



Loading Analysis Plan and Supporting Data Acquisition Needed for the East Fork Little Miami River Basin

Total Maximum Daily Load Development



Ohio EPA Technical Report AMS/2012-EFLMR-3

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Assessment and Modeling Section

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Introduction

This document provides an overview of the information considered in proposing the strategy to address water quality impairments in the East Fork Little Miami River (East Fork LMR) watershed. These recommendations are based on data collected as part of a biological and water quality study in 2012. A description of the project area, sites, data types, methods and results can be found in the Biological and Water Quality Study of the East Fork Little Miami River and Select Tributaries, 2012 (Ohio EPA, 2014a) technical report document at (epa.ohio.gov/Portals/35/documents/East_Fork_LMR_TSD_2014.pdf).

In December 2013, U.S. EPA announced a new “Vision” for the Clean Water Act (CWA) Section 303(d) program to provide an updated framework for implementing responsibilities under the impaired waters program (for additional information see: epa.gov/tmdl/new-vision-implementing-cwa-section-303d-impaired-waters-program-responsibilities). U.S. EPA recognized that “... there is not a one-size-fits-all approach to restoring and protecting water resources.” Under the new Vision, states will be able to develop tailored strategies to implement the 303(d) program in the context of their water quality goals. Ohio EPA has picked the East Fork LMR watershed as a pilot project for implementing the new Vision approach. This is due to the watershed’s unique circumstances of aquatic life and public water supply uses. These conditions provide the opportunity to integrate these uses into an alternative Total Maximum Daily Load (TMDL) framework that offers improved remediation and protection outcomes to existing methods. This alternative approach also provides direct engagement with the priorities of the well-established East Fork Watershed Cooperative (EFWCoop) stakeholder group; see: epa.gov/water-research/east-fork-watershed-research-and-cooperative.

Research efforts undertaken by EFWCoop, led by U.S. EPA’s Office of Research and Development (ORD), have been extensive in the East Fork LMR watershed. Ohio EPA intends to tap into many of these research projects as noted throughout this plan. Much of ORD’s focus of this research has been to understand the feasibility and mechanics of water quality source trading in the watershed. Ohio EPA is focusing on developing a TMDL report that will incorporate/facilitate water quality trading as much as possible within the Agency’s legal authority. This focus on stakeholder engagement and attention to adaptive management alternatives is another aspect of the East Fork LMR TMDL report being a new Vision project.

Sites in the East Fork LMR watershed were assessed for aquatic life use, recreation use, and public water supply use. The attainment of aquatic life and recreation use is based on specific restoration targets. Public water supply use attainment is based on atrazine and algal toxin thresholds. This document examines those targets and thresholds and lays out proposals for addressing each impairment. Where appropriate, methods are outlined to develop TMDLs for specific pollutants.

Aquatic Life Use

Evaluation of Biocriteria

Attainment of Ohio EPA’s biocriteria are based on fish and macroinvertebrate scores, as measured by the Index of Biotic Integrity (IBI), Modified Index of well-being (MIwb) and Invertebrate Community Index (ICI). Further explanations of Ohio EPA’s biocriteria can be found in Ohio Administrative Code (OAC) Chapter 3745-1-07 and additionally at epa.ohio.gov/dsw/bioassess/BioCriteriaProtAqLife. Goals for those indices in the East Fork LMR watershed are shown in Table 1. The attainment status for each site is shown in Figure 1 and the scores for impaired sites are shown in Table 2. Note that Table 2 includes impairments that are outlined in the East Fork LMR biological and water quality report (Ohio EPA, 2014a) based on assessment site *and* overall watershed assessment unit (HUC-12). Within the Ohio EPA 2014a report, the assessment site impairments are located in that report’s Table 2 while HUC-12 impairments are explained on Table 1.

Table 1 – Biological criteria applicable in the East Fork Little Miami River watershed for aquatic life use designations.

Ecoregion	Biological Index	Assessment Method ^{2, 3}	Biological Criteria for the Applicable Aquatic Life Use Designations ¹	
			EWB	WWH
Eastern Cornbelt Plains (ECBP)	IBI	Headwater	50	40
		Wading	50	40
		Boat	48	42
	MIwb	Wading	9.4	8.3
		Boat	9.6	8.5
	ICI	All ⁵	46	36
	Interior Plateau (IP)	IBI	Headwater	50
Wading			50	40
Boat			48	38
MIwb		Wading	9.4	8.1
		Boat	9.6	8.7
ICI		All ⁵	46	30

¹ Aquatic Life Use (ALU) designations: warmwater habitat (WWH) and exceptional warmwater habitat (EWH).

² In general, the assessment method used at a site is determined by its drainage area (DA) according to the following:
Headwater: DA ≤ 20 mi²; wading: DA >20 mi² and ≤ 500 mi²; boat: DA > 500 mi².

³ MIwb not applicable to drainage areas less than 20 mi² (headwater sites).

⁵ Limited to sites with appropriate conditions for artificial substrate placement.

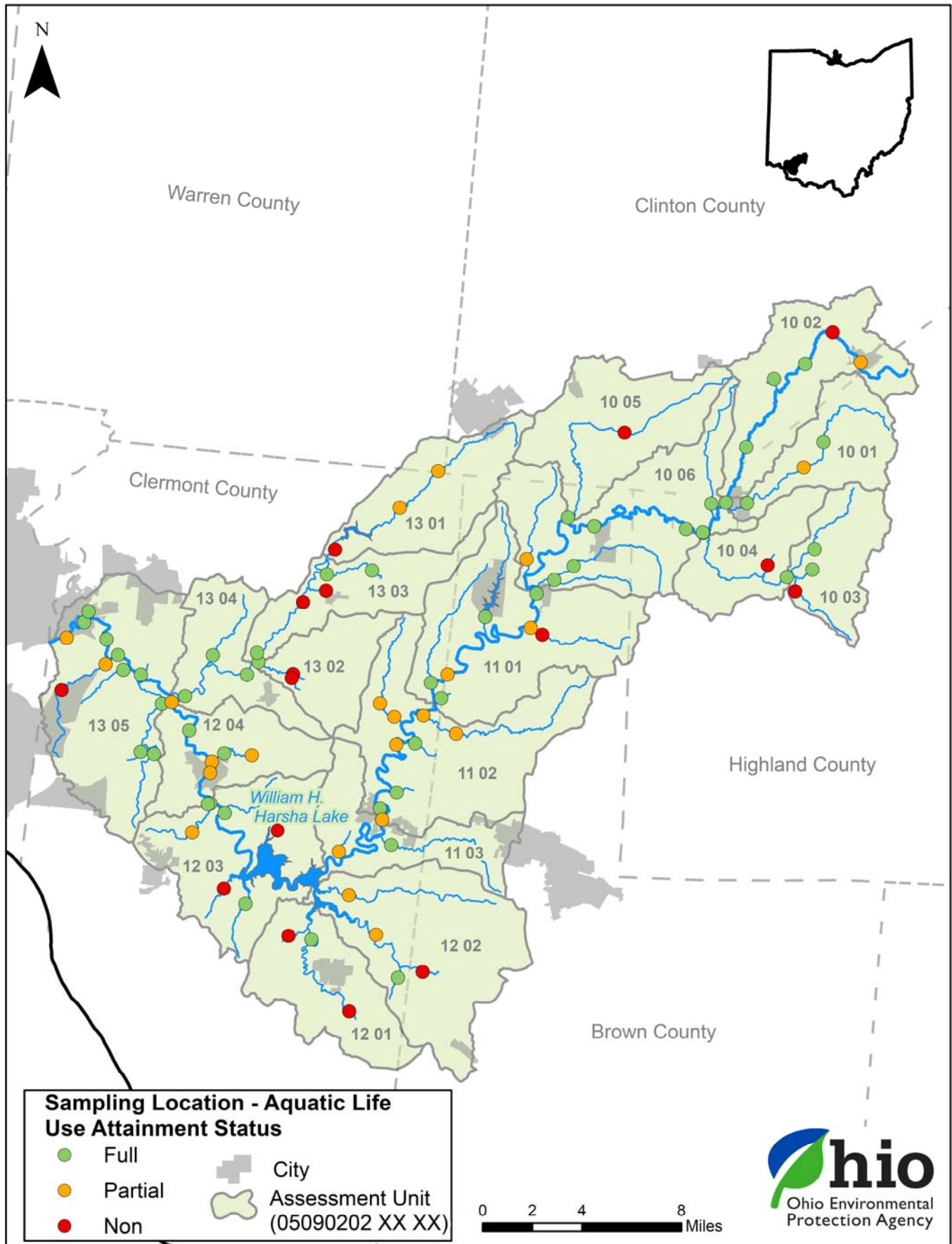


Figure 1 – Map summarizing ALU attainment status in the East Fork Little Miami River watershed in 2012.

Table 2 – Aquatic life use attainment information for impaired sampling locations in the East Fork Little Miami River watershed, 2012.

Station	Location	ALU	River Mile ^a	Drain. Area (mi ²)	IBI	MIwb ^b	ICI ^c	QHEI	Attain. Status	Causes	Sources
05090202 10 01 – Turtle Creek – overall impairment caused by nutrient enrichment											
200508	Turtle Creek at Bald Knob Rd.	WWH	4.4 ^B	13.7	36	--	F	44.8	PARTIAL	Nutrient/eutrophication biological indicators	Agriculture
										Habitat limited by bedrock	Quarry
05090202 10 02 – Headwaters East Fork Little Miami River– overall impairment caused by organic enrichment											
M04S17	East Fork LMR at SR 28	WWH	84.1 ^W	3.0	38 ^{NS}	--	F	58.5	PARTIAL	Low D.O., Organic enrichment	Runoff from New Vienna
M04S35	East Fork LMR at Thornbird Rd.	WWH	82.4 ^W	5.4	34*	--	F	76.8	NON	Low D.O., Organic enrichment	New Vienna
05090202 10 03 – Headwaters Dodson Creek – overall impairment caused by habitat											
301888	S. Fork Dodson Creek at Tedrick Rd.	WWH	0.9 ^W	2.3	34	--	P	44.5	NON	Organic enrichment, low D.O. condition exacerbated by poor habitat and low flow	Low-head dam at Roush Rd.
05090202 10 04 – Anthony Run-Dodson Creek – overall impairment caused by nutrient enrichment											
301890	Trib to Dodson Creek at RM 4.52 at US 50	WWH	0.6 ^W	4.9	50	--	P	72.3	NON	Low D.O.	
05090202 10 05 – West Fork East Fork Little Miami River – overall impairment caused by habitat											
301891	West Fork East Fork LMR at Frazier Rd.	WWH	7.5 ^W	8.2	26	--	MG	39.5	NON	Poor habitat, condition exacerbated by low flow	Natural
05090202 10 06 – Glady Creek-East Fork Little Miami River – overall impairment caused by organic enrichment											
200474	Sycamore Creek at Glady Rd.	WWH	0.8 ^W	6.6	42	--	F	56.8	PARTIAL	Low D.O., sedimentation/siltation, organic enrichment	
05090202 11 01 – Solomon Run-East Fork Little Miami River – overall impairment caused by habitat and low dissolved oxygen											

