Environmental Protection Agency

Loading Analysis Plan and Supporting Data Acquisition Needed for the

Middle Great Miami River and Principal Tributaries

Total Maximum Daily Load Development

Middle Great Miami River

Ohio EPA Technical Report AMS/2009-MDGMR-3

Division of Surface Water
Assessment and Modeling Section
July 2023

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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 Middle Great Miami River and principal tributaries. These recommendations are based on data collected as part of a biological and water quality study in 2009. A description of the project area, sites, data types and methods can be found in the Middle Great Miami River and principal tributaries study plan document (Ohio EPA, 2009). A summary of the study results can be found in the biological and water quality report (Ohio EPA, 2010).

Sites in the Middle Great Miami River and principal tributaries were assessed for aquatic life use, recreation use, and public drinking water supply use. The attainment of aquatic life and recreation use is based on specific restoration targets. The attainment of the public drinking water supply use is detailed in the current cycle of Ohio's Integrated Report (Ohio EPA, 2022). This document examines those targets and lays out proposals for addressing each impairment. Where appropriate, methods are outlined to develop total maximum daily loads (TMDL) for specific pollutants.

The federal Clean Water Act (CWA) requires that states identify waters not meeting water quality goals and then prioritize them for action to restore their beneficial uses. The resulting list of prioritized impaired waters is known as the 303(d) list. The process of listing involves assigning a condition status (a category) for each of the four beneficial uses (aquatic life, human health, recreation, and public water supply) for each assessment unit. For more information on impaired water listings and categories, please see Ohio's Integrated Water Quality Monitoring and Assessment Report (Ohio EPA, 2022).

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. Goals for those indices in the Middle Great Miami River and principal tributaries 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. Assessment for aquatic life use (ALU) was completed at 71 sites throughout Miami, Shelby, Montgomery, and Clark counties. Of the 71 sites, 67 were in full attainment and 4 were in partial attainment.

Table 1 – Biological criteria applicable in the Middle Great Miami River and principal tributaries watershed for aquatic life use designations.

Ecoregion	Biological Index	Assessment Method[2, 3]	Biological Criteria for the Applicable Aquatic Life Use Designations[1]		
			EWH	WWH	MWH[4]
Eastern Cornbelt Plains (ECBP)	IBI	Headwater	50	40	24
		Wading	50	40	24
		Boat	48	42	24 / 30
	MIwb	Wading	9.4	8.3	6.2
		Boat	9.6	8.5	5.8 / 6.6
	ICI	All[5]	46	36	22

[1] Aquatic Life Use (ALU) designations: warmwater habitat (WWH); exceptional warmwater habitat (EWH); modified warmwater habitat (MWH); coldwater habitat (CWH), limited resource waters (LRW) and seasonal salmonid habitat (SSH) do not have associated biological criteria.

[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).

[4] Biocriteria depend on type of MWH. MWH-C (due to channelization) is listed first, MWH-I (due to impoundment) is listed second, and MWH-A (mine affected) is listed third (only applicable in the WAP).

[5] Limited to sites with appropriate conditions for artificial substrate placement

