July 2012

Ohio Environmental Protection Agency

Total Maximum Daily Loads for the Maumee River (lower) Tributaries and Lake Erie Tributaries Watershed

Final Report
July 5, 2012

Photo caption: Otter Creek near the intersection of Eastmoreland Drive and Sylvandale Avenue.

Photo credit: Dave Derrick, U.S. Army Corps of Engineers

Maumee River (Lower) Tributaries and Lake Erie Tributaries TMDL Report

July 5, 2012

Prepared for

U.S. Environmental Protection Agency, Region 5
Ohio Environmental Protection Agency

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Units of Measure

ac	acres
cfs	cubic feet per second
$kg/km^2/y$	kilograms per square kilometer per year
mgd	million gallons per day
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
mi^2	square miles
mL	milliliter

Abbreviations and Acronyms

ALU	aquatic life use
AOC	area of concern
BOD	biochemical oxygen demand
CAFF	concentrated animal feeding facility
CAFO	concentrated animal feeding operation
CBOD	carbonaceous biochemical oxygen demand
CWA	Clean Water Act
DDD	dichlorodiphenyldichloroethane
DDE	dichlorodiphenyldichloroethylene
DMR	discharge monitoring report
ESL	Ecological Screening Level
FG	future growth
GLNPO	Great Lakes National Program Office
gpd	gallons per day
HELP	Huron/Erie Lake Plains ecoregion
HSG	hydrologic soil group
HSTS	home sewage treatment system
HUC	hydrologic unit code
IBI	Index of Biological Integrity
ICI	Invertebrate Community Index
LA	load allocation
LID	low impact development
MHP	mobile home park
MIwb	Modified Index of well- being
MOS	margin of safety
MS4	municipal separate storm sewer system
MWH	modified warmwater habitat
NASS	National Agricultural Statistic Service
NCDC	National Climatic Data Center
NOAA	National Oceanic and Atmospheric Administration (U.S. Department of Commerce)
NPDES	National Polluant Discharge Elimination System
OAC	Ohio Administrative Code
ODOT	Ohio Department of Transportation
Ohio EPA	Ohio Environmental Protection Agency
OMZA	outside mixing zone average
OMZM	outside mixing zone maximum or outside mixing zone minimum
OTC	Ohio Turnpike Commission
PAH	polynuclear aromatic hydrocarbon
PCB	polychlorinated biphenyls
PCR	primary contact recreation
QHEI	Qualitative Habitat Evaluation Index
RAP	remedial action plan
SRV	sediment reference value
TSD	technical support document
TSS	total suspended solids
TMACOG	Toledo Metropolitan Area Council of Governments
TMDL	total maximum daily load
USDA	U.S. Department of Agriculture

U.S. EPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey (U.S. Department of the Interior)
WLA	waste load allocation
WRP	Watershed Restoration Plan
WTP	water treatment plant
WWH	warmwater habitat
WWTP	wastewater treatment plant

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Executive Summary

The tributaries of the lower Maumee River and those that drain to Lake Erie between the Maumee and Toussaint rivers are warmwater habitat streams located within and southeast of Toledo. The lower Maumee River tributaries drain approximately 77 square miles, and the Lake Erie tributaries drain approximately 205 square miles; all are part of the Maumee Area of Concern (AOC). The Lake Erie tributaries in the AOC are Turtle Creek, Crane Creek, Cedar Creek, Wolf Creek, Berger Ditch, and Otter Creek. The lower Maumee River tributaries are Grassy Creek, Grassy Creek Diversion, Crooked Creek, Delaware Creek, and Duck Creek. The tributaries appear on Ohio's section 303(d) list because of impairments caused by one or more of the following: bacteria, sedimentation/siltation, dissolved oxygen, total phosphorous, nitrate plus nitrite, ammonia, organic enrichment, contaminated sediments, flow regime alterations, and direct habitat alterations.

The Clean Water Act (CWA) and U.S. Environmental Protection Agency (U.S. EPA) regulations require that states develop Total Maximum Daily Loads (TMDLs) for waters on the section 303(d) lists. The TMDL and water quality restoration planning process involves several steps including watershed characterization, target identification, source assessment, and allocation of loads. TMDL targets and allocations are derived from the water quality standards (designated uses, narrative and numeric criteria), which are approved by the Ohio Environmental Protection Agency (Ohio EPA). The TMDL allocations are separated into waste load allocations (WLAs) for point sources and load allocations (LAs) for nonpoint sources.

This document presents the results of a TMDL study for the Maumee River (lower) tributaries and Lake Erie tributaries, including a summary of available water quality data from the biological studies and water quality investigations conducted on the tributaries. Valuable background information is provided in the *Biological and Water Quality Study of the Portage River Basin, Select Lake Erie Tributaries, and Select Maumee River Tributaries, 2006-2008* report (Ohio EPA 2010a). This document summarizes results for parameters and factors that could contribute to the impairment of biological communities. Because source assessments are an important component of water quality management planning and TMDL development, this report describes potential sources in the drainage of the Maumee River (lower) tributaries and Lake Erie tributaries.

TMDLs were developed for ammonia (2), *E. coli* (9), nitrate plus nitrite (1), total phosphorus (as a pollutant [7] and as a surrogate pollutant for dissolved oxygen [2] and organic enrichment [2]), and total suspended solids (TSS; as a surrogate for sedimentation/siltation [4]). Figure E - 1 presents a map of these TMDLs. Typically, in the rural portions of the project area, ammonia, *E. coli*, and total phosphorus were derived from malfunctioning or failing home sewage treatment systems and unsewered communities. Storm water and agriculture (including livestock, row crops with drain tiles, and fertilizer and manure application) were also sources of *E. coli*, total phosphorus and TSS in rural areas. In developed areas and urban portions of the project area, *E. coli*, nitrate plus nitrite, total phosphorus, and TSS were derived from urban runoff.

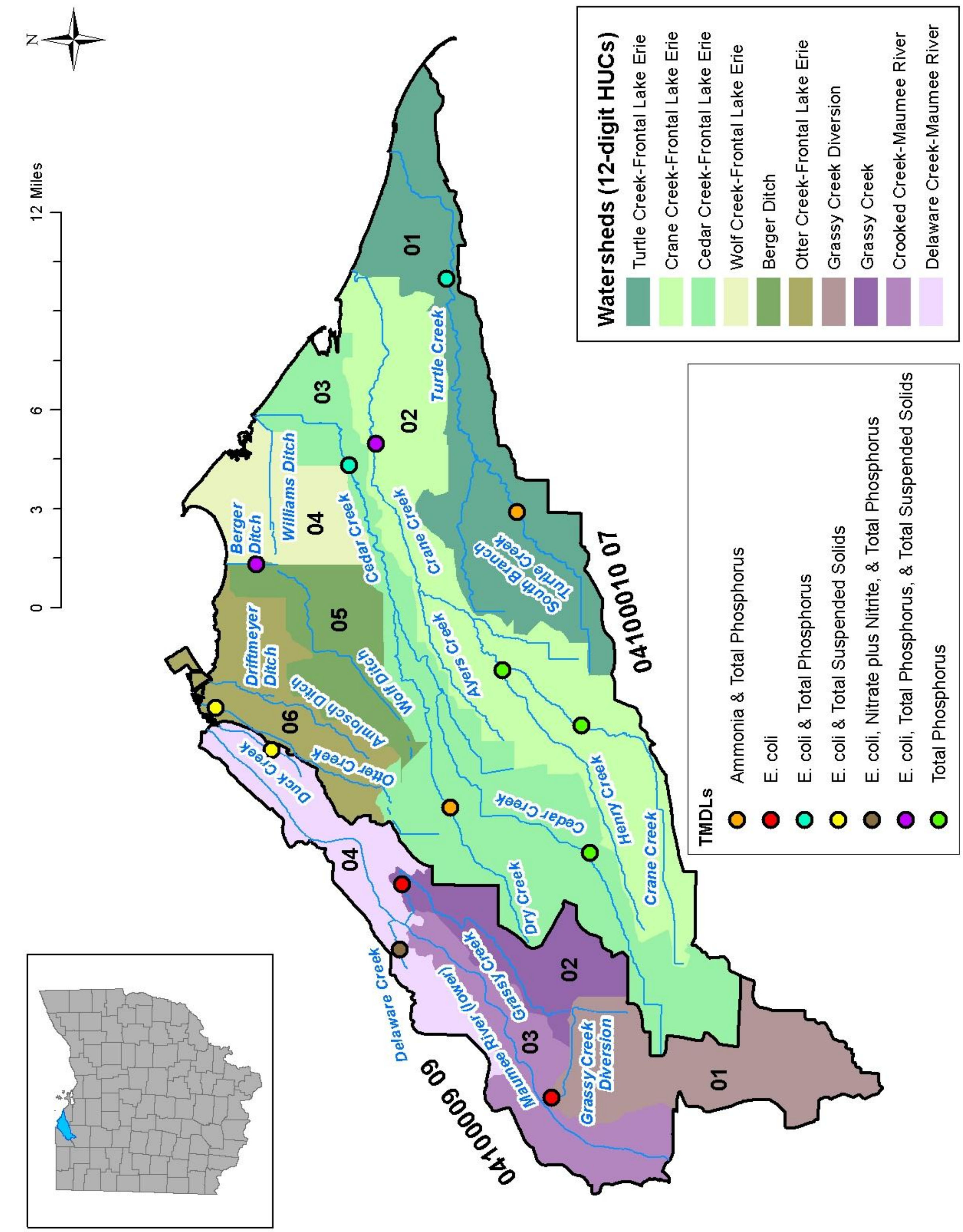


Figure E - 1. TMDLs in the Maumee River (lower) tributaries and Lake Erie tributaries project area.

1 Introduction

The tributaries of the lower Maumee River and those that drain to Lake Erie between the Maumee and Toussaint rivers are warmwater habitat streams located within and southeast of Toledo. The lower Maumee River tributaries drain approximately 77 square miles, and the Lake Erie tributaries drain approximately 205 square miles; all are part of the Maumee Area of Concern (AOC; see Figure 1-1). The Lake Erie tributaries in the AOC are Turtle Creek, Crane Creek, Cedar Creek, Wolf Creek, Berger Ditch, and Otter Creek; they are all part of the 10-digit hydrologic unit code (HUC) *Cedar Creek – Frontal Lake Erie* (04100010 07). The lower Maumee River tributaries are Grassy Creek, Grassy Creek Diversion, Crooked Creek, Delaware Creek, and Duck Creek; these watersheds are part of the 10-digit HUC *Grassy Creek – Maumee River* (04100009 09). The tributaries appear on Ohio's §303(d) list because of impairments caused by one or more of the following: bacteria, sedimentation/siltation, dissolved oxygen, total phosphorous, nitrate/nitrite, ammonia, organic enrichment, contaminated sediments, flow regime alterations, and direct habitat alterations.

The Clean Water Act and U.S. Environmental Protection Agency (U.S. EPA) regulations require that states develop Total Maximum Daily Loads (TMDLs) for waters on the §303(d) lists. The TMDL and water quality restoration planning process involves several steps including watershed characterization, target identification, source assessment, and allocation of loads. TMDL targets and allocations are derived from the water quality standards (designated uses, narrative and numeric criteria), which are approved by the Ohio Environmental Protection Agency (Ohio EPA). The TMDL allocations are separated into waste load allocations (WLAs) for point sources and load allocations (LAs) for nonpoint sources.

This document presents the results of a TMDL study for the lower Maumee River and Lake Erie tributaries. Information on Ohio's water quality standards as they pertain to developing the TMDL for the tributaries and a presentation of the impairments are provided in Section 2. The watershed characterization, including background information on the setting, climate, soils, hydrology, and other key characteristics that could affect water quality in the tributaries is presented in Section 3. Known point and nonpoint sources are identified and evaluated in Section 4. Linkage analyses for the designated aquatic life uses and recreation uses are presented in Sections 5 and 6, respectively. The allocations for each TMDL are presented in Section 7 and the water quality improvement strategy is presented in Section 8.

Supplemental background information on the project area is available in the following documents:

- *Biological and Water Quality Study of the Portage River Basin, Select Lake Erie Tributaries, and Select Maumee River Tributaries, 2006 - 2008* (Ohio EPA 2010a)
- *Maumee Area of Concern Stage 2 Watershed Restoration Plan, Volume 1* (Maumee Remedial Action Plan [RAP] and Duck and Otter Creeks Partnership, Inc. 2006)
- *Toledo Metropolitan Area Council of Governments Area Wide Water Quality Management Plan* (TMACOG 2011)

The Maumee River (lower) tributaries and Lake Erie tributaries are warmwater habitat streams located within and southeast of Toledo. The lower Maumee River tributaries (HUC 041100009 09) drain approximately 77 square miles, and the Lake Erie tributaries (HUC 041100010 07) drain approximately 205 square miles. Figure 1-2 presents the watershed boundaries for the project area.

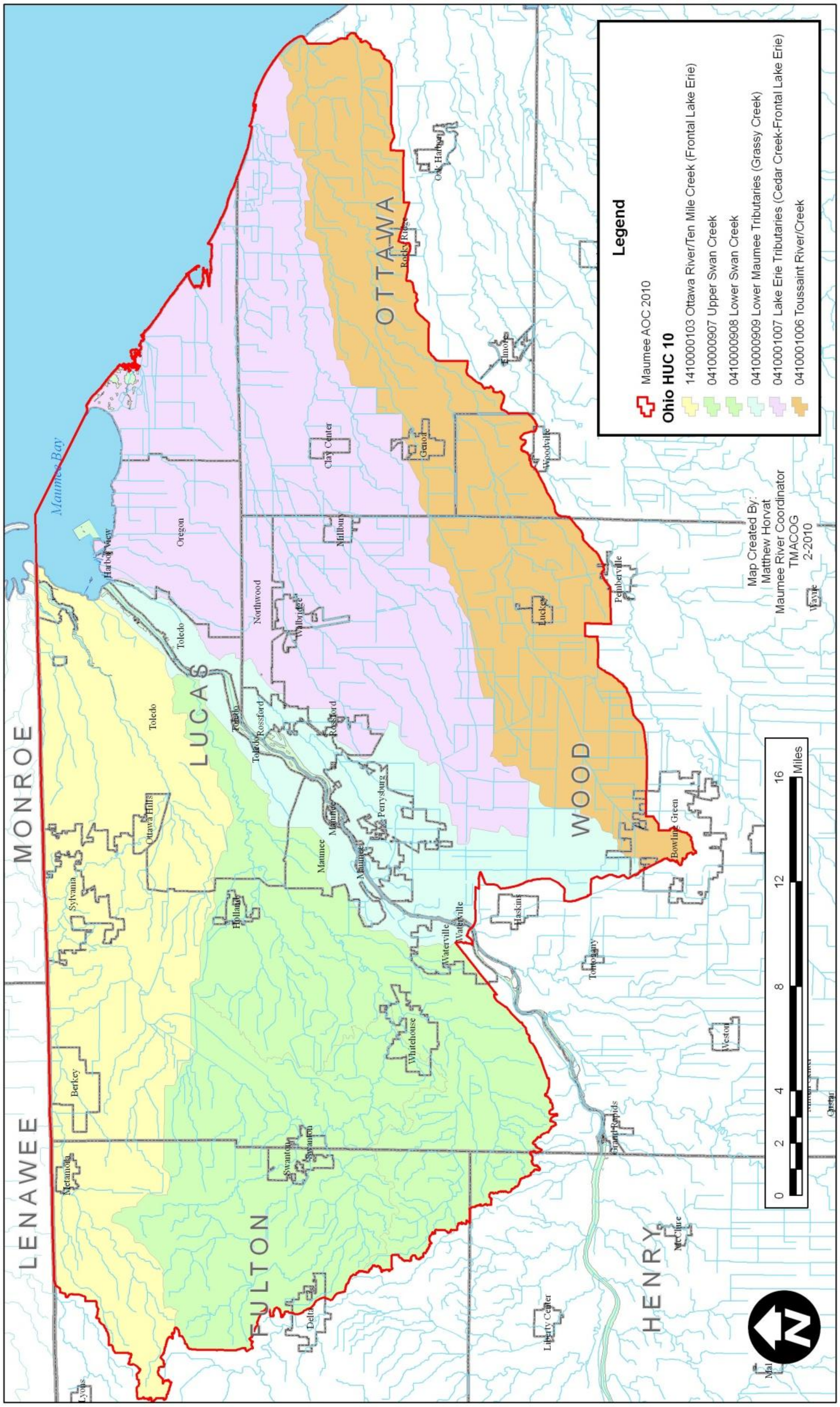


Figure 1-1. Maumee Area of Concern (AOC).

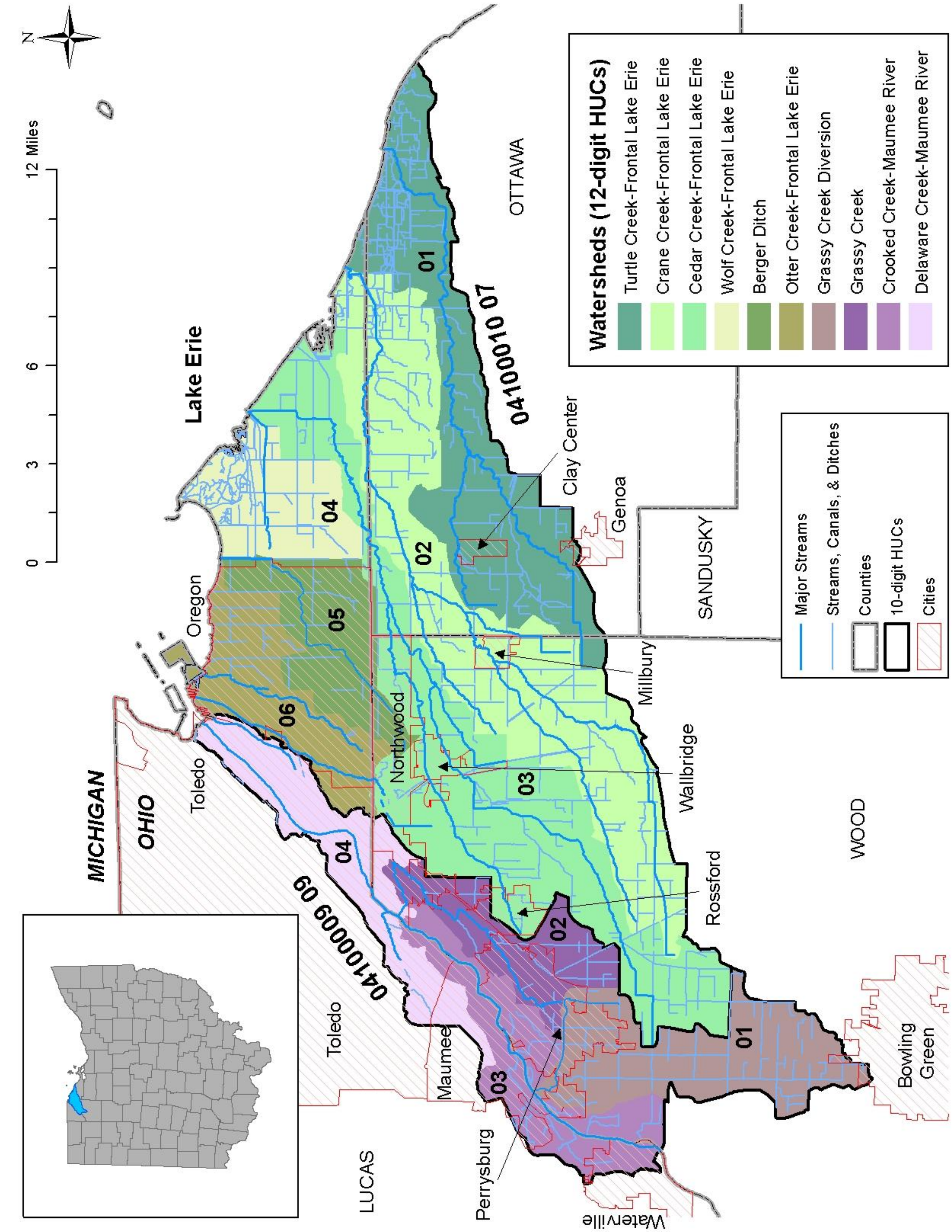


Figure 1-2. Maumee River (lower) tributaries and Lake Erie tributaries project area map.

2 Water Quality Standards and Impairments

This section presents summaries of the applicable water quality standards for waters in the project area (Table 2-1) and summaries of the waterbody impairments. The water quality standards for Ohio are presented in Ohio Administrative Code (OAC) in chapter *3745-1*. For a full analysis of the impairments, see the *Biological and Water Quality Study of the Portage River Basin, Select Lake Erie Tributaries, and Select Maumee River Tributaries, 2006 - 2008* (Ohio EPA 2010a).

Table 2-1. Ohio water quality standards [a]

Component	Description
Designated Use [b]	Designated use reflects how the water could be used by humans and how well it supports a biological community. Every water in Ohio has a designated use or uses; however, not all uses apply to all waters (i.e., they are waterbody specific).
Numeric Criteria	Chemical criteria represent the concentration of a pollutant that can be in the water and still protect the designated use of the waterbody. Biological criteria indicate the health of the in-stream biological community by using one of three indices: ▪ Index of Biotic Integrity (IBI) (measures fish community health). ▪ Modified Index of well-being (MIwb) (measures fish community health). ▪ Invertebrate Community Index (ICI) (measures benthic macroinvertebrate community health).
Narrative Criteria	These are the general water quality criteria that apply to all surface waters. These criteria state that all waters must be free from sludge; floating debris; oil and scum; color- and odor-producing materials; substances that are harmful to human, animal or aquatic life; and nutrients in concentrations that can cause algal blooms.
Antidegradation Policy	This policy establishes situations under which Ohio EPA may allow new or increased discharges of pollutants, and requires those seeking to discharge additional pollutants to demonstrate an important social or economic need.