Station	Location	ALU	River Mile ^a	Drain. Area (mi ²)	IBI	MIwb ^b	ICI ^c	QHEI	Attain. Status	Causes	Sources
M04S12	East Fork LMR at SR 131	EWH	54.4 ^W	165.0	45*	8.81*	44 ^{NS}	69.3	PARTIAL	Low D.O., historic channelization	Agriculture, natural
301738	East Fork LMR at SR 286	EWH	46.9 ^W	178.0	40*	8.00*	46	68.8	PARTIAL	Historic channelization	
301893	Saltlick Creek at US 68	WWH	0.6 ^W	5.7	28	--	HF	51.5	NON	Marginal habitat, condition exacerbated by low flow	Natural
05090202 11 02 – Fivemile Creek-East Fork Little Miami River – overall impairment caused by organic enrichment											
M04S22	Pleasant Run at Blue Sky Park Rd.	WWH	1.4 ^W	5.3	42	--	LF	67.5	PARTIAL	Natural conditions	
M04S46	Pleasant Run at Marathon Rd.	WWH	0.4 ^W	7.8	38	--	F	62.5	PARTIAL	Natural conditions	
301895	Fivemile Creek at Blue Sky Park Rd. (upper crossing)	WWH	2.3 ^W	8.3	32	--	MG	54.3	PARTIAL	Organic enrichment, condition exacerbated by low flow and marginal habitat	Unknown, Agriculture
M04S49	Fivemile Creek at Blue Sky Park Rd. (lower crossing)	WWH	0.5 ^W	10.6	36	--	F	51.5	PARTIAL	Low D.O., organic enrichment, condition exacerbated by low flow	Unknown, Agriculture
M04S10	East Fork LMR at Jackson Pike	EWH	41.1 ^W	221.0	45*	8.72*	46	77.8	PARTIAL	Unknown	
M04S08	East Fork LMR at Main St.	EWH	34.9 ^W	237.0	46 ^{NS}	8.80*	50	70.5	PARTIAL	Organic enrichment	Williamsburg
05090202 11 03 – Todd Run-East Fork LMR – overall impairment caused by nutrient enrichment											
200471	Kain Run at Williamsburg - Batam Rd.	WWH	0.3 ^W	5.9	30	--	G	64.0	PARTIAL	Bedrock, low flow, nutrient	Natural, Urban runoff
05090202 12 01 – Poplar Creek – overall impairment caused by low dissolved oxygen											
301900	Poplar Creek at Bethel Maple Rd.	WWH	8.4 ^W	5.8	28	--	F	70.5	NON	Low D.O., condition exacerbated by low flow	Unknown, Agriculture
301901	Sugartree Creek adj. South Campbell Rd.	WWH	1.0 ^W	3.6	34	--	F	58.8	NON	Low D.O., condition exacerbated by low flow	
05090202 12 02 – Cloverlick Creek – overall impairment caused by low dissolved oxygen											

Station	Location	ALU	River Mile ^a	Drain. Area (mi ²)	IBI	MIwb ^b	ICI ^c	QHEI	Attain. Status	Causes	Sources
301898	Cloverlick Creek at Bethel New Hope Rd.	WWH	8.5 ^W	12.4	28	--	F	64.3	NON	Low D.O., condition exacerbated by low flow	Unknown, Agriculture
200468	Cloverlick Creek at SR 133	WWH	5.2 ^W	23.0	34	7.15	G	62.0	PARTIAL	Low D.O. accompanied by D.O. swing >11 mg/L	Unknown, Agriculture
200469	Barnes Run at Concord – Bethel Rd.	WWH	1.9 ^W	7.9	30	--	G	64.3	PARTIAL	Low D.O. – unknown source	Unknown, Agriculture
05090202 12 03 – Lucy Run-East Fork LMR – overall impairment caused by natural causes											
M04S44	Lucy Run dst Lucy Run Cemetery	WWH	1.9 ^W	3.7	30	--	MG	63.5	PARTIAL	Low flow, no riffle	Natural
301902	Back Run at Foozer Rd.	WWH	1.2 ^W	2.4	34	--	F	73.0	NON	Low flow, no riffle	Natural, small package plant
M04S45	Slabcamp Run at Zagar Rd.	WWH	2.6 ^W	0.7	12	--	F	65.8	NON		
05090202 12 04 – Backbone Creek-East Fork LMR – overall impairment caused by low dissolved oxygen											
301904	Trib to Backbone Creek at Elmwood Rd.	WWH	0.9 ^W	3.8	28	--	G	62.8	PARTIAL	Low D.O., condition exacerbated by low flow	Unknown, Natural
M04S31	East Fork LMR at Main St.	EWH	13.8 ^W	363.0	48 ^{NS}	8.56*	E	80.0	PARTIAL	Unknown	
M04S05	East Fork LMR at SR 32	EWH	13.2 ^W	364.0	44	8.69*	56	81.0	PARTIAL	Unknown	
M04S03	East Fork LMR at Olive Branch-Stonelick Rd.	EWH	9.1 ^W	380.0	45	8.58*	48	87.0	PARTIAL	Unknown	
05090202 13 01 – Headwaters Stonelick Creek – overall impairment caused by organic enrichment											
200492	Stonelick Creek at Woodville	WWH	20.0 ^W	4.9	38	--	F	57.3	PARTIAL	Low D.O., organic enrichment, condition exacerbated by low flow	Unknown, Agriculture Stonelick Reservoir backwaters
M04S42	Stonelick Creek adj. SR 133	WWH	17.7 ^W	11.6	30	--	MG	64.0	PARTIAL		Stonelick Res.
301905	Stonelick Creek at SR 727	WWH	13.4 ^W	23.0	32	5.60	F	73.0	NON		
05090202 13 02 – Brushy Fork – overall impairment caused by low dissolved oxygen											
301911	Brushy Fork at Brushy Fork Rd.	WWH	2.2 ^W	5.7	26	--	G	49.0	NON	Low D.O., condition exacerbated by low flow and bedrock habitat	

Station	Location	ALU	River Mile ^a	Drain. Area (mi ²)	IBI	MIwb ^b	ICI ^c	QHEI	Attain. Status	Causes	Sources
301913	Patterson Run at Brushy Fork Rd.	WWH	0.1 ^W	4.2	20	--	G	57.3	NON	Low D.O., organic enrichment, condition exacerbated by marginal habitat	Clermont NE Local Schools
05090202 13 03 – Moores Fork-Stonelick Creek – overall impairment caused by low dissolved oxygen and organic enrichment											
301148	Trib to Stonelick Creek RM 10.61 at	WWH	0.9 ^W	2.0	34	--	P	61.8	NON	Organic enrichment, condition exacerbated by low flow	Newtownsville
M04S41	Stonelick Creek at Cedarville Rd.	WWH	9.8 ^W	38.0	34	6.31	VG	69.0	NON	Low D.O., organic enrichment condition exacerbated by low flow	Stonelick Reservoir
05090202 13 05 – Salt Run-East Fork LMR – overall impairment caused by low dissolved oxygen											
610530	East Fork LMR at S. Milford Rd.	EWH	0.8 ^B	498.0	42*	9.39	50	72.3	PARTIAL	Natural conditions	
200481	Hall Run dst. Summerside Rd.	WWH	2.3 ^W	3.1	26	--	G	58.0	NON	Low D.O., condition exacerbated by low flow	Urban runoff
M04P13	Hall Run at Roundbottom Rd.	WWH	0.2 ^W	5.5	30	--	MG	47.8	PARTIAL	Low D.O., condition exacerbated by low flow and poor habitat	Urban runoff

- a River Mile (RM) represents the Point of Record (POR) for the station and may not be the actual sampling RM. (B = a site where fish were collected using the boat method; W = wading)
- b MIwb is not applicable to headwater streams with drainage areas ≤ 20 mi².
- c A narrative evaluation of the qualitative sample based on attributes such as EPT taxa richness, number of sensitive taxa, and community composition was used when quantitative data was not available or considered unreliable. VP=Very Poor; P=Poor; LF=Low Fair; F=Fair; MG=Marginally Good; G=Good; VG=Very Good; E=Exceptional
- ns Nonsignificant departure from biocriteria (≤ 4 IBI or ICI units, or ≤ 0.5 MIwb units).
- * Indicates significant departure from applicable biocriteria (>4 IBI or ICI units, or >0.5 MIwb units). Underlined scores are in the Poor or Very Poor range.

Proposed Actions

Ohio EPA considers many factors when deciding how to address impairments. For some projects, no TMDL is required. The sites within the watershed may be in attainment or the impairment is being addressed by another program/entity so no further action by the Division of Surface Water is necessary. Additionally, the cause of impairment may be natural (i.e., flow or habitat), in which case no action is required. For those needing a TMDL, the complexity of each impairment—including the primary origin of the pollutant, its delivery mechanisms and the waterbody kinetics involved—will determine the complexity needed in a model.

As a part of the new Vision TMDL the East Fork Little Miami River watershed's several causes of aquatic life use impairment will be addressed via a single TMDL modeling approach. Different from many previous TMDLs developed by Ohio EPA, most aquatic life use TMDLs will be developed via the watershed assessment unit (based on the HUC-12 breakdown) rather than impaired assessment site. Several of these assessment units overlap with the public water supply TMDL approach. The approach to addressing this overlap is explained later in this plan. A summary of Ohio EPA's preliminary modeling approaches for aquatic life use impairments is presented in Table 3. Within Table 3, a handful of impairments apply to specific assessment sites or only parts of the HUC-12 watershed. The impairments that only apply to a particular site and just parts of the HUC-12 that are noted within parentheses on the "Cause(s) of impairment" field of the table. Entries with no parenthetical are to be considered addressing the entire HUC-12.

Table 3 – Summary of ALU impairments and potential modeling approaches

HUC 12 (05090202)	Cause(s) of Impairment	Source(s) of Impairment	Action	Method ¹
10 01	Nutrient enrichment	Multiple sources	TMDL	SWAT
	Direct habitat alterations (200508)	Quarry	Other	4c
10 02	Organic enrichment	Multiple sources	TMDL	SWAT
10 03	Organic enrichment	Multiple sources	TMDL	SWAT
	Direct habitat alterations (301888)	Low-head dam	Other	4c
10 04	Organic enrichment	Multiple sources	TMDL	SWAT
10 05	Direct habitat alterations (301891)	Multiple sources and natural	Other	4c
10 06	Organic enrichment	Multiple sources	TMDL	SWAT
	Direct habitat alterations (200474)	Multiple sources and natural	Other	4c
11 01	Low dissolved oxygen	Multiple sources	TMDL	SWAT
	Direct habitat alterations (301893)	Multiple sources and natural	Other	4c
11 02	Organic enrichment	Multiple sources	TMDL	SWAT
	Direct habitat alterations (301895)	Multiple sources and natural	Other	4c
11 03	Nutrient enrichment	Multiple sources	TMDL	SWAT
12 01	Low dissolved oxygen	Multiple sources	TMDL	SWAT
12 02	Low dissolved oxygen	Multiple sources	TMDL	SWAT
12 03	Natural conditions - flow/habitat	Natural sources	Other	4c
12 04 ³	Low dissolved oxygen (Backbone)	Multiple sources	TMDL	SWAT ³
	Cause unknown (EFk LMR sites)	Source unknown	Other	4c
13 01	Organic enrichment	Multiple sources	TMDL	SWAT
13 02	Low dissolved oxygen	Multiple sources	TMDL	SWAT
13 03	Organic enrichment and low dissolved oxygen	Multiple sources	TMDL	SWAT
13 05 ⁴	Low dissolved oxygen (Hull Run)	Multiple sources	TMDL	SWAT ⁴
	Natural conditions (EFk LMR)	Natural sources	Other	4c

- 1 Due to space limitations there are several abbreviations used to describe the analysis or remediation method. Those abbreviations are defined in the following table.
- 2 TMDLs developed for habitat impairment are developed on a site basis. The sites for habitat TMDL development are noted in parenthesis next to the cause.
- 3 The SWAT modeling TMDL for the 12 04 HUC12 will only be developed for the Backbone Creek portion of the watershed.
- 4 The SWAT modeling TMDL for the 13 05 HUC12 will only be developed for the Hull Run portion of the watershed.

Abbreviation	Definition/interpretation
TMDL	A Total Maximum Daily Load (TMDL) will be completed for the impairment.
SWAT	"Soil and Water Assessment Tool" model used to approximate existing conditions and allocate TMDLs to various sources.
4c	TMDL not required; impairment not caused by a pollutant.

Enrichment - Nutrients

Linking impairment to TMDL pollutants

As noted in the East Fork LMR's biological and water quality report (Ohio EPA 2014a), a cause of widespread aquatic life use impairment in this watershed was organic enrichment of a general nature. Impacts from organic enrichment were most commonly evidenced by low dissolved oxygen; however, obvious oxygen demanding substances or their immediate sources were only sporadically observed. At a few sites, some sources delivered from watershed activities, such as poorly treated sewage, were noted; at others, algal mats were observed. The relatively dry and low flow conditions of the 2012 assessment year were also considered as were limitations imposed by altered habitat. None of these sources, however, were the clear driver explaining the overall enrichment. Nor were the accumulation of these sources considered to be fully responsible for the observed impairment.