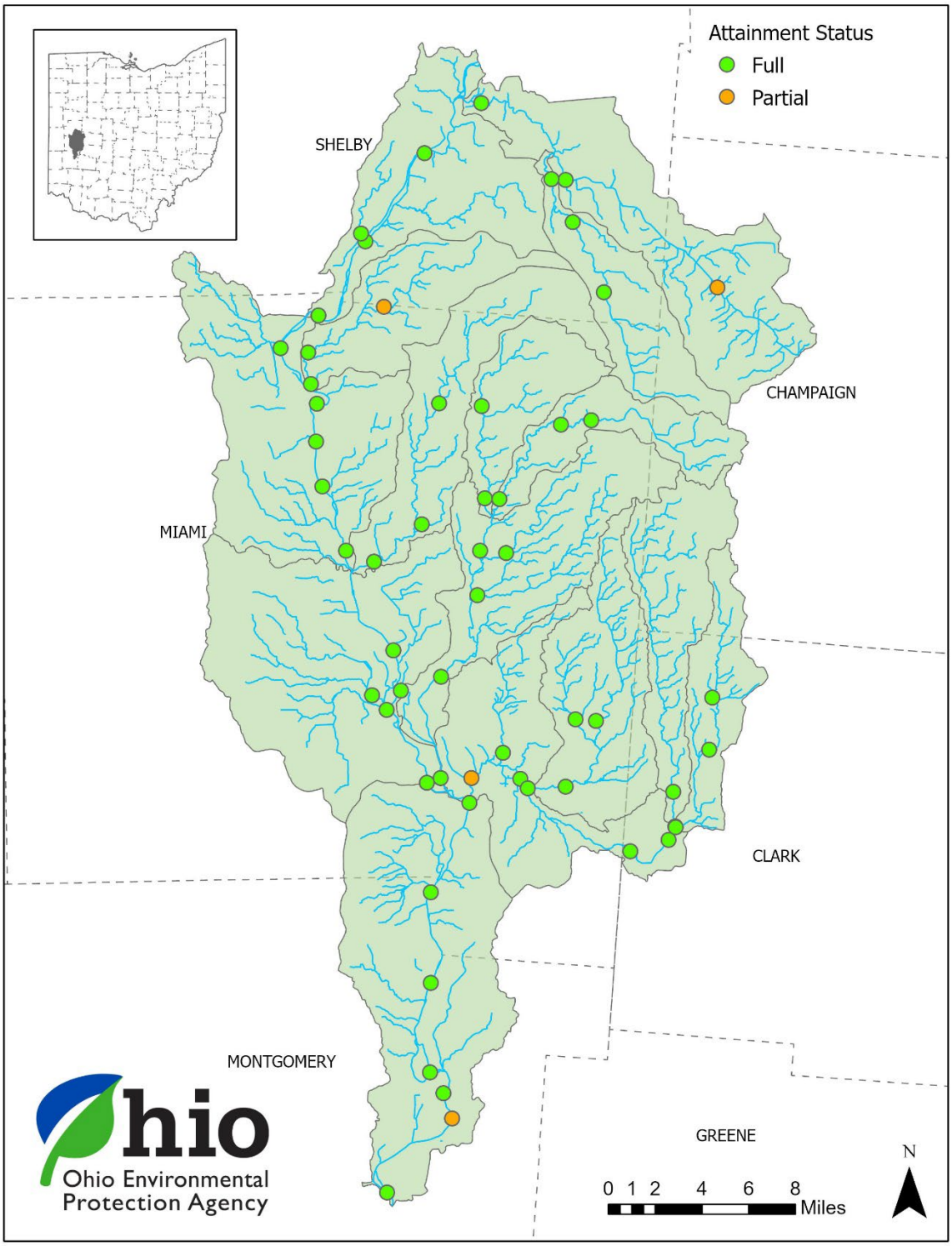

Figure 1 — *Map summarizing ALU a*ttainment status in the Middle Great Miami River and principal tributaries watershed in 2009.

Table 2 – Aquatic life use attainment information for impaired sampling locations in the Middle Great Miami River and principal tributaries watershed, 2009.

Station	Location	ALU	River Mile[a]	Drain. Area (mi^2)	IBI	MIwb[b]	ICI[c]	QHEI	Attain. Status	Causes	Sources
HUC 12 - TRIB. TO MOSQUITO CREEK (05080001 07 02)											
300714	MOSQUITO CREEK DST. KISER LAKE @ LICKLIDER RD.	WWH	7.75^H	9.0	46	-	F*	47.0	PARTIAL	Wetland stream (Elevated ammonia-N)	Natural (Former swamp stream)
										Nutrient Enrichment (Low DO)	Natural/Structural (Plankton export from Kaiser Lake dam pool)
HUC 12 - RUSH CREEK (05080001 07 04)											
300719	RUSH CREEK @ VANDEMARK RD. (TROY-SIDNEY RD.)	WWH	5.30^H	7.2	34*	-	MG^{ns}	55.5	PARTIAL	Transitional Segment (PHW- HW)	Natural
HUC 12 - PLEASANT RUN (05080001 20 04)											
H05P16	HONEY CREEK E OF TIPP CITY @ ST. RT. 202	EWH	0.84^W	87.8	44*	10.29	46	57.5	PARTIAL	Sedimentation (non-silt)	Channel Modification (historical) Natural/Structural
HUC 12 - POPLAR CREEK (05080001 20 05)											
H05S18	GREAT MIAMI R. NEAR DAYTON, DST N REG. WWTP, ADJ S.R. 202	EWH	86.13^B	1,170.0	52	10.61	38*	70.5	PARTIAL	Ammonia (modest toxicity)	Major WWTP (Tri-Cities WWTP)

a River Mile (RM) represents the Point of Record (POR) for the station and may not be the actual sampling RM.
b MIwb is not applicable to headwater streams with drainage areas ≤ 20 mi^2.
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.
H Headwater site (draining ≤20 miles^2).
W Wading site (non-boat site draining >20 miles^2).
B Boat site (large or deep waters, necessitating the use of boat sampling methods