Notes
a. Ohio's water quality standards are available at http://epa.ohio.gov/dsw/wqs/index.aspx
b. According to OAC 3745-1-07(A)(1) each waterbody is assigned a designated use. Any streams in Ohio that are undesignated still must attain the chemical criteria associated with the warmwater habitat designation. There is no similar protection for recreation use.

2.1 Designated Uses

Beneficial use designations define the existing and potential uses of a waterbody. They consider the use and value of water for public water drinking supplies, protection and propagation of aquatic life, recreation both in and on the water, human health (fish tissue), agricultural and industrial purposes. Each Ohio waterbody is assigned one or more aquatic life habitat use designations, one or more water supply designations, one or more recreational designations, and a human health designation. Beneficial uses for the project area are presented Table 2-2.

Table 2-2. Designated uses for streams in the project area

HUC	Stream	Aquatic life			Water supply		Recreation		
		WWH	MWH	LRW	AWS	IWS	B	C	SCR
Lake Erie tributaries (HUC 04100010 07)									
01	Turtle Creek	X			X	X	X		
	North Branch Turtle Creek	X			X	X	X		
	South Branch Turtle Creek	X			X	X	X		
02	Crane Creek	X			X	X	X		
	Ayers Creek	X			X	X	X		
	Little Crane Creek	X			X	X	X		
	Henry Creek	X			X	X	X		
	Two Root Creek	X			X	X	X		
03	Cedar Creek	X			X	X	X		
	Dry Creek	X			X	X	X		
	Little Cedar Creek	X			X	X	X		
04	Williams Ditch	X			X	X	X		
	Wolf Creek	X			X	X	X		
05	Berger Ditch [a]	X					X		
	Wolf Ditch [b]	X					X	X	
06	Otter Creek (HW to RM 7.0)			X	X	X		X	
	(RM 7.0 to RM 0.0)		X		X	X	X		
	Driftmeyer Ditch [c]			X	X	X			X
	Amlosch Ditch [c]			X	X	X			X
Maumee River (lower) tributaries (HUC 04100009 09)									
01	Grassy Creek Diversion [a]	X					X		
02	Grassy Creek	X			X	X	X		
04	Duck Creek	X			X	X	X		
	Delaware Creek	X			X	X	X		

Sources: *OAC-3745-1-11*, *OAC-3745-1-23*, and Ohio EPA 2010a.

Notes

AWS = agricultural water supply; B = primary contact recreation class B; C = primary contact recreation class C; HW = headwaters; IWS = industrial water supply; LRW = limited resource water; MWH = modified warmwater habitat; SCR = secondary contact recreation; WWH = warmwater habitat

a. Berger Ditch is undesignated in *OAC-3745-1-23* and Grassy Creek Diversion is not present in *OAC-3745-1-23*. Recommended designations from Ohio EPA (2010) are displayed.

b. The headwaters portion of Wolf Creek is PCR Class C, while the lower reaches are PCR Class B.

c. These LRW creeks are defined as small drainageway maintenances, which is defined in *OAC-3745-1-07(B)(1)(g)(ii)*.

2.2 Numeric Criteria

Numeric criteria are based on concentrations of chemicals and degree of aquatic life toxicity allowable in a waterbody without adversely affecting its beneficial uses. They consist of biological criteria, chemical criteria, and whole effluent toxicity levels. The criteria applicable to the project area that are pertinent to the TMDL project are presented in the following sections.

2.2.1 Biological Criteria

The biological water quality criteria (also referred to as biocriteria) in Ohio are numeric and vary by aquatic life use (ALU) designation and Level III Ecoregion. ALU designations in Ohio include coldwater habitat, exceptional warmwater habitat, seasonal salmonid habitat, warmwater habitat (WWH), modified warmwater habitat (MWH), and limited resource waters. The ability of a waterbody to meet its ALU designation is based primarily on the scores it receives on three community indices, as applicable: the Index of Biological Integrity (IBI), the Modified Index of well-being (MIwb), and the Invertebrate

Community Index (ICI). The IBI and MIwb are based on the composition of the fish community, and the ICI is based on the composition of the macroinvertebrate community.

Waters of concern in the project area are of varying size and are designated WWH and MWH.[1] Table 2-3 presents a summary of the biocriteria for the protection of aquatic life in the HELP ecoregion, which varies by ALU designation and stream size.

Table 2-3. Biocriteria for HELP

Index	Size	WWH	MWH
IBI	Wading	32	20
	Headwaters	28	20
MIwb	Wading	7.3	5.6
ICI	All [a]	34	22

Notes
Based on Table 7-15 of *OAC-3745-1-07.*
IBI = Index of Biotic Integrity; ICI = Invertebrate Community Index; MIwb = Modified Index of Well-being; MWH = modified warmwater habitat; WWH = warmwater habitat.
a. ICI scoring using the modified Hester-Dendy artificial substrate samplers. See Table 7-15 of *OAC-3745-1-07.*

2.2.2 Chemical Criteria

Ohio has numeric criteria for parameters pertinent to the project area including *Escherichia coli (E. coli)*, dissolved oxygen, and ammonia.

2.2.2.1 E. coli

Ohio has numeric water quality criteria for *E. coli* that are applicable during the recreation season only: May 1 through October 31, as defined in *OAC-3745-1-07(4);* Table 2-4 gives a summary of *OAC-3745-1-07, Table 7-13*.

Table 2-4. *E. coli* standards for Ohio

	E. coli (counts/100 mL)	
Recreation use	Seasonal geometric mean	Single sample maximum [a]
Bathing Waters	126	235 [b]
PCR – Class A	126	298
PCR – Class B	161	523
PCR – Class C	206	940
SCR	1,030	1,030

Notes
Based on Table 7-13 of *OAC-3745-1-07*.
PCR = primary contact recreation; SCR = secondary contact recreation
a. Except as noted in footnote b, those criteria must not be exceeded in more than 10 percent of the samples taken during any 30-day period.
b. This criterion will be used for issuing beach and bathing water advisories.

The *E. coli* standards vary by recreation use designation. In the project area, all waters of concern are designated primary contact recreation (PCR) as Class B or Class C. The major tributaries discharge to the Maumee River (PCR Class A) and Lake Erie (Bathing Waters). Bathing Waters are “heavily used for swimming” during the recreation season (*OAC-3745-1-07(B)(4)(a)*). PCR Class A waters “support, or

[1] Designated uses for the Maumee River basin are presented in *OAC-3745-1-11* and designated uses for the Portage River basin (i.e., for the Lake Erie tributaries) are presented in *OAC-3745-1-23*.

potentially support, *frequent* primary contact recreation activities;" whereas, PCR Class B waters "support, or potentially support, *occasional* primary contact recreation activities" and PCR Class C waters "support, or potentially support, *infrequent* primary contact recreation activities" (*OAC-3745-1-07(B)(4)(b)*; emphases added). The seasonal geometric mean calculated from samples collected during the recreation season (May 1st through October 31st) and must not exceed 126 *E. coli* counts per 100 milliliters (mL) for PCR Class A waters, and must not exceed 161 per 100 mL for PCR Class B waters. The single sample maximum is also presented in Table 2-4 but is not further discussed in this report because the single sample maximum is typically only used to determine use support at beaches, not for streams; these TMDLs are located on streams, upstream of the beaches on Lake Erie.

The Maumee River (lower) is designated PCR Class A, and Lake Erie is designated as a Bathing Water. All the tributaries to the Maumee River (lower) and Lake Erie are designated either PCR Class B or PCR Class C. To protect downstream uses, any National Pollutant Discharge Elimination System (NPDES)-permitted facility or a TMDL on a stream designated PCR Class B that is within 5 river miles of the Maumee River or Lake Erie will be subject to the criteria from the Maumee River's PCR Class A or Lake Erie's Bathing Water designated uses, respectively (Ohio EPA 2010b).

2.2.2.2 Dissolved Oxygen

Ohio also has two numeric criteria for dissolved oxygen that vary by ALU designation. The outside mixing zone minima (OMZM) and outside mixing zone 24-hour averages (OMZA) for WWH and MWH waters are presented in Table 2-5. Both criteria are only applicable downstream of any mixing zone from any wastewater discharge, where the OMZM is an instantaneous minimum and the OMZA is the minimum arithmetic mean of all samples collected within any 24-hour period (*OAC-3745-1-02(B)(58)* and *OAC-3745-1-07 Table 1*).

Table 2-5. Dissolved oxygen standards for Ohio

ALU designation	Outside mixing zone minimum (mg/L)	Outside mixing zone 24-hour average (mg/L)
WWH	4.0	5.0
MWH	3.0 / 2.5 [a]	4.0

Source: *OAC-3745-1-07*, Table 7-1
Notes
mg/L = milligrams per liter
a. The OMZM is 2.5 mg/L for streams in the HELP ecoregion.

2.2.2.3 Ammonia

Ohio's numeric criteria for ammonia vary by designated use, season, temperature and pH. Tables of the criteria are presented in *OAC-3745-1-07*.

2.3 Narrative Criteria and Guidance

Narrative criteria are the general water quality criteria that apply to all surface waters. Those criteria, promulgated in *OAC-3745-1-04*, state that all waters must be free from sludge, floating debris, oil and scum, color- and odor-producing materials, substances that are harmful to human, animal or aquatic life, and nutrients in concentrations that can cause algal blooms.

2.3.1 Nutrients

Ohio EPA does not have statewide numeric criteria for nutrients. TMDL targets are selected on the basis of evaluating reference stream data published in a technical report titled *Association between Nutrients,* *Habitat, and the Aquatic Biota in Ohio Rivers and Streams* (Ohio EPA 1999; referred to throughout as the *Associations* document). The document identifies ranges of concentrations for nitrate plus nitrite nitrogen and total phosphorus on the basis of observed concentrations at all sampled ecoregional reference sites. Those reference stream concentrations will be used as TMDL targets. The nitrate plus nitrite and total phosphorus targets for WWH and MWH are shown in Table 2-6. One of the methods that U.S. EPA recommends is basing nutrient criteria on the 75th percentile of the frequency distribution of reference streams (U.S. EPA 2000). That method was used to set the TMDL nutrient targets. It is important to note that those nutrient targets are not codified in Ohio's water quality standards.

Table 2-6. Statewide-suggested nutrient criteria for the protection of aquatic life

Stream size	Beneficial use	
	WWH	MWH
Total phosphorus concentration (mg/L)[a]		
Headwaters	0.08	0.34
Wading	0.10	0.28
Nitrate plus nitrite concentrations (mg/L)[b]		
Headwaters	1.0	1.0
Wading	1.0	1.6

Source: Ohio EPA 1999
Notes
mg/L = milligrams per liter
Headwaters streams drain less than 20 square miles. Wading streams drain 20 to 100-200 square miles (the upper limit depends on sampling method: wading or boating).
a. Statewide total phosphorus recommendations were generated by Ohio EPA (1999) with ANOVA analyses of statewide pooled data.
b. Statewide nitrate plus nitrite recommendations were calculated by Ohio EPA (1999) as the 75th percentile of statewide pooled reference stream data.

2.3.2 Habitat

The Qualitative Habitat Evaluation Index (QHEI) is a quantitative expression of a qualitative, visual assessment of habitat in free-flowing streams and was developed by Ohio EPA to assess available habitat for fish communities (Rankin 1989, 1995). The QHEI is a composite score of six physical habitat categories:

- Substrate
- In-stream cover
- Channel morphology
- Riparian zone and bank erosion
- Pool/glide and riffle/run quality
- Gradient

Each of those categories is subdivided into specific attributes that are assigned a point value reflective of the attribute's effect on the aquatic life. Highest scores are assigned to the attributes correlated to streams with high biological diversity and integrity and lower scores are progressively assigned to less desirable habitat features. A QHEI evaluation form[2] is used by a trained evaluator while at the sampling location. Each of the components is evaluated on-site, recorded on the form, the score totaled, and the data later analyzed in an electronic database.

The QHEI is a macro-scale approach that measures the emergent properties of habitat (sinuosity, pool/riffle development) rather than the individual factors that shape the properties (current velocity, depth, substrate size). The QHEI is used to evaluate the characteristics of a short stream segment, as

[2] The evaluation form is available at http://www.epa.ohio.gov/portals/35/documents/QHEIFieldSheet061606.pdf.

opposed to the characteristics of a single sampling site. As such, individual sites could have poorer physical habitat because of a localized disturbance yet still support aquatic communities closely resembling those sampled at adjacent sites with better habitat, provided water quality conditions are similar. However, QHEI evaluations are segment specific and do not give a strong indication of the quality of the habitat in other stream segments.

QHEI scores can range from 12 to 100. The appropriate QHEI target score was determined by statistical analysis of Ohio's statewide database of paired QHEI and IBI scores. Simple linear and exponential regressions and frequency analyses of combined and individual components of QHEI metrics in relation to the IBI were examined. The regressions indicate that the QHEI is significantly correlated with the IBI. QHEI scores of more than 75 generally indicate excellent stream habitat, scores between 60 and 75 indicate good habitat quality, and scores of less than 45 demonstrate habitat that is not conducive to WWH. Scores between 45 and 60 need separate evaluation by trained field staff to determine the stream's ALU potential.

2.3.3 Sediment Concentration

Using total suspended solids (TSS) as an indicator of sediment in the water column is fairly common and has been used in numerous TMDL reports; however, TSS concentrations can be an underestimation of sediment loads because they account only for particles small enough to remain suspended in the water column. Larger particles, such as sand and coarser particles that might have the most influence on aquatic life and stream substrates are often not included in TSS concentrations because they usually settle out of the water column.

Ohio does not have water quality standards for TSS. However, Ohio EPA has calculated TSS statistics for reference sites throughout the HELP ecoregion. Ohio EPA's evaluation of reference data includes only data collected between June 15 and October 15. Data from high-flow events as noted by field personnel or as determined from USGS gages that are excluded (Ohio EPA 1999, p. 18). The 75^{th} percentile statistic for reference sites (non-urban, unmodified) in the HELP is 24.0 mg/L for both headwaters and wading streams (Ohio EPA 1999, Appendix I, p. 24).

2.3.4 Sediment Quality

Ohio does not have sediment quality criteria. Ohio-specific sediment reference values (SRVs) are presented in Ohio EPA Division of Environmental Response and Revitalization's *Ecological Risk Assessment Guidance* (Ohio EPA 2008). The SRVs are summarized in Table 2-7.

Table 2-7. Sediment Reference Values (mg/kg)

Parameter	HELP ecoregion	Statewide
Arsenic	11	--
Cadmium	0.96	--
Chromium	51	--
Copper	42	--
Lead	--	47
Mercury	--	0.12
Nickel	36	--
Selenium	1.4	--
Strontium	250	--
Zinc	190	--

Source: Ohio EPA 2008 (Appendix H, Table 2).

2.4 Impairments

The Maumee River (lower) tributaries and Lake Erie tributaries appear on Ohio's Clean Water Act (CWA) section 303(d) list because of impairments from one or more of the following: bacteria, sedimentation/siltation, dissolved oxygen, total phosphorous, nitrate plus nitrite, ammonia, organic enrichment, flow regime alteration, and direct habitat alteration. Listing on the CWA section 303(d) list is because of the failure to attain water quality standards. Table 2-8 and Table 2-9 present specific impairments and identify potential sources by watershed (equivalent to a 12-digit HUC).

Table 2-8. Impairments to the Lake Erie tributaries (HUC 04100010 07)

Watershed (HUC 04100010)	Cause(s) of impairment	Potential source(s) of impairment
Turtle Creek – Frontal Lake Erie (07 01)	Bacteria	▪ HSTS ▪ Package plants ▪ Village of Martin
	Ammonia (total), direct habitat alterations, DO, TP, and sedimentation/siltation	▪ Channelization ▪ Non-irrigated crop production ▪ HSTS
Crane Creek – Frontal Lake Erie (07 02)	Bacteria	▪ HSTS ▪ Package plants ▪ Williston (unsewered)
	TP and sedimentation/siltation	▪ Channelization ▪ Urban runoff
Cedar Creek – Frontal Lake Erie (07 03)	Bacteria	▪ HSTS ▪ Curtis (unsewered) ▪ Septic discharges
	Ammonia (total), DO, organic enrichment (sewage) biological indicators, and sedimentation/siltation	▪ Channelization ▪ Non-irrigated crop production ▪ HSTS
Berger Ditch (07 05)	Bacteria	▪ HSTS
	Organic enrichment (sewage) biological indicators, TP, and sedimentation/siltation	▪ Channelization ▪ HSTS
Otter Creek – Frontal Lake Erie (07 06)	Bacteria	▪ HSTS ▪ Package plants
	Sedimentation/siltation and contaminated sediments [a]	▪ Commercial districts (industrial parks) ▪ Contaminated sediments ▪ Channelization

Source: Ohio EPA 2010a.
Notes
DO = dissolved oxygen; HSTS = home sewage treatment system; TP = total phosphorus.
a. Constituents in the sediment exceed Ohio's ecological sediment screening values (Ohio EPA 2008).

Table 2-9. Impairments to the lower Maumee River tributaries (HUC 04100009 09)

Watershed (HUC 04100009)	Cause(s) of impairment	Potential source(s) of impairment
Grassy Creek Diversion (09 01)	Bacteria	▪ HSTS ▪ Urban Area
Grassy Creek (09 02)	Bacteria	▪ HSTS ▪ Urban Area
	Sedimentation/siltation	▪ Channelization ▪ Urban runoff and storm sewers
Delaware Creek – Maumee River (09 04)	Bacteria	▪ HSTS ▪ Golf course
	Flow regime alterations, nitrate plus nitrite, phosphorus (total), sedimentation/siltation.	▪ Channelization ▪ Urban runoff and storm sewers ▪ Channel erosion/incision from upstream hydromodifications

Source: Ohio EPA 2010a.
Note: HSTS = home sewage treatment system.

Ohio EPA identified aquatic life use (ALU) impairments in 7 of the 10 watersheds in the project area and identified recreation use impairments in 8 of 10 watersheds in the project area. Ohio EPA (2010) fully discusses the impairments. The assessment sites and designated uses are displayed in Figure 2-1 and Figure 2-2.

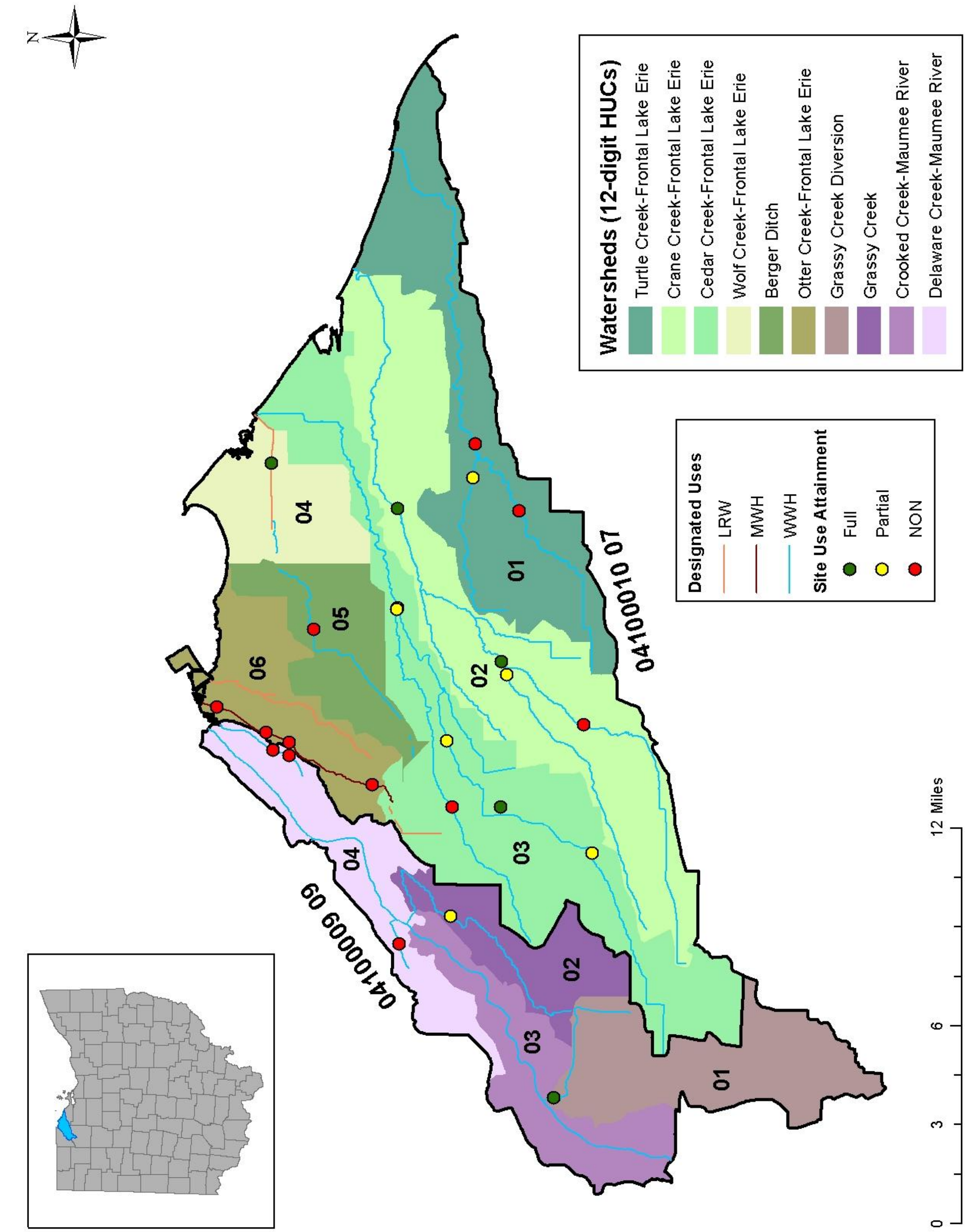


Figure 2-1. ALU designations and attainment in the project area.