Because of this ambiguous connection between pollutant sources and cause of impairment, a further examination of the response to pollutants in this system is warranted. The 2014 report examined the relationships between water quality, physical measurements and biological assemblages. An important component of this investigation was to group assessment sites by similar fish assemblages utilizing hierarchical clustering. In an objective manner, this isolated two cluster groups of assessment sites with the most impairment. Of sites in these groups, total Kjeldahl nitrogen (TKN) was determined as one of the strongest indicators of fish community health when a matrix of all water quality and physical data were analyzed. TKN, being composed of organic nitrogen and ammonia, is the best water quality parameter representing organic enrichment that Ohio EPA regularly collects. Although the analyses in the 2014 report supported the conclusion that organic enrichment was responsible for much of the aquatic life use impairment, it did not completely explain the mechanism behind the enrichment, nor did it offer much explanation of the pollutant sources.

As previously noted, some assessment sites had clear sources of enrichment, but most did not. Of those that did not, the 2014 report suggested an indirect mechanism that involves a feedback cycle between decreasing stream flows leading to lower dissolved oxygen concentrations that, in turn, resulted in remineralization of stored nitrogen. Some water quality evidence for this is given; however, the study admits that the mechanism offered is circumstantial, and that the complete nature of the problem is not fully understood. What is clear is that nitrogen is a marker for organic enrichment and is therefore an identifiable and manageable stressor limiting the biological communities. The 2014 report notes that, "...given that many of the small streams in the East Fork basin routinely experience low or intermittent stream flow during the summer, and are therefore naturally prone to oxygen depletion, reducing nitrogen inputs from diffuse sources would likely help maintain dissolved oxygen during critical periods."

A consideration of phosphorus is required in this linkage discussion. In the 2014 East Fork LMR report, total phosphorus (TP) was also shown to be as good a predictor of impairment as TKN (see Ohio EPA, 2014a Figure 25 and Table 13). Several environmental measures - stream flow, habitat aspects, and TP - are noted as having collinearity with TKN and explanatory power for poor biological performance. Phosphorus is the nutrient most commonly targeted to limit excessive primary production in TMDLs developed by Ohio, and many other efforts in freshwater (Miltner, 2010; Kane, 2014 and Schindler, 2012). Typically, this is because freshwaters tend to be (but not always) phosphorus limited, and phosphorus removal by treatment plants is generally cheaper and easier to implement than nitrogen removal when management is directed toward point sources. However, for diffuse sources, nitrogen and phosphorus are often co-limiting (or co-ad libitum as the case may be), so neither should be completely ignored.

The above two paragraphs show that both nitrogen and phosphorus are pollutants associated with enrichment and low dissolved oxygen concentration impairments in the East Fork LMR. The sources of these pollutants listed in the 2014 report for impacted sites are the normal sources Ohio EPA lists for nutrient enrichment. Throughout the watershed these sources of pollution include agriculture, urban runoff/storm sewers, package plants, municipal point source discharges and onsite sewage treatment. These anthropogenic sources of nutrients regularly receive allocations in nutrient enrichment TMDLs. Based on a weight of evidence approach in considering all factors discussed here, nutrients are the appropriate pollutants to address enrichment in this watershed.

It is reasonable to develop TMDLs for both TN and TP. This is primarily because, although enrichment as a cause of impairment was unambiguous, the relative contribution of nitrogen or phosphorus in facilitating enrichment was less clear; therefore, reducing both macronutrients to acceptable levels provides more assurance that recovery will occur.

The nature of nutrient pollution reduction also needs consideration. In agricultural landscapes, the source of phosphorus and nitrogen are obviously related, and efforts to reduce delivery to water bodies of one nutrient may reduce the other. For example, the use of cover crops reduces phosphorus loss by slowing down sediment during runoff events and reduces nitrogen by locking up nitrate that would otherwise leach out of the field (ARS, 2015). More simply, the amount and timing of fertilizer application can have a significant influence on nutrient loss from fields (Miller et al. 2012). Due to this, TMDLs to reduce both nutrients do not double the required effort, rather, they provide a more comprehensive tool to address impairments.

Due to the widespread nature of this aquatic life use impairment, a nutrient TMDL calculated using the Soil and Water Assessment Tool (SWAT) model will be developed for all but one HUC-12 upstream of Harsha Lake. Table 3 outlines the assessment units where nutrient TMDLs for aquatic life use impairments will be developed. The 10 05 West Fork East Fork Little Miami River HUC-12 is impaired for its aquatic life use due to non-nutrient causes. However, as explained in the public water supply use below, a nutrient TMDL will be developed for 10 05 based on the drinking water impairments. Downstream of Harsha Lake, every HUC-12 except for 13 04 lower Stonelick Creek will have a complete or partial HUC-12 nutrient TMDL developed. The HUC-12s 12 04 and 13 05 will only have nutrient TMDLs developed for the tributaries Backbone Creek and Hull Run, respectively. No nutrient TMDL will be developed for the mainstem East Fork Little Miami River downstream of Harsha Lake. Refer to the *Nutrient TMDLs Based on Multiple Uses of Impairment* section near the end of this report for a map showing the areas where nutrient TMDLs will be developed.

Based on this analysis, the nutrient TMDLs developed using the SWAT model will address nutrient enrichment, organic enrichment and low dissolved oxygen causes of impairment.

Modeling methods

Throughout the East Fork LMR watershed nutrient loading and stream flows have been modeled using SWAT by U.S. EPA, ORD. SWAT is a river basin-scale model developed by U.S. Department of Agriculture (ARS) at the Blackland (Texas) Research Center (TAMU, 2019). SWAT is a physically based model that operates on a daily time step (continuously) and effectively over several years. SWAT models nitrogen and phosphorus from diffuse, landscape sources and point sources. Landscape sources can be fine-tuned to conditions (i.e., soils, slopes, and hydrologic routings) and management practices (i.e., agricultural crop rotations, timing/types of fertilizers, and conservation practices). Once satisfactorily calibrated to existing conditions, SWAT can be used to examine various nutrient reduction scenarios. These scenarios can include the adoption of various types of agricultural and urban conservation practices and/or point source nutrient reductions. SWAT has been used extensively in the U.S. for

TMDL applications including in Ohio (Ohio EPA, 2009 and Ohio EPA, 2012), and has been accepted by U.S. EPA as a modeling strategy for TMDL load development (U.S. EPA 1999).

SWAT was chosen by U.S. EPA ORD because it can simulate the complexities involved in nutrient source trading. Sufficient daily flow information due to U.S. Geological Survey (USGS) gages were available for calibrating and validating the model. A robust stream nutrient dataset was available for model evaluation due to sampling activities carried out by U.S. EPA ORD and the Clermont County Office of Environmental Quality. Nutrient data collected and analyzed by Ohio EPA were also used in model evaluation. More information on this model will be available when Nietch, et al, in revision is published.

Model set-up, calibration and validation were carried out by U.S. EPA ORD for this effort. Nearly 16,000 hydrologic response units were developed for the upper East Fork LMR SWAT model with the intent to improve the spatial resolution for management scenario simulations (Karcher, 2013). This allows for model output at the approximate spatial scale of individual land parcels as seen on Figure 2. Calibration and validation goodness of fit (GOF) statistics for the upper East Fork LMR SWAT model are given in Tables 4 and 5, respectively. Figure 3 shows a plot of observed vs. simulated data for flow on both daily and monthly time series. The model performance statistics are based on the parameterization that optimized the model fit for all primary variables of interest, i.e., flow, sediment, and nitrogen and phosphorus species. It is important to note certain sensitive parameters affect more than one of the variables of interest. Therefore, maximizing the model fit for one variable may not result in the best fit for another. It is not practical to have multiple model parameterizations when running management scenarios, so the 'best' parameterization is somewhat subjective. For instance, goodness of fit for flow was set as highest priority, followed by TN and then TP.

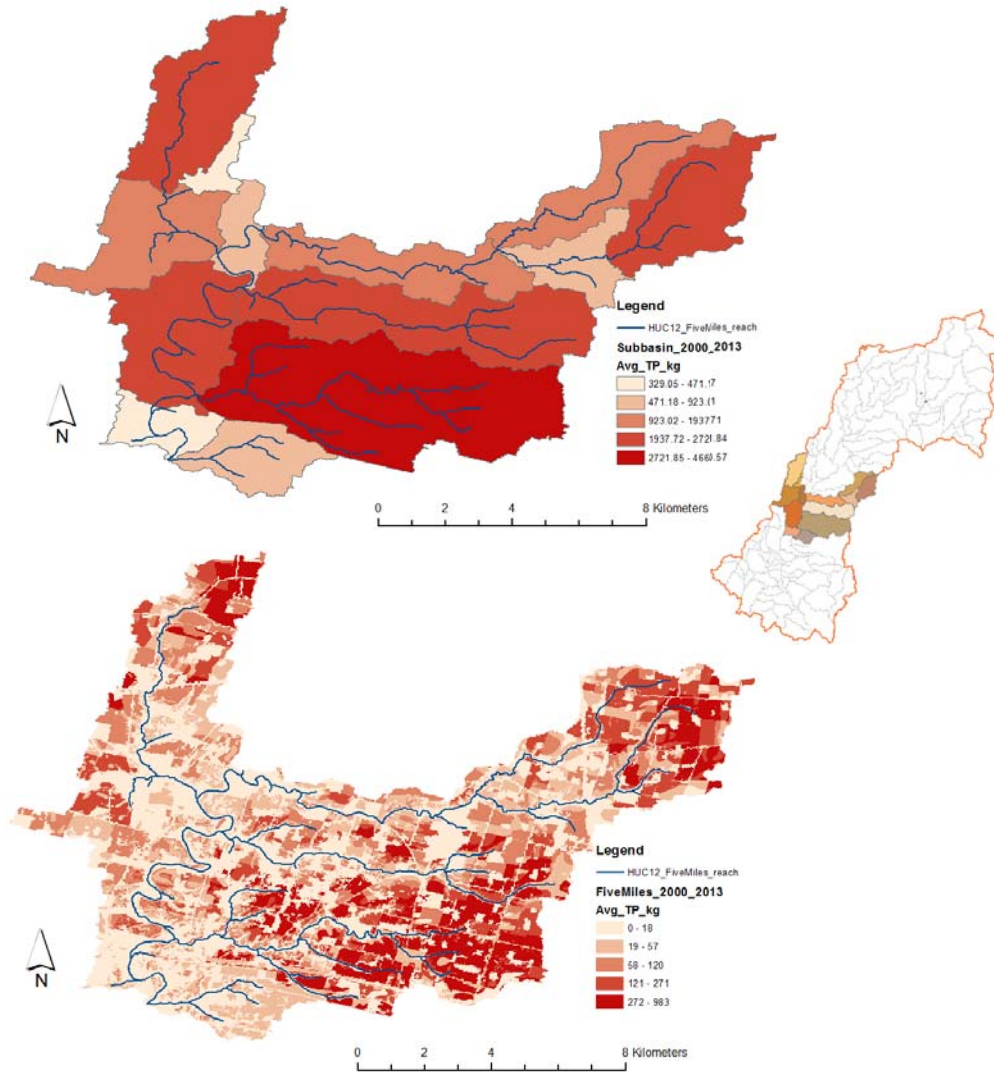


Figure 2 — Example spatial resolution of total phosphorus loading model output for the Five Mile Creek HUC12 (11 02). Maps show Top: the modeled subwatershed scale and Bottom: the hydrologic response unit scale TP loading model output. (Adapted from: Nietch, et al in revision)

Table 4 – Upper East Fork LMR SWAT model GOF statistics for model calibration.

Summary based on comparing observed and simulated data from the “best” model run using a daily timestep. NSE=Nash-Sutcliffe Efficiency. bR2=R2 multiplied by the coefficient of the regression line between simulated and observed. The p-factor quantifies the fraction of the measured data that is bracketed by the 95% probability prediction interval (95PPU) of multiple model runs for uncertainty analysis (with values closer to 1 considered better). The r-factor is the average width of the 95PPU band divided by the standard deviation of the measured variable (a value less than 1 is considered good).