Aquatic Life Use 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. Ohio EPA must also take into consideration ongoing efforts in the watershed, previous TMDL analyses, the questions to be answered by a model and the amount of effort required to complete the model. Depending on the method selected, the Agency may be required to return to the watershed and collect additional data, and it is possible the modeling approach may change. A summary of Ohio EPA's preliminary modeling approaches is presented in Table 3.

Table 3 – Summary of ALU impairments and potential modeling approaches.

Station	Stream Name	River Mile	Assessment Unit (05080001)	Cause(s) of Impairment	Source(s) of Impairment	IR Cat.[1]	Action[2]	Method[3]	Parameter[4]
300714	MOSQUITO CREEK DST. KISER LAKE @ LICKLIDER RD.	7.75	02 07	Wetland Stream (Elevated ammonia-N)	Natural (Former swamp stream)	4C	N/A	-	-
				Nutrient Enrichment (Low DO)	Natural/Structural (Plankton export from Kaiser Lake dam pool)	4C	N/A	-	-
300719	RUSH CREEK @ VANDEMARK RD. (TROY-SIDNEY RD.)	5.30	07 04	Transitional Segment (PHW- HW)	Natural	4C	N/A	-	-
H05P16	HONEY CREEK E OF TIPP CITY @ ST. RT. 202	0.84	20 04	Sedimentation (non-silt)	Channel Modification (historical) Natural/Structural	5	TMDL	QHEI-sed	Sediment
H05S18	GREAT MIAMI R. NEAR DAYTON, DST N REG. WWTP, ADJ S.R. 202	86.13	20 05	Ammonia (modest toxicity)	Major WWTP (Tri-Cities WWTP)	5	Other	Follow-up	-

[1] IR Cat. (Integrated Report Category)

Category	Definition/interpretation
4C	Water body is impaired for this parameter, but the parameter is not considered a pollutant and therefore a TMDL is not required
5	Water body is impaired for this parameter, and it needs to be addressed by additional actions

[2] Action

Abbreviation	Definition/interpretation
N/A	Not applicable, no action needed
Other	Action will be taken outside of a new TMDL
TMDL	A Total Maximum Daily Load (TMDL) will be developed

[3] Method

Abbreviation	Definition/interpretation
Follow-up	Follow-up sampling is required to determine if the attainment status has changed after ongoing implementation has occurred or to clarify/verify the listed cause of impairment.
QHEI-sed	Sub-metrics of the QHEI (Qualitative habitat evaluation index) will be used to address sedimentation and embeddedness.

[4] Parameter – For TMDL or Other actions, the parameter listed in this field will be the pollutant or non-pollutant stressor used to address impairment. This parameter will match a heading in the Proposed Targets section.

The following subsections are organized to explain the various methods being used to address the proposed actions outlined in Table 3 above.

No action required due to natural causes of impairment: IR Cat: 4C - Action: N/A

The cause of impairment for two sites outlined on *Table 3* for Middle Great Miami River and principal tributaries watershed was due to natural causes. Mosquito Creek Dst. Kiser Lake @ Licklinder Rd. (RM 7.75) was impaired due to elevated ammonia and dissolved oxygen. These elevated levels can be attributed to the presence of a former swamp upstream and Plankton export from the Kaiser Lake dam pool. Rush Creek @ Vandemark Rd. (Troy-Sidney Rd.) (RM 5.30) was impaired due to a transitional cline between primary headwaters and standard headwaters. Because these sites are impaired due to natural causes, they are exempt from TMDL requirements for this type of impairment.

