4	0.045	1.034	<0.139	0.964
Taylor Creek	Taylor Creek	0.6	TYC0.6	2	Dry	8/6/15 10:10	24,200	130	0.230	2.369	1.800	0.569
Taylor Creek	Taylor Creek	0.6	TYC0.6	2	Dry	9/3/15 10:35	2,748	<1.5	0.051	0.752	0.297	0.455
Taylor Creek	Taylor Creek	0.6	TYC0.6	2	Dry	9/17/15 10:50	1,304	9	0.066	1.519	0.864	0.655
Taylor Creek	Taylor Creek	0.6	TYC0.6	2	Dry	10/1/15 11:00	2,452	4	0.055	0.965	0.441	0.524
Taylor Creek	Taylor Creek	0.6	TYC0.6	2	Dry	10/15/15 11:00	3,080	2	0.065	0.676	0.329	0.347
Taylor Creek	Taylor Creek	0.6	TYC0.6	2	Dry	10/29/15 10:15	4,350	3	0.084	1.333	0.541	0.792
Taylor Creek	Taylor Creek	0.6	TYC0.6	2	Wet	7/9/15 10:40	3,870	6	0.089	1.308	0.610	0.698
Taylor Creek	Taylor Creek	0.6	TYC0.6	2	Wet	8/20/15 11:40	12,030	17	0.127	1.574	0.695	0.879
Taylor Creek	Taylor Creek	0.6	TYC0.6	2	Wet	11/12/15 11:10	8,660	14	0.084	1.022	0.511	0.511
Taylor Creek	Taylor Creek	0.6	TYC0.6	3	Dry	5/26/16 10:30	4,880	<1.2	0.088	1.404	0.567	0.837
Taylor Creek	Taylor Creek	0.6	TYC0.6	3	Dry	6/9/16 10:15	1,164	2	0.124	1.231	0.556	0.675
Taylor Creek	Taylor Creek	0.6	TYC0.6	3	Dry	7/21/16 10:25	944	<1.2	0.144	1.115	0.458	0.657
Taylor Creek	Taylor Creek	0.6	TYC0.6	3	Dry	8/4/16 11:20	996	5	0.134	1.375	0.483	0.892
Taylor Creek	Taylor Creek	0.6	TYC0.6	3	Dry	9/1/16 10:45	576	2	<0.045	1.272	0.712	0.560
Taylor Creek	Taylor Creek	0.6	TYC0.6	3	Dry	9/15/16 11:10	6,870	19	0.063	1.406	0.821	0.585
Taylor Creek	Taylor Creek	0.6	TYC0.6	3	Dry	10/13/16 11:00	7,700	5	0.111	3.280	2.240	1.040
Taylor Creek	Taylor Creek	0.6	TYC0.6	3	Dry	10/27/16 10:45	4,610	14	0.149	1.136	0.585	0.551
Taylor Creek	Taylor Creek	0.6	TYC0.6	3	Dry	11/10/16 10:00	1,304	<1.2	0.088	0.774	0.484	0.290
Taylor Creek	Taylor Creek	0.6	TYC0.6	3	Dry	4/13/17 10:45	15,530	2	0.262	3.771	3.350	0.421
Taylor Creek	Taylor Creek	0.6	TYC0.6	3	Dry	4/27/17 10:45	1,232	<1.4	0.091	1.729	1.010	0.719
Taylor Creek	Taylor Creek	0.6	TYC0.6	3	Dry	6/8/17 10:15	1,548	5	0.085	1.185	0.538	0.647
Taylor Creek	Taylor Creek	0.6	TYC0.6	3	Dry	7/13/17 10:40	1,044	2	0.117	1.206	0.591	0.615
Taylor Creek	Taylor Creek	0.6	TYC0.6	3	Dry	9/7/17 10:45	2,452	11	0.109	1.284	0.686	0.598