Statistics for daily observed and simulated data							
Variable	Timeframe	Units	p-factor	r-factor	NSE	bR2	PBIAS
Flow	1/1/2000 - 07/31/2011	m ³ /sec	0.57	0.70	0.52	0.23	2.90
Sediment		ton/day	0.20	14.64	0.28	0.09	4.30
ORGP	4/10/2008 - 07/31/2011	kg/day	0.54	1.54	0.23	0.06	-48.90
MINP		kg/day	0.16	0.62	0.18	0.09	1.10
TP		kg/day	0.22	1.03	0.26	0.08	-25.00
ORGN		kg/day	0.28	0.16	0.28	0.26	-17.80
NO3		kg/day	0.16	0.59	0.05	0.21	6.70
NH4		kg/day	0.30	0.41	0.27	0.40	-4.30
TN		kg/day	0.17	0.31	0.38	0.38	-6.60
Statistics for daily observed and simulated data aggregated to a monthly							
Variable	Timeframe	Units	p-factor	r-factor	NSE	bR2	PBIAS
Flow	1/1/2000 - 07/31/2011	m ³ /sec	0.57	0.70	0.73	0.62	2.60
Sediment		ton/day	0.20	14.64	0.51	0.31	4.20
ORGP	4/10/2008 - 07/31/2011	kg/day	0.54	1.54	0.40	0.23	-49.20
MINP		kg/day	0.16	0.62	0.21	0.26	0.40
TP		kg/day	0.22	1.03	0.41	0.23	-25.50
ORGN		kg/day	0.28	0.16	0.54	0.29	-18.20
NO3		kg/day	0.16	0.59	0.38	0.39	7.40
NH4		kg/day	0.30	0.41	0.60	0.42	-4.50
TN		kg/day	0.17	0.31	0.65	0.45	-6.60

Table 5 – Upper East Fork LMR SWAT model GOF statistics for model validation.

Summary based on comparing observed and simulated data from the “best” model run using a daily timestep. For column field description see Table 4.

Statistics for daily observed and simulated data							
Variable	Timeframe	Units	p-factor	r-factor	NSE	bR2	PBIAS
Flow	08/01/2011 - 02/28/2014	m ³ /sec	0.24	0.59	0.43	0.23	-51.50
Sediment		ton/day	0.34	5.12	0.33	0.11	-42.50
ORGP		kg/day	0.48	1.86	0.17	0.05	42.70
MINP		kg/day	0.17	0.47	0.29	0.10	18.20
TP		kg/day	0.25	1.14	0.30	0.10	29.70
ORGN		kg/day	0.22	0.41	0.25	0.16	31.70
NO3		kg/day	0.17	1.06	-0.03	0.00	-23.00
NH4		kg/day	0.19	0.27	0.31	0.09	23.70
TN		kg/day	0.18	0.80	0.35	0.11	1.50
Statistics for daily observed and simulated data aggregated to monthly							
Variable	Timeframe	Units	p-factor	r-factor	NSE	bR2	PBIAS
Flow	08/01/2011 - 02/28/2014	m ³ /sec	0.24	0.59	0.33	0.56	51.20
Sediment		ton/mon	0.34	5.12	0.66	0.73	41.50
ORGP		m ³ /mon	0.48	1.86	0.14	0.10	-42.70
MINP		kg/mon	0.17	0.47	0.22	0.22	-18.30
TP		kg/mon	0.25	1.14	0.27	0.22	-29.70
ORGN		kg/mon	0.22	0.41	0.14	0.40	3.00
NO3		kg/mon	0.17	1.06	0.24	0.44	47.60
NH4		kg/mon	0.19	0.27	0.72	0.55	9.50
TN		kg/mon	0.18	0.80	0.69	0.72	27.90

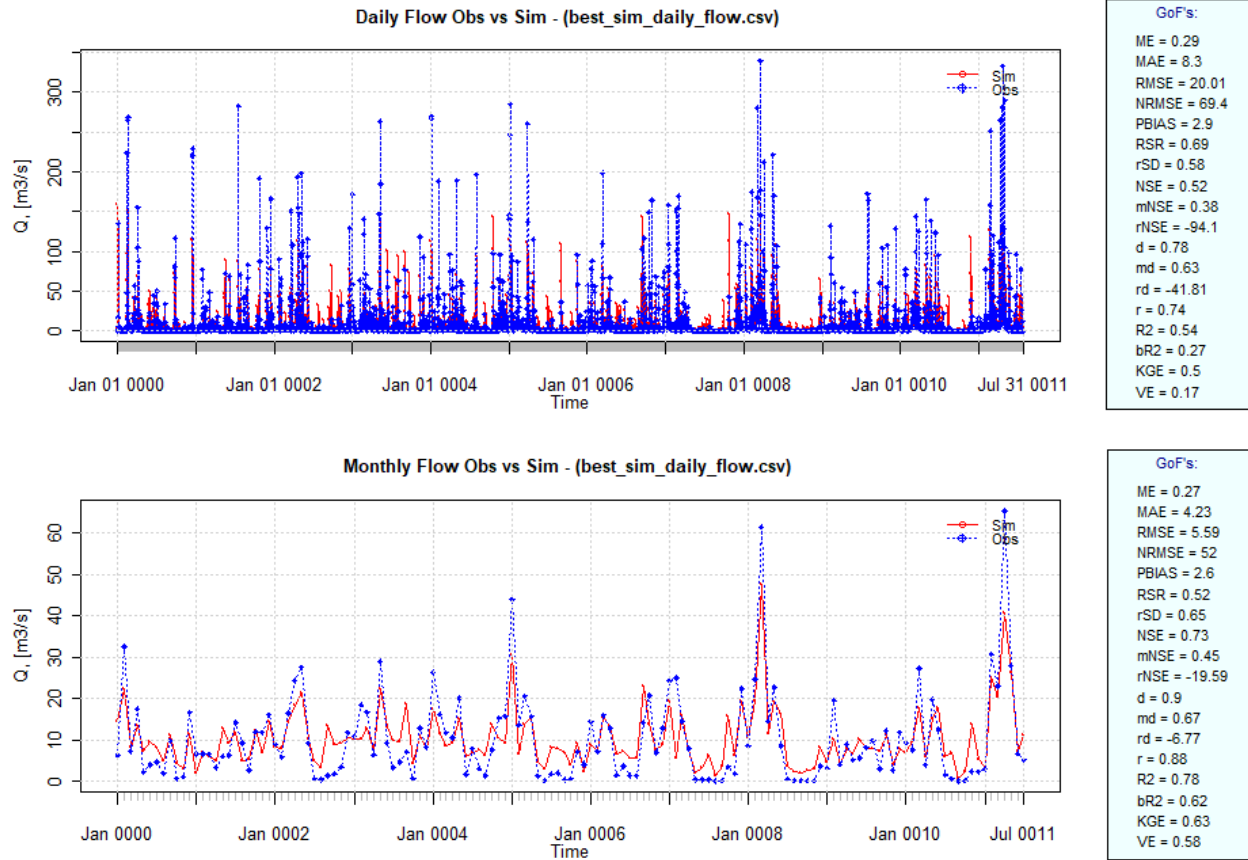


Figure 3. Upper East Fork LMR SWAT simulated and observed flow time series after calibration. Daily (top) and monthly (bottom) plots based on daily data along with GOF statistics adjacent to each ME= Mean Error, MAE= Mean Absolute Error, RMSE=Root Means Square Error, NRMSE%=Normalized Root Means Square Error, PBIAS%=Percent Bias, RSR=Ratio of RMSE to the standard deviation of the observations, rSD=Ratio of Standard Deviations, NSE=Nash-Sutcliffe Efficiency, mNSE=modified Nash-Sutcliffe Efficiency, rNSE=relative Nash-Sutcliffe Efficiency, d=Index of Agreement, md=Modified Index of Agreement, rd=Relative Index of Agreement, r=Pearson Correlation Coefficient, R2=Coefficient of Determination, bR2=R2 multiplied by the coefficient of the regression line between simulated and observed, KGE=Kling-Gupta Efficiency, VE=Volumetric Efficiency. The time scale for this modeling run includes 2000 through 2011.

For the aquatic life use nutrient TMDLs in the East Fork LMR watershed the SWAT model will be used to 1) quantify the existing sources of nutrients, in terms of relative magnitudes, 2) calculate the TMDL loading capacity and 3) develop rational reduction apportionments to meet nutrient targets.

Extensive outreach with the existing EFWCoop stakeholder group will occur following the publishing of this loading analysis plan. Through this collaboration reduction scenarios that meet the TMDLs will be examined. Scenarios that have the most buy-in will be included in Ohio EPA's Preliminary Modeling Results and TMDL reports.

Proposed Targets to Address Aquatic Life Use Impairment

Enrichment - Nutrients

The same target concentrations used to address the public drinking water impairments due to algae will be applied to the aquatic life use impairments due to enrichment. These are described below in the public drinking water section of this report.

Recreation Use

The recreation use impairments in the East Fork LMR watershed, listed in Table 6 below, are included in the Multi-watershed Bacteria TMDL project. This project entails the development of TMDLs for over 400 watershed assessment units through the state of Ohio to address recreation use impairment. Additional information regarding this project is available at: epa.ohio.gov/dsw/wq.

Table 6 – East Fork LMR watershed units included in the Multi-watershed Bacteria TMDL Project

<i>Little Miami (05090202)</i>								
<i>Watershed Unit</i>	<i>Station ID</i>	<i>Stream Name</i>	<i>River Mile</i>	<i>Drainage Area</i>	<i>Sample Year</i>	<i># of Samples</i>	<i>Geo Mean</i>	<i>Max Value</i>
10-01	M04S52	Turtle Creek	1.2	17.2	2012	9	319	9500
10-02	M04S15	East Fork Little Miami River	75.33	26.2	2012	7	294	960
10-04	M04S51	Dodson Creek	0.05	32.5	2012	8	360	14000
10-05	M04S50	West Fork East Fork Little Miami River	0.12	28.3	2012	10	199	410
10-06	M04S34	East Fork Little Miami River	70.9	54	2012	8	439	2900
11-01	301738	East Fork Little Miami River	46.92	178	2012	10	249	1600
11-02	M04S08	East Fork Little Miami River	34.91	237	2012	10	351	8500
12-02	200468	Cloverlick Creek	5.2	23	2012	10	178	9300
12-04	M04S03	East Fork Little Miami River	9.1	380	2012	10	127	2200
13-03	301148	Tributary to Stonelick Creek	0.89	2	2012	8	301	4900
13-04	M04P09	Stonelick Creek	1	75	2012	9	325	8000
13-05	610530	East Fork Little Miami River	0.77	498	2012	10	640	6800

Public Water Supply Use

Evaluation of Criteria

The public water supply use includes surface waters from which public drinking water is supplied. Attainment determination associated with this use designation, shown in Table 7, apply within five hundred yards of surface water intakes. Table 8 outlines the watershed assessment units with impaired public water supply uses.

Table 7 – Attainment determination metrics for public drinking water supply use

Indicator	Full attainment conditions	“Watch List” conditions	Impaired Conditions
Algae: Cyanotoxins ^a	No more than one excursion ^b above the state drinking water thresholds (microcystins = 1.6 µg/L, cylindrospermopsin = 3.0 µg/L, and saxitoxins = 1.6 µg/L) within the 5-year period	Maximum instantaneous value ≥ 50% of the state drinking water thresholds	Two or more excursions ^b above the state drinking water thresholds (microcystins = 1.6 µg/L) within the 5-year period
Atrazine	Annual average does not exceed the WQ criteria (atrazine = 3.0 µg/L)	Running quarterly average > WQ criteria OR Maximum instantaneous value > 4x WQ criteria	Annual average exceeds WQ criteria (atrazine = 3.0 µg/L)

^a Impaired conditions based on source water detections at inland public water supply systems and detections at public water system intakes for Lake Erie source waters. Cyanotoxins include: microcystins, saxitoxins, anatoxin-a and cylindrospermopsin.

^b Excursions must be at least 30 days apart in order to capture separate or extended source water quality events.

Table 8 – Public drinking water use attainment information for impaired watershed assessment units in the East Fork Little Miami River watershed.

Public Drinking Water System	Pollutant	Attain. Status
05090202 07 02 – Second Creek ¹		
Blanchester	Atrazine	Impaired
05090202 10 05 – West Fork East Fork Little Miami River		
Blanchester	Atrazine	Impaired
05090202 12 03 – Lucy Run-East Fork Little Miami River (Harsha Lake)		
Clermont County	Algae	Impaired
05090202 13 01 – Headwaters Stonelick Creek		
Blanchester	Atrazine	Impaired

¹ This HUC-12 is not in the East Fork Little Miami River watershed, rather it drains to the Little Miami River via Todd Fork. This assessment unit is included in this project in order to address the three sources for the Village of Blanchester within the same effort.