Follow-up monitoring is recommended prior to TMDL development to address some causes: IR Cat: 5 - Action: Other

The impairment at Great Miami R. Near Dayton, Dst N Reg. WWTP, ADJ S.R. 202 (RM 86.13) was caused from impacts that may not persist. Subsequent to the 2009 survey, upgrades and changes have been made to Tri-Cities WWTP that further support the recommendation to conduct resampling at affected locations to get a more accurate depiction of current water quality conditions. In the past few years Tri-Cities WWTP has replaced the media in the nitrification towers and is currently working on plans for a facility upgrade to be finished between 2028 and 2030. Because of these factors, follow-up monitoring is recommended prior to a TMDL is developed. When this follow-up monitoring occurs, another study plan, water quality results, and loading analysis plan will be published prior to any new TMDL development. All three of those future documents will include public comment periods before they are considered final.

TMDL to address sediment impairments required: IR Cat: 5 - Action: TMDL

Honey Creek E Of Tipp City @ ST. RT. 202 (RM 0.84) was impaired due to sedimentation. The sedimentation is largely due to channelization. A sediment TMDL calculated using QHEI sub-metrics will appropriately address this cause of impairment. Sediment impairments for this watershed will be developed in a separate report that will include several other watersheds. Updates to this separate sediment TMDL report will be posted to Ohio EPA's multi-watershed TMDL webpage.

Aquatic Life Use Proposed Targets

Sediment

Since its development, the QHEI has been used to evaluate habitat at most biological sampling sites and there is an extensive database that includes QHEI scores and other water quality variables. Strong correlations exist between QHEI scores and the biological indices used in Ohio's water quality standards such as the Index of Biotic Integrity (IBI). Through statistical analyses of data for the QHEI and the biological indices, target values have been established for QHEI scores with respect to the various aquatic life use designations (Ohio EPA 1999).

Numeric targets for sediment are based on three sub-metrics of the QHEI. Although the QHEI evaluates the overall quality of stream habitat, some of its component sub-metrics consider particular aspects of stream habitat that are closely related to and/or impacted by the sediment delivery and transport processes occurring in the system. The QHEI sub-metrics used in the sediment TMDL are the substrate, channel morphology, and bank erosion/riparian zone. Table 4 lists targets for each of these metrics.

Table 4 – QHEI targets for sediment TMDLs

Sediment TMDL Targets		
QHEI Category	WWH/ MWH	EWH
Substrate	≥ 13	≥ 15
Channel	≥ 14	≥ 15
Riparian	≥ 5	≥ 5
Sediment TMDL ►	≥ 32	≥ 35

The substrate sub-metric evaluates predominant substrate types, the amount and origin of these types and the degree of embeddedness and silt cover. This is a qualitative evaluation of the amount of excess fine material in the system and the ability of the channel to assimilate or sort the sediment load.

The channel morphology sub-metric considers sinuosity, riffle and pool development, channelization, and channel stability. Except for stability, each of these aspects is directly related to channel form, sediment transport, erosion, and deposition within the channel. Stability reflects the degree of channel erosion, which indicates the potential of the stream to be a significant sediment source.

The bank erosion and riparian zone sub-metric also reflects the likely degree of in-stream sediment sources. The evaluation of floodplain quality is included in this sub-metric, which relates to the capacity of the system to assimilate sediment loads.

Total Dissolved Solids

Ohio has adopted a statewide numeric water quality criterion for total dissolved solids (TDS) for the protection of aquatic life, as detailed in OAC 3745-1-35, Table 35-1.

Table 5 – Water quality criteria for total dissolved solids.

Chemical	OMZA
Dissolved Solids	1500 mg/L[a]

[a] Equivalent 25°C specific conductance value is 2400 micromhos/cm.

Concentrations of TDS exceeding the water quality criterion can be due to both pervasive and direct sources. Two predominant pathways exist for TDS delivery to water bodies: via direct discharge (point source) or precipitation-driven wash-off (nonpoint source). Due to these mechanisms of delivery, the sources of dissolved solids in surface waters can be determined to a certain extent via the level of stream flow observed. Therefore, Ohio EPA proposes using the load duration curve (LDC) framework for TDS TMDLs. LDCs are an empirical method of determining TMDL pollutant loading and needed reductions. The main advantage of the use of LDCs is in this method's ability to differentiate loads from various types of sources based on stream flow regime. While this is a fairly simple modeling method, relationships between TDS source contributions and flow regimes are straight forward. In-stream processes and interactions between sources are simplified, mitigating the major weaknesses of the technique. More details on the LDC method are presented in the Recreation Use section.