Watershed	Stream	RM	LocID	Period	Precip Condition	Date	E. coli (mpn/100 ml)	TSS (mg/L)	TP (mg/L)	TN (mg/L)	TKN (mg/L)	N/N (mg/L)
Taylor Creek	Taylor Creek	0.6	TYC0.6	3	Dry	9/21/17 10:40	3,264	12	0.108	1.078	0.726	0.352
Taylor Creek	Taylor Creek	0.6	TYC0.6	3	Dry	10/19/17 10:25	1,588	2	0.116	3.954	3.210	0.744
Taylor Creek	Taylor Creek	0.6	TYC0.6	3	Dry	11/16/17 10:50	2,908	7	0.132	1.428	0.958	0.470
Taylor Creek	Taylor Creek	0.6	TYC0.6	3	Dry	4/19/18 10:45	5,790	14	0.072	1.145	0.435	0.710
Taylor Creek	Taylor Creek	0.6	TYC0.6	3	Dry	6/14/18 10:40	2,748	10	0.093	1.182	0.618	0.564
Taylor Creek	Taylor Creek	0.6	TYC0.6	3	Dry	7/12/18 10:05	1,232	6	0.114	1.123	0.591	0.532
Taylor Creek	Taylor Creek	0.6	TYC0.6	3	Dry	7/26/18 10:45	996	15	0.070	1.011	0.473	0.538
Taylor Creek	Taylor Creek	0.6	TYC0.6	3	Dry	9/13/18 10:05	1,304	10	0.097	1.520	0.410	1.110
Taylor Creek	Taylor Creek	0.6	TYC0.6	3	Dry	9/27/18 9:45	912	10	0.076	1.444	0.334	1.110
Taylor Creek	Taylor Creek	0.6	TYC0.6	3	Dry	10/18/18 10:45	432	3	0.077	0.731	0.168	0.563
Taylor Creek	Taylor Creek	0.6	TYC0.6	3	Dry	3/21/19 9:40	500	4	0.062	1.519	0.509	1.010
Taylor Creek	Taylor Creek	0.6	TYC0.6	3	Dry	4/25/19 10:30	2,316	9	0.079	1.211	0.552	0.659
Taylor Creek	Taylor Creek	0.6	TYC0.6	3	Dry	5/9/19 10:15	840	7	0.077	1.334	0.294	1.040
Taylor Creek	Taylor Creek	0.6	TYC0.6	3	Dry	6/13/19 10:10	10,460	95	0.182	1.748	1.050	0.698
Taylor Creek	Taylor Creek	0.6	TYC0.6	3	Dry	7/11/19 10:20	19,860	42	0.154	1.499	0.577	0.922
Taylor Creek	Taylor Creek	0.6	TYC0.6	3	Dry	7/25/19 9:40	888	6	0.079	0.918	0.149	0.769
Taylor Creek	Taylor Creek	0.6	TYC0.6	3	Dry	8/15/19 11:20	1,088	2	0.075	1.189	0.473	0.716
Taylor Creek	Taylor Creek	0.6	TYC0.6	3	Dry	9/12/19 10:15	324	3	0.088	1.224	0.563	0.661
Taylor Creek	Taylor Creek	0.6	TYC0.6	3	Dry	9/26/19 10:20	856	<1.4	0.096	0.930	0.561	0.369
Taylor Creek	Taylor Creek	0.6	TYC0.6	3	Dry	10/24/19 10:25	460	4	0.071	0.917	0.610	0.307
Taylor Creek	Taylor Creek	0.6	TYC0.6	3	Dry	11/14/19 10:00	1,232	<1.4	0.089	0.917	0.437	0.480
Taylor Creek	Taylor Creek	0.6	TYC0.6	3	Wet	4/14/16 11:00	1,844	<1.2	0.085	1.180	0.528	0.652
Taylor Creek	Taylor Creek	0.6	TYC0.6	3	Wet	4/28/16 10:25	8,160	30	0.198	1.772	1.130	0.642
Taylor Creek	Taylor Creek	0.6	TYC0.6	3	Wet	5/12/16 10:50	876	7	0.108	1.289	0.527	0.762
Taylor Creek	Taylor Creek	0.6	TYC0.6	3	Wet	6/23/16 13:20	24,200	80	0.325	2.018	1.190	0.828
Taylor Creek	Taylor Creek	0.6	TYC0.6	3	Wet	7/7/16 11:10	1,040	3	0.159	1.290	0.789	0.501

Watershed	Stream	RM	LocID	Period	Precip Condition	Date	E. coli (mpn/100 ml)	TSS (mg/L)	TP (mg/L)	TN (mg/L)	TKN (mg/L)	N/N (mg/L)
Taylor Creek	Taylor Creek	0.6	TYC0.6	3	Wet	8/18/16 10:40	6,130	20	0.186	1.763	0.910	0.853
Taylor Creek	Taylor Creek	0.6	TYC0.6	3	Wet	9/29/16 10:10	11,200	32	0.150	1.272	0.709	0.563
Taylor Creek	Taylor Creek	0.6	TYC0.6	3	Wet	5/11/17 10:25	1,740	10	0.137	1.487	0.736	0.751
Taylor Creek	Taylor Creek	0.6	TYC0.6	3	Wet	5/25/17 10:45	19,860	149	0.283	1.963	1.470	0.493
Taylor Creek	Taylor Creek	0.6	TYC0.6	3	Wet	6/22/17 9:45	2,192	3	0.130	1.134	0.550	0.584
Taylor Creek	Taylor Creek	0.6	TYC0.6	3	Wet	7/27/17 10:05	24,200	75	0.383	2.308	1.710	0.598
Taylor Creek	Taylor Creek	0.6	TYC0.6	3	Wet	8/17/17 10:10	500	2	0.102	0.876	0.515	0.361
Taylor Creek	Taylor Creek	0.6	TYC0.6	3	Wet	3/29/18 10:20	1,304	26	0.137	1.444	0.777	0.667
Taylor Creek	Taylor Creek	0.6	TYC0.6	3	Wet	5/10/18 10:25	1,304	3	0.032	0.887	0.530	0.357
Taylor Creek	Taylor Creek	0.6	TYC0.6	3	Wet	5/24/18 10:15	5,790	30	0.283	1.724	0.742	0.982
Taylor Creek	Taylor Creek	0.6	TYC0.6	3	Wet	8/23/18 9:40	796	8	0.101	1.247	0.247	1.000
Taylor Creek	Taylor Creek	0.6	TYC0.6	3	Wet	11/15/18 9:35	8,660	39	0.316	1.577	0.925	0.652
Taylor Creek	Taylor Creek	0.6	TYC0.6	3	Wet	5/23/19 10:35	24,200	114	0.265	2.117	1.540	0.577