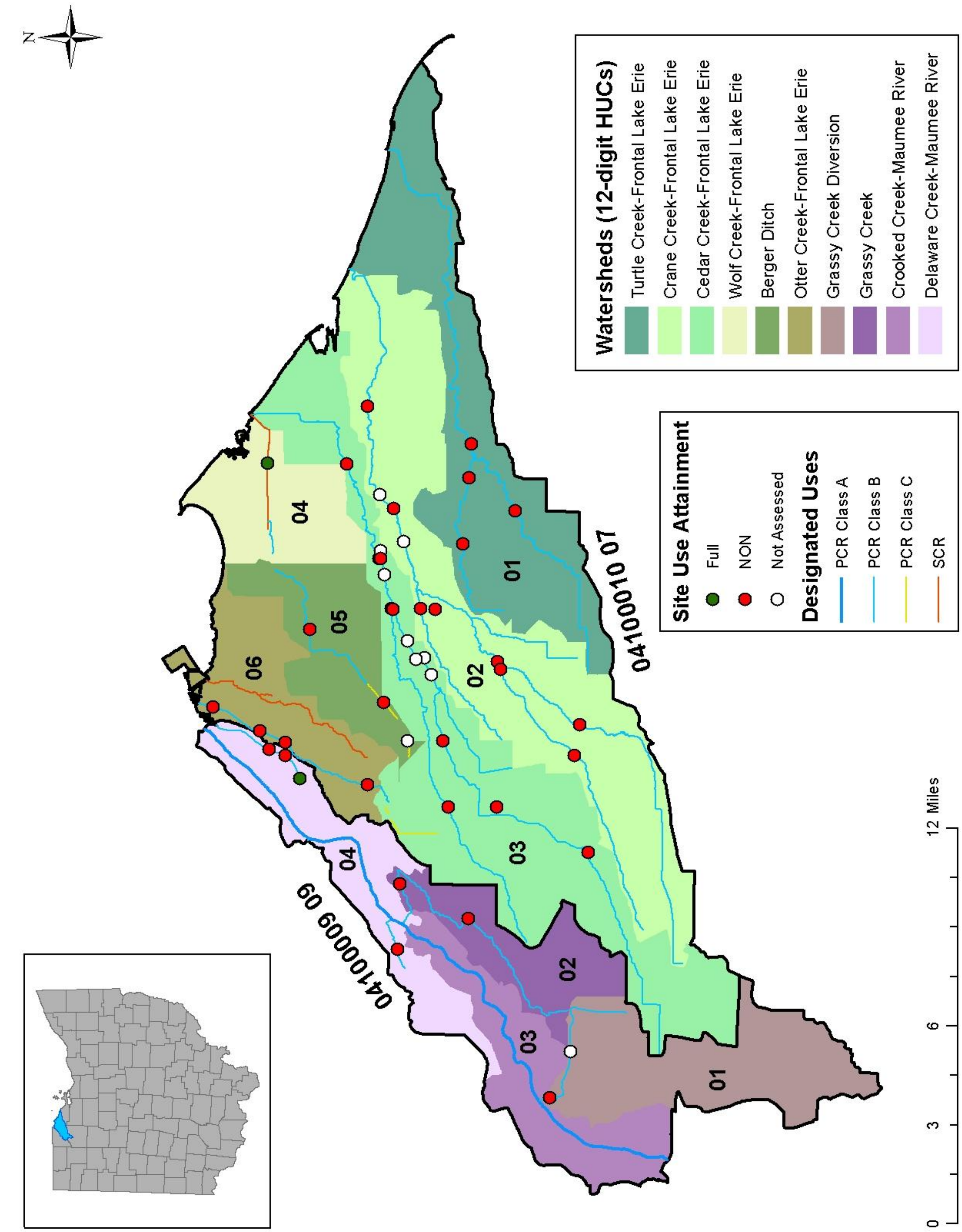


Figure 2-2. Recreation use designations and attainment in the project area.

3 Watershed Characterization

The Maumee River (lower) tributaries and Lake Erie tributaries ("project area") are warmwater habitat streams located within and southeast of Toledo in Lucas, Ottawa, and Wood counties. Much of the southern portion of the project area is rural, while the northern portion is urban, with some rural areas in eastern Lucas County. Urban development occurs along the Maumee River, which flows through the northern portion of the project area, and along Maumee Bay. Both the Maumee River and Lake Erie (including Maumee Bay) are outside the scope of this document. The lower Maumee River tributaries (HUC 041100009 09) drain approximately 77 square miles, and the Lake Erie tributaries (HUC 041100010 07) drain approximately 205 square miles.

3.1 Project Setting

The Lake Erie tributaries are part of the *Cedar Creek – Frontal Lake Erie* 10-digit HUC (04100010 07), and include the following: Turtle Creek, Crane Creek, Cedar Creek, Wolf Creek, Berger Ditch, and Otter Creek. Ohio EPA (2010a) provides descriptions of select Lake Erie tributaries, including descriptions of all impaired tributaries. Cedar Creek, Crane Creek, and Turtle Creek are each 20 to 25 miles long and flow through Lucas, Wood, and Ottawa counties. Otter Creek is nearly 8 miles long and flows northeast from the city of Northwood through the cities of Toledo and Oregon to Maumee Bay, just east of the Maumee River. Wolf Creek also begins at Northwood and flows through Oregon before entering the Maumee Bay State Park marina. With the exception of Otter Creek, these Lake Erie tributaries flow primarily through agricultural land. Agricultural practices that affect water quality in the tributaries include channelization, non-irrigated crop production, manure runoff, and hydrologic alterations caused by crop land drainage (subsurface field tiles/drains) (Ohio EPA 2010a). In contrast, Otter Creek flows through urbanized land and is affected by urban runoff, industrial runoff and channelization. A summary of the watersheds is presented in Table 3-1.

Table 3-1. Summary of Lake Erie tributaries (HUC 04100010 07)

Watershed name	HUC (04100010)	Narrative description	Drainage area (mi^2)
Turtle Creek – Frontal Lake Erie	07 01	Turtle Creek plus Lake Erie drainage between Crane Creek and Toussaint Creek	40.66
Crane Creek – Frontal Lake Erie	07 02	Crane Creek (includes Henry Creek)	56.48
Cedar Creek – Frontal Lake Erie	07 03	Cedar Creek including Reno Side Cut and Ward Canal plus Lake Erie drainage between Reno Side Cut and Crane Creek	58.05
Wolf Creek – Frontal Lake Erie	07 04	Lake Erie drainage between Berger Ditch and Reno Side Cut	15.16
Berger Ditch	07 05	Wolf Ditch and Berger Ditch	16.06
Otter Creek – Frontal Lake Erie	07 06	Lake Erie drainage between the Maumee River and Berger Ditch	18.00

Source: Ohio EPA 2010a.

The Maumee River (lower) tributaries are in Lucas and Wood counties. The tributaries are delineated by the *Grassy Creek – Maumee River* 10-digit HUC (04100009 09) and consist of the following: Grassy Creek, Grassy Creek Diversion, Crooked Creek, Delaware Creek, and Duck Creek *(*Figure 1-2*)*. Ohio EPA (2010) provides a description of select lower Maumee River tributaries. Grassy Creek begins in Perrysburg and flows parallel along the south side of the Maumee River toward Rossford where it joins the Maumee River mainstem at river mile 9.6. The combined drainage area of Grassy Creek and Grassy Creek Diversion is 38.6 miles. Delaware Creek is a small tributary that flows through the city of Toledo, entering the Maumee at river mile 9.2 (Ohio EPA 2010a). With the exception of Grassy Creek Diversion, these Maumee River (lower) tributaries generally flow through densely developed or urbanized areas. Broad water quality effects caused by urban development are urban storm water runoff, industrial runoff, and channelization (Ohio EPA 2010a). A summary of the watersheds in the lower Maumee River is presented in Table 3-2.

Table 3-2. Summary of Maumee River (lower) tributaries (HUC 04100009 09)

Watershed name	HUC (04100009)	Narrative description	Drainage area (mi^2)
Grassy Creek Diversion	09 01	Grassy Creek Diversion	24.78
Grassy Creek	09 02	Grassy Creek	13.68
Crooked Creek – Maumee River	09 03	Maumee River below North Granger Island to above Grassy Creek (except Grassy Creek Diversion)	18.89
Delaware Creek – Maumee River	09 04	Maumee River below Grassy Creek to Lake Erie (except the Swan River)	19.25

3.2 Land Use and Land Cover

The most significant effects on water quality often result from surrounding land use practices. For example, activities in agricultural areas can sometimes result in increased concentrations of pollutants such as bacteria, sediment, nutrients, and pesticides being delivered from land surfaces to nearby waters. In general, industrial land uses can result in a wide variety of pollutants, including metals and toxic organic compounds. Urban development increases impervious cover, which can increase runoff rates and volume. As a result, a wide variety of pollutants can wash from impervious surfaces into surface waters.

Land use in the Lake Erie tributaries is dominated by cultivated cropland (64 percent). Other land uses include low-intensity development (10 percent), emergent herbaceous wetlands (8 percent), and developed open space (6 percent). Figure 3-1 shows land use in the watersheds draining to the Lake Erie tributaries. The acreage and percent of land use in the Lake Erie tributaries (HUC 041100010 07) are shown in Table 3-3.

Land use in the Maumee River (lower) tributaries, as shown in Figure 3-1, is dominated by cultivated cropland (36 percent), low intensity development (23 percent), and developed open space (15 percent). Other land uses include medium-intensity development (9 percent) and open water (7 percent). The acreage and percent of land use in the lower Maumee River (lower) tributaries (HUC 041100009 09) are shown in Table 3-3.

Table 3-3. Land cover in the project area

Land cover class	Project area		Lake Erie tributaries		Maumee River (lower) tributaries	
	Acres	Percent	Acres	Percent	Acres	Percent
Open Water	5,743	3%	2,277	2%	3,466	7%
Developed, Open Space	15,723	9%	8,305	6%	7,417	15%
Developed, Low Intensity	23,502	13%	12,478	9%	11,024	22%
Developed, Medium Intensity	9,161	5%	4,630	3%	4,531	9%
Developed, High Intensity	4,143	2%	2,473	2%	1,669	3%
Barren Land	1,119	<1%	827	<1%	292	<1%
Deciduous Forest	4,485	2%	2,815	2%	1,670	3%
Evergreen Forest	17	<1%	13	<1%	4	<1%
Grassland/Herbaceous	2,925	2%	2,397	2%	529	1%
Pasture/Hay	1,109	<1%	1,058	<1%	51	0%
Cultivated Crops	100,536	56%	83,127	64%	17,409	36%
Woody Wetlands	100	<1%	55	<1%	45	<1%
Emergent Herbaceous Wetlands	10,960	6%	10,110	8%	850	2%
Total	**179,523**	**100%**	**130,565**	**100%**	**48,957**	**100%**

Source: 2006 NLCD (MRLC 2006).
Note: Acreages and percentages were rounded to the nearest integer.

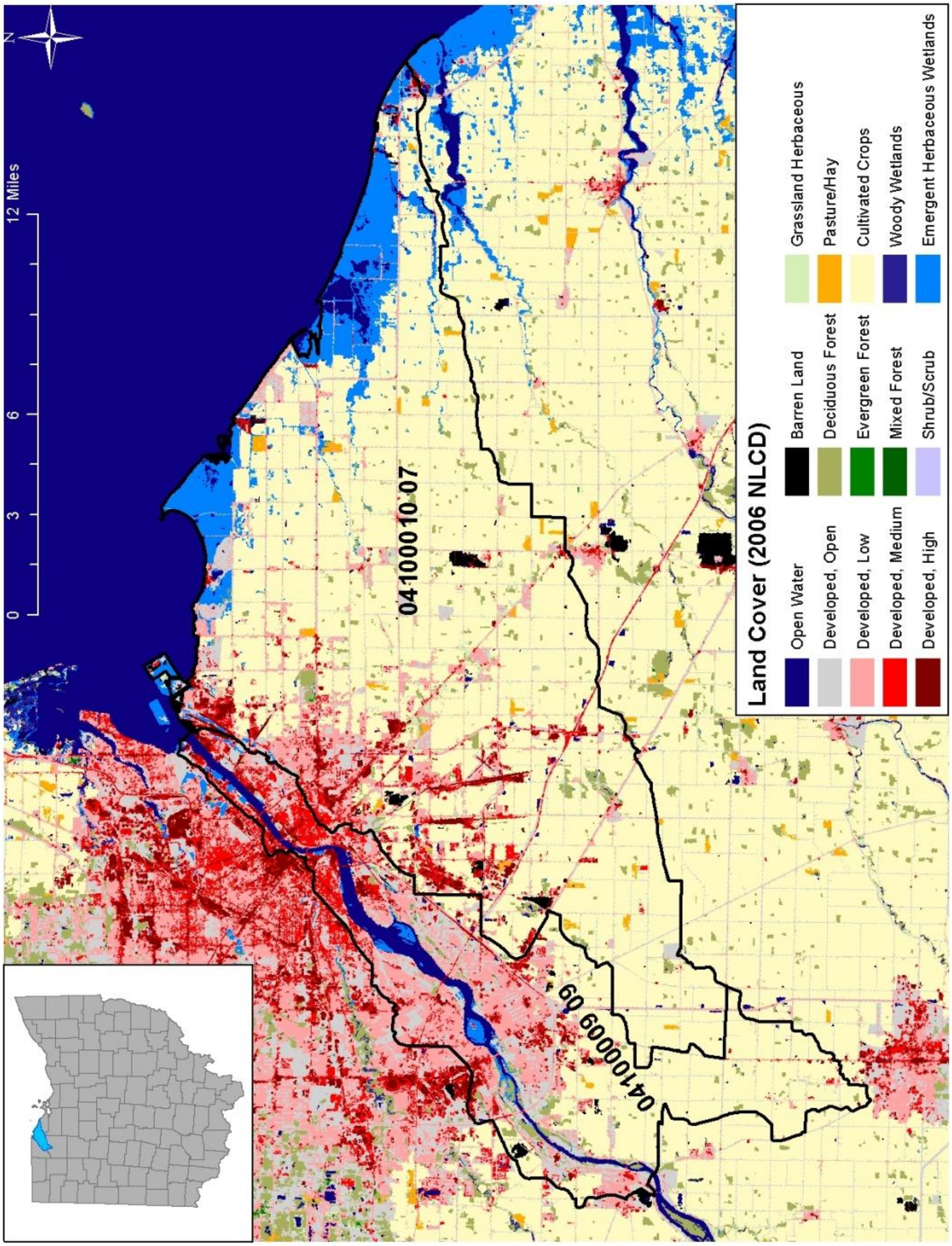


Figure 3-1. Project area land use.

3.3 Geology and Soils

The Maumee AOC, which includes the project area, is in the Huron/Erie Lake Plains (HELP) ecoregion (Maumee RAP and Duck and Otter Creek Partners, Inc. 2006). Glacial advance and retreat was highly influential in the topography, geology, and soils that developed in the HELP ecoregion. Glacial advances and retreats occurred during the Illinoisan and Wisconsin Glaciations (WCCGHD 2004). In general, as glaciers advanced, existing rocks and soils were eroded repeatedly. These materials were re-deposited as sediments during several ice advance, melt, and retreat cycles. Such glacial materials were deposited as sands, gravels, silts, and clays; the melt water created large rivers, which carried and spread the deposited glacial materials throughout the region. Glacial deposits and associated land forms exerted a major effect that influences present day hydrology, soil types, and land cover.

3.3.1 Ecoregion Overview

The project area is in the HELP level III ecoregion 57 and includes three level IV ecoregions (Figure 3-2). The general physiography and geology (Table 3-4) and soils (Table 3-5) of these three level IV ecoregions are described below.

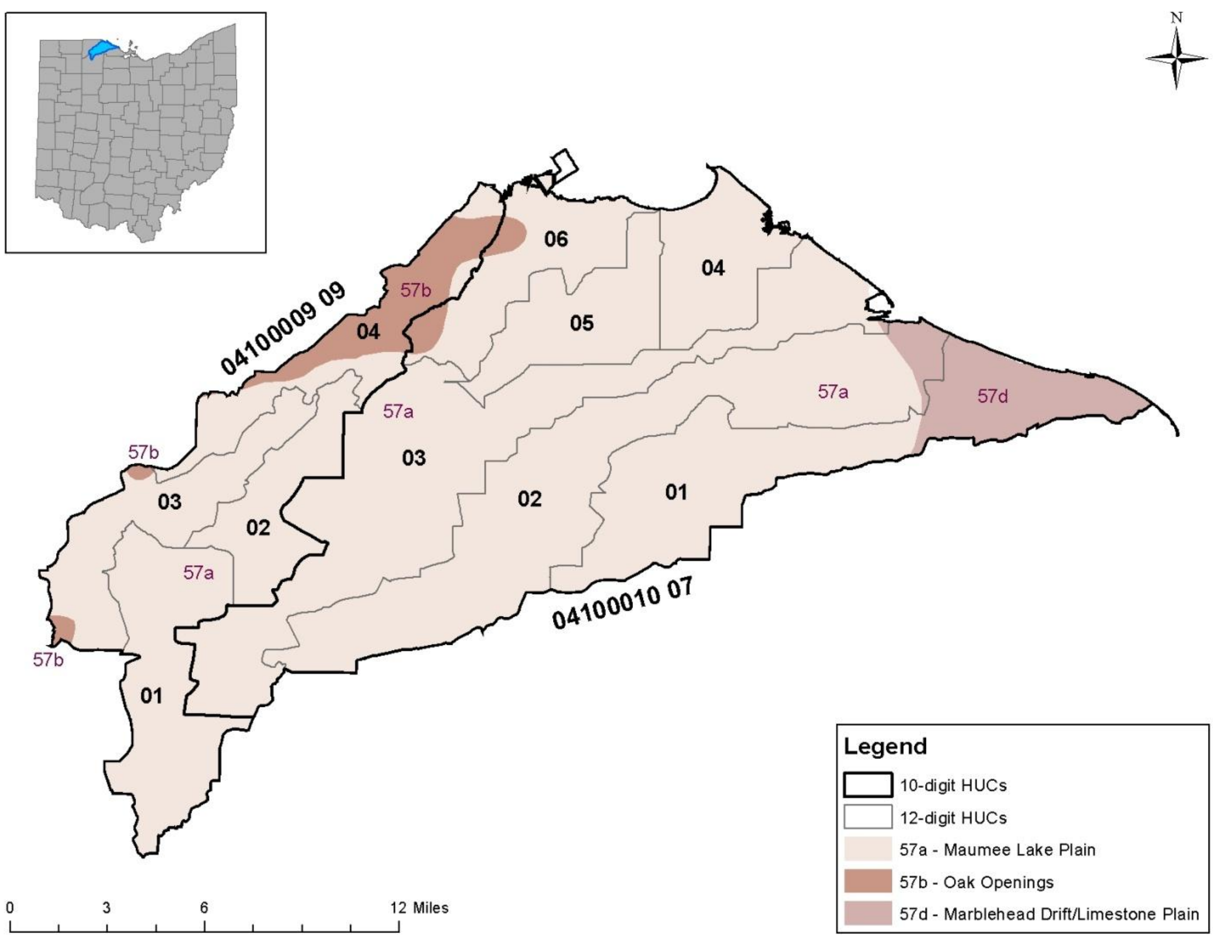


Figure 3-2. Level IV ecoregions in the project area.

Table 3-4. Summary of level IV ecoregion physiography and geology

Ecoregion	Physiography	Geology
Maumee Lake Plain (57a)	Glaciated. Nearly level to depressional glacial lake plain with paleobeach ridges, limestone ridges, and end moraines. Sluggish, low gradient streams, many with high loads of suspended clay. Channelized streams and ditches with clayey channels are common.	Fine, poorly drained, water-worked glacial till and lacustrine sediment; also coarser end moraine and beach ridge deposits. Occasional outcrops of underlying Silurian and Devonian limestone and dolomite occur.
Oak Openings (57b)	Glaciated. Low, relict sand dunes, paleobeach ridges, sand sheets, and intervening pans occur.	Late-Wisconsinan sand dunes, sandy beach ridges, clayey glacial till, and fine lacustrine material overlie Devonian and Mississippian carbonates and shale.
Marblehead Drift/ Limestone Plain (57d)	Glaciated. Mostly a broad lake plain with exposures of carbonate bedrock, end moraines, beach ridges, sand dunes at Cedar Point, marl prairies near Castalia, and sink holes. Streams often flow on carbonate bedrock.	Sometimes thin, fine, poorly drained, water-worked, glacial till and lacustrine sediment; also coarser end moraine and beach ridge deposits. Outcrops of the underlying Silurian and Devonian carbonate bedrock occur.

Source: Woods et al. 2011.

All three of the level IV ecoregions have soils with temperature and mesic/udic and aquic moisture regimes (Woods et al. 2011). A summary of soil orders and common series are presented in Table 3-5.

Table 3-5. Summary of level IV ecoregion soils

Ecoregion	Common soil series
Maumee Lake Plain (57a)	On water-worked glacial till: Hoytville, Nappanee, Blount, Miamian. On clayey to very clayey lake deposits: Toledo, Latty. On coarser sediments above lacustrine material: Mermill.
Oak Openings (57b)	On sandy sediments: mostly Ottokee, Granby, and Tedrow. In scattered loamy areas: Colwood, Mermill.
Marblehead Drift/Limestone Plain (57d)	On glacial lake sediments: Kibbie, Toledo. On water-worked glacial till: Hoytville, Nappanee, Blount. On or near dolomitic limestone bedrock: Castalia, Milton, Millsdale.