Recreation Use

Evaluation of Criteria

Attainment of recreation use goals is based on numeric criteria for *Escherichia coli* (*E. coli*) as an indicator bacterium. These criteria, shown in Table 6, are also the targets used for TMDLs. Table 7 lists attainment of

recreation use based on criteria at the time of assessment, which were different than the current standards. However, any TMDLs created for those assessment units will use the updated values in Table 6.

Table 6 – Water quality criteria for recreation use

Recreation Use	*Escherichia coli* (colony forming units per 100 mL)	
	90-day geometric mean	Statistical threshold value[1]
Bathing water	126	410[a]
Primary contact recreation	126	410
Secondary contact recreation	1030	1030

[1] These criteria shall not be exceeded in more than 10 percent of the samples taken during any 90-day period.

[a] A beach action value of 235 *E. coli* colony forming units per 100 mL shall be used for the purpose of issuing beach and bathing water advisories.

Table 7 – Recreation use attainment information for impaired sampling locations in the Middle Great Miami River and principal tributaries watershed, 2009.

Station	Stream Name	HUC-12 (05080001)	RM	# Samples	Geo. Mean	Max. Value	Possible Source(s)
300717	Leatherwood Creek	07 01	1.2	8	281	2200	Agricultural runoff
H02P08	Tawawa Creek	07 02	0.22	14	185	1550	Urban runoff, Agricultural runoff
H02P06	Mosquito Creek	07 02	1.00	8	537	4300	Agricultural runoff
H02W39	Great Miami River	07 03	120.5	7	133	750	Agricultural runoff
300718	Mill Branch	07 03	0.34	8	184	1500	Agricultural runoff
300641	Rush Creek	07 04	1.68	10	679	2800	Agricultural runoff
H02S19	Great Miami River	07 05	114.1	8	168	600	Urban runoff, Agricultural runoff
H05P12	Lost Creek	08 02	11.7	7	187	2800	Livestock access to stream, Unsewered community, Agricultural runoff
H05P04	East Fork Honey Creek	20 01	1.58	8	345	3100	Agricultural runoff
H05W10	West Fork Honey Creek	20 02	8.9	7	1757	47000	Livestock access to stream, Unsewered community, Agricultural runoff
300731	Indian Creek	20 03	1.52	8	170	630	Agricultural runoff
H05S20	Honey Creek	20 04	3.18	12	276	1550	Agricultural runoff
H05W32	Great Miami River	20 05	87.05	8	157	540	Urban runoff
203499	Poplar Creek	20 05	0.7	8	388	10000	Urban runoff
Station	**Stream Name**	**HUC-12 (05080002)**	**RM**	**# Samples**	**Geo. Mean**	**Max. Value**	**Possible Source(s)**
610060	Great Miami River	01 05	80.74	11	276	13000	Urban runoff

[1] Due to space limitations there are several abbreviations used to describe the analysis or remediation method. Those abbreviations are defined as follows:

Abbreviation	**Definition/interpretation**
TMDL	A Total Maximum Daily Load (TMDL) will be completed for the impairment.
LDC	"Load duration curve" method used to address the listed cause of impairment.

Recreation Use Proposed Actions

Concentrations of *E. coli* exceeding the water quality standard are due to both pervasive and direct sources. Two predominant pathways exist for pathogen delivery to water bodies. The first pathway is pathogen-rich discharge, including material such as poorly treated or untreated effluent from wastewater treatment plants, combined sewer overflows, sanitary sewer overflows, household sewage treatment systems and livestock access to streams. This is delivered to the stream by direct discharge. The second pathway is pathogen-rich runoff/drainage from nonpoint sources. The associated delivery mechanism is precipitation-driven wash-off. This type of transport involves the delivery of pathogen-rich material by overland flow during precipitation and runoff events (e.g., summer storms, snowmelt, etc.).

Due to these mechanisms of delivery, the sources of pathogens in surface waters can be determined to a certain extent via the level of stream flow observed. Therefore, Ohio EPA proposes using the load duration curve (LDC) framework for recreation use TMDLs. LDCs are an empirical method of determining TMDL pollutant loading and needed reductions. The main advantage of the use of LDCs is in this method's ability to differentiate loads from various types of sources based on stream flow regime. While this is a fairly basic modeling method, relationships between bacteria source contributions and flow regimes are straight forward. In-stream processes and interactions between pathogen sources are assumed conservative (i.e., not occurring) in this method. Figure 2 shows an example LDC with corresponding TMDL calculations represented in Table 8.