Twelvemile Creek Water Quality Data

Watershed	Stream	RM	LocID	Period	Precip Condition	Date	E. coli (mpn/100 ml)	TSS (mg/L)	TP (mg/L)	TN (mg/L)	TKN (mg/L)	N/N (mg/L)
Twelvemile Creek	Brush Creek	0.3	BRC0.3	3	Dry	8/31/16 10:50	236	8	<0.045	0.939	0.920	0.019
Twelvemile Creek	Brush Creek	0.3	BRC0.3	3	Dry	9/14/16 11:45	316	2	0.232	11.897	0.997	10.900
Twelvemile Creek	Brush Creek	0.3	BRC0.3	3	Dry	10/12/16 11:20	76	<1.2	0.231	4.440	1.210	3.230
Twelvemile Creek	Brush Creek	0.3	BRC0.3	3	Wet	8/17/16 11:20	43,500	1,230	1.910	4.640	4.470	0.170
Twelvemile Creek	Brush Creek	0.3	BRC0.3	3	Wet	9/28/16 11:25	220	2	0.244	16.747	0.647	16.100
Twelvemile Creek	Twelvemile Creek	3.0	TMC3.0	2	Dry	7/22/15 11:30	644	28	0.081	1.806	0.496	1.310
Twelvemile Creek	Twelvemile Creek	3.0	TMC3.0	2	Dry	8/5/15 10:30	236	10	0.033	2.850	0.780	2.070
Twelvemile Creek	Twelvemile Creek	3.0	TMC3.0	2	Dry	8/19/15 10:55	64	38	0.105	8.920	1.070	7.850
Twelvemile Creek	Twelvemile Creek	3.0	TMC3.0	2	Dry	9/2/15 10:26	136	9	0.047	8.980	1.360	7.620
Twelvemile Creek	Twelvemile Creek	3.0	TMC3.0	2	Dry	9/16/15 10:40	80	4	0.059	6.707	0.627	6.080
Twelvemile Creek	Twelvemile Creek	3.0	TMC3.0	2	Dry	9/30/15 11:25	9,800	31	0.167	2.680	1.060	1.620
Twelvemile Creek	Twelvemile Creek	3.0	TMC3.0	2	Dry	10/14/15 11:10	264	6	0.117	15.810	0.510	15.300
Twelvemile Creek	Twelvemile Creek	3.0	TMC3.0	2	Wet	7/8/15 11:05	688	12	0.102	9.890	1.030	8.860
Twelvemile Creek	Twelvemile Creek	3.0	TMC3.0	2	Wet	10/28/15 11:10	24,200	136	0.376	1.980	1.530	0.450
Twelvemile Creek	Twelvemile Creek	3.0	TMC3.0	2	Wet	11/11/15 10:55	92	4	0.094	4.111	0.601	3.510
Twelvemile Creek	Twelvemile Creek	3.0	TMC3.0	3	Dry	5/25/16 11:35	184	<1.2	0.116	1.476	0.638	0.838
Twelvemile Creek	Twelvemile Creek	3.0	TMC3.0	3	Dry	6/8/16 10:45	252	13	0.124	3.222	0.912	2.310
Twelvemile Creek	Twelvemile Creek	3.0	TMC3.0	3	Dry	7/20/16 10:55	408	12	0.155	8.090	1.000	7.090
Twelvemile Creek	Twelvemile Creek	3.0	TMC3.0	3	Dry	8/3/16 11:30	768	47	0.164	4.480	1.150	3.330
Twelvemile Creek	Twelvemile Creek	3.0	TMC3.0	3	Dry	8/31/16 11:11	254	9	<0.045	2.930	0.980	1.950
Twelvemile Creek	Twelvemile Creek	3.0	TMC3.0	3	Dry	9/14/16 11:30	208	4	0.211	9.314	1.339	7.975
Twelvemile Creek	Twelvemile Creek	3.0	TMC3.0	3	Dry	10/12/16 11:05	100	17	0.202	3.301	1.235	2.066
Twelvemile Creek	Twelvemile Creek	3.0	TMC3.0	3	Dry	10/26/16 10:35	276	12	0.208	5.630	1.350	4.280
Twelvemile Creek	Twelvemile Creek	3.0	TMC3.0	3	Dry	11/9/16 11:25	96	10	0.106	6.740	1.550	5.190