Source: Woods et al. 2011.

3.3.2 Bedrock Geology

Limestone bedrock underlies the glacial drift throughout the project area. “The uppermost bedrock strata consist of Silurian dolomite and dolomitic limestone” (OCGHD 2004, p. 6). In the eastern regions of Wood County, bedrock is present at the ground surface (WCCGHD 2004). This carbonate aquifer in Silurian and Devonian rocks, which underlies much of the project area, is the primary rural domestic and irrigation water supply (Breen and Dumochelle 1991).

Breen and Dumochelle (1991) reported that the Greenfield formation, which is Silurian-aged brown bedrock and about 50 feet thick, underlies the areas along the lower Maumee River and the Maumee Bay in the project area. The lower portions of the Turtle Creek and Frontal Lake Erie watershed (HUC 04100010 07 01) are underlain by the Bass Islands Group, also a Silurian-age bedrock. The Bass Islands Group in this area overlies Lockport Dolomite. The remaining portions of the project area are underlain by the gray to white Lockport Dolomite bedrock, which is 125 to 145 feet thick.

An in-depth discussion of the geologic setting (e.g., bedrock stratigraphy, structural features) can be found in *Geohydrology and Quality of Water in Aquifers in Lucas, Sandusky, and Wood Counties, Northwestern Ohio* (Breen and Dumochelle 1991).

3.3.3 Soils

Soils in the project area are typical of the HELP ecoregion, which consists of glacial till and *lacustrine* (relating to lake) deposits, and are very poorly drained; the glacial till is primarily ground moraine overlying limestone bedrock (Ohio EPA 2010a). The glacial tills and lacustrine deposits are derived from the Wisconsin Glaciation (OCGHD 2004). The thickness of the till is highly variable across the project area from over 120 feet to only a few feet (Breen and Dumochelle 1991).

Portions of the lower Maumee River watershed and Lake Erie drainage are in the Great Black Swamp. The Great Black Swamp was the bottom of a glacial lake and is made of impermeable silt and clay soils with occasional sand ridges or lenses (TMACOG 2011, p. 15). Certain areas of the Maumee Lake Plains level IV ecoregion (refer back to the map in Figure 3-2) have shallow bedrock and seasonally high ground water. Ditches were constructed during settlement to drain the swamp and provide for more productive farming (TMACOG 2011).

The National Cooperative Soil Survey publishes soil surveys for each county in the United States. Soil surveys contain predictions of soil behavior and also highlight limitations and hazards inherent in the soil, general improvements needed to overcome the limitations, and the effect of selected land uses on the environment. The soil surveys are designed for many different uses, including land use planning.

Hydrologic soil group (HSG) refers to the grouping of soils according to their runoff potential. Soil properties that influence HSGs include depth to seasonal high water table, infiltration rate and permeability after prolonged wetting, and depth to slow permeable layer. Table 3-6 identifies those HSGs found in the tributary watersheds and provides a summary description of each group.

Figure 3-3 identifies soil groups in the project area watershed surrounding the lake and river tributaries respectively. Generally, soils in this area are typically composed of fine particles that are very poorly drained. Very poorly drained soils are characterized as follows, “water is removed from the soil so slowly that free water remains at or on the surface during most of the growing season. Unless the soil is artificially drained, most crops cannot be grown” (Maumee RAP and Duck and Otter Creek Partners, Inc. 2006). Table 3-7 presents a summary of HSGs in the project area.

Table 3-6. HSG descriptions

HSG	Group description
A	Sand, loamy sand or sandy loam types of soils. Low runoff potential and high infiltration rates even when thoroughly wetted. Consist chiefly of deep, well- to excessively drained sands or gravels with a high rate of water transmission.
B	Silt loam or loam. Moderate infiltration rates when thoroughly wetted. Consist chiefly or moderately deep to deep, moderately well- to well-drained soils with moderately fine to moderately coarse textures.
C	Soils are sandy clay loam. Low infiltration rates when thoroughly wetted. Consist chiefly of soils with a layer that impedes downward movement of water and soils with moderately fine to fine structure.
D	Soils are clay loam, silty clay loam, sandy clay, silty clay or clay. Group D has the highest runoff potential. Low infiltration rates when thoroughly wetted. Consist chiefly of clay soils with high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface and shallow soils over nearly impervious material.
A/D B/D C/D	Dual HSGs. Certain wet soils are placed in group D solely on the basis of the presence of a water table within 24 inches of the surface even though the saturated hydraulic conductivity might be favorable for water transmission. If these soils can be adequately drained, they are assigned to dual HSGs (A/D, B/D, and C/D) according to their saturated hydraulic conductivity and the water table depth when drained. The first letter applies to the drained condition and the second to the un-drained condition.

Source: Soil Data Viewer 6.0 (NRCS 2011).

Table 3-7. Summary of HSG distribution in the project area

HUC	Watersheds	A	B	C	D	A/D	B/D	C/D	NR
Lake Erie tributaries (HUC 04100010 07)									
01	Turtle Creek – Frontal Lake Erie	1%	--	<1%	18%	<1%	<1%	**76%**	4%
02	Crane Creek – Frontal Lake Erie	2%	<1%	--	11%	<1%	<%	**84%**	3%
03	Cedar Creek – Frontal Lake Erie	1%	<1%	--	4%	<1%	2%	**85%**	8%
04	Wolf Creek – Frontal Lake Erie	<1%	--	--	1%	--	--	**95%**	5%
05	Berger Ditch	--	1%	--	1%	1%	6%	**91%**	1%
06	Otter Creek – Frontal Lake Erie	<1%	1%	--	1%	1%	9%	22%	**66%**
Maumee River (lower) tributaries (HUC 04100009 09)									
01	Grassy Creek Diversion	2%	1%	--	3%	1%	0%	**92%**	1%
02	Grassy Creek	<1%	--	--	7%	--	3%	**82%**	7%
03	Crooked Creek – Maumee River	1%	11%	--	10%	1%	7%	**47%**	23%
04	Delaware Creek – Maumee River	<1%	1%	--	1%	1%	9%	22%	**66%**

Notes
NR = not reported
A double dash (--) indicates that an HSG was not present in the watershed. **Bolded** values are the largest percentage per watershed.
Values might not sum to 100 percent because of rounding.

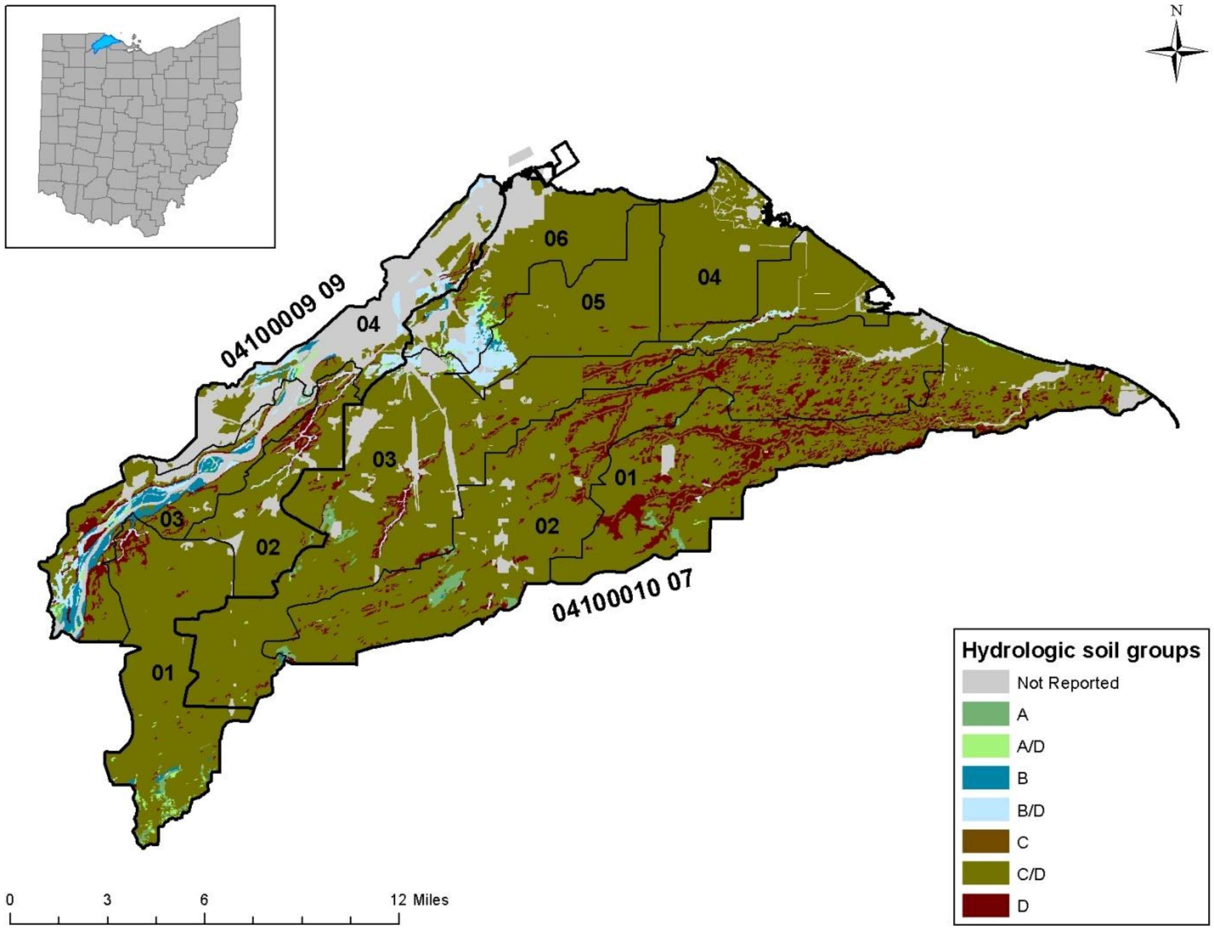


Figure 3-3. HSGs in the project area.

3.4 Climate

The climate of the Great Lakes region is determined primarily by westerly atmospheric circulation, the latitude, and the local modifying influence of nearby Lake Erie (Derecki 1976). This combination tends to increase humidity and can create lake effect precipitation during the cold fall and winter months. Despite that, the proximity to Lake Erie also moderates the local climate as the large waterbody acts as a heat sink or source, warming the air in cold months and cooling the air in the summer.

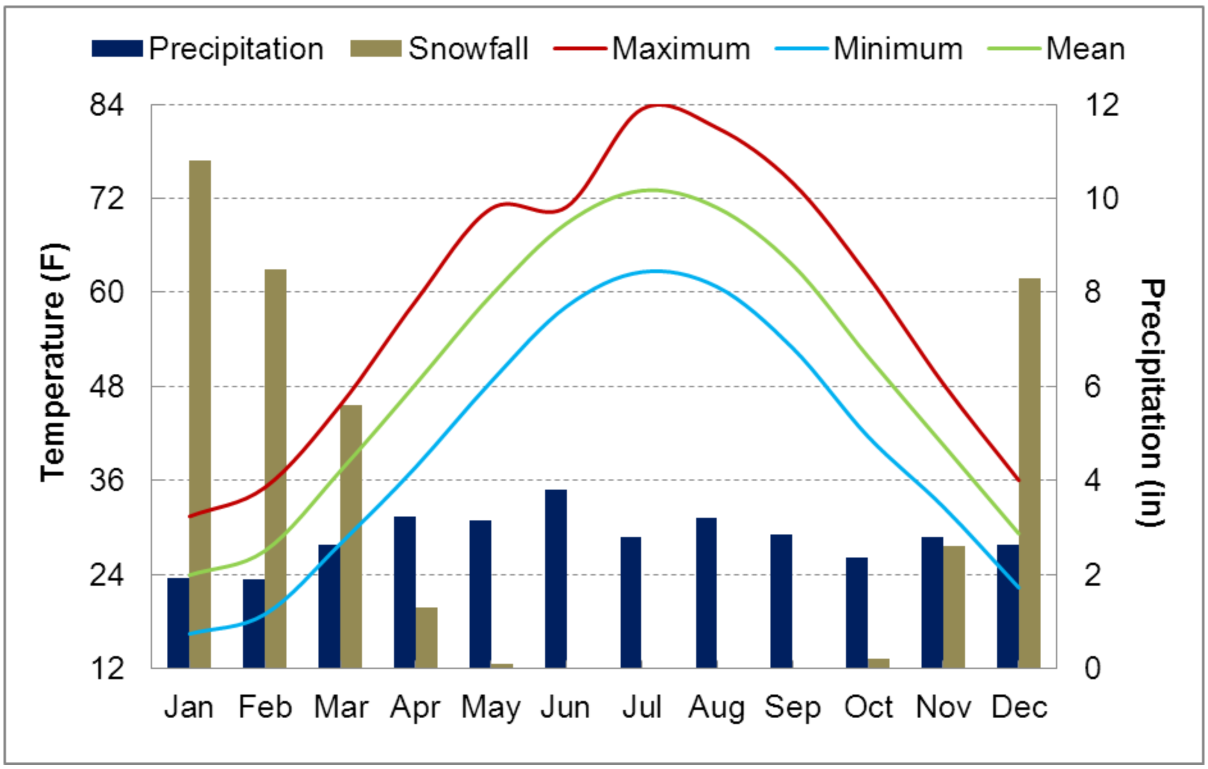
Table 3-8 contains historic temperature and precipitation data collected at Toledo (station 338357) from 1971 to 2000. The average winter temperature in Toledo during this period was 26.7 degrees Fahrenheit (°F) and the average summer temperature was 70.9 °F (Table 3-8). The median growing season (consecutive days with low temperatures of 32 °F or higher) is 160 days. Total annual precipitation is approximately 33.21 inches. Snowfall in the region is approximately 38 inches, which is roughly 3.8 inches of precipitation assuming a 10:1 ratio of snowfall to water equivalent. Monthly temperature and precipitation are depicted in Figure 3-4 for Toledo.

Examination of precipitation patterns is a key part of watershed characterization. Rainfall intensity and timing affect the watershed response to precipitation. That information is important in evaluating the effects of storm water on the tributaries. Figure 3-5 presents one way to show rainfall intensity. Using

1955 to 2000 data from the Toledo Express Airport station, 63 percent of the precipitation events were very low intensity (i.e., less than 0.2 inch). On the other hand, 4.1 percent of the measurable precipitation events were greater than one inch.

Table 3-8. Temperature and precipitation data summary for Toledo (station 338357).

Parameter/month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average high (°F)	31.4	35.1	45.6	58.9	70.7	70.9	83.4	81.0	74.0	62.1	48.3	36.0
Average low (°F)	16.4	18.9	27.9	37.7	48.6	58.2	62.6	60.7	52.9	41.6	32.6	22.3
Average mean (°F)	23.9	27.0	37.2	48.3	59.6	68.8	73.0	70.8	63.5	51.8	40.5	29.2
Average precipitation (in)	1.93	1.88	2.62	3.24	3.14	3.80	2.80	3.19	2.84	2.35	2.78	2.64
Average snowfall (in)	10.8	8.5	5.6	1.3	0.1	0	0	0	0	0.2	2.6	8.3



Note: Temperatures and precipitation are reported as monthly averages.

Figure 3-4. Summary of temperature and precipitation for Toledo (338357).

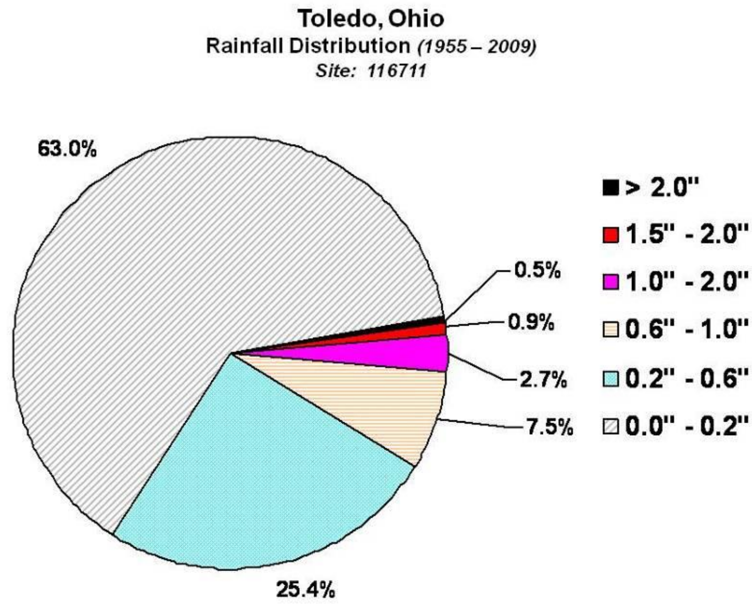


Figure 3-5. Precipitation intensity at the Toledo Express Airport.

3.5 Hydrology

Hydrology plays an important role in evaluating water quality. In the project area, hydrology is primarily driven by local climate conditions. This includes situations that often result in flashy flows, where the stream responds to and recovers from precipitation events relatively quickly. The project area is in the Great Black Swamp, an area characterized by poorly infiltrating soils. The clay soils of the Swamp resulted in heavy, and at times deep, mud. Such conditions historically limited settlement until the area was drained by the construction of extensive ditches. It is now estimated that there are three miles of man-made streams for every mile of natural stream are in the swamp (Maumee RAP and Duck and Otter Creek Partners, Inc. 2006). Once drained, the area was more suitable for settlement, and agriculture quickly spread.

Converting the Great Black Swamp to agricultural land also was helped by installing subsurface tiles to improve drainage. That practice is generally referred to as *field tiling* and involves subsurface drains (e.g., corrugated plastic tile or pipe) installed below the surface that serve as conduits to collect or convey drainage water, either to a stream channel or to a surface field drainage ditch. While the drainage improvements increase the amount of land available for cultivation, they also influence the hydrology, aquatic habitat, and water quality of area streams.

Drains intercept precipitation and snowmelt as it infiltrates the subsurface soil layer. The intercepted water would normally reach the water table where it would be stored as ground water. Instead, the subsurface flow is quickly conveyed through the network of drains and ditches to nearby waterbodies. The process can increase the volume of water that reaches local streams during rainfall and snowmelt events, which leads to a rapid rise in stream levels during runoff events. Often, the rapid response is similar to that observed in areas where natural vegetation has been replaced by impervious surfaces. Extensive tiling can also alter the quality of drainage water exiting the fields to receiving waters. For example, shorter delivery times to a stream often reduce the benefits associated with longer filtration through soil layers.

The lower segments of each of the tributaries discharging to Lake Erie are lacustrine, which means that waters from the streams and Lake Erie mix within a freshwater estuary These lacustuaries are slack water that can ebb and flow as lake seiches affect water levels and are generally located between the farthest downstream riffle of the tributary and Lake Erie proper. All tributaries of lacustuaries are considered lacustuaries below the Lake Erie mean high water level. The TMDLs presented in this report were developed at sites just upstream of the lacustuaries. TMDLs were not generated in the lacustruaries because the ebb and flow makes the loadings less predictable.

The U.S. Geological Survey (USGS) maintains flow gages at several locations in or nearby to the project area (Table 3-9). Below is a summary of hydrologic trends in the Maumee River (lower) tributaries and Lake Erie tributaries. Figure 3-6 and Figure 3-7 illustrate the potential variability of flow for streams in the project area using the Ottawa River and Berger Ditch gages. The graphs also show daily precipitation measured at the Toledo airport site.

Table 3-9. USGS stream gages in the project vicinity

Gage ID	Area (mi.^{2})	Location	Latitude	Longitude	Period of record
04177000	150	Ottawa River at Toledo	41° 39' 35"	83° 36' 45"	1945–2012
04193500	6,330	Maumee River at Waterville	41° 30' 00"	83° 42' 46"	1898–2012
04194082	13.1	Wolf Ditch at Oregon	41° 39' 10"	83° 22' 59"	2010–2012
04194085	15.4	Berger Ditch near Oregon	41° 40' 32"	83° 22' 16"	2006–2012

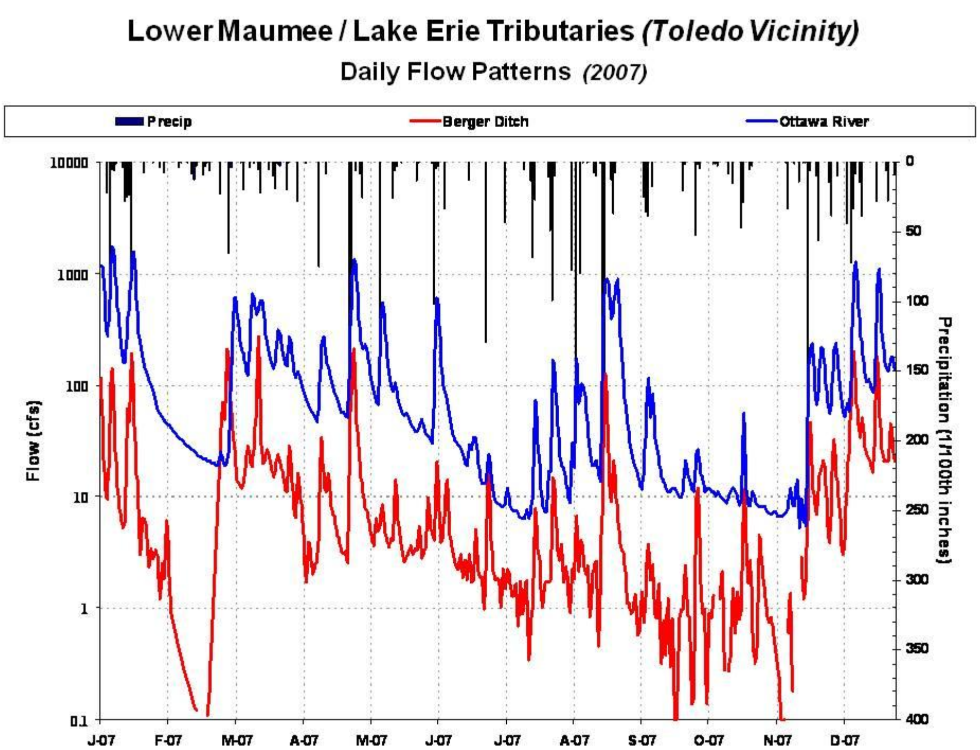


Figure 3-6. Daily average flow at several USGS gages in the project area, 2007.