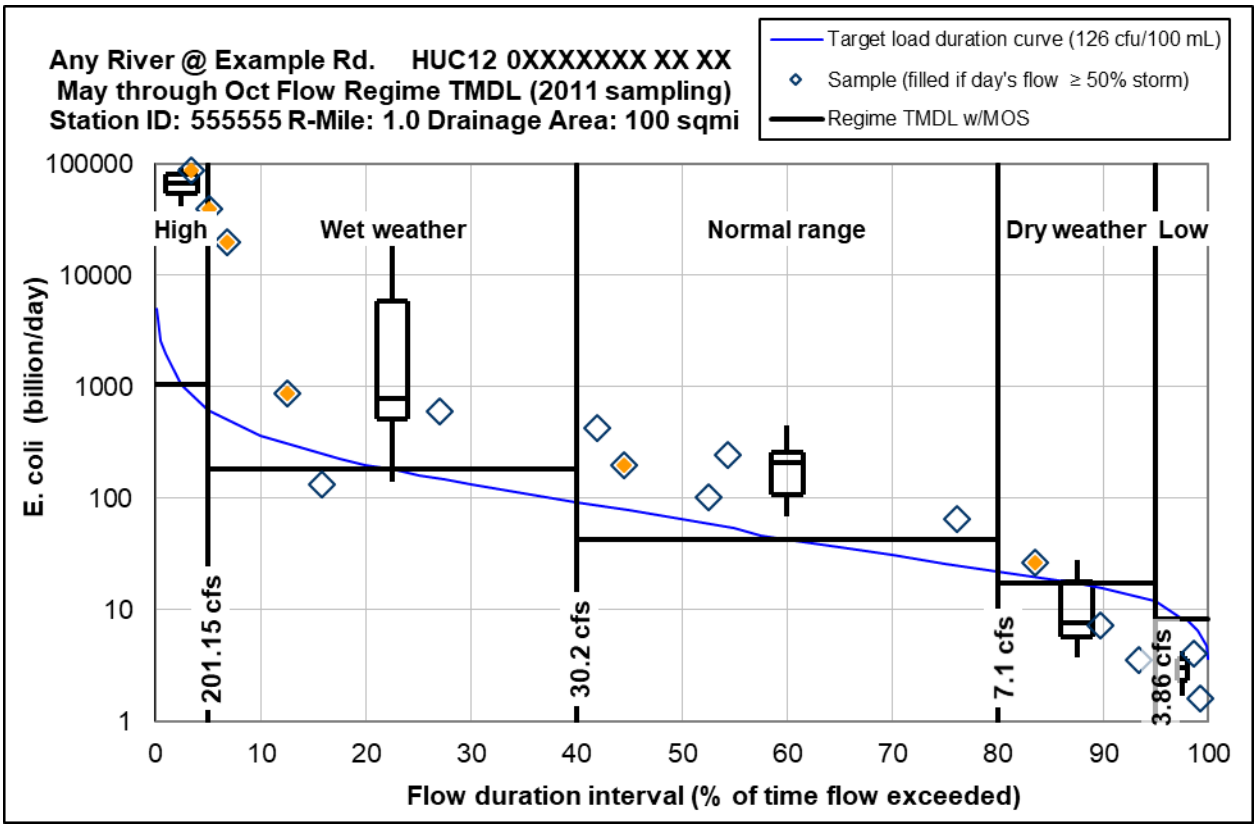

Figure 2 – Example load duration curve.

Table 8 – Example TMDL table calculations (from above load duration curve).

TMDL and duration intervals	High 0-5%	Wet weather 5-40%	Normal range 40-80%	Dry weather 80-95%	Low 95-100%
Samples Per Regime	2	4	5	3	2
Median Sample load	66807	781	209.25	7.72	2.99
Total Load Reduction Required	98.9%	82.8%	84.7%	NA	NA
Total Maximum Daily Load	1036.68	182.09	43.25	17.26	8.35
Margin of Safety: 20%	207.34	36.42	8.65	3.45	1.67
Allowance for Future Growth	62.20	10.93	2.60	1.04	0.50
Load Allocation	740.71	127.29	27.63	8.98	2.58
Wasteload Allocation Total	26.43	7.46	4.37	3.80	3.60
MS4	23.01	4.04	0.96	0.38	0.19
Example Town WWTP XPX00XXX	3.41	3.41	3.41	3.41	3.41

Recreation Use Proposed Targets

The primary contact recreation geometric mean criterion of 126 colony forming units per 100 mL *E. coli* will be used as the target concentration for the recreation use TMDL. As shown as the blue curve in the example load duration curve of Figure 2, above, this target concentration is converted into a load throughout the calculated flow regime. The black horizontal lines in Figure 2 and the "Total Maximum Daily Load" row in Table 10 show the TMDL values for five flow regime categories. This TMDL is the median of the curve load within each flow regime category.