Watershed	Stream	RM	LocID	Period	Precip Condition	Date	E. coli (mpn/100 ml)	TSS (mg/L)	TP (mg/L)	TN (mg/L)	TKN (mg/L)	N/N (mg/L)
Twelvemile Creek	Twelvemile Creek	3.0	TMC3.0	3	Dry	4/12/17 11:20	8,160	45	0.219	1.514	1.140	0.374
Twelvemile Creek	Twelvemile Creek	3.0	TMC3.0	3	Dry	4/26/17 11:10	64	5	0.089	4.837	0.807	4.030
Twelvemile Creek	Twelvemile Creek	3.0	TMC3.0	3	Dry	5/10/17 10:45	9,210	57	0.215	1.785	1.360	0.425
Twelvemile Creek	Twelvemile Creek	3.0	TMC3.0	3	Dry	6/7/17 11:05	460	13	0.105	3.290	1.060	2.230
Twelvemile Creek	Twelvemile Creek	3.0	TMC3.0	3	Dry	6/21/17 11:35	460	9	0.174	4.200	1.000	3.200
Twelvemile Creek	Twelvemile Creek	3.0	TMC3.0	3	Dry	7/12/17 11:05	240	10	0.136	3.233	0.903	2.330
Twelvemile Creek	Twelvemile Creek	3.0	TMC3.0	3	Dry	7/26/17 11:10	568	15	0.136	3.630	1.160	2.470
Twelvemile Creek	Twelvemile Creek	3.0	TMC3.0	3	Dry	8/16/17 12:10	172	13	0.128	9.980	1.030	8.950
Twelvemile Creek	Twelvemile Creek	3.0	TMC3.0	3	Dry	9/6/17 11:40	92	2	0.117	7.336	0.946	6.390
Twelvemile Creek	Twelvemile Creek	3.0	TMC3.0	3	Dry	9/20/17 11:45	136	3	0.140	4.120	1.190	2.930
Twelvemile Creek	Twelvemile Creek	3.0	TMC3.0	3	Dry	10/18/17 11:30	160	3	0.174	12.773	0.673	12.100
Twelvemile Creek	Twelvemile Creek	3.0	TMC3.0	3	Dry	4/18/18 10:45	876	7	0.099	1.243	0.565	0.678
Twelvemile Creek	Twelvemile Creek	3.0	TMC3.0	3	Dry	5/9/18 11:40	496	16	0.197	2.720	1.390	1.330
Twelvemile Creek	Twelvemile Creek	3.0	TMC3.0	3	Dry	6/13/18 11:05	560	16	0.296	11.956	0.656	11.300
Twelvemile Creek	Twelvemile Creek	3.0	TMC3.0	3	Dry	7/11/18 11:30	184	7	0.198	6.790	1.690	5.100
Twelvemile Creek	Twelvemile Creek	3.0	TMC3.0	3	Dry	7/25/18 11:15	296	16	0.145	3.934	0.824	3.110
Twelvemile Creek	Twelvemile Creek	3.0	TMC3.0	3	Dry	9/12/18 11:20	432	23	0.240	3.073	0.953	2.120
Twelvemile Creek	Twelvemile Creek	3.0	TMC3.0	3	Dry	10/17/18 11:05	116	<1.4	0.140	3.991	<0.102	3.940
Twelvemile Creek	Twelvemile Creek	3.0	TMC3.0	3	Dry	11/14/18 11:05	92	<1.4	0.111	3.947	0.587	3.360
Twelvemile Creek	Twelvemile Creek	3.0	TMC3.0	3	Dry	3/20/19 11:45	88	8	0.110	3.096	0.336	2.760
Twelvemile Creek	Twelvemile Creek	3.0	TMC3.0	3	Dry	4/24/19 12:30	372	4	0.103	0.991	0.793	0.198
Twelvemile Creek	Twelvemile Creek	3.0	TMC3.0	3	Dry	5/8/19 11:20	352	14	0.087	0.934	0.382	0.552
Twelvemile Creek	Twelvemile Creek	3.0	TMC3.0	3	Dry	5/22/19 13:20	308	5	0.099	2.000	0.420	1.580
Twelvemile Creek	Twelvemile Creek	3.0	TMC3.0	3	Dry	6/12/19 11:30	716	7	0.104	3.434	0.384	3.050
Twelvemile Creek	Twelvemile Creek	3.0	TMC3.0	3	Dry	7/10/19 11:50	168	4	0.087	4.355	0.495	3.860
Twelvemile Creek	Twelvemile Creek	3.0	TMC3.0	3	Dry	7/24/19 11:00	448	47	0.100	1.992	0.802	1.190