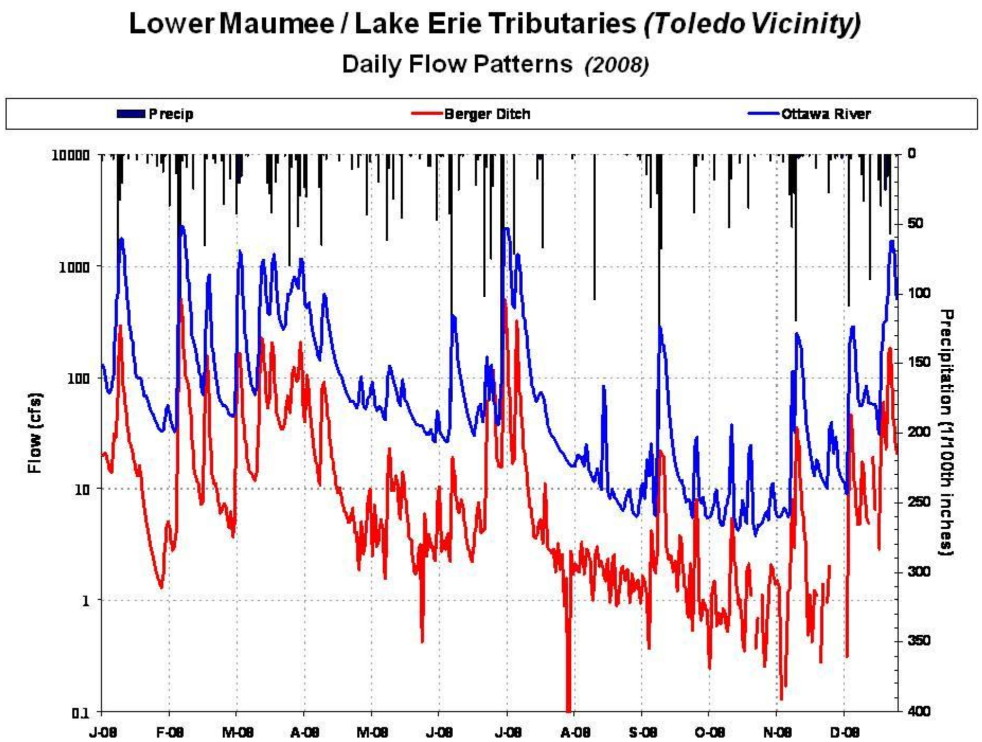


Figure 3-7. Daily average flow at several USGS gages in the project area, 2008.

3.6 Community Profile

Lake Erie, and specifically the Maumee region, was one of the last areas of the Great Lakes region to be discovered and populated by Europeans (Maumee RAP and Duck and Otter Creek Partners, Inc. 2006). The area remained relatively undeveloped until the region experienced rapid population growth in response to the industrialization in the late 1800s and early 1900s. With the completion of the Erie Canal, industry and commerce began to grow. By 1880, Toledo's population was more than 50,000.

The automotive industry, glass manufacturing, and oil refiners found the abundant water supply of the Maumee River and Lake Erie a valuable resource (Maumee RAP and Duck and Otter Creek Partners, Inc. 2006). As industry grew, so did surrounding populations and water quality effects. In the 1960s, industry began to leave the area, and a population shift from urbanized areas to suburban areas occurred. As an example of this shift, between 1990 and 2000, Toledo lost 5.8 percent of its population, and between 2000 and 2010, the City lost 8 percent. In contrast, rapid growth occurred in surrounding areas such as Rossford (increased 109 percent) and Millbury Village (increased 107 percent) (Maumee RAP and Duck and Otter Creek Partners, Inc. 2006).

Population changes for major population centers in the project area are summarized in Table 3-10. The most densely populated areas of the project area are near Toledo and Oregon (Figure 3-8).

Table 3-10. Major population centers in the project area

Location	2000 Census	2010 Census	Change
Lucas County	**455,054**	**441,815**	**–2.9%**
Maumee (city)	15,237	14,286	–6.2%
Oregon (city)	19,355	20,291	+4.8%
Toledo (city)	313,619	287,208	–8.4%
Ottawa County	**40,985**	**41,428**	**+1.1%**
Allen (township)	3,591	3,780	+5.3%
Benton (township)	2,621	2,641	+0.8%
Carroll (township)	1,931	2,135	+10.6%
Clay (township)	5,118	5,058	–1.2%
Wood County	**121,065**	**125,488**	**+3.7%**
Bowling Green (city)	29,636	32,028	+8.1%
Lake (township)	10,350	10,972	+6.0%
Northwood (city)	5,471	5,265	–3.8%
Perrysburg (city)	16,945	20,623	+2.2%
Perrysburg (township)	13,613	12,512	–8.1%
Rossford (city)	6,406	6,293	–1.8%

Source: U.S. Census Bureau 2011

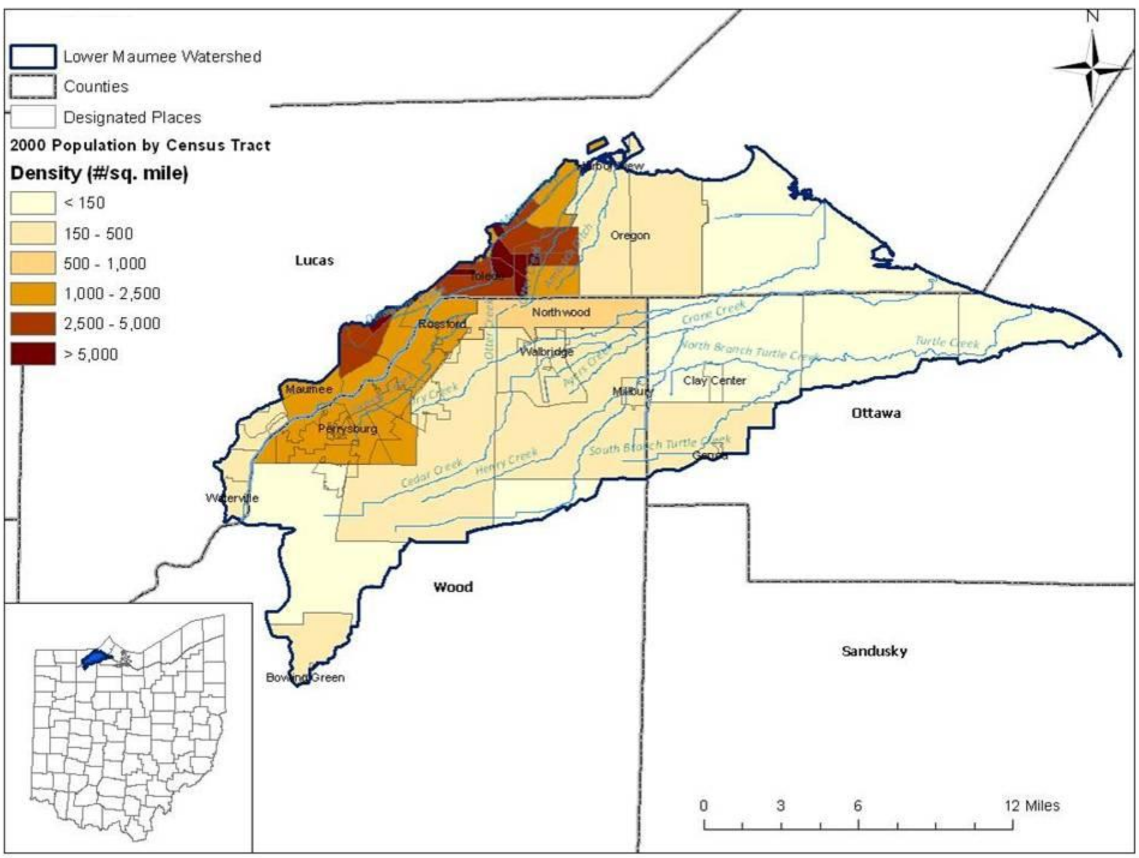


Figure 3-8. Project area population density.

4 Source Assessment

Source assessments are an important component of water quality management plans and TMDL development. These analyses are generally used to evaluate the type, magnitude, timing, and location of pollutant loading to a waterbody (U.S. EPA 1999). Source assessment methods vary widely with respect to their applicability, ease of use, and acceptability. The purpose of this section is to identify possible sources in the Maumee River (lower) tributaries and Lake Erie tributaries project area.

To facilitate the source assessment, the Maumee River (lower) tributaries and Lake Erie tributaries drainages have been partitioned into watersheds that are consistent with 12-digit HUCs. Using watersheds creates an opportunity for watershed managers to relate source information to water quality monitoring results and sets the stage for the TMDL linkage analysis. The ability to summarize information at different spatial scales strengthens the overall TMDL development process and enables more effective targeting of implementation efforts.

The first section below presents the pollutants of concern that cause impairments in the project area. The next two sections provide general information regarding point sources and nonpoint sources in the project area. The chapter then continues with sections devoted to the evaluation of basic characteristics of each watershed (12-digit HUC). Each section that describes a watershed also includes analyses of selected Ohio EPA sample sites that are most representative of the impairments in that watershed. The subwatersheds draining to important Ohio EPA water quality sampling stations were delineated using USGS StreamStats (Koltun 2006)[3].

4.1 Pollutants of Concern

Pollutants of concern discussed in this source assessment include bacteria, sedimentation/siltation, ammonia, nitrate plus nitrite, total phosphorus, dissolved oxygen, and organic enrichment. These pollutants can originate from an array of sources including point source discharges (e.g., industrial pipes) and surface runoff, particularly storm water and agricultural runoff.

4.1.1 Escherichia coli

Microorganisms are ubiquitous across the world and while most are not harmful to humans, pathogens (i.e., disease causing microorganisms) are a small subset of microorganisms that can cause sickness or death when taken into the body (U.S. EPA 2001). Certain bacteria typically indicate the presence of pathogens. *E. coli* is an indicator of pathogenic bacteria and Ohio has established numeric criteria for *E. coli* based upon designated recreation uses.

In-stream pathogen levels decrease over time. The die-off is controlled by factors including: sunlight, temperature, moisture conditions, and salinity (U.S. EPA 2001, p. 2-7). In-stream pathogen levels are dependent upon the die-off rate and the time and distance from the source to the waterbody of interest.

Typical sources of pathogenic bacteria include WWTP and CSOs (U.S. EPA 2001). Sewage that is not sufficiently treated or that bypasses wastewater treatment (e.g., CSOs) may result in elevated levels of in-stream pathogens when discharged to a surface waterbody. “Other point sources that can contribute substantial loads of pathogens and fecal indicators to waterbodies include concentrated animal feeding operations, slaughterhouses and meat processing facilities; tanning, textile, and pulp and paper factories; and fish and shellfish processing facilities” (U.S. EPA 2001, p. 2-6). Regulated storm water may transport

[3] StreamStats for Ohio is located online at http://streamstats.usgs.gov/ohio.html.

animal excrement deposited by pets or wildlife to nearby streams following precipitation events that result in storm water runoff.

Nonpoint sources of pathogens can be residential (e.g., HSTS, pets), agricultural (e.g., livestock, manure application to crops fields), and natural (e.g., wildlife). HSTS that are not functioning properly may discharge untreated sewage to downstream waterbodies. Pet excrement deposited in residential areas, wildlife excrement deposited in rural areas, livestock excrement deposited on pastures and barnyards, and manure applied to crop fields or stored improperly may be transported to streams after precipitation events that result in storm water runoff.

Pathogens can also enter the water column when pathogens attached to sediment are re-suspended. Runoff will increase the velocity of water in a stream, which may yield sufficient power to scour the bottom of the stream.

4.1.2 Sedimentation and Siltation

Sedimentation and siltation are controlled by stream hydrology. Streams with high flows can result in channel scour and erosion of the stream channel. Those steams are also able to transport larger sediment particles further distances. Streams that are dominated by lower flow conditions will deposit sediment and associated pollutants resulting in poor quality habitat and loss of spawning beds. In addition, low flowing streams will have lower dissolved oxygen levels. A stream’s assimilative capacity for pollutant loads from the watershed will depend on its ability to balance all those factors.

Stream channels develop in response to hydrologic regimes. Urban streams transport many times more sediment than streams in undeveloped areas (Schueler 2004). When urban flow regimes replace natural flow regimes, streams must change and that usually involves increasing the cross-sectional area to accommodate larger flows (Schueler 1994). The urban streams tend to have impervious surfaces that alter the hydrologic regime (e.g., higher magnitude flows, more frequent high flows), which then increases the erosion of the streambed and banks and increases resuspension of bed sediment (U.S. EPA 2010). Additionally, urban streams can contain sediment that is contaminated with toxic substances (Schueler 2004). Incision, erosion, channel enlargement, and other such alterations that occur in response to the urban hydrologic regime can be a produced slowly over a long time or in response to a single large storm water runoff event (Shaver et al. 2007). Such stream channel alterations result in channel instability that degrades habitat (Schueler 1994).

Agricultural activities such as livestock grazing and the plowing or tilling of crop fields result in de-vegetated, exposed soil that is susceptible to erosion (U.S. EPA 2012). Drain tiles may also increase erosion since runoff that travels through tiles has increased peak flows and faster velocities, both of which increase erosion. Runoff transported by tiles may have higher concentrations of suspended sediment and may contribute to sedimentation at the pipe outfall if the flow in the stream has a slower velocity than the flow in the tile.

Channelized streams are present throughout the project area. Streams are channelized to purposefully direct and control flow in both urban and rural areas. Channelization results in higher peak flows that travel more rapidly; these more powerful flows have greater capacity to erode the channels banks and can carry more sediment farther. The effects of channelization with regards to erosion and sedimentation are presented in Section 4.3.3.2.

Typical sources of sediment derived from in-stream processes include: incised channels, channel modification, and eroding and collapsing stream banks (U.S. EPA 2012). Sediment is also derived from eroding soil from anthropogenic activities in both agricultural areas (e.g., livestock grazing, plowing) and urban areas (e.g., construction, roads) and eroding soil from natural processes (e.g., landslides, burnt forests) (U.S. EPA 2012).

4.1.3 Nitrogen Species

Ammonia, nitrate, and nitrite are part of the nitrogen cycle, which is critical to any ecosystem; for a brief summary of the nitrogen cycle see the *Associations* document (Ohio EPA 1999, p. 11) and the *Protocol for Developing Nutrient TMDLs* (U.S. EPA 1999, p. 2-3). Basically, molecular nitrogen (N_2) is extremely stable and unreactive; molecular nitrogen must be *fixed* (i.e., combined with other elements) to become biologically available (Spiro and Stigliani 2003, p. 358). "The majority of naturally occurring nitrogen fixation is accomplished by certain bacteria and blue-green algae" that reduce molecular nitrogen to ammonia (NH_3) (Spiro and Stigliani, p. 358). Plants uptake ammonia and use it to create plant proteins. Organic nitrogen from plants and animals that die is converted back to ammonia through bacterial decomposition (i.e., *ammonification*). Other bacteria convert ammonia to nitrite and then to nitrate by oxidation in aerobic conditions (i.e., *nitrification*). Plants can also uptake nitrate; "[t]hus, there is a continual cycling between oxidized and reduced forms of fixed nitrogen in soils" (Spiro and Sigliani, p. 361). In anaerobic conditions, nitrate can be converted back to molecular nitrogen (i.e., *denitrification*). U.S. EPA (1999, p. 2-3) describes nitrogen cycling in aquatic ecosystems as follows:

> Nitrogen continuously cycles in the aquatic environment, although the rate is temperature-controlled and thus very seasonal. Aquatic organisms incorporate available dissolved inorganic nitrogen into proteinaceous matter. Dead organisms decompose, and nitrogen is released as ammonia ions and then converted to nitrite and nitrate, where the process begins again. If a surface water lacks adequate nitrogen, nitrogen-fixing organisms can convert nitrogen from its gaseous phase to ammonia ions.

Inorganic nitrogen does not strongly sorb to sediment like phosphorus and can be transported in water in either as dissolved ions or as particulates (U.S. EPA 1999). Molecular nitrogen may dissolve directly into surface water while its dissolved forms may be transported through subsurface flow (e.g., interflow, ground water flow). Once nitrogen-species enter surface waters, they

> can be taken up by algae, macrophytes and micro-organisms (either in the water column or in the benthos); sorbed to organic or inorganic particles in the water and sediment; accumulated or recycled in the sediment; or transformed and released as a gas from the waterbody (denitrification) (U.S. EPA 2000, p. 7).

Ammonia and nitrate plus nitrite are pollutants of concern in the Maumee River (lower) tributaries and Lake Erie tributaries project area; each of these nitrogen-species is discussed in a section below.

4.1.3.1 Ammonia

Though ammonia is an important component of the natural world, at elevated concentrations it can produce harmful effects. Ammonia is toxic to aquatic life, and ammonia nitrification to nitrate creates an oxygen demand that lowers dissolved oxygen levels (U.S. EPA 2002). Ammonia toxicity is addressed in this report as related to ALU designations; there are no impairments of human health or public water supply designated uses in the project area. For a brief discussion of ammonia with regard to water quality, see the TSD (Ohio EPA 2010a, Appendix A).

Ammonia in streams is toxic to aquatic life, particularly fish. When aquatic life is exposed to elevated levels of ammonia, the internal ammonia concentrations increase affecting internal organs, nervous system function, and respiration. Mammals use various mechanisms to incorporate ammonia into amino acids and can tolerate larger exposures to ammonia. Ohio's water quality standards were developed to protect aquatic life from toxic effects.

In addition to toxicity, ammonia can also be an issue when waterbodies are impaired by dissolved oxygen. When low dissolved oxygen concentrations are associated with nitrogen species, it is usually due to the process of nitrification where ammonia is converted to nitrite which is then converted to nitrate (Ohio EPA 1999). Eutrophication itself can affect ammonia levels because excess algae productivity can consume significant amounts of dissolved oxygen (thereby preventing nitrification) and can kill aquatic vegetation that will then decay and release ammonia.

Sources of ammonia include wastewater, animals (e.g. livestock, wildlife), and application of chemicals or manure to crop fields (U.S. EPA 2012). Before treatment, ammonia and organic nitrogen are the primary nitrogen species in wastewater (U.S. EPA 2002). Thus, a wastewater treatment system that does not provide adequate treatment can discharge high levels of ammonia to surface water or ground water. Ammonia derived from animal waste can enter surface waters through direct deposition of waste to streams or waste deposited in the floodplain can be washed into streams during precipitation events (U.S. EPA 2012). Similarly, ammonia-containing fertilizers or manure that are applied to crop fields can wash off during precipitation events and enter surface streams.

4.1.3.2 Nitrate and Nitrite

Similar to ammonia, nitrate and nitrite are important components of aquatic ecosystems. Both nitrate and nitrite are dissolved forms of nitrogen that are bioavailable (U.S. EPA 1999). Plants and algae uptake mineralized nitrogen in the form of the nitrate ion; refer back to Section 4.1.3 for a synopsis of the nitrogen cycle. Nitrate is more stable than nitrite, which is typically found in very low levels because it is rapidly converted to more stable forms of nitrogen ions.

The effects of high levels of nitrate in drinking water are well known (e.g., Blue Baby Syndrome); however, nitrate plus nitrite is addressed in this report as related to ALU designations. There are no impairments of human health or public water supply designated uses in the project area. Nitrate is toxic to aquatic life (Camargo et al. 2005; Monson 2010) and contributes to eutrophication, which results in decreased dissolved oxygen levels. For a brief discussion of nitrate plus nitrite with regard to water quality, see the TSD (Ohio EPA 2010a, Appendix A).

Nitrate toxicity to aquatic life is similar to nitrate toxicity to mammals in that oxygen-carrying compounds are converted to other compounds that cannot carry oxygen (Camargo et al. 2005). In a review of studies, Camargo et al. (2005) found that nitrate toxicity to aquatic invertebrates, fish, and amphibians increased as nitrate concentrations and exposure times increased, while nitrate toxicity decreased with increasing body size and water salinity for aquatic invertebrates.

"High loadings of nitrate-N can adversely affect lakes, reservoirs and estuaries, typically through compositional changes in phytoplankton" (Ohio EPA 1999, p. 32). Increased algal production, due to increases in nutrient levels, including nitrate, reduces dissolved oxygen levels, which harms aquatic life (refer to Section 4.1.5 for the effects of dissolved oxygen upon aquatic communities).

Sources of nitrate in surface and ground waters include: agricultural runoff, animal or human waste, industrial waste, natural soil inorganic matter, nitrogen fixation, and rain (Camargo et al. 2005; Eby 2004). Both ammonia and nitrate are derived from animal and human waste; bacterial processes control how much of these nitrogen species are reactive. Similar to the ammonia sources discussed in Section 4.1.3.1, animal waste may enter surface waterbodies via direct deposition (e.g., waterfowl excretion) or through surface runoff (e.g., pet waste deposition on urban lawns, application of manure to crop fields).

Sources of human waste are derived from inadequate treatment (e.g., WWTP without tertiary treatment, failing HSTS). In addition to manure application, nitrogen-bearing fertilizers may also be applied to crop fields; runoff from precipitation events may transport fertilizers on crop fields to streams via overland flow or through drain tiles.