Proposed Actions

Both types of public drinking water use impairments, atrazine and algae, will be addressed via TMDLs. Atrazine TMDLs will be developed for the watersheds draining to each of the three village of Blanchester drinking water sources. The algae impairment in the Clermont County’s drinking water source, Harsha Lake, is due to multiple raw water samples of microcystins, a cyanotoxin that often occurs from harmful algal blooms (HABs). In order to address this impairment, a TMDL must be developed for all of Harsha Lake’s contributing watershed. Because of this, TMDLs are developed for several more HUC-12s than the one declared impaired for this use. A summary of Ohio EPA’s preliminary modeling approaches for public drinking water use impairments is presented in Table 9.

Table 9 – Summary of public drinking water use impairments and potential TMDL modeling approaches

HUC-12 (05090202)	Portion of HUC-12 (TMDL Assessment Area)	Cause(s) of Impairment	Method
07 02 ¹	Whittacres Run upstream reservoir	Atrazine	
10 01	All	Algae	SWAT ² (nutrients)
10 02	All	Algae	SWAT ² (nutrients)
10 03	All	Algae	SWAT ² (nutrients)
10 04	All	Algae	SWAT ² (nutrients)
10 05	All	Algae	SWAT ² (nutrients)
	W. Fk. E. Fk. LMR upstream of impoundment	Atrazine	
10 06	All	Algae	SWAT ² (nutrients)
11 01	All	Algae	SWAT ² (nutrients)
11 02	All	Algae	SWAT ² (nutrients)
11 03	All	Algae	SWAT ² (nutrients)
12 01	All	Algae	SWAT ² (nutrients)
12 02	All	Algae	SWAT ² (nutrients)
12 03	Ulrey, Back & Slabcamp runs	Algae	SWAT ² (nutrients)
13 01	Stonelick Creek upstream reservoir	Atrazine	

¹ This HUC-12 is not in the East Fork Little Miami River watershed, rather it drains to the Little Miami River via Todd Fork. This assessment unit is included in this project in order to address the three sources for the Village of Blanchester within the same effort.

² SWAT is the "Soil and Water Assessment Tool" model used to approximate existing conditions and allocate TMDLs to various sources.

Atrazine

Atrazine is the cause of public water supply impairment for the village of Blanchester's drinking water sources. This TMDL will be based on a calculated daily concentration target developed to ensure atrazine concentrations do not exceed the 90-day rolling average community action level concentration. Streamflows applied to this daily target concentration will be derived using the SWAT model which is explained in the aquatic life use nutrients TMDLs proposed actions above, and by other reasonable means. A TMDL will be developed for five flow regimes for each impaired assessment area. This will improve the ability to understand and address various pollutant sources.

Algae (nutrients)

Linking impairment to TMDL pollutants

Public drinking water use impairment for Harsha Lake is based on cyanobacteria water sample results. Multiple raw water samples collected from Clermont County public water system source water locations on Harsha Lake (East Fork Lake State Park) from 2012 to 2017 exceeded the microcystins threshold. Maximum concentration observed was 190 µg/L in June 2014. Saxitoxins were also detected in source water but below the threshold (see Table 7, above).

U.S. EPA ORD has routinely monitored sites on Harsha lake since 2009, while the U.S. Army Corp of Engineers (USACE) has conducted routine monitoring of algae dating back to 1987, and nutrient species starting in 1999. In 2013, ORD expanded its watershed stream sampling program to support research into the feasibility of water

quality trading programs. Because nutrient targets were needed for the feasibility research to proceed, they were established using a two-pronged approach that 1) relies on the spatial and temporally intensive monitoring program to establish “natural” nutrient background conditions for the majority of lotic habitat in the watershed and 2) considers survey data that supports relationships between nutrient levels and lake algae determined for this and similar systems (i.e., (Miltner 2010, Ohio EPA 2010, Miltner 2011, Ohio EPA 2014a)).

First, a reference condition approach was taken to determining the natural background nutrient concentrations in the Upper East Fork watershed (UEFW) (U.S. EPA 1998, 2000b, a, Stoddard et al. 2006). Here, the “natural background” will be considered equivalent to the nutrient “reference” condition. In this context sites minimally impacted by known sources of excess nutrients are prioritized within the monitoring program that was established to identify the full range of nutrient concentrations experienced by streams in the system. Hence, the ‘reference’ concentration is rationalized dependent on the context under which the watershed monitoring program was established, and in this case is different than the guidelines used to establish ‘reference’ values at eco-regional scales (U.S. EPA 2000a).

Figure 4 shows the location of the sample sites in the UEFW that ORD used to characterize the nutrient concentrations in the watershed’s streams. A few sites used in the analysis do not actually fall within the UEFW but were included in the analysis because of their relevant physio-geographic properties. Specifically, the site known as NWT resides in the Stonelick Creek subwatershed of the lower East Fork LMR watershed (LEFW) and was included as a validation site for septic system impacts, given the known density of failing systems in its drainage. The site LRC is in the LEFW also. It was used as one of the sites for establishing natural background conditions (i.e., a nutrient reference site), because its drainage has similar soils to most sites in the UEFW, but has minimal agricultural land-use, rather is mostly forest and low-density urban area. LRC is in full biological attainment according to Ohio EPA’s 2012 survey (Ohio EPA 2014a). SRE and SRW are two headwater sites falling just outside of the UEFW boundary on the east side. They have similar soils, slopes, and row crop management operations. They were included as a validation for FVM, a headwater stream site in the Five Mile Run subwatershed, and a National Water Quality Initiative (NWQI) Priority Watershed (USDA 2018) that has been found to be one of the most impacted streams in the UEFW (see Appendix A for sites and the characteristics of each that were used in this analysis).

The site TBS was set as the primary nutrient reference site for the UEFW. It has a similar complement and relative distribution of soil types in its small drainage as most of the watershed and no land use impacts from anthropogenic sources. Its catchment is 100% forested. Site LRC was used as a secondary nutrient reference site. Although it is in the LEFW, it contains a similar distribution of dominant soil types as most sites in the UEFW. LRC is at the confluence to lower East Fork LMR draining a 3rd order subwatershed, and, therefore, was large enough to be included among sites in the 2012 bioassessment. LRC was in full attainment for fish and macroinvertebrate biotic integrity (Ohio EPA 2014a). Figure 5 shows the distribution of TN and TP concentrations among the ORD monitoring sites. Reference sites are depicted in black. For its research, ORD set the natural, background conditions for TN and TP in the UEFW at the TBS site medians of TN and TP; 432.5 ppb and 54.9 ppb, respectively. Nutrient targets, established for the feasibility research were set at the 75th percentile of the reference site distribution, which was 707.25 ppb and 77.25 ppb, for TN and TP, respectively.

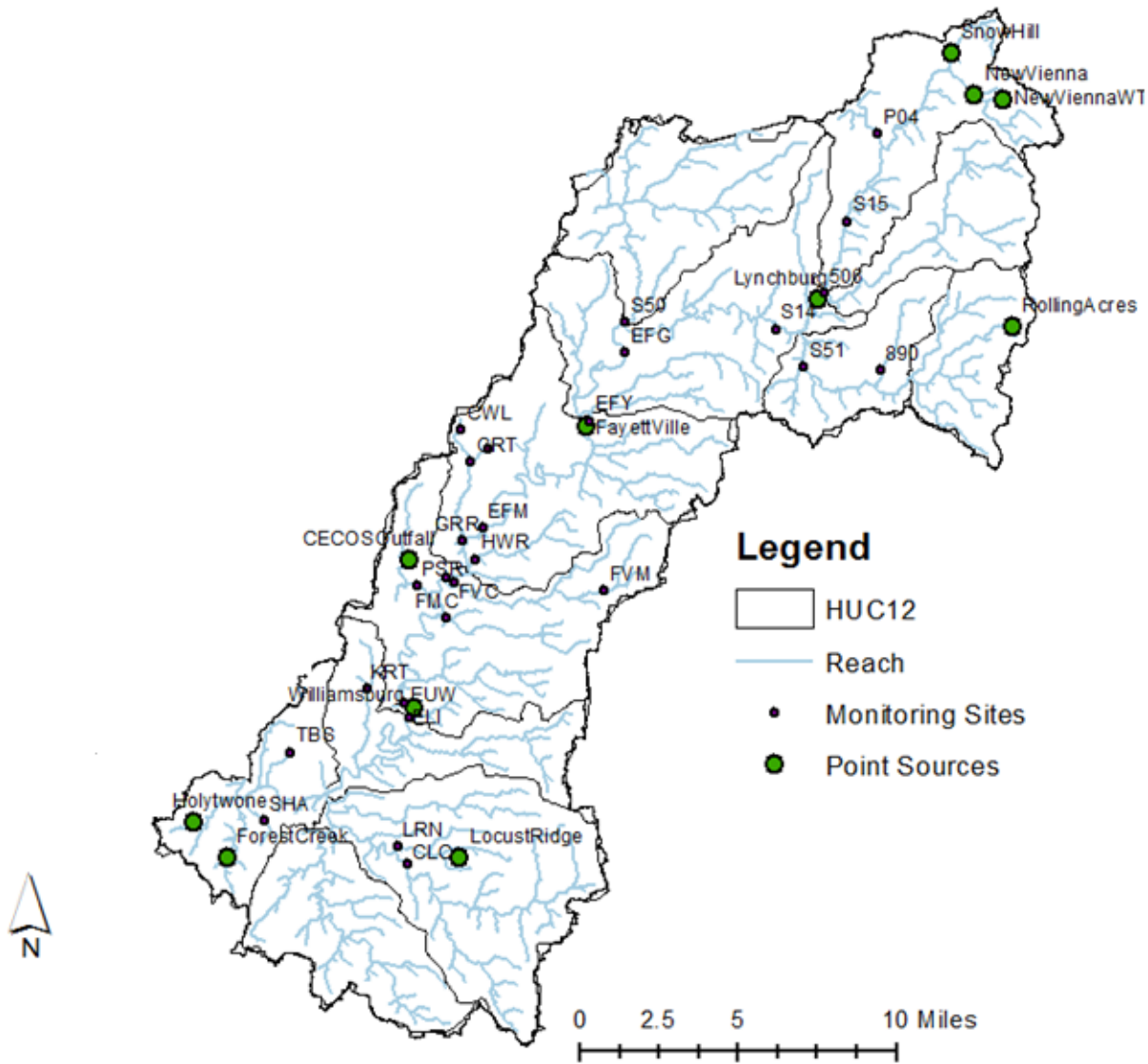


Figure 4: U.S. EPA ORD’s monitoring sites and point source discharges in the upper East Fork LMR Watershed (UEFW). This shows the primary drainage upstream of Harsha Lake.