Watershed	Stream	RM	LocID	Period	Precip Condition	Date	E. coli (mpn/100 ml)	TSS (mg/L)	TP (mg/L)	TN (mg/L)	TKN (mg/L)	N/N (mg/L)
Twelvemile Creek	Twelvemile Creek	3.0	TMC3.0	3	Dry	8/14/19 12:15	460	7	0.210	9.122	0.182	8.940
Twelvemile Creek	Twelvemile Creek	3.0	TMC3.0	3	Dry	9/11/19 11:25	84	4	0.282	9.040	1.600	7.440
Twelvemile Creek	Twelvemile Creek	3.0	TMC3.0	3	Dry	9/25/19 12:00	56	3	0.374	16.870	1.770	15.100
Twelvemile Creek	Twelvemile Creek	3.0	TMC3.0	3	Dry	10/23/19 11:00	48	2	0.353	18.076	0.576	17.500
Twelvemile Creek	Twelvemile Creek	3.0	TMC3.0	3	Dry	11/13/19 11:20	100	4	0.202	4.270	1.120	3.150
Twelvemile Creek	Twelvemile Creek	3.0	TMC3.0	3	Wet	4/13/16 11:45	1,380	29	0.155	1.530	0.879	0.651
Twelvemile Creek	Twelvemile Creek	3.0	TMC3.0	3	Wet	4/27/16 10:40	9,800	46	0.178	1.325	1.030	0.295
Twelvemile Creek	Twelvemile Creek	3.0	TMC3.0	3	Wet	5/11/16 11:10	15,530	87	0.234	1.692	1.390	0.302
Twelvemile Creek	Twelvemile Creek	3.0	TMC3.0	3	Wet	6/22/16 10:30	128	3	0.147	9.001	0.891	8.110
Twelvemile Creek	Twelvemile Creek	3.0	TMC3.0	3	Wet	7/6/16 10:20	640	20	0.166	5.800	1.120	4.680
Twelvemile Creek	Twelvemile Creek	3.0	TMC3.0	3	Wet	8/17/16 10:50	30,800	385	4.010	16.808	15.900	0.908
Twelvemile Creek	Twelvemile Creek	3.0	TMC3.0	3	Wet	9/28/16 11:15	124	5	0.250	9.800	1.210	8.590
Twelvemile Creek	Twelvemile Creek	3.0	TMC3.0	3	Wet	5/24/17 11:10	944	13	0.076	3.180	1.120	2.060
Twelvemile Creek	Twelvemile Creek	3.0	TMC3.0	3	Wet	11/15/17 11:10	184	3	0.190	3.430	1.130	2.300
Twelvemile Creek	Twelvemile Creek	3.0	TMC3.0	3	Wet	3/28/18 10:35	4,610	120	0.335	1.967	1.630	0.337
Twelvemile Creek	Twelvemile Creek	3.0	TMC3.0	3	Wet	5/23/18 12:45	19,860	325	0.705	2.788	2.090	0.698
Twelvemile Creek	Twelvemile Creek	3.0	TMC3.0	3	Wet	8/22/18 10:40	300	22	0.178	3.748	0.478	3.270
Twelvemile Creek	Twelvemile Creek	3.0	TMC3.0	3	Wet	9/26/18 11:35	2,596	34	0.223	2.350	1.000	1.350
Twelvemile Creek	Twelvemile Creek	3.9	TMC3.9	3	Dry	8/31/16 11:30	292	6	0.081	11.490	0.887	10.600
Twelvemile Creek	Twelvemile Creek	3.9	TMC3.9	3	Dry	9/14/16 10:50	168	2	<0.045	1.240	1.110	0.126
Twelvemile Creek	Twelvemile Creek	3.9	TMC3.9	3	Dry	10/12/16 10:50	992	2	0.048	0.743	0.724	0.019
Twelvemile Creek	Twelvemile Creek	3.9	TMC3.9	3	Wet	8/17/16 10:30	1,600	44	0.185	1.292	1.060	0.232
Twelvemile Creek	Twelvemile Creek	3.9	TMC3.9	3	Wet	9/28/16 5:50	36	15	<0.045	1.165	1.250	0.065

Appendix B1 – Biological Data

Macroinvertebrate assessment results are listed in tables beginning with the Fourmile Creek watershed, followed by the Taylor Creek and Twelvemile Creek watersheds. The MBI metrics included in the tables are as follows:

- Percent Chironomidae+Oligochaeta (%Chir+%Olig) – calculates the relative abundance of pollution tolerant organisms; increasing metric values generally indicate declining water quality conditions.
- Percent Primary Clingers (%CIngP) – calculates the relative abundance of organisms that require hard/silt-free substrates; increasing metric values generally indicate improving substrate stability.
- Percent Ephemeroptera (%Ephem) – calculates the abundance of mayfly species (insect order Ephemeroptera), which are pollution sensitive; metric is only utilized for assessing headwater streams.
- Modified Percent EPT Abundance (m%EPT) – calculates the abundance of pollution sensitive organisms (specifically insect orders of Ephemeroptera, Plecoptera and Trichoptera); increasing metric values generally indicate improving water quality and habitat conditions.
- Genus Ephemeroptera, Plecoptera, Trichoptera Richness (G-EPT) – calculates the total number of distinct genera of pollution sensitive organisms in a composite sample; increasing metric values generally indicate improving water quality and habitat conditions.
- Genus Taxa Richness (G-TR) – calculates the total number of genera in a composite sample; increasing metric values generally indicate improving water quality and habitat conditions.
- Modified Hilsenhoff Biotic Index (mHBI) – calculates the overall pollution tolerance of the benthic macroinvertebrate community (including arthropods) (Lenat 1993); increasing metric values generally indicate decreasing water quality conditions.