4.1.4 Total Phosphorus

Phosphorus is necessary for aquatic life and is needed at some level in a waterbody to sustain life. The natural amount of phosphorus in a waterbody varies depending on the type of system. A pristine mountain spring might have little to almost no phosphorus, whereas a lowland, mature stream flowing through wetland areas might have naturally high concentrations. Phosphorus can be released into the environment through different anthropogenic sources including septic systems, WWTPs, fertilizer application, and livestock operations. Once released into the environment, phosphorus generally attaches to soil particles and organic matter and is transported with eroded sediments (U.S. EPA 1999).

Phosphorus, like other nutrients, rarely approaches concentrations in the ambient environment that negatively affect aquatic life; in fact, nutrients are essential in minute amounts for properly functioning, healthy, aquatic ecosystems. However, nutrient concentrations in excess of those minute needs can exert negative effects on the aquatic ecosystem by increasing algal and aquatic plant life production (Sharpley et al. 1994). Increased plant production increases turbidity, decreases average dissolved oxygen concentrations, and increases fluctuations in diurnal dissolved oxygen and pH levels. Such changes shift aquatic species composition away from functional assemblages composed of intolerant species, benthic insectivores, and top carnivores that are typical of high-quality streams toward less desirable assemblages of tolerant species, generalists, omnivores, and detritivores that are typical of degraded streams (Ohio EPA 1999). Such a shift in community structure lowers the diversity of the system.

In its evaluation of biological data for reference (i.e., least-affected) streams, Ohio EPA found that IBI and ICI scores do not meet the WWH biocriteria when associated with higher levels of total phosphorus, (Ohio EPA 1999, p. 26). Ohio EPA further concludes that “[t]he processing of nutrients in lotic ecosystems is complex, variable, and affected by abiotic factors such as flow, gradient, ground water quality and quantity, and channel morphology” (Ohio EPA 1999, p.10). In the HELP ecoregion, Ohio EPA (1999, p. 27) finds that low gradient headwaters and wading streams (similar to those in the project area) had higher total phosphorus concentrations than higher gradient streams.

An in-depth summary of the effects of nutrients on aquatic life and the interrelationships of water quality, habitat, and biota are presented in the *Associations* document (Ohio EPA 1999); a brief discussion of that same topic is in the TSD (Ohio EPA 2010a, Appendix A).

Typical sources of total phosphorus are human and animal waste, fertilizer application to agricultural crops and urban lawns/gardens, erosion in stream channels, wetlands, and re-suspension of phosphorus bound to sediment from an upstream source. The potential sources identified by Ohio EPA in the 303(d) list are HSTS, package treatment plants, non-irrigated crop production, and urban runoff/storm sewers.

4.1.5 Organic Enrichment and Low Dissolved Oxygen

Algae and macrophytes produce and consume oxygen in water. During daylight hours, oxygen is produced by photosynthesis. Plants and algae then consume oxygen from the water column at night (respiration). The entire process is part of the natural cycle of most plants, and this cycle causes dissolved oxygen concentrations to fluctuate throughout the water column in a day. This is called a diurnal oxygen cycle. Various other processes also produce and consume dissolved oxygen in the water column.

Processes that consume oxygen include organic decomposition, respiration by fish and invertebrates, and sediment oxygen demand. Additional dissolved oxygen is produced through atmospheric exchange.

Oxygen depletion occurs when the balance between oxygen consumption and production is altered, either causing excessive oxygen consumption or reduced oxygen production. Eutrophication derived from excess levels of nutrients, including total phosphorus and nitrate, tends to lower dissolved oxygen concentrations because of respiration and decay of excessive vegetation.

If the dissolved oxygen concentration in a waterbody becomes too low, it threatens all oxygen-breathing aquatic life. Aquatic organisms need oxygen to live and they can experience nonlethal effects (e.g., lowered reproduction rates) and mortality with lowered dissolved oxygen concentrations. Ohio EPA (1999) presents analyses of the effects of eutrophication and low dissolved oxygen on aquatic life. For example, in Ohio streams and rivers, Ohio EPA (1999, p. 39) reports that marginal or variable dissolved oxygen levels and increased chemical stress are typically associated with chronic stress on fish communities, specifically with an increased presence of DELT (deformities, eroded fins, lesions, or tumors) anomalies.

In Ohio, diel dissolved oxygen levels varied considerably at reference sites that also exhibited “excessively high algal production” (Ohio EPA 1999, p. 28). Reference sites with exceptional IBI and ICI scores and total phosphorus concentrations less than 0.10 mg/L rarely had dissolved oxygen levels less than 5 mg/L; similarly, when total phosphorus was detected at levels greater than 2 mg/L, dissolved oxygen levels tended to be less than 5 mg/L (Ohio EPA 1999, p. 28). Brief discussions regarding organic enrichment, dissolved oxygen, and nutrient effects are in the TSD (Ohio EPA 2010a, Appendix A).

4.2 Point Sources

Point source pollution is defined by CWA section 502(14) as, “any discernible, confined and discrete conveyance, including any ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation [CAFO], or vessel or other floating craft, from which pollutants are or may be discharged. This term does not include agriculture storm water discharges and return flow from irrigated agriculture.”

Point sources can include facilities such as municipal wastewater treatment plants (WWTPs), industrial facilities, CAFOs, or regulated storm water including municipal separate storm sewer systems (MS4s). Under the CWA, all point sources are regulated under the NPDES program. NPDES permit holders in the project area are discussed below. Although combined sewer overflow communities are in the project area, none of the combined sewer overflow outfalls are on streams that are tributaries to the Maumee River (lower) or Lake Erie; many discharge directly to the Maumee River (lower). Illicit connections to storm or sanitary sewers and infiltration and inflow were identified as potential sources of pollutants by TMACOG (2011) for some of the public wastewater treatment facilities. No permitted CAFOs are in the project area. Package treatment plants that are not permitted under the NPDES program are also present throughout the project area.

4.2.1 Facilities with Individual NPDES Permits

A municipality, industry, or operation must apply for an NPDES permit if an activity at that facility discharges wastewater to surface water. Examples of facilities with individual NPDES permits in the project area are municipal and industrial WWTPs.

In the project area, 39 facilities are covered under individual NPDES permits, and 5 facilities are covered under general NPDES permits (excluding general permits for storm water and regulated MS4s); a list of these facilities is presented in Appendix B. The project scope is limited to impaired streams that are tributaries to the Maumee River (lower) and Lake Erie. Therefore, NPDES-permitted facilities that only discharge directly to the Maumee River (lower) or Lake Erie are not evaluated (refer to Appendix B for a list of these facilities). A detailed discussion of each NPDES permitted facility is provided by subwatershed in Sections 4.4.1through 4.5.2.

Package treatment plants without NPDES permits exist throughout the project area, although in recent years there are fewer of them (TMACOG 2011, p. 287). Public sewer lines are being extended to eliminate package treatment plants. The *TMACOG Areawide Water Quality Management Plan* (TMACOG 2011, p. 287) states,

> Ohio EPA has historically given priority to issu[ing] NPDES to larger package plants: those discharging more than 25,000 gpd [gallons per day]. In 2008, 87% (20 of 23 active package plants over 25,000 gpd) had individual NPDES permits in the TMACOG region, while 28% (42 out of 151 active package plants) smaller than 25,000 gpd have NPDES permits.

4.2.2 Regulated Storm Water

Regulated storm water runoff can be a significant source of pollutants to the tributaries of the Maumee River (lower) and Lake Erie. Storm water runoff can contain sediment, nutrients, and bacteria in addition to numerous other pollutants. In addition, storm water runoff rates and volumes can cause impacts to stream channels and habitat. The sections below present general information regarding pollutant transport in urban storm water and a summary of Ohio's storm water program, including information that is specific to the project area.

4.2.2.1 Urban Storm Water

The type of development and land uses generally determine the quality of and constituents in the storm water (Shaver et al. 2007) as does the level of automobile activity (Burton and Pitt 2002). Storm water from transportation land uses (e.g., roads, bridges, service stations) can contain petroleum hydrocarbons or copper derived from brake pads whereas storm water derived from washoff of fertilized residential lawns, golf courses, and manicured or landscaped areas can contain elevated levels of nutrients (Shaver et al. 2007). Urban and suburban storm water runoff characteristics typically differ considerably as compared to rural and undeveloped areas (Pitt et al. 1995; U.S. EPA 1983).

Any constituents that are deposited on impervious surfaces will typically remain there until they are picked up and transported by urban storm water. For example, when pet waste is improperly disposed of, it can be picked up by storm water runoff and washed into storm drains or nearby waterbodies. Since storm drains do not always connect to treatment facilities, untreated animal feces often end up in lakes and streams. In undeveloped areas, some constituents will be transported to shallow aquifers as water infiltrates. However, because infiltration cannot occur on impervious surfaces, pollutants that accumulate on impervious surfaces will be rapidly carried to surface waterbodies through runoff or storm water conveyance systems where they can pose a risk to human and ecological health (Shaver et al. 2007; Schueler 1994).

Many toxic constituents bond to particulate matter and can be transmitted in storm water while adsorbed to the sediment. For example, "hydrocarbons are normally attached to sediment particles or organic matter carried in urban runoff" (Shaver et al. 2007 p. 3-48). Because storm water tends to travel rapidly over impervious surfaces, the high-velocity water has an increased "ability to detach sediment and associated pollutants, to carry them off site, and to deposit them downstream" (Burton and Pitt 2002, p. 31). The sediment and adsorbed pollutants can accumulate in bottom sediments "where they are readily available to aquatic organisms and possible resuspension during future storm events" (Masterson and Bannerman 1994, p. 131). Sedimentation can increase in downstream ponds or slower-moving streams when sediment-laden, high-velocity storm water discharges to the waterbodies.

Pitt et al. (1996, p.4) evaluated urban storm water and found that metals were typically detected in high concentrations. Masterson and Bannerman (1994) generally found that heavy metal concentrations in urban streams in Wisconsin exceeded the concentrations in reference streams. Stress and lethality to aquatic organisms can occur from episodic exposure to storm water laden with metals (Burton and Pitt 2002, p. 77). The typical sources of nutrients (e.g., nitrates and phosphates) in urban runoff include fertilizer washoff from lawns, landscaped areas, and golf courses (Shaver et al. 2007, p. 3-47). Bacteria sources include pet and wildlife waste that are transported via runoff from a precipitation event to storm sewers and streams; illicit connections to the storm sewers are also a potential source of bacteria since the domestic waste from the illicit connection does not get treated. Typical sources of sediment in urban storm water include bank erosion, which increases due to faster and more powerful stream flows caused by urban development, and runoff from construction or industrial sites that is not properly contained (e.g., silt fences) and treated (e.g., settling pond).

4.2.2.2 Ohio's Storm Water Program

Ohio EPA regulates storm water through various individual and general NPDES permits. Storm water discharge from nine facilities is covered by individual NPDES permits. These facilities are further discussed in subsequent sections that present evaluations of sources present in each watershed.

The Multi-Sector General Permit, which addresses storm water discharges associated with industrial activities (OHR00005), is effective from January 2012 through December 2016. As of January 2012, and about 50 facilities in the project area have NPDES general permit coverage for storm water discharges associated with industrial activities. The NPDES general permit for storm water discharges associated with construction activities (U.S. EPA ID OHC000003) is effective from April 2008 through April 2013. From 2006 through 2011, more than 275 construction sites were issued general permit coverage throughout the project area.

Ohio also has a general NPDES permit for storm water discharges associated with industrial activity from marinas (OHRM00001). In the project area, three marinas have Marina general permit coverage. However, two marinas (Brenner 75 at Harrisons [Ohio EPA ID 2GRM00016] and Brenner 75 Marine [2GRM00033]) discharge directly to the lower Maumee River, and one marina (Anchor Pointe Boat-A-Minium [Ohio EPA ID 2GRM00027]) discharges directly to Lake Erie. Because the Maumee River and Lake Erie are beyond the scope of this TMDL, those marinas are not discussed further.

Under Phase I of the NPDES Storm Water Program, MS4s serving populations of over 100,000 people are considered medium or large MS4s.The city of Toledo is a Phase I MS4. Phase II of the NPDES Storm Water Program outlines regulations for MS4s serving populations of fewer than 100,000 people. These regulated small MS4s are required to obtain NPDES permit coverage for their storm water discharges when the MS4 is located within the Urbanized Area as defined by the U.S. Census or when they have been designated by the director of the Ohio EPA. In Ohio, regulated small MS4s may operate under the statewide Small MS4 general permit (OHQ000002), which first requires dischargers to file a Notice of Intent and Storm Water Management Program.

The Small MS4 general permit requires MS4s to implement a Storm Water Management Plan designed to reduce the discharge of pollutants to the maximum extent practical, to protect water quality, and to satisfy the appropriate water quality requirements of Ohio Revised Code chapter 6111 and the Clean Water Act, by implementing six minimum control measures. The six minimum control measures are public education, public involvement, illicit discharge detection and elimination programs, control of construction site runoff, post-construction storm water management in new development and redevelopment, and pollution prevention/good housekeeping for municipal operations. Permitted entities operating under the Small MS4 general permit in the project area are identified in Table 4-1. Small MS4s include cities, villages, townships, and county road authorities. Townships are all co-permitees with county road authorities and are identified in Table 4-1 as “and others”. Ohio Department of Transportation (ODOT) and Ohio Turnpike Commission (OTC) are also regulated MS4s in the project area.

Table 4-1. Regulated MS4s in the Maumee River (lower) and Lake Erie tributaries project area

Permit type	Permit ID	Operator name	County
MS4 Phase I	2PI00003	City of Toledo	Lucas
MS4 Phase II	2GQ00001	City of Oregon	
	2GQ00012	City of Maumee	
	2GQ00006	Lucas County and Others	
	2GQ00002	City of Northwood	Wood
	2GQ00018	City of Perrysburg	
	2GQ00017	City of Rossford	
	2GQ00007	Village of Millbury	
	2GQ00003	Village of Walbridge	
	2GQ00028	Wood County and Others	
	2GQ00022	Ottawa County and Others	Ottawa
	4GQ00000	ODOT	Lucas, Ottawa, and Wood
	3GQ00022	OTC	

The project area is in ODOT District 2, which serves eight counties. Its MS4 area in District 2 includes one office, one garage, one outpost, and 117.5 miles of roadway (ODOT 2011).[4] The MS4-regulated roadways in District 2 include 53.6 miles of interstate highways, 20.6 miles of U.S. routes, and 43.3 miles of state routes. Although ODOT is a nontraditional MS4, it still complies with all the requirements of the Small MS4 general permit; its activities are presented in the *Stormwater Management Plan and 2010 Annual Report* (ODOT 2011).

The OTC is also a nontraditional MS4 and includes 56.9 miles of interstate toll road in four urban areas across the state of Ohio (OTC 2003). In the greater Toledo area, 10.91 miles of the turnpike are in the MS4. OTC maintains 4 toll plazas, two pairs of service plazas, and two maintenance buildings in the Toledo area. Only one facility is located in the 2000 Census Urbanized Area: toll plaza TP4 at milepost 59.50 (OTC 2003, Appendices 1 and 2).[5] Although OTC is a nontraditional MS4, it still complies with all the requirements of the Small MS4 general permit; its activities are presented in the *Ohio Turnpike Commission Stormwater Plan* (OTC 2003).

For this report, each city or village covered under its own Small MS4 general permit receives an individual WLA based upon its municipal jurisdictional boundary (i.e., the incorporated area). Each county road authority also receives an individual WLA. OTC and ODOT also each receive their own WLAs; the ODOT MS4 WLA represents the interstates (excluding the toll road I-90/I-90), U.S. routes, and state routes. A summary of surrogate MS4 areas that will receive WLAs is presented in Table 4-2.

[4] A map of ODOT’s MS4 jurisdiction in Districts 1 and 2 is available at: http://www.dot.state.oh.us/stormwater/mapping/Pages/default.aspx.
[5] Figure 2 of Appendix 6 of *Ohio Turnpike Commission Storm Water Plan* (OTC 2003) shows the MS4 area in the greater Toledo area.

Table 4-2. Surrogate MS4 areas in the project area

Permit ID	Regulated entity	Description of surrogate MS4 area	Area (acres)
2PI00003	City of Toledo	incorporated area [a]	10,465
2GQ00001	City of Oregon	developed area [b]	8,111
2GQ00012	City of Maumee	incorporated area [a]	4,365
2GQ00006	Lucas County and Others	county roads within the 2000 Census urbanized area [b] developed land in Jerusalem Township [b]	489 2,790
2GQ00002	City of Northwood	incorporated area [a]	5,287
2GQ00018	City of Perrysburg	incorporated area [a]	5,684
2GQ00017	City of Rossford	incorporated area [a]	
2GQ00007	Village of Millbury	incorporated area [a]	616
2GQ00003	Village of Walbridge	incorporated area [a]	1,066
2GQ00028	Wood County and Others	county roads within the 2000 Census urbanized area [b] developed land in Lake Township [b] developed land in Middleton Township [b] developed land in Perrysburg Township [b]	77 4,884 1,129 7,317
2GQ00022	Ottawa County and Others	county roads within the 2000 Census urbanized area [b] developed land in Allen Township [b] developed land in Clay Township [b]	5 1,683 741
4GQ00000	ODOT	Interstates (excluding the Ohio turnpike), U.S. routes, and state routes within the 2000 Census urbanized area [c]	736
3GQ00022	OTC	Ohio turnpike within the 2000 Census urbanized area [c]	56

Notes
a. The surrogate MS4 areas for road authorities were subtracted from the incorporated areas.
b. The developed area is calculated as the summation of the developed land classes (developed, open; developed, low intensity; developed, medium intensity; and developed, high intensity) from the 2006 NLCD for each jurisdiction.
c. The areas for road authorities were calculated as a 60-foot buffer around the segments of the roads located within the 2000 Census urbanized area. These areas include non-municipal roads within incorporated areas.

4.3 Nonpoint Sources

The term *nonpoint source pollution* is defined as any source of pollution that does not meet the legal definition of point sources. Nonpoint source pollution typically results from storm water runoff and background conditions. Note that storm water collected and conveyed through a regulated MS4 is considered a point source. Since agricultural practices such as crop cultivation (56 percent) and pasture/hay (1 percent) cover an estimated 57 percent of the project area, nonpoint source pollution can contribute a significant amount of the total pollutant load. In addition to runoff and erosion, significant nonpoint sources also include home sewage treatment system, and animals.

4.3.1 Home Sewage Treatment Systems

Home sewage treatment systems (HSTS; also known as onsite wastewater treatment systems or septic systems) that are properly designed and maintained should not serve as a source of contamination to surface waters. However, onsite systems do fail for a variety of reasons. Common soil-type limitations that contribute to failure are seasonal water tables, compact glacial till, bedrock, coarse sand and gravel outwash and fragipan. When septic systems fail hydraulically due to surface breakouts or inadequate soil filtration, adverse effects on surface waters can result (Horsely and Witten 1996). HSTS contain all the water discharged from homes and business and can be significant sources of pathogens (e.g., bacteria) and nutrients (e.g., total phosphorus and nitrate nitrogen). Effects on surface water from HSTS are dependent on numerous factors, including soil characteristics, topography, hydrography, and their proximity to streams. A summary of the regulation of, design, and environmental issues related to HSTS is presented in *TMACOG Areawide Water Quality Management Plan* (TMACOG 2011, Chapter 5).

If properly designed, sited, installed, operated, and maintained, HSTS will remove suspended solids, biodegradable organic compounds, and fecal coliforms (U.S. EPA 2002, p.3-22). If HSTS do not sufficiently treat wastewater, then the following pollutants may be found in HSTS wastewater: nitrates, pathogens, and phosphorus (U.S. EPA 2002, p. 3-20). If a subsurface pollutant plume expands to the water table, then these pollutants may be transported via ground water and discharged to surface water.

TSS may also be present in HSTS effluent, though most properly working systems remove most of the TSS (e.g., TSS settles out [i.e., sedimentation occurs] in septic tanks). If too much TSS enters the system, it may clog the system and reduce infiltration. Directly discharging HSTS may contaminate surface waters as the TSS forms sludge that will detrimentally affect benthic macroinvertebrates (U.S. EPA 2002).

Application of domestic septage to farm fields is regulated by local health departments, the Ohio Department of Health, Ohio EPA, and U.S. EPA. Land application of septage is generally not allowed in Lucas County, is authorized on a case-by-case basis in Ottawa County (although the practice is not currently used), and is an acceptable practice in Wood County (TMACOG 2011, p. 286). WWTPs in Lucas and Wood counties also accept septage for disposal and treatment. Domestic septage that is applied to crop fields may be transported via runoff from precipitation events to surface streams. Crop fields with septage application that are drained by tiles will more rapidly transport runoff containing septage to streams and open ditches. The tile drains yield larger and faster flows that can carry septage farther downstream.

The three counties in the project area conduct HSTS programs which are briefly summarized in the sections below. TMACOG (2011, p. 275) reports that a 2008 study by the Ohio Department of Health found that 26 percent of HSTS in northwest Ohio were failing.

4.3.1.1 Lucas County

Much of the Lucas County portion of the project area is sewered; the cities of Maumee, Oregon, Toledo, and Waterville are connected to public wastewater treatment systems (TMACOG 2011). Certain communities outside Lucas County also connect to sewerage systems in Lucas County (e.g., Rossford, Walbridge). Only the unincorporated areas between Maumee and Waterville (western edge of project area) and between the city of Oregon and Lake Erie do not own and operate their own public sewerage systems. Some portions of these unincorporated areas of Lucas County were connected to public sewers in the past decade; however, many homes and businesses still use HSTS or package treatment plants.