Public Drinking Water Supply Use

Evaluation of Criteria

The public drinking water supply (PDWS) beneficial use in the WQS (OAC 3745-1-33) currently applies within 500 yards of drinking water intakes and for all publicly owned lakes. Ohio EPA has developed an assessment methodology for this beneficial use which focuses on source water contaminants not effectively removed through conventional treatment methods. Source water quality is assessed though comparison of water quality data to numeric chemical water quality criteria for three core indicators: nitrate; pesticides (atrazine); and cyanotoxins (Table 9).

The Integrated Water Quality Monitoring and Assessment Report (Ohio IR) describes this methodology (Ohio EPA, 2022). The Ohio IR is updated on a two-year cycle, and the current report was published in 2022.

Table 10 lists assessment units not meeting their public drinking water supply use designation and the impaired indicator(s) in Middle Great Miami River and principal tributaries.

Table 9 – Water quality criteria for public drinking water supply use

Indicator	Full attainment conditions	"Watch List" conditions	Impaired Conditions
Pesticides	Annual average for atrazine does not exceed 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.

Public Water Supply Proposed Actions

As mentioned in the Aquatic Life Use Proposed Action section above, Ohio EPA considers many factors when determining an action to address a water quality impairment. Table 10 shows the public drinking water supply impairment and proposed action for this project. The City of Piqua uses several surface water sources and participates in Syngenta Crop Protection's AMP1. Swift Run Lake (impounded section of Swift Run) is one of the three drinking water sources, and the atrazine annual average was 3.62 µg/L in 2008 (annual average exceeded WQC in 2011, 2018, and 2019). In recent years, atrazine results remained at levels of concern with several lake samples exceeding 12.0 µg/L (4x WQC; maximum 38.5 µg/L in 2011, 17.1 µg/L in 2014, 16.1 µg/L in 2017, 36.5 µg/L in 2018, and 52.4 µg/L in 2019). These exceedances are sampled from the raw source water and are representative of the of the facility's finished water. City of Piqua Public Water System has built a new water treatment plant (facility) since the most recent 2009 survey. This new facility came into service in June 2017. The treatment at the new facility includes powdered activated carbon and granulated activated carbon contactors. This advanced treatment practice may be effective to remove atrazine. Additionally, the water system has multiple river intakes that could be used to avoid issues in source water. Because of these recent improvements, follow-up sampling is recommended for the public water supply impairment.

Table 10 – Summary of public drinking water use impairments and potential TMDL modeling approaches

HUC-12 (05080001)	Portion of HUC-12 (TMDL Assessment Area)	Cause(s) of Impairment	Action	Method
07 05	Garbry Creek-Great Miami River	Pesticides	Other	Follow-up[1]

Abbreviation	Definition/interpretation
[1] Follow-up	Follow-up assessment is required to determine if the attainment status has changed or to clarify/verify the listed cause of impairment.

References

Ohio EPA (Ohio Environmental Protection Agency – Division of Surface Water). 2022. *Integrated Water Quality Monitoring and Assessment Report*. Published at: ***epa.ohio.gov/wps/portal/gov/epa/divisions-and-offices/surface-water/reports-data/ohio-integrated-water-quality-monitoring-and-assessment-report***

Ohio EPA (Ohio Environmental Protection Agency – Division of Surface Water). 2010 Biological and Water Quality Study of the Middle Great Miami River and Principal Tributaries, 2009. Shelby, Miami, Montgomery, Clark, and Champaign Counties, Ohio at: ***https://epa.ohio.gov/static/Portals/35/documents/MGMR_TSD_2010.pdf***

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Ohio EPA (Ohio Environmental Protection Agency – Division of Surface Water). Multi-Watershed TMDL Projects at: ***https://epa.ohio.gov/divisions-and-offices/surface-water/reports-data/multi-watershed-tmdl-projects***