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Fourmile Creek Macroinvertebrate Scores

Watershed	Stream	RM	LocID	Year	Site Type	%Chir+ %Olig	%CIngP	%Ephem	G-EPT	G-TR	m%EPT	mHBI	MBI_Genus	MBI_Genus Rating
Fourmile Creek	Fourmile Creek	6.9	FMC6.9	2012	H	41.56	50.22	5.83	1	18	5.83	6.35	31.61	Poor
Fourmile Creek	Fourmile Creek	6.9	FMC6.9	2016	H	37.29	47.19	3.30	9	44	4.62	6.24	41.09	Fair
Fourmile Creek	Fourmile Creek	0.5	FMC0.5	2012	W	7.95	53.21	N/A	7	32	35.03	5.68	57.80	Fair
Fourmile Creek	Fourmile Creek	0.5	FMC0.5	2016	W	30.13	67.95	N/A	6	39	2.24	6.13	49.95	Fair
Fourmile Creek	Owl Creek	0.4	OWC0.4	2012	H	7.17	70.19	8.97	7	29	9.94	5.37	48.90	Fair
Fourmile Creek	Owl Creek	0.4	OWC0.4	2016	H	44.37	37.62	4.82	7	27	6.11	5.65	34.87	Poor

Taylor Creek Macroinvertebrate Scores

Watershed	Stream	RM	LocID	Year	Site Type	%Chir+ %Olig	%CIngP	%Ephem	G-EPT	G-TR	m%EPT	mHBI	MBI_Genus	MBI_Genus Rating
Taylor Creek	Covert Run	0.2	TYC0.7-CVR0.2	2012	H	13.55	50.47	1.40	2	25	1.40	6.41	36.05	Poor
Taylor Creek	Covert Run	0.2	TYC0.7-CVR0.2	2016	H	72.69	7.24	1.97	2	25	2.63	6.48	19.56	Poor
Taylor Creek	Woodlawn Creek	1.3	TYC0.9-WLC1.3	2012	H	4.04	60.00	7.87	4	15	22.34	4.99	45.15	Fair
Taylor Creek	Woodlawn Creek	1.3	TYC0.9-WLC1.3	2016	H	55.59	25.46	2.79	4	32	3.41	5.59	30.02	Poor
Taylor Creek	Taylor Creek	0.6	TYC0.6	2012	H	20.30	29.39	7.02	3	19	7.89	6.17	32.82	Poor
Taylor Creek	Taylor Creek	0.6	TYC0.6	2016	H	84.04	5.54	7.49	2	26	7.82	6.73	19.43	Poor

Twelvemile Creek Macroinvertebrate Scores

Watershed	Stream	RM	LocID	Year	Site Type	%Chir+%Olig	%CingP	G-EPT	G-TR	m%EPT	mHBI	MBI_Genus	MBI_Genus Rating
Twelvemile Creek	Twelvemile Creek	3.9	TMC3.9	2012	W								No Data
Twelvemile Creek	Twelvemile Creek	3.9	TMC3.9	2016	W	22.61	62.74	12	47	21.66	5.42	61.59	Good
Twelvemile Creek	Twelvemile Creek	3	TMC3.0	2012	W	0.62	94.75	7	24	19.44	4.66	60.60	Good
Twelvemile Creek	Twelvemile Creek	3	TMC3.0	2016	W	17.59	75.24	6	30	45.28	5.03	63.70	Good
Twelvemile Creek	Brush Creek	0.3	BRC0.3	2012	W	2.53	84.18	6	23	45.57	4.51	55.86	Good
Twelvemile Creek	Brush Creek	0.3	BRC0.3	2016	W	10.12	66.96	8	40	51.79	4.55	69.63	Excellent

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Appendix B2 – Biological Data

Habitat assessment results are listed in tables beginning with the Fourmile Creek watershed, followed by the Taylor Creek and Twelvemile Creek watersheds. The RBP metrics included in the tables are as follows:

- Bank Stability (BankSta) – estimates actual or potential streambank erosion; eroded banks indicate sediment movement and deposition issues.
- Bank Vegetative Protection (BankVegP) – estimates the vegetative protection adjacent to the stream; differing vegetative types provide various abilities to resist erosion.
- Channel Flow Status (ChaFlowS) – estimates the degree to which the stream channel is filled with water; relates to the amount of substrate that is suitable for aquatic organisms.
- Channel Alteration (ChanAlter) – characterizes large scale or direct changes to the shape of the stream channel; relates to the amount of natural habitat with meandering streams having greater potential and straightened or deepened channels have less potential and subject to scouring.
- Embeddedness – estimates the extent of stream bottom substrate covered by silt, sand, or mud due to sedimentation; greater embeddedness decreases habitat diversity.
- Epifaunal Substrate/Available Cover (EpiFauSub) – estimates the relative quantity and variety of natural structures (e.g., boulders, logs, aquatic vegetation, etc.) in the stream that provide habitat; greater habitat opportunities provide greater potential for aquatic organism colonization.
- Frequency of Riffles (FreqOfRiffles) – determines the sequence of riffles occurring in the stream system; higher frequencies typically provide better habitat opportunities.
- Riparian Vegetative Zone Width (RipVegZW) – estimates the width of the vegetation from the edge of the streambank to the edge of the riparian zone; larger undisturbed riparian zones support more robust stream systems.
- Sediment Deposition (SedDep) – estimates the amount of stream bed sediment accumulation in pools; deposition signifies an unstable regime that is not suitable from many organisms.
- Velocity/Depth Regime (Vel/Dep Regime) – determines the occurrence pattern of stream velocity and stream depth regimes (i.e., slow-deep, slow-shallow, fast-deep and fast-shallow); the number of patterns present relates to the stability of the aquatic environment.