4.3.1.2 Ottawa County

The Ottawa County General Health District (OCGHD 2004, p. 5) estimates that 11,300 housing units across the county use HSTS, with a majority of systems using leach beds and leaching tile fields. In the project area, the unincorporated areas of Curtice, Martin, Trowbridge, and Williston are served by HSTS; Genoa and Clay Center are served by public sanitary sewerage systems (OCGHD 2004, p. 22). Package treatment plants without NPDES permits are present throughout the county.

OCGHD (2004) has approximately 9,500 permits dating back to the 1950s and estimates that approximately 1,800 systems operate without permits. Of the 7,000 permits in an electronic database, 88 percent are leaching systems and 12 percent are aeration or sand filter systems. OCGHD estimates that 42 percent of septic systems are at or near their lifespan (OCGHD 2004, p. 24).

4.3.1.3 Wood County

In 2004, almost 15,000 households were served by HSTS in Wood County (Wood County Combined General Health District [WCCGHD] 2004, p. 4). Northwood, Perrysburg and Rossford use public sewerage systems; package treatment plants that do not have NPDES permits are present throughout the county.

WCCGHD maintains a HSTS permitting program; however, fewer than 7,000 systems have permits. Of these permits, 36 percent are identified as leach systems, 21 percent as sand filter systems, 16 percent as aeration systems, 1 percent as experimental (Wisconsin mound), and 26 percent were not defined (WCCGHD 2004, p. 42). About 40 percent of HSTS in Wood County are not functioning properly (WCCGHD 2004, p. 4).

4.3.2 Storm Water Runoff (Non-regulated)

During wet-weather events (snowmelt and rainfall), pollutants are incorporated into runoff and can be delivered to downstream waterbodies. The resultant pollutant loads are linked to the land uses and practices in the watershed. Agricultural and developed areas can have significant effects on water quality if proper best management practices are not in place. The main pollutants of concern associated with agricultural runoff are sediment, nutrients, pesticides, and bacteria. Storm water from developed areas can be contaminated with oil, grease, chlorides, pesticides, herbicides, nutrients, viruses, bacteria, metals, and sediment. In urban areas, some connections to storm sewers are illicit, which includes residences and businesses that discharge untreated wastewater to the storm sewers.

In addition to pollutants, alterations to a watershed’s hydrology as a result of land uses changes can detrimentally affect habitat and biological health. Imperviousness associated with developed land uses and agricultural field tiling can result in increased peak flows and runoff volumes and decreased base flow as a result of reduced ground water discharge. The increased peak flows and runoff volumes tend to increase streambank erosion. These more powerful flows have more capacity to move larger sediment particles farther, which may result in downstream sedimentation when the in-stream flow decreases and slows down. Drain tiles also transport agricultural runoff directly to ditches and streams, whereas runoff flowing over the land surface may infiltrate to the subsurface and may flow through vegetated riparian areas. Thus, runoff transported through drain tiles will contain all of the pollutants that it contained when the runoff entered the tile system; surficial runoff may lose pollutants as its filtered during infiltration and passing through the vegetated riparian corridor.

TMACOG Areawide Water Quality Management Plan (TMACOG 2011) devotes chapters to agricultural runoff (Chapter 5) and urban runoff (Chapter 6). For a general review of the effects of urbanization and storm water and references to additional resources, see the *CADDIS Urbanization Module* (U.S. EPA 2012) and *The Importance of Imperviousness* (Schueler 1994). Regulated storm water sources are discussed in Section 4.2.2. Sources of pollutants in non-regulated storm water are discussed in the sections below.

4.3.3 Erosion

Sedimentation and siltation were identified as causes of impairment for many streams in the project area. For sedimentation (i.e., deposition of sediment) to occur, a source of sediment must be present. Various forms of erosion are a common source of sediment. Typically, erosion will increase as stream velocity and peak flow increases. Runoff over impervious surfaces and through agricultural drain tiles will have higher velocities and peak flows, and thus, increase erosion.

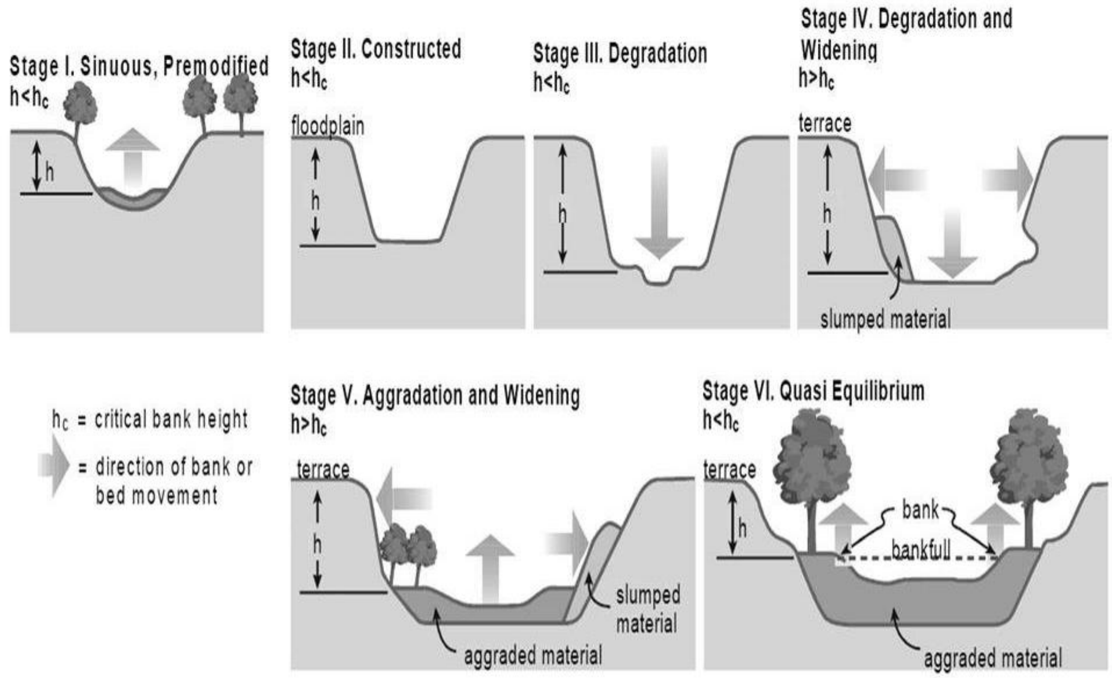
4.3.3.1 Sheet and Rill Erosion

Sheet erosion is the detachment of soil particles by raindrop impact and their removal by water flowing overland as a sheet instead of in channels or rills. Rill erosion refers to the development of small, ephemeral concentrated flow paths, which function as both sediment source and sediment delivery systems for erosion on hillsides. Sheet and rill erosion occur more frequently in areas that lack or have sparse vegetation. Sheet and rill erosion may transport contribute to a phosphorus impairment if the sediment that is eroded includes phosphorus sorbed to the sediment particles. Sheet or rill erosion may also transport pathogens from animal waste that was deposited by livestock, pets, or wildlife and from manure or septage that is applied to crop fields.

4.3.3.2 Bank and Channel Erosion

Bank and channel erosion refers to the wearing away of the banks and channel of a stream or river. High rates of bank and channel erosion can often be associated with water flow and sediment dynamics being out of balance. This can result from land use activities that either alter flow regimes, adversely affect the floodplain and streamside riparian areas, or a combination of both. Hydrology is a major driver for both sheet/rill and stream channel erosion.

Stream geomorphology pertains to the shape of stream channels and their associated floodplains. The capacity of a stream system to assimilate pollutants such as sediment, nutrients, and organic matter depends on features related to its geomorphology. This is especially the case for floodplains which, if connected to the channel, can store large quantities of sediment. A conceptual model of channel evolution was used to characterize varying stages of channel modification through time, as illustrated in Figure 4-1 (Simon and Hupp 1986). Stage I, undisturbed conditions, is followed by the construction phase (Stage II) where vegetation is removed or the channel is modified significantly (through altered hydrology, for example). Degradation (Stage III) follows and is characterized by channel incision. Channel degradation leads to an increase in bank heights and angles, until critical conditions of the bank material are exceeded. Eventually, stream banks fail by mass wasting processes (Stage IV). Sediments eroded from upstream degrading reaches and tributary streams are deposited along low-gradient downstream segments. This process reflects channel aggradation and begins in Stage V. Aggradation continues until stability is achieved through a reduction in bank heights and bank angles. Stage VI (re-stabilization) is characterized by the relative migration of bank stability upslope, point-bar development, and incipient meandering. Stages I and VI represent two true *reference* or attainment conditions.



Source: Simon and Hupp 1986.

Figure 4-1. Channel evolution model.

Bank erosion is a natural process. Acceleration of this process, however, leads to a disproportionate sediment supply, channel instability, and aquatic habitat loss (Rosgen 2006). Bank erosion processes are driven by two major components: streambank characteristics (e.g., erodibility) and hydraulic forces. Many land use activities affect both these components, which can lead to increased bank erosion. Riparian vegetation and floodplain protection provide internal bank strength. Bank strength can protect banks from fluvial entrainment and subsequent collapse. For instance, when riparian vegetation is changed from woody species to annual grasses, the internal strength is weakened, thus accelerating bank erosion processes. The material from the eroded banks is later deposited via sedimentation in a segment of the stream that is flowing more slowly or where water stops flowing (e.g., a lake).

Confronted by more frequent and severe floods that increase hydraulic forces, stream channels must respond. They typically increase their cross-sectional area to accommodate the higher flows. As described previously, this is done either through widening of the stream banks, down cutting of the stream bed, or frequently both. This phase of channel instability, in turn, triggers a cycle of stream bank erosion and habitat degradation.

Discharge flow rate is a major factor that affects sediment transport in stream systems. Higher discharge volumes lead to increased flow velocities, thus raising shear stress and stream power exerted on the channel bed and banks. This effect, combined with channel stability, determines the amount of sediment that is mobilized, which in turn influences habitat and aquatic biota. In many areas of the project area, storm flows are higher than occurred under predevelopment conditions because of land use changes and increased efficiency brought about by channelization in urban and rural areas. These storm flows have greater power to erode sediment and can transport larger sediment loads downstream. When the sediment finally settles, within a slowly flowing reach or standing waterbody, it may impair aquatic life by filling in fish and benthic macroinvertebrate stream-bottom habitat.

Channelization increases peak flows as it allows flood waves to pass more quickly through the basin, increasing the volume and the erosive force of the water. Because bank erosion is often a symptom of larger, more complex problems, long-term solutions often involve much more than bank stabilization.

4.3.4 Livestock

Livestock are potential sources of bacteria, nutrients, and sediment (indirectly) to streams, particularly when direct access is not restricted or where feeding structures are adjacent to or connected to riparian areas. Grazing patterns and the types of cattle operations influence the bacteria, nutrient, and sediment loads that cattle contribute to surface waters. Since livestock grazing patterns vary by season, the pollutant loads derived from livestock vary by season. Runoff from an actively grazed pasture during the spring will yield higher loads than those generated from an unused pasture in the winter when the livestock are in barns.

Livestock with unrestricted access to surface waters may deposit waste directly into streams. While moving along the banks and into streams, hoof shear may loosen soil that is then transported downstream by the creek. Livestock moving along the stream banks may trample or consume vegetation, which contributes to bank instability, and ultimately, downstream sedimentation. Livestock that have restricted access to surface waters may still contribute bacteria and nutrients to streams if sufficient practices are not implement to limit runoff from livestock areas. Finally, runoff on crop fields with manure application can transport bacteria and nutrients in the manure via overland flow or through drain tiles to nearby streams. Manure application varies by season and crop; thus, the magnitude of loads of bacteria, nutrients, and sediment from crop field runoff are controlled by when the manure is applied.

The presence of cattle usually increases the bacteria counts in pasture runoff. For example, in pastures in Utah, grazing season bacteria counts in runoff were often five times larger than the counts recorded in the non-grazing season (Coltharp and Darling 1975). Similarly, in Oregon rangeland, fecal coliform counts from rangeland with cattle were approximate six times greater than when cattle were absent (Tiedermann et al. 1987).

In general, as the density of animals within an area increases, the potential bacteria load in runoff increases. Intensified grazing management, which includes practices to attain uniform livestock distribution and improved forage production, showed a tenfold-increase in fecal coliform counts over less intensive management (Tiedermann et al. 1987).

The proximity of grazing to surface waters also impacts the bacteria and nutrient load contribution from cattle. When alternative sources of water are made present, cattle can be kept away from streams. In a field study of off-stream water supply for grazing land in a Virginia beef pasture, Sheffield et al. (1997) reported that the presence of an off-stream water source reduced the time cattle spent in the stream for drinking by 92 percent and led to an in-stream reduction of fecal coliform counts by 51 percent. Meals (2000) reported reductions of 44 to 58 percent in *E. coli*, fecal coliform, and fecal strep. counts in Vermont streams draining small agricultural watersheds following livestock exclusion and riparian zone restoration. The decrease in indicator bacteria was attributed mainly to preventing direct deposition of waste into the streams, rather than filtration through a riparian buffer.

Many agricultural and rural properties have small numbers of livestock which do not require a CAFO[6] or Concentrated Animal Feeding Facility[7] (CAFF) permit. Watershed-specific data are not available for

[6] CAFOs are regulated under the CWA by U.S. EPA and the states through the NPDES program. No concentrated animal feeding operations (CAFOs) are located in the project area.

livestock populations. However, countywide data available from the National Agricultural Statistic Service (NASS) were downloaded and area weighted to estimate animal population in the watershed (Appendix B).

Table 4-3. Livestock animal units by county, based on a weighted estimate

Animal unit	County	Number of animal units	Number of farms
Cattle and calves	Lucas	621	29
	Ottawa	1,523	89
	Wood	6,287	144
Goats	Lucas	137	14
	Ottawa	138	23
	Wood	505	37
Hogs and pigs	Lucas	4,268	12
	Ottawa	3,639	15
	Wood	4,530	30
Horses and ponies	Lucas	491	69
	Ottawa	444	63
	Wood	1,004	1,238
Poultry	Lucas	--	25
	Ottawa	--	22
	Wood	--	47
Sheep and lambs	Lucas	255	17
	Ottawa	335	12
	Wood	672	21

Source: 2007 Census of Agriculture (NASS 2009 Ohio's county-level data in Tables 11-17).

4.3.4.1 Lucas County[8]

With the exception of a single facility that boards approximately 50 horses, only hobby farms and small livestock operations are present in the eastern portion of Lucas County that drains to Lake Erie. Livestock do not typically have unrestricted access to streams; most owners have installed exclusion fencing. Land application of manure occurs on a very small scale and is typically applied only to pastureland, not to row crops.

4.3.4.2 Ottawa County[9]

No large animal operations are in Ottawa County, but small operations and hobby farms are throughout the county including a dairy farm and small hog operation. The hog operation in the lower Turtle Creek watershed likely has a few hundred hogs but is smaller than a CAFF; manure is likely applied to nearby farm fields. The dairy farm may have 50 to 60 cows and might also provide manure for application to farm fields. Neither operation is in the subwatersheds draining to Ohio EPA's assessment sites (i.e., these operations could not have caused the non-attainment of ALU or recreation use). Many farmers in Ottawa County do not have livestock; for those that do, the number of animal units is typically fewer than 10. In Ottawa County, few animals have unrestricted access to streams.

[7] CAFFs are regulated by the Ohio Department of Agriculture, through the Livestock Environmental Permit Program. CAFF Permits to Operate require CAFF owners to submit plans for manure management, insect and rodent control, mortality management, and emergency response (Ohio Department of Agriculture 2011). No CAFFs are located in the project area.
[8] Cheryl Rice, NRCS, personal communication, March 28, 2012.
[9] Mike Libben, Ottawa SWCD, personal communications, December 23 & 30, 2011.

4.3.4.3 Wood County[10]

Larger animal operations are in Wood County including a CAFF, which is near but not within the project area. Only small operations and hobby farms are in the project area. The small animal operations have fewer than 100 animal units. In northeast Wood County, hobby farms are typically a few acres and a few horses are owned. Manure is applied during the wheat rotation in northeast Wood County, and application tends to occur in July through October. Such operations are in the headwaters of some of streams that are impaired by *E. coli* and total phosphorus.

4.3.5 Wildlife

Wildlife such as deer, raccoon, waterfowl, riparian small mammals (e.g., beaver, otter) can be sources of bacteria and nutrients. The animal habitat and proximity to surface waters are important factors that determine if animal waste can be transported to surface waters. Waterfowl and riparian mammals deposit waste directly into streams while other riparian species deposit waste in the floodplain, which can be transported to surface waters by runoff from precipitation events. Animal waste deposited in upland areas can also be transported to streams and rivers; however, due to the distance from uplands to surface streams, only larger precipitation events can sustain sufficient amounts of runoff to transport upland animal waste to surface waters.

When wildlife are determined to be a significant source of bacteria and population estimates for individual species are not known, deer population data can be used as surrogates for estimating wildlife populations. The 2006 Ohio Department of Natural Resources white-tail deer status report indicates that the 2006 statewide population was expected to be around 600,000 deer (ODNR 2007) and present in all 88 Ohio counties (ODNR 2007).

4.3.6 Pesticides and Fertilizers

Application of chemicals including pesticides and fertilizers is a potential source of nitrogen and phosphorus species in both urban and rural environments. In urban areas, pesticides and fertilizers are applied to manage developed areas such as residential lawns and gardens, athletic fields, parks, recreational facilities, and green spaces surrounding larger industrial or commercial complexes. After precipitation events, pesticides and fertilizers can contribute pollutants to runoff that enters streams through the storm sewers.

Cultivated crop fields are present throughout the project area and along properties adjacent to impaired streams. Fertilizers are potential sources of nitrogen and phosphorus species that can cause nutrient-related impairments. During precipitation events, fertilizers can wash off crop fields and travel overland or through drain tiles to surface streams. Unless ammonia is bound to sediment, it will nitrify to nitrate. Ammonia and total phosphorus can travel downstream while bound to sediment. The effects of fertilizer-derived loads may be seasonal because fertilizers are applied during the growing season, which varies by crop. Phosphorus may remain in the stream system bound to sediment long after phosphorus-fertilizers are applied.

Fertilizer application is dependent on numerous factors (e.g., soil type, soil moisture content, crop type). The next three sections provide summaries of fertilizer information for each county in the project area.

[10] Jim Carter, Wood SWCD, personal communication, December 23, 2011.

4.3.6.1 Lucas County[11]

Cropland in eastern Lucas County typically consists of a 2-crop rotation of soybeans and corn. A small number of farmers include wheat for a 3-crop rotation and some farmers plant alfalfa. Phosphorus-containing fertilizers tend to be applied in July or August in the middle of the 2-crop rotation. Smaller numbers of farmers use starter applications of phosphorus fertilizers. Anhydrous ammonia is applied via side-dress in this portion of Lucas County.

Sludge from municipal WWTP in the greater Toledo area is land-applied to farmland in the eastern portion of Lucas County that drains to Lake Erie.

4.3.6.2 Ottawa County[12]

Anhydrous ammonia is not applied to crops in Ottawa County. The most common nitrogen-containing fertilizer is a liquid with 28 percent nitrogen; urea is generally not applied. Phosphorus-containing fertilizers are applied in the project area. Throughout the county, few farming operations broadcast their fertilizers. Wheat, corn, and soybeans are the dominant crops. Very few farmers fertilize their fall wheat, but when they do, the application occurs in September. Corn tends to be fertilized in the starter application when the crop is planted; this is usually in late April and early May.

4.3.6.3 Wood County[13]

Phosphorus- and nitrogen-containing fertilizers are applied throughout Wood County for corn and wheat fields. Soybeans tend to be fertilized only with potassium. In northeast Wood County, anhydrous ammonia, urea, and other blends with ammonia are applied in the dry or liquid states. The dominant form of application is a side-dress after planting. Ammonia-containing granular or liquid fertilizers tend to be applied in late February for winter wheat. Such fertilizers are applied in April through June for corn plantings.

Phosphorus fertilizers tend to be applied from blends or mixes that also contain nitrogen species. Dry fertilizers tend to be broadcast; the liquid tends to be applied as a starter for corn (late spring through early summer). For wheat, the fertilizers are applied as a starter.

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[11] Cheryl Rice, NRCS, personal communication, March 28, 2012.
[12] Mike Libben, Ottawa SWCD, personal communication, December 23 & 30, 2011.
[13] Jim Carter, Wood SWCD, personal communication, December 23, 2011.

4.4 Lake Erie Tributaries (HUC 04100010 07)

The Lake Erie tributaries watersheds are generally influenced by agriculture and sewage from small villages and residential areas that are not sewered (Ohio EPA 2010a). Ohio EPA (2010a) also noted urban runoff and storm sewers as potential pollutant sources in some of these watersheds. As shown in Table 4-4, the *Cedar Creek – Frontal Lake Erie* 10-digit HUC covers approximately 204 square miles south and southeast of Toledo (Figure 4-2). The area consists of six 12-digit HUC watersheds. For this analysis, Wolf Creek and Berger Ditch are grouped because of proximity and similar watershed characteristics. Although Duck Creek is technically in the 8-digit HUC 04100009, it is next to Otter Creek in the urbanized portion of east Toledo and has similar characteristics to Otter Creek. Thus, it is included in the discussion on Otter Creek. No information regarding wildlife (e.g., deer, ducks, geese, turkeys, beaver, and muskrats) is available for the project area.

Table 4-4. Lake Erie tributaries (HUC 04100010 07)

HUC (04100010)	Name	Area (acres)	Area (sq. mi.)
07 01	Turtle Creek – Frontal Lake Erie	25,988	40.6
07 02	Crane Creek – Frontal Lake Erie	36,095	56.4
07 03	Cedar Creek – Frontal Lake Erie	37,100	58.0
07 04	Wolf Creek – Frontal Lake Erie	9,686	15.1
07 05	Berger Ditch	10,260	16.0
07 06	Otter Creek – Frontal Lake Erie	11,436	17.9
Total		**130,565**	**204.0**

Note: Areas were calculated in ArcGIS 10 using the North American Datum of 1983 for Ohio State Plane North (FIPS 3401) and were rounded to the nearest acre and one-tenth square mile.

Land cover varies across the Lake Erie tributaries, as shown in Table 4-5. Urban area (summation of developed land classes) varies from 9 percent in the Turtle Creek watershed to 66 percent in the Otter Creek and Duck Creek watershed group. Grassland and agricultural lands range from 27 percent in the Otter Creek and Duck Creek watershed group to 76 percent in the Crane Creek watershed. Total forest cover was always less than 3 percent of a watershed or watershed group.

The levels of impervious cover also vary considerably in HUC 04100010 07, with the highest levels in the Toledo area, as shown in Figure 4-3. The lowest levels of watershed-scale imperviousness are in the Berger Ditch (2 percent), Turtle Creek (3 percent), and Crane Creek (4 percent) watersheds. The area draining to Otter Creek has the highest watershed impervious cover (27 percent).

Figure 4-3 also presents 35 individual and 5 general NPDES-permitted facilities; general permits for storm water are not presented in this figure. The facilities are discussed in the following subsections by watershed.

In addition to package treatment plants and other NPDES-permitted facilities and sites, Ohio EPA identified HSTS as sources of impairment to the tributaries in HUC 04100010 07. Figure 4-4 presents a map of areas that are covered by public sewers and of critical sewerage areas identified in TMACOG (2011). The critical sewerage areas are generally areas with failing HSTS or other non-public sewerage systems that are affecting surface waters.

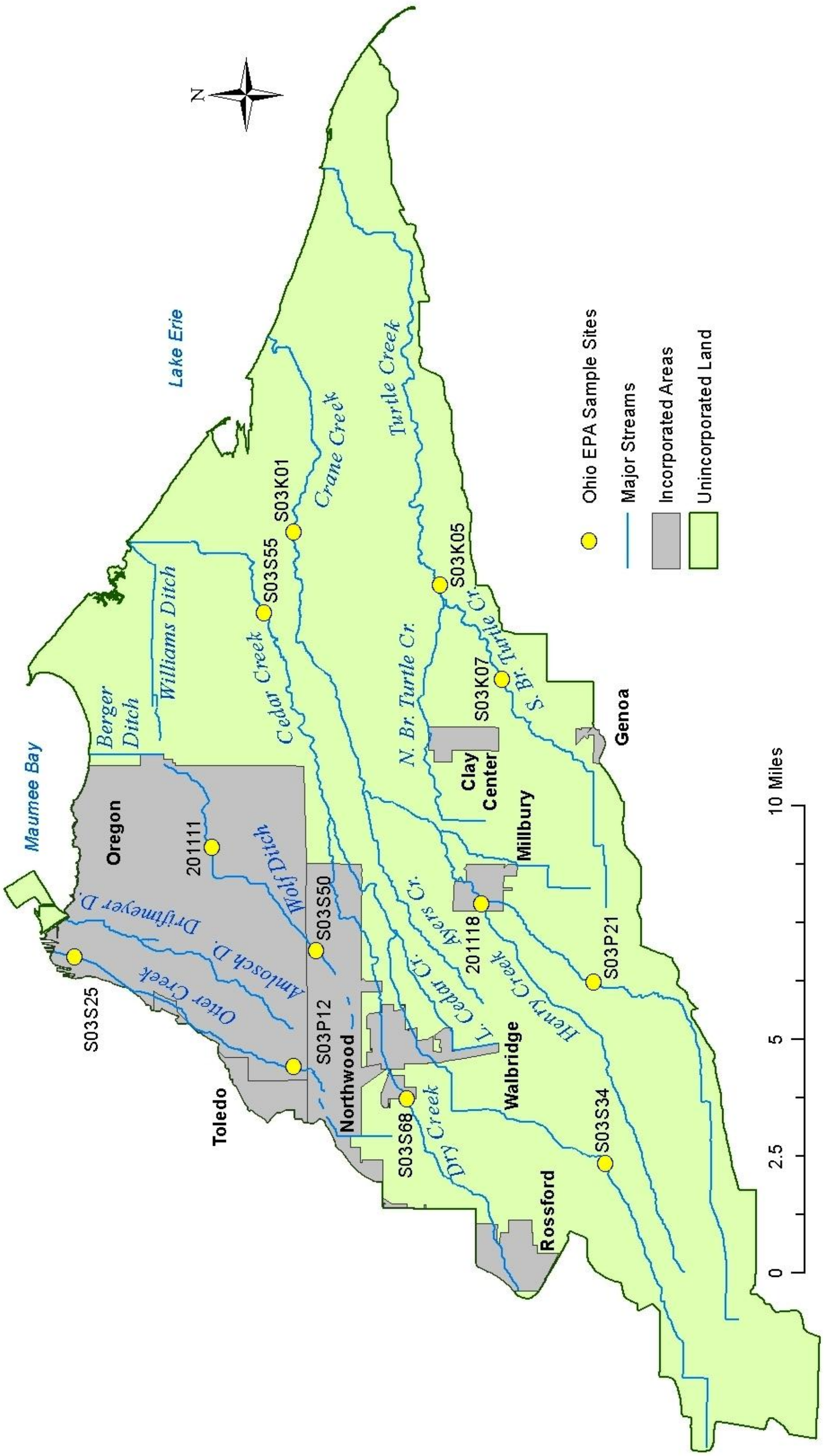


Figure 4-2. Lake Erie tributaries (HUC 04100010 07).

Table 4-5. Land cover in the Lake Erie tributaries (HUC 04100010 07)

Land cover class	Lake Erie tributaries [a] (HUC 04100010 07)		Turtle Creek		Crane Creek		Cedar Creek	
	Acres	%	Acres	%	Acres	%	Acres	%
Open Water	2,277	2%	551	2%	961	3%	200	<1%
Developed, Open	8,305	6%	1,086	4%	2,039	6%	2,506	7%
Developed, Low	12,478	9%	1,030	4%	2,052	6%	4,290	12%
Developed, Medium	4,630	3%	203	<1%	505	1%	1,934	5%
Developed, High	2,473	2%	109	<1%	146	<1%	1,177	3%
Barren Land	827	<1%	291	1%	23	<1%	404	1%
Deciduous Forest	2,815	2%	624	2%	916	2%	805	2%
Evergreen Forest	13	<1%	0	--	2	<1%	1	<1%
Grassland/Herbaceous	2,397	2%	434	2%	624	2%	735	2%
Pasture/Hay	1,058	<1%	234	1%	204	<1%	446	1%
Cultivated Crops	83,127	64%	17,663	68%	26,546	73%	23,787	64%
Woody Wetlands	55	<1%	4	<1%	20	<1%	23	<1%
Emergent Herbaceous Wetlands	10,110	8%	3,759	14%	2,058	6%	791	2%
Total	**130,565**	**100%**	**25,988**	**100%**	**36,096**	**100%**	**37,099**	**100%**

Land cover class	Wolf Creek and Berger Ditch		Otter Creek and Duck Creek	
	Acres	%	Acres	%
Open Water	443	2%	148	1%
Developed, Open	1,135	6%	1,936	15%
Developed, Low	2,041	10%	3,581	28%
Developed, Medium	413	2%	1,937	15%
Developed, High	112	<1%	1,094	8%
Barren Land	18	<1%	93	<1%
Deciduous Forest	376	2%	112	<1%
Evergreen Forest	10	<1%	0	--
Grassland/Herbaceous	459	2%	145	1%
Pasture/Hay	174	<1%	0	--
Cultivated Crops	11,835	59%	3,295	25%
Woody Wetlands	6	<1%	2	<1%
Emergent Herbaceous Wetlands	2,924	15%	621	5%
Total	**19,946**	**100%**	**12,964**	**100%**

Source: Land cover of the MRLC 2006.
Notes
Areas were calculated in ArcGIS 10 using the North American Datum of 1983 for Ohio State Plane North (FIPS 3401) and were rounded to the nearest acre and percent.
a. The values in the Lake Erie tributaries exclude Duck Creek.

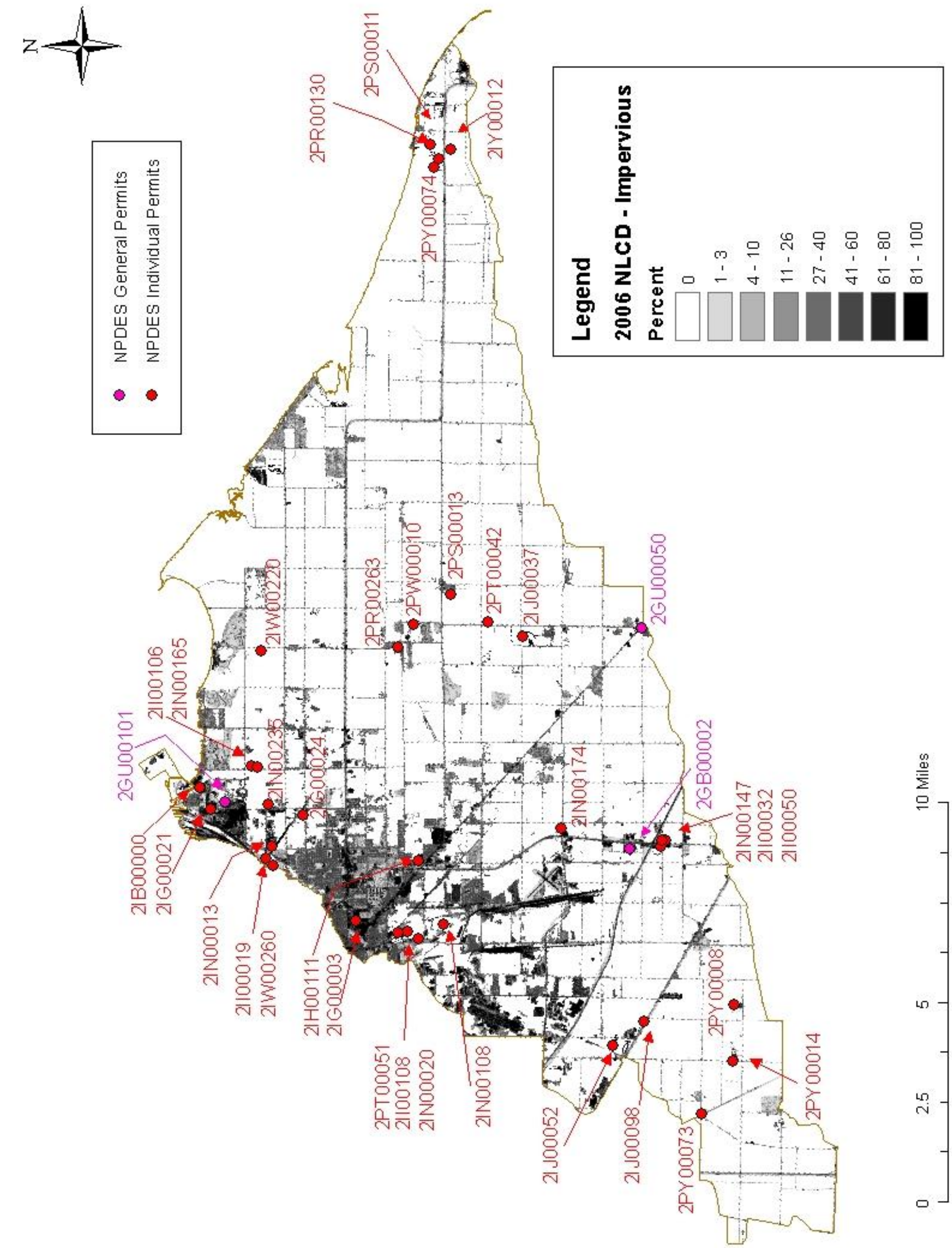
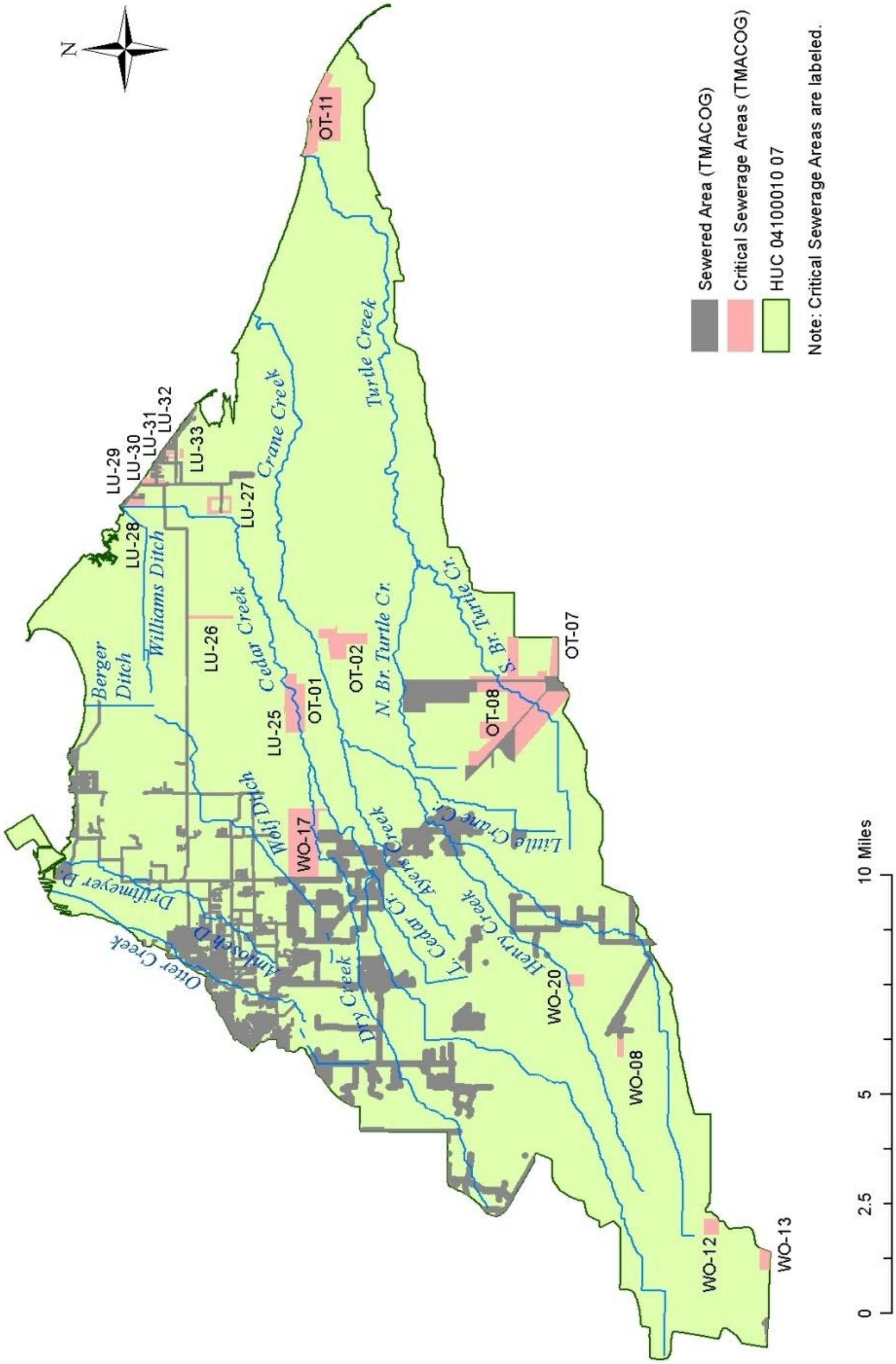


Figure 4-3. NPDES facilities and impervious cover in HUC 04100010 07.[14]

[14] Figure 4-3 does not include the Toledo Machining Plant (Ohio EPA ID 2GN00024) and Toledo Edison DuPont Road facility (Ohio EPA ID 2GU00101) whose permits became effective in August 2011 and April 2011, respectively. NPDES general permits for storm water are not displayed.



Sources: Ohio EPA 2010a; TMACOG 2011.

Figure 4-4. Sewered areas and critical sewerage areas in HUC 04100010 07.

4.4.1 Turtle Creek – Frontal Lake Erie (HUC 04100010 07 01)

Figure 4-5. Turtle Creek at Nissen Road (2010).

Turtle Creek flows generally northeast from near Millbury to Lake Erie, southeast of Toledo. Figure 4-5 shows a ground view of one segment of Turtle Creek taken at the Nissen Road monitoring site. The Turtle Creek watershed is approximately 40.6 square miles in Ottawa and Wood counties (Table 4-4). Land use in this watershed is predominantly agricultural and has relatively little developed land in its drainage area (Table 4-5).

Predominant land uses are cultivated cropland (68 percent) and emergent herbaceous wetlands (14 percent). Ohio EPA listed the Turtle Creek watershed as impaired, with the following causes: ammonia, direct habitat alteration, *E. coli*, sedimentation/siltation, and total phosphorus

An evaluation of aerial imagery of the Turtle Creek watershed showed that riparian buffers are on the lower portions of the North Branch and South Branch, and the headwaters portions of both branches are ditched without forested riparian buffers. Both branches are abutted by agricultural fields and rural residences. The mainstem is occasionally buffered and is typically abutted by agricultural fields and rural residences.

Rural portions of the Turtle Creek and Frontal Lake Erie HUC (04100010 07 01) are served by HSTS; Clay Center and Genoa are on public sewers. OCGHD evaluated the Elmwood Parkway subdivision in Clay Township, which is just north of Genoa, and found that the old HSTS were not properly treating effluent (OCGHD 2004, p. 28). Unsewered areas in Section 20 of Clay Township are degrading water quality in the South Branch of Turtle Creek (TMACOG 2011). Clay Center also has old HSTS. OCGHD (2004, p. 30) found that some systems were connected to the storm water collection system and might be contaminating the North Branch of Turtle Creek.

A number of package treatment plants are along the Lake Erie coast for marinas, mobile home parks (MHPs), and residences (TMACOG 2011). TMACOG recommends public sewerage systems for the small-lot homes to replace the many package treatment plants.

Six facilities are covered by individual NPDES permits in the Turtle Creek watershed (Table 4-6). They are a mix of municipal and industrial permits including sources such as campgrounds, schools, and marinas. Excluding regulated storm water, the only facility covered by a general NPDES permit (petroleum-related corrective actions) is held by BP Oil Company for its Site 16400 (Ohio EPA ID 2GU00050). The facility does not discharge bacteria loads.

Table 4-6. Facilities with individual NPDES permits in the Turtle Creek watershed

Ohio EPA ID	U.S. EPA ID	Facility	Permitee	Type	Size (mgd)	Waterbody
2PT00042	OH0132438	Allen Elementary School [a]	Genoa Local Schools	Municipal	0.0075	North Branch Turtle Creek
2IY00012	OH0125440	Carroll Water and Sewer District		Industrial	0.039	unnamed tributary to Turtle Creek
2PR00130	OH0125784	Fenwick Marina [b]	John Gradel	Municipal	0.015	Turtle Creek
2PY00074	OH0141674	Inland Marina and MHP [b]		Municipal	0.035	Turtle Creek
2PS00011	OH0122220	Turtle Creek Marina and Campground [b]		Municipal	0.020	Turtle Creek
2IJ00037	OH0002861	White Rock Quarry	Stoneco, Inc.	Industrial	6.91	unnamed tributary to North Branch Turtle Creek

Notes
a. Allen Elementary School (2PT00042) is no longer operational and cannot discharge.
b. Fenwick Marina (Ohio EPA ID 2PR00130), Inland Marina and MHP (Ohio EPA ID 2PY00074), and Turtle Creek Marina and Campground (Ohio EPA ID 2PS00011) are located on Turtle Creek, near the creek's mouth on Lake Erie and within the lacustrine zone.

Carroll Water and Sewer District (Ohio EPA ID 2IY00012), Fenwick Marina (Ohio EPA ID 2PR00130), Inland Marina and MHP (Ohio EPA ID 2PY00074), and Turtle Creek Marina and Campground (Ohio EPA ID 2IJ00037) are located downstream of the TMDL site on Turtle Creek and North Lickett Harder Road (RM 5.3); these facilities were not evaluated in the linkage analyses and did not receive WLAs since they are downstream of the TMDL site. Allen Elementary School (Ohio EPA ID 2PT00042) was demolished and no longer discharges; its WLA were set to zero in each TMDL that the facility appeared in. White Rock Quarry (Ohio EPA ID IJ00037) is the only operational facility of concern; it is a potential source of TSS but is not a source of *E. coli* or total phosphorus.

The subwatersheds draining to two of Ohio EPA's sample sites are discussed in the following subsections (refer to Appendix A for site information for each Ohio EPA station). These sites are representative of the impairments to the Turtle Creek watershed.

4.4.1.1 South Branch Turtle Creek at Moline-Martin Road (S03K07; RM 2.65) subwatershed

South Branch Turtle Creek runs along roads and along and through row crop fields and unsewered rural residential properties. It begins as a ditch and becomes a meandering stream near Reiman Road. The creek flows through the unsewered Clay Township (north of Genoa) in critical sewerage area OT-8 (see Figure 4-4; TMACOG 2011). The sample site at Moline-Martin Road (S03K07, RM 2.65) is near the unsewered community of Martin. No feedlots or livestock operations are apparent in the 2010 aerial imagery along the entire length of the creek.

No facilities with individual NPDES permits or unpermitted package treatment plants are in the South Branch Turtle Creek subwatershed (Ohio EPA 2010a; TMACOG 2011). Therefore, the potential sources of ammonia and total phosphorus at sample station S03K07 are HSTS, animal waste (excluding CAFOs, which are not present in the subwatershed and manure application, which does not occur in the subwatershed[