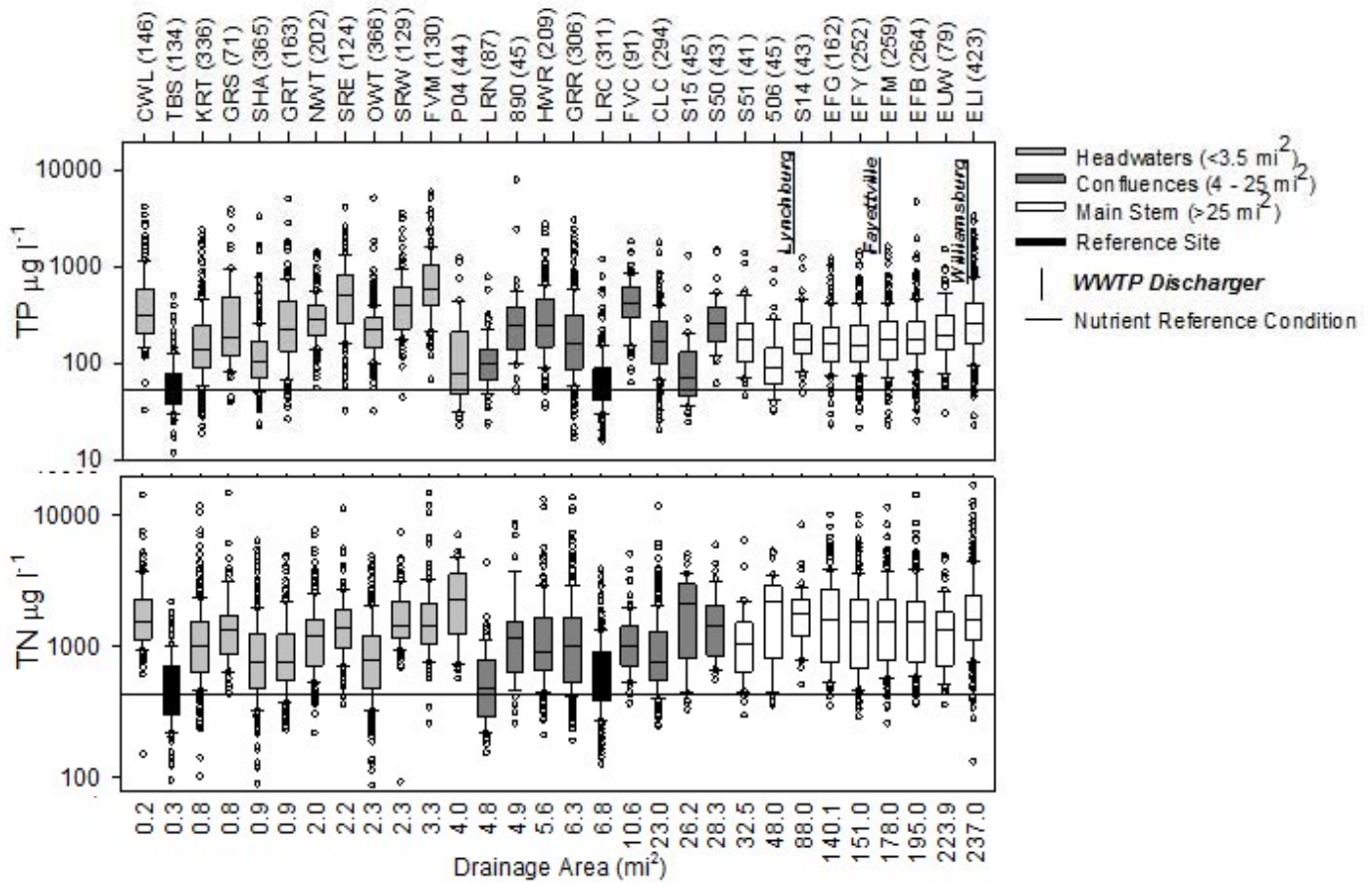


Figure 5. Distribution of nutrient concentrations at ORD stream monitoring sites starting in 2008. Sites are ordered by drainage area. The relative locations of three WWTPs that discharge directly to the main stem are noted. Site ID's with number of samples that contribute to each box and whisker distribution are in parenthesis and given on the top x-axis (See site characterization table in Appendix A.). Black horizontal line delineates the median concentration at the TBS site used as the reference condition.

Next, ORD considered if the nutrient targets (for TP and TN, specifically) established for the streams and rivers in the UEFW, would be applicable to supporting the designated uses of Harsha Lake. To meet this objective, they considered historical TN and TP concentrations in Harsha Lake, spanning the period when harmful algal blooms (HABs) became a problem for the lake. Figure 6 shows cyanobacteria cell density trends in 20 reservoirs managed and monitored by the Louisville District of the USACE in Kentucky, Ohio, and Indiana, and including Harsha Lake, which has among the highest cell densities of reservoirs receiving drainage from agricultural watersheds. A forthcoming article explains the analysis and notes that increases in cyanobacteria cell densities began around 2003 and especially since 2005 many reservoirs have been above the regime of “high risk” according to the World Health Organization criteria (Smucker et al, In prep). Compiled water quality data collected by the USACE and ORD’s own monitoring program for the lake prior to and after this period shows a significant increasing trend in TN and TP concentrations (Figure 7). TN in the surface waters of Harsha lake has increased by over 50%, while TP has increased by a factor of 5. Prior to the HABs, lake TN concentrations averaged around 1000 ppb, while TP concentrations were close to 50 ppb. An interpretation of these results could be that to maintain cell densities below the WHO high risk threshold TN and TP concentrations should be lower than 1000 and 50 ppb, respectively. These values align reasonably well with the reference and target concentrations noted previously for the watershed’s streams.

The alignment of the UEFW's stream natural background nutrient conditions provided by the reference site approach and the nutrient concentrations preceding HABs in Harsha Lake suggests that reducing nutrient concentrations based on the aforementioned would limit the production of HABs and provides sufficient evidence that TP and TN reductions are adequate TMDL parameters for this impaired use.

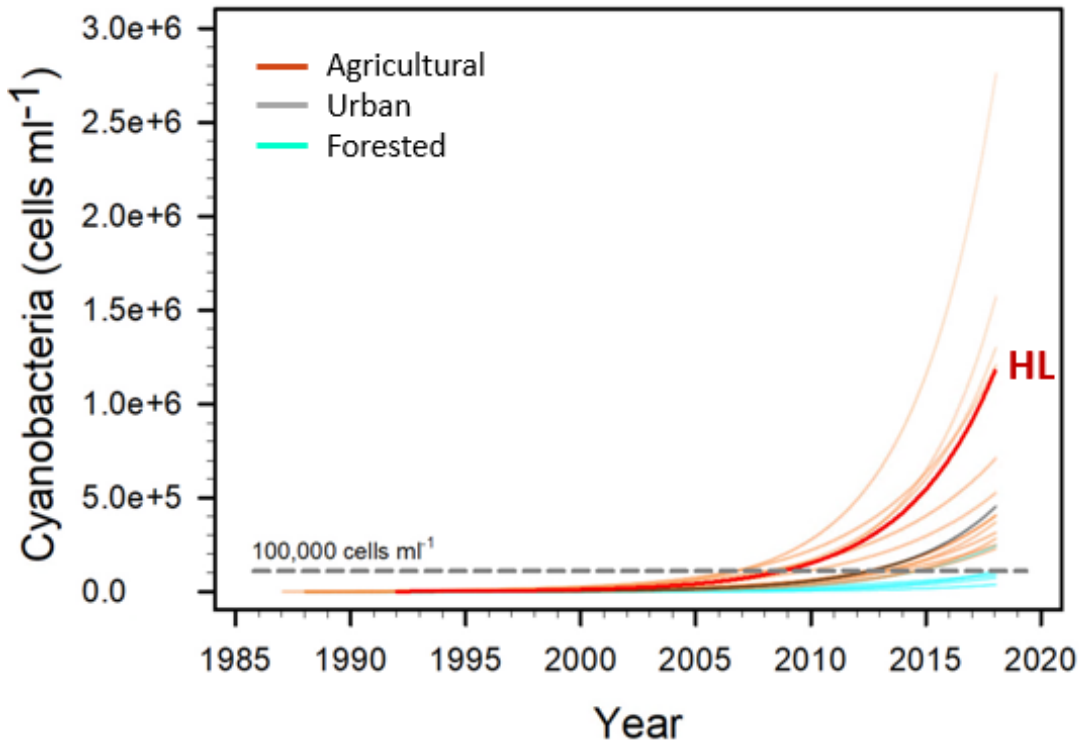


Figure 6: Trends of increasing cyanobacteria cell densities for 20 reservoirs in the Ohio River Basin. HL=Harsha Lake. Curves represent best fit for data from samples taken from 0 to 20 ft depths at the deepest site sampled in each reservoir.

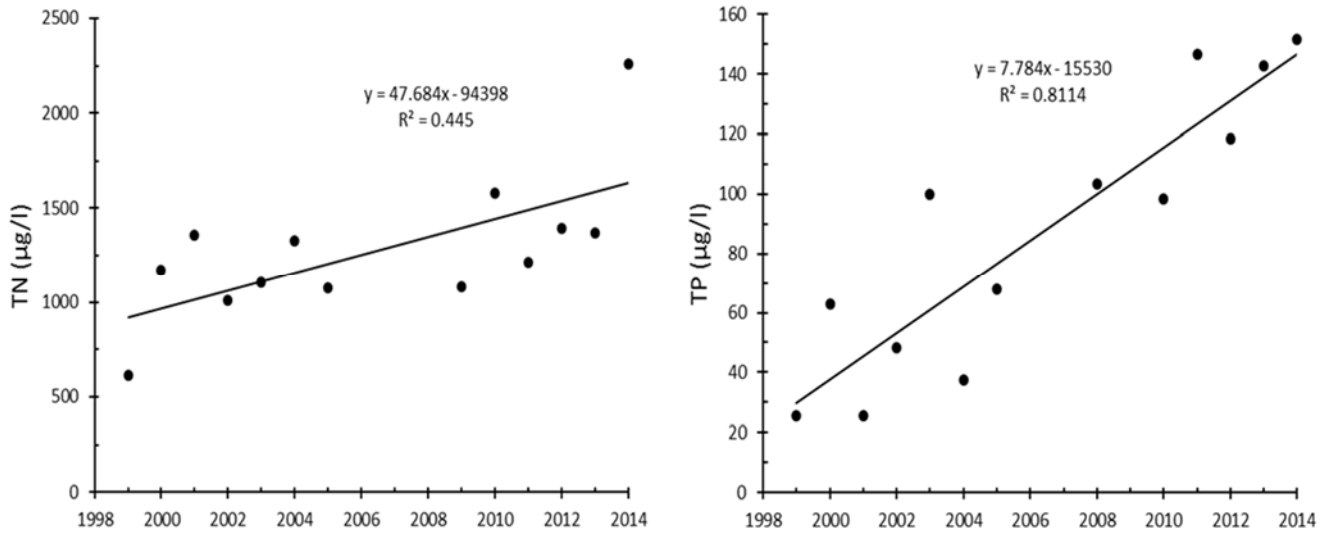


Figure 7. Yearly averages for TN and TP concentrations of samples collected during April thru August and from 0 to 15 ft depths. Averages calculated for each year are from samples collected from between four and seven different lake sampling sites, pending the year.

Modeling methods

This TMDL will be addressed by the same SWAT model developed by ORD that is explained above in the aquatic life use nutrient TMDL methods. For each assessment HUC-12, or partial HUC-12, the public drinking water use nutrient TMDLs will include existing sources of nutrients, the TMDL loading capacity and will produce reduction allocations to meet nutrient targets. These will likely be presented as annual and daily values following guidance from U.S. EPA, 2007.

Extensive outreach with the existing EFWCoop stakeholder group will occur following the publishing of this loading analysis plan. Through this collaboration reduction scenarios that meet the TMDLs will be examined. Scenarios that have the most buy-in will be included in Ohio EPA's Preliminary Modeling Results and TMDL reports.

Proposed Targets to Address Public Drinking Water Use Impairment

Atrazine

U.S. EPA has a 3.0 µg/L maximum contaminant level (MCL) standard for atrazine (pesticide) in drinking water. Violations of the atrazine MCL, and impairment criteria, are based on the running annual average calculated from the four most recent quarterly (90-day) averages. Since TMDL's must be expressed as daily loads, the TMDL target development for this TMDL will establish a concentration-based loading capacity as outlined by U.S. EPA, 2007.

Blanchester draws surface water from Whitacre Run, Stonelick Creek and West Fork East Fork Little Miami River. As mandated by an agreement with Syngenta and U.S. EPA, abundant atrazine sampling of Blanchester's raw drinking water has taken place. The Syngenta monitoring has been of water blended from the three sources at the treatment plant. A more modest sampling dataset has been collected by Ohio EPA from the three individual source waters. Both the Syngenta and Ohio EPA data will be used for TMDL development following protocols outlined for identify daily expressions for non-daily concentration based TMDLs (U.S. EPA 2007).

Algae (nutrients)

In the linking of public drinking water use impairments to TMDLs subsection above, ORD's detailed assessment of watershed monitoring data and setting of reference and target concentrations are described. The reference concentrations for TP and TN are 0.055 and 0.433 mg/L, respectively. **The target TP and TN concentrations of 0.077 and 0.707 mg/L, respectively, will be used for the TMDL loading reduction requirements.**

As noted above, the same target concentrations will be used for the TMDLs addressing the aquatic life use enrichment impaired watershed assessment units. The aquatic life enrichment linkage discussion, above, that considered the organic and nutrient enrichment impairments throughout the East Fork LMR watershed, make it clear that both phosphorus and nitrogen reductions are required. It is reasonable that the same reduced nutrient concentrations that limit excessive algal growth in Harsha Lake (the public drinking water use targets) will sufficiently reduce the near-field nutrient caused stress on aquatic life.

This is backed up by another, recent U.S. EPA ORD study. A metagenomic approach was used to characterize the stream diatom communities across 25 stream sites in the East Fork LMR watershed. The sites differed significantly in their observed TN and TP concentrations, forming a gradient among them that spanned <50 to >500 ppb average TP concentrations and <280 to >1300 ppb for TN concentrations over the weekly sampling period that took place from July to October in 2016 (Smucker et al, 2020). This research involved amplifying DNA extracted from the community of organisms growing on stream substrates (i.e. pieces of gravel and cobble). After extraction and amplification, primers that are specific for diatoms are added in a sequencing step. Species-specific sequences of diatom DNA are identified in a final bioinformatic analysis. Different diatom species are coded as unique operational taxonomic units (OTUs) in this approach. Multiple statistical methods were then used to identify and validate change points in the relative abundance of diatom OTUs along the nutrient gradients established across sites. Threshold indicator taxa analysis (TITAN) was used to categorize the taxa OTUs into low and high nutrient classes and quantify changes along the gradient when communities shift from being dominated by low to high nutrient taxa. The class association and change points were validated with boosted regression and gradient forest analyses, independently. Figure 8 depicts the results of the TITAN analysis while the dotted vertical marker lines identify probable change points for the diatom community composition based on all responses from TITAN, boosted regression, and gradient forest statistical methods. Significant change points, and, therefore, possible targets for managing against diatom community changes occur at concentrations as low as 75 ppb and 525 ppb for TP and TN, respectively. These values are remarkably similar to the TMDL nutrient concentration targets, explained above, providing extra validation that these targets are acceptable. Further, the TP target concentration used in this TMDL falls within the "low ecological risk" range of Ohio EPA's proposed Stream Nutrient Assessment Procedure (Ohio EPA 2014b).

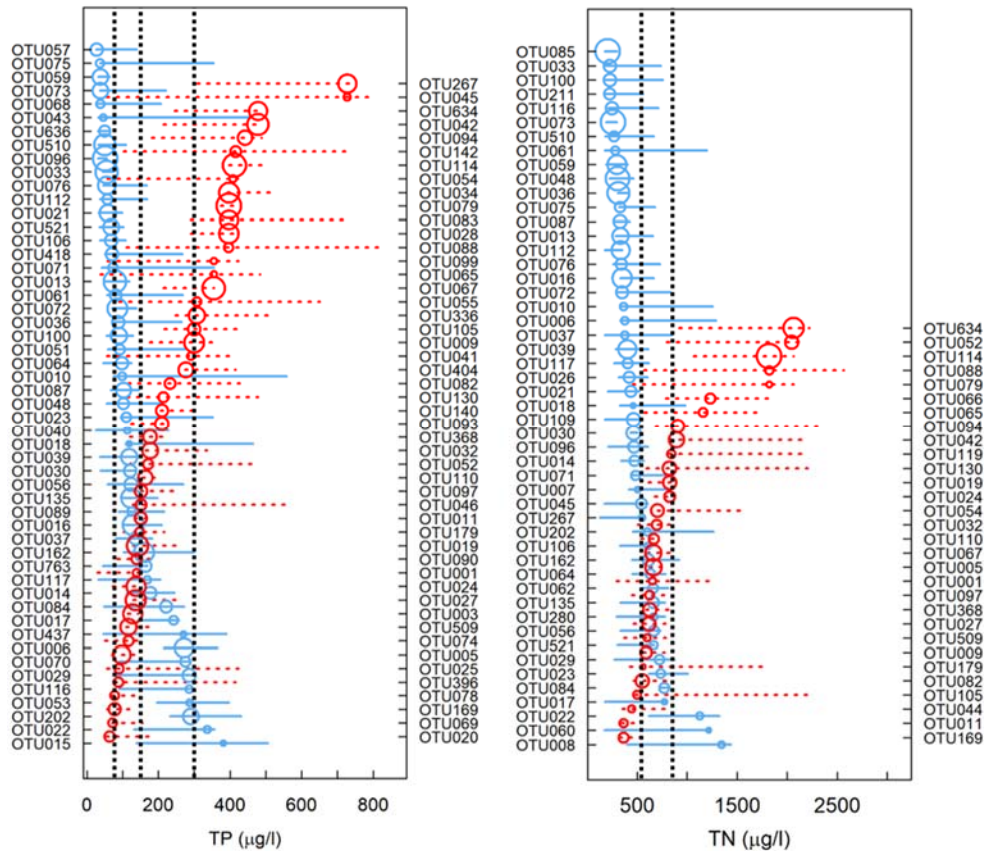


Figure 8 Results of diatom community metagenomic analysis. OTUs in blue, left y-axis, are low nutrient taxa, while OTUs in red, right y-axis, are high nutrient taxa. Circle size characterize relative abundance with horizontal blue and red-dotted lines representing range of occurrence. Dotted vertical lines delineate possible nutrient targets for community change points summarizing all responses from TITAN, boosted regression and gradient forest analyses.

Current Pollutant Reduction Implementation Efforts

The following section briefly outlines implementation actions that have occurred since the 2012 biological and water quality survey.

Nonpoint Source efforts

The Clermont Soil and Water Conservation District (SWCD) has been active in developing nonpoint source implementation strategies (aka 9-Element Plans) in the East Fork LMR watershed. There are currently two HUC-12s (11-02 Fivemile Creek and 13-05 Salt Run) plans approved by the state of Ohio to address near-field aquatic life use impairments. These plans allow the SWCD, and other stakeholders, to be eligible for funding of implementation practices from various sources, such as U.S. EPA's Section 319 grant funds. An example active project in the Salt Run HUC-12 is restoring/stabilizing sections of Avey's Run through Shor Park with creation of pocket wetlands. The project involves daylighting 200 linear feet of Avey's Run, riffle construction over 200 linear feet of stream, bank stabilization along 550 feet, the creation of three pocket wetlands, and 11.5 acres of invasive species removal.

Additionally, several United States Department of Agriculture (USDA) funded nutrient management projects are ongoing in the UFW in accordance with addressing the HABs problems in Harsha Lake. Much of the opportunity

has stemmed from the stakeholder engagement activities of the EFWCoop. The Clermont County SWCD received a Conservation Innovation Grant in 2012 to design, oversee the construction, and measure the effectiveness of a novel subsurface vegetated bed (aka wetland) nutrient removal practice on a private farm receiving runoff from 85 acres of row crops. The project is providing valuable insight to a recently funded effort by Ohio Department of Natural Resources using State of Ohio H2Ohio grant funds that focuses on the feasibility, design, and implementation of treatment wetlands throughout the watershed. The UEFW has received special recognition from Ohio Natural Resources Conservation Service (NRCS), that has directed additional Environmental Quality Incentives Program (EQIP) funds over the last few years for nutrient management practices. Among the Clermont County, Brown County, and Highland County SWCDs 125 active EQIP-funded projects are underway with \$2.75 million obligated and including 17,000 acres in cover crops. In 2019, 122 fields applied for EQIP funds, covering 2950 acres. There were not enough funds to cover all the applications. In 2017, the Clermont and Brown County SWCD's received funding under the Regional Conservation Partnership Program (RCPP). The RCPP funded cover crops (32 practices, 5798 ac), nutrient management (37 practices, 5885 ac), a nutrient management plan (940 ac), amending soil with gypsum products (266 ac), conservation crop rotation (312 ac) and the initiation of an edge-of-field monitoring study that includes a paired-catchment, before after control impact (BACI) design to assess the effectiveness of cover crops and help validate model simulations of nutrient runoff from row crops.

Wastewater treatment plant upgrades

Several upgrades to the wastewater treatment plants (WWTPs) have taken place since the 2012 survey of the East Fork LMR watershed. The following summarized this work:

New Vienna WWTP: This plant was identified as a source of impairment in the 2012 stream survey. A plant upgrade was completed in 2014 which included the addition of floating baffles and the replacement of air diffusers and mechanical blowers. Based upon self-monitoring data, the upgrade appears to have resulted in an improved effluent quality. When the NPDES permit for the New Vienna WWTP was renewed in January of 2020, Ohio EPA included more restrictive final effluent limits for total suspended solids (TSS) to be consistent with statewide design policy for lagoon treatment systems. The reduced TSS load will, to some extent, lessen the organic load to the receiving stream which was identified as a cause of impairment. The NPDES permit also restricts discharges from the facility during June – September, which is the time of the year when the aquatic biotic are more susceptible to pollutant-related impacts due to low stream flows and warmer temperatures. During November-April, when the receiving stream has more flow and cooler temperatures, the facility is permitted to discharge at a rate of 90 gallons per minute for every cubic ft per sec of stream flow, which translates to a minimum dilution of one gallon of treated wastewater for every five gallons of stream flow. During seasonal transition months of May and October, the facility must maintain a minimum dilution of one gallon of treated wastewater for every ten gallons of stream flow.

Locust Ridge Nursing Home: This WWTP was also identified as a source of impairment (low dissolved oxygen). The facility completed a plant rehabilitation project in 2013. The project also included the addition of ultraviolet light for disinfection as a replacement for the chlorine disinfection. The plant rehabilitation project did not include an increase in hydraulic capacity.

Williamsburg WWTP: This plant was identified as a source of impairment (organic enrichment) during the 2012 stream survey. The initial upgrade to the Williamsburg WWTP took place in 2010 and was anticipated to help resolve impairments due to discharges with excessive ammonia. In 2013 facility personnel also initiated a chemical addition (alum) to the WWTP which enabled them to achieve lower total phosphorus (TP) concentrations in their final effluent. The village also completed an additional WWTP

upgrade in 2016, which included increasing the average daily design flow from 0.5 million gallons per day (MGD) to 0.9 MGD. At the same time, facility personnel incorporated operational changes that facilitate biological nutrient removal at the WWTP. The current NPDES permit for the Williamsburg WWTP reflects TP limits of 1.0 mg/l for a monthly average concentration and 1.5 mg/l for a weekly average concentration. It should also be noted that the Village of Williamsburg completed a sanitary sewer extension project in 2019. This project was designed to serve unsewered areas that had discharging systems and failing onsite sewage treatment systems.

Stonelick State Park Campgrounds WWTP: Although not specifically identified as a source of impairment it is noted that upgrades were also completed at this WWTP. The upgrade included the installation of aeration to the lagoon wastewater treatment system.

The Clermont County Commissioners were issued Director's Findings and Orders in January 2020 to provide wastewater collection and treatment for the former Village of Newtonsville. A permit to install was obtained for construction of the sewerage and treatment facility in July 2020. The wastewater treatment plant is being designed for a average daily volume of 57,000 gpd. When complete, the sewer project will serve a population of about 400 residents and eliminate 48 discharging household wastewater systems. The orders require completion of the project by 2024.

Clermont County Board of Developmental Disabilities: The Clermont County Board of Developmental Disabilities facility was a previously unidentified discharger and received an NPDES permit in 2016. Due to the issuance of the NPDES permit and the final effluent discharge limits within the permit, the facility upgraded the WWTP to include an ultraviolet light disinfection system in 2017.

Special Considerations for the New Vision

With the inclusion of the East Fork LMR watershed as a priority in Ohio EPA's new TMDL Vision program, extra focus on several aspects of the TMDL development have been undertaken. The following outlines the special and unique factors that will be incorporated into this TMDL.

Nutrient TMDLs Based on Multiple Uses of Impairment

As explained above, nutrient TMDLs will be developed for aquatic life and public drinking water use impairments throughout the East Fork LMR watershed. TMDLs for both uses will be developed for both TN and TP and the same targets will be utilized. There are several watershed assessment unit HUC-12s that will receive nutrient TMDLs for both uses. This overlap is outlined in Table 10. Throughout the TMDL process, considerations in differences to the pollutant reductions and/or implementation actions may be determined in order to address the different designated uses.

Nutrient TMDLs for overlapping impairment uses allows for a more robust network of resource protection. Since the overlap exists throughout most of the Harsha Lake watershed, this will result in a prioritization of those assessment units.

Table 10 – Nutrient TMDLs based on different impaired beneficial uses

HUC 12 (05090202)	Aquatic life use	Public drinking water use
10 01	Entire HUC-12	Entire HUC-12
10 02	Entire HUC-12	Entire HUC-12
10 03	Entire HUC-12	Entire HUC-12
10 04	Entire HUC-12	Entire HUC-12
10 05	--	Entire HUC-12
10 06	Entire HUC-12	Entire HUC-12
11 01	Entire HUC-12	Entire HUC-12
11 02	Entire HUC-12	Entire HUC-12
11 03	Entire HUC-12	Entire HUC-12
12 01	Entire HUC-12	Entire HUC-12
12 02	Entire HUC-12	Entire HUC-12
12 03	--	Ulrey, Back & Slabcamp runs only
12 04	Backbone Creek only	--
13 01	Entire HUC-12	--
13 02	Entire HUC-12	--
13 03	Entire HUC-12	--
13 05	Hull Run only	--

Stakeholder Involvement

Engagement with the EFWCoop stakeholder group will be a key aspect of this TMDL development. The SWAT model and the nutrient targets used in this TMDL have been developed by this group. Within the acceptable parameters of TMDL development, determining the detailed mechanics of each nutrient TMDL (e.g., margin of safety, allowance of future growth, exact flow regime cutoffs, etc) will be determined via stakeholder engagement prior to the project's Preliminary Modeling Results publication.

Water Quality Source Trading

As noted in the introduction, a focus of research carried out by U.S. EPA's ORD has been to understand the feasibility and mechanics of water quality source trading in the watershed. Ohio EPA is focusing on developing a TMDL that will incorporate/facilitate water quality trading as much as possible within the Agency's legal authority. This stakeholder engagement and attention to adaptive management alternatives is another aspect of the East Fork LMR TMDL being a new Vision project.

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Appendix A

Stream sampling sites to support ORD's water quality trading feasibility research analysis in the UEFW. Sites highlighted in grey are the primary reference sites. Those highlighted in blue are the secondary. See the notes column for site selection information.

EPA SiteID	OEPA 2012 Survey ID	DESCRIPTION	Lat	Long	Drainage Type	Drainage Area_mi2	% Row Crop	% Forest	% Pasture	% Urban	TP 25th Centile ($\mu\text{g}\cdot\text{l}^{-1}$)	TP median ($\mu\text{g}\cdot\text{l}^{-1}$)	TN 25th Centile ($\mu\text{g}\cdot\text{l}^{-1}$)	TN median ($\mu\text{g}\cdot\text{l}^{-1}$)	Notes
CWL	NA	Cornwell Stream at Stahl driveway Marathon Edenton Rd.	39.1839	-84.0134	Headwater	0.15	78	16	0	6	207	323	1138	1570	Catchment houses AgBMP demonstration site
TBS	NA	Twin Bridges Stream crossing in East Fork Lake State Park	39.0380	-84.1202	Headwater	0.31	0	100	0	0	39	55	301	433	Primary nutrient reference site for UEFW
KRT	NA	Kain Run off of St Route 271, East of St Route 32 overpass	39.0662	-84.0740	Headwater	0.81	40	19	12	29	91	138	644	1000	Agricultural headwater sampling site since 2006
GRS	NA	Grassy Fork at US 131 Brown County; river left tributary	39.1741	-83.9982	Headwater	0.83	68	17	15	0	121	187	874	1340	Established to account for all reaches in the GRR subwatershed
SHA	NA	South Harsha Stream at Elk Lick Rd crossing in East Fork Lake State Park	39.0072	-84.1368	Headwater	0.89	6	67	21	5	72	105	473	772	Original nutrient reference site for UEFW, but found to have septic and animal sources
GRT	NA	Grassy Fork Tributary	39.1686	-84.0083	Headwater	0.93	61	21	12	6	137	223	547	770	Sampling site downstream of CWL
AVR	NA	Aveys Run in Cincinnati Nature Center	39.1232	-84.2463	Headwater	1.14	0	31	0	69	42	59	282	500	Nutrient reference site in LEFW. High urban cover in headwater reaches and Edenton and Cincinnati soils groups makes applicability to UEFW questionable
NWT	301148	Tributary to Stonelick Creek at Cedarville Rd.	39.1854	-84.0950	Headwater	2.00	43	29	22	6	197	286	720	1200	Catchment has high density of failing septic systems
SRE	NA	Sterling Run at stream crossing on Rt286 between Moon and Dietrick Rds	39.10444	-83.88711	Headwater	2.17	85	9	0	6	263	502	993	1375	Similar soils, slopes, and agricultural management as FVM, Sampled by Brown County SWCD

EPA SiteID	OEPA 2012 Survey ID	DESCRIPTION	Lat	Long	Drainage Type	Drainage Area_mi2	% Row Crop	% Forest	% Pasture	% Urban	TP 25th Centile ($\mu\text{g}\cdot\text{l}^{-1}$)	TP median ($\mu\text{g}\cdot\text{l}^{-1}$)	TN 25th Centile ($\mu\text{g}\cdot\text{l}^{-1}$)	TN median ($\mu\text{g}\cdot\text{l}^{-1}$)	Notes
OWT	NA	Owensville Stream at County lift station off of St. Louis Rd	39.1278	-84.1364	Headwater	2.32	26	38	20	16	145	224	480	801	Mixed-use headwater sampling site since 2006
SRW	NA	Sterling Run at intersection of Greenbush East Rd and Rt 68	39.07561	-83.92561	Headwater	2.35	85	9	0	6	230	410	1175	1430	Similar soils, slopes, and agricultural management as FVM, Sampled by Brown County SWCD
FVM	NA	Five Mile Creek at stream crossing just north of Rt 68 and Rt 286 Junction	39.1073	-83.9325	Headwater	3.28	85	9	0	6	403	603	1063	1465	Agricultural headwater sampling site in Five Mile Run Priority Watershed
P04	M04P04	Tributary to East Fork Little Miami River at Rapid Forge Rd	39.3133	-83.7614	Headwater	4.00	70	10	13	7	49	79	1233	2290	Site impacted by hog farm upstream and in Loamy, High Lime Till Plains ecoregion, draining lands with high prevalence of Xenia soil group
LRN	NA	Light Run Tributary to Cloverlick Creek	38.9930	-84.0590	Confluence	4.79	28	48	19	5	67	98	297	483	Site downstream of Locust Ridge Nursing Home NPDES discharge
890	301890	Tributary to Dodson Creek at river mile 4.52 and US Rt. 50	39.2043	-83.7642	Confluence	4.90	82	12	6	0	140	250	642	1170	Relatively large single reach (1st order) agricultural stream sampling site
HWR	301894	Howard Run at Burdsall Rd	39.1240	-84.0073	Confluence	5.60	70	20	10	0	151	246	655	918	Originally established as paired subwatershed sampling site with GRR - 'control watershed'
GRR	301345	Grassy Fork at Glancy Corner-Marathon Rd	39.1329	-84.0152	Confluence	6.30	53	23	20	3	88	162	531	1013	Originally established as paired subwatershed sampling site with HWR - 'treatment watershed'
SAR	M99Q10	Salt Run at Barge Salt Rd bridge crossing near Roundbottom Rd	39.1372	-84.2458	Confluence	6.40	0	55	4	42	29	38	272	441	Nutrient reference site in LEFW. High urban cover in headwater reaches and Edenton and Cincinnati soils groups makes applicability to UEFW questionable
LRC	M04S43	Lucy Run, South of Batavia, Oh, near mouth	39.0570	-84.1795	Confluence	6.83	1	52	18	29	42	58	388	647	Nutrient reference site in the LEFW and also applicable as reference site for UEFW - in full biological attainment in OEPA 2012 survey

EPA SiteID	OEPA 2012 Survey ID	DESCRIPTION	Lat	Long	Drainage Type	Drainage Area_mi2	% Row Crop	% Forest	% Pasture	% Urban	TP 25th Centile ($\mu\text{g}\cdot\text{l}^{-1}$)	TP median ($\mu\text{g}\cdot\text{l}^{-1}$)	TN 25th Centile ($\mu\text{g}\cdot\text{l}^{-1}$)	TN median ($\mu\text{g}\cdot\text{l}^{-1}$)	Notes
FVC	M04S49	Fivemile Creek at Blue Sky Park Rd., lower crossing	39.1136	-84.0203	Confluence	10.60	65	19	9	7	298	424	722	1000	Outlet of NWIS Priority Watershed
CLC	200468	Cloverlick Creek, Northeast of Bethel, Oh, at St. Rt. 133	38.9853	-84.0531	Confluence	23.00	35	39	22	4	99	174	556	759	2nd largest tributary draining to Harsha Lake.
S15	M04S15	East Fork Little Miami River upstream of Lynchburg, Oh at Canada Rd	39.2733	-83.7814	Confluence	26.20	62	13	17	9	47	73	810	2130	Site on the mainstem but in the High Lime Till Plains ecoregion, draining lands with high prevalence of Xenia soil group
S50	M04S50	West Fork of the East Fork Little Miami at St. Rt. 123	39.2306	-83.9145	Confluence	28.30	73	16	6	5	170	261	852	1460	HUC 12 Confluence with East Fork Little Miami River
S51	M04S51	Dodson Creek at 134, near confluence with East Fork Little Miami River	39.2070	-83.8100	MainStem	32.50	64	14	16	5	107	180	647	1040	Major tributary to East Fork Little Miami River
506	200506	East Fork Little Miami River upstream of Lynchburg WWTP	39.2407	-83.7961	MainStem	48.00	62	13	16	9	61	91	818	2175	Upstream sampling site for NPDES discharge point
S14	M04S14	East Fork Little Miami River downstream of Lynchburg WWTP at Wise Rd	39.2250	-83.8258	MainStem	88.00	64	14	17	5	127	179	1200	1810	Downstream sampling site for NPDES discharge point
EFG	NA	East Fork Little Miami River at Morgan Rd and Hwy 68	39.21682	-83.91485	MainStem	140.12	65	16	14	5	106	161	764	1590	Mainstem sampling site downstream of confluence with S50
EFY	M04S13	East Fork Little Miami River at Fayetteville, Oh, US. Rt. 50	39.1858	-83.9372	MainStem	151.00	64	17	13	5	106	151	684	1545	Site served as proximal upstream sampling for the Fayetteville WWTP, but bank degradation made sampling unsafe. Decommissioned in Winter of 2018
EFM	301738	East Fork Little Miami River near Marathon, Oh, at ST. RT. 286	39.1380	-84.0028	MainStem	178.00	62	19	13	6	111	177	778	1530	Mainstem sampling site upstream of HWR and GRR paired watershed confluences

EPA SiteID	OEPA 2012 Survey ID	DESCRIPTION	Lat	Long	Drainage Type	Drainage Area_mi2	% Row Crop	% Forest	% Pasture	% Urban	TP 25th Centile ($\mu\text{g}\cdot\text{l}^{-1}$)	TP median ($\mu\text{g}\cdot\text{l}^{-1}$)	TN 25th Centile ($\mu\text{g}\cdot\text{l}^{-1}$)	TN median ($\mu\text{g}\cdot\text{l}^{-1}$)	Notes
EFB	M04S11	East Fork Little Miami River at Blue Sky Park Rd	39.1158	-84.0250	MainStem	195.00	62	20	13	6	128	178	775	1553	Mainstem sampling site downstream of HWR and GRR paired watershed confluences
EUW	M04S09	East Fork Little Miami River at SR 32	39.06659	-84.05453	MainStem	223.88	60	21	13	6	142	198	719	1360	Upstream sampling site for Williamsburg WWTP NPDES discharge. Site visited over period 10/2011 to 4/2013, decommissioned as part of routine monitoring
ELI	M04S08	East Fork Little Miami River in Williamsburg, Oh. at Main St. bridge crossing	39.0525	-84.0500	MainStem	237.00	60	21	14	6	163	258	1140	1620	Site house USGS continuous water level gage. Last mainstem sampling location upstream of Harsha Lake, main inflow to Lake
ALL						300.00	47	28	15	7	91	171	607	1030	All sites, all observations