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Fourmile Creek Habitat Index Scores

Watershed	Stream	RM	LocID	Year	Site Type	BankSta-LB	BankSta-RB	BankVegP-LB	BankVegP-RB	ChaFlows	ChanAlter	Embeddedness	EpiFauSub	FreqORfites	RipVegZW-LB	RipVegZW-RB	SedDep	Vel/Dep Regime	RBP_HA	RBP_HA Rating
Fourmile Creek	Fourmile Creek	6.9	FMC6.9	2012	H	5	5	4	5	15	13	10	12	11	2	3	16	13	114	Poor
Fourmile Creek	Fourmile Creek	6.9	FMC6.9	2016	H	7	8	6	6	16	11	16	14	16	3	3	14	10	130	Poor
Fourmile Creek	Fourmile Creek	0.5	FMC0.5	2012	W	1	2	6	7	6	11	8	9	16	7	9	8	12	102	Poor
Fourmile Creek	Fourmile Creek	0.5	FMC0.5	2016	W	2	2	4	4	3	11	8	6	11	6	7	7	11	82	Poor
Fourmile Creek	Owl Creek	0.4	OWC0.4	2012	H	7	5	7	9	10	16	15	15	15	3	10	11	14	137	Poor
Fourmile Creek	Owl Creek	0.4	OWC0.4	2016	H	5	4	6	8	15	14	16	15	14	3	9	14	14	137	Poor

Taylor Creek Habitat Index Scores

Watershed	Stream	RM	LocID	Year	Site Type	BankSta-LB	BankSta-RB	BankVegP-LB	BankVegP-RB	ChaFlows	ChanAlter	Embeddedness	EpiFauSub	FreqORRifles	RipVegZW-LB	RipVegZW-RB	SedDep	Vel/Dep Regime	RBP_HA	RBP_HA Rating
Taylor Creek	Covert Run	0.2	TYC0.7-CVR0.2	2012	H	3	3	3	3	14	4	4	3	15	1	1	4	8	66	Poor
Taylor Creek	Covert Run	0.2	TYC0.7-CVR0.2	2016	H	3	4	3	4	15	12	10	8	14	1	1	12	12	99	Poor
Taylor Creek	Woodlawn Creek	1.3	TYC0.9-WLC1.3	2012	H	2	0	1	1	10	4	10	5	4	1	0	9	8	55	Poor
Taylor Creek	Woodlawn Creek	1.3	TYC0.9-WLC1.3	2016	H	7	8	3	1	8	4	11	4	14	1	2	11	10	84	Poor
Taylor Creek	Taylor Creek	0.6	TYC0.6	2012	H	4	4	4	4	16	5	6	5	13	1	1	5	8	76	Poor
Taylor Creek	Taylor Creek	0.6	TYC0.6	2016	H	1	3	4	5	13	6	11	5	14	3	3	12	10	90	Poor

Twelvemile Creek Habitat Index Scores

Watershed	Stream	RM	LocID	Year	Site Type	BankSta-LB	BankSta-RB	BankVegP-LB	BankVegP-RB	ChaFlows	ChanAlter	Embeddedness	EpiFauSub	FreqORRifles	RipVegZW-LB	RipVegZW-RB	SedDep	Vel/Dep Regime	RBP_HA	RBP_HA Rating
Twelvemile Creek	Twelvemile Creek	3.9	TMC3.9	2012	W															No Data
Twelvemile Creek	Twelvemile Creek	3.9	TMC3.9	2016	W	5	7	5	7	11	13	17	16	11	4	7	12	13	128	Fair
Twelvemile Creek	Twelvemile Creek	3	TMC3.0	2012	W	8	7	9	8	15	14	9	14	6	6	6	12	13	127	Fair
Twelvemile Creek	Twelvemile Creek	3	TMC3.0	2016	W	9	8	9	8	18	15	14	16	11	7	9	6	12	142	Good
Twelvemile Creek	Brush Creek	0.3	BRC0.3	2012	W	7	3	7	7	14	14	12	13	13	3	9	14	14	130	Good
Twelvemile Creek	Brush Creek	0.3	BRC0.3	2016	W	7	6	5	4	11	12	6	8	13	6	6	8	10	102	Poor

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Appendix C – Stream Stability Data

Rapid stability assessment results are listed in tables beginning with the Fourmile Creek watershed, followed by the Taylor Creek and Twelvemile Creek watersheds. The stability metrics included in the tables are as follows:

- Bank (LEFT_BANK and RIGHT_BANK) – Bank height and bank angle are utilized to calculate the risk of bank failure score for each stream bank (i.e., left bank and right bank) based on logistic regression thresholds developed from NKY stream systems. Each stream bank is assessed separately with scores ranging from 0 (stable) to 10 (unstable).
- Shape (SHAPE) – Floodplain connectivity and stream bed irregularity are utilized to determine the channel shape score. Each parameter is assessed separately (a score of 5 is stable and a score of 0 is unstable) and then added together for a total score.
- Bedrock (BEDROCK) – Percent of bedrock is utilized to determine the bedrock score as follows: <2% receives a score of 10 (good), 2-10% receives a score of 4 (fair), and >10% receives a score of 0 (poor).
- Pool Depth (POOL) – Depth of the deepest pool in the assessment reach is used to determine the pool depth score as follows: <2.5' receives a score of 10 (good) and >2.5' receives a score of 0 (poor).
- Embeddedness (EMBEDD) – Percent of embeddedness in the assessment reach is utilized to determine the embeddedness score as follows: 0-25% receives a score between 20 and 16 (Optimal), 25-50% receives a score between 15 and 11 (Suboptimal), 50-75% receives a score between 10 and 6 (Marginal), and >75% receives a score between 5 and 0 (Poor).
- Frequency of Riffles (RIFLE_FREQ) – Number of riffles occurring in the assessment reach is used to determine the riffle frequency score as follows: “relatively frequent” receives a score between 20 and 16 (Optimal), “infrequent” receives a score between 15 and 11 (Suboptimal), “occasional” receives a score between 10 and 6 (Marginal), and “generally all flat water” receives a score between 5 and 0 (Poor).

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Fourmile Creek Stream Stability Index Scores

DATE	SITE	LEFT_BANK	RIGHT_BANK	SHAPE	BEDROCK	EMBEDD	POOL	RIFFLE FREQ	SITE SCORE
6/27/2012	FMC0.5	7	3	0	10	8	0	16	0.50
12/16/2015	OWC0.4	0	10	0	4	10	10	11	1.35
12/16/2015	FMC6.9	10	8	0	4	13	10	17	4.80

Taylor Creek Stream Stability Index Scores

DATE	SITE	LEFT_BANK	RIGHT_BANK	SHAPE	BEDROCK	EMBEDD	POOL	RIFFLE FREQ	SITE SCORE
8/28/2012	TYC0.6	10	7	0	10	11	10	4	1.80
8/28/2012	TYC0.7-CVR0.2	7	10	0	10	8	10	14	3.55
8/28/2012	TYC0.9-WLC1.3	9	0	0	10	11	10	16	3.60

Twelvemile Creek Stream Stability Index Scores

DATE	SITE	LEFT_BANK	RIGHT_BANK	SHAPE	BEDROCK	EMBEDD	POOL	RIFFLE FREQ	SITE SCORE
12/16/2015	BRC0.3	10	4	5	4	13	10	11	4.2
6/27/2012	TMC3.0	10	10	10	4	11	10	11	6.1
12/16/2015	TMC3.0	10	10	10	4	12	10	12	6.6

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Appendix D – Stream Condition Index Scores

Stream Condition Index Basin Trend Scores by Site – Period 2 (2012 - 2015)

Watershed	Site	Water Quality Score	Biology Score	Habitat Score	Stream Stability Score	Score
Fourmile Creek	0.5	5.63	7.22	4.47	0.50	4.46
	7.0	6.15	4.12	4.04	4.80	4.78
	OWC0.4	NA	7.06	4.86	1.35	4.42
Taylor Creek	0.6	4.15	4.26	2.70	1.80	3.23
	CVR0.2	NA	4.65	2.34	3.55	3.51
	WLC1.3	NA	6.28	1.95	3.60	3.94
Twelvemile Creek	3.0	6.00	7.65	9.06	6.35	7.27
	3.9	NA	NA	NA	NA	NA
	BRC0.3	NA	5.92	9.90	4.20	6.67

Note: An overall monitoring site score is only calculated if 3 out of the 4 categories are populated.

Stream Condition Index Basin Trend Scores by Site – Period 3 (2016 - 2019)

Watershed	Site	Water Quality Score	Biology Score	Habitat Score	Stream Stability Score	Score
Fourmile Creek	0.5	6.03	6.24	3.60	NA	5.29
	7.0	6.21	5.44	4.61	NA	5.42
	OWC0.4	NA	4.51	4.86	NA	NA
Taylor Creek	0.6	5.05	2.67	3.19	NA	3.64
	CVR0.2	NA	2.69	3.51	NA	NA
	WLC1.3	NA	3.93	2.98	NA	NA
Twelvemile Creek	3.0	6.12	8.43	10.00	NA	8.18
	3.9	6.30	7.90	9.38	NA	7.86
	BRC0.3	5.15	9.91	4.47	NA	6.51

Note: An overall monitoring site score is only calculated if 3 out of the 4 categories are populated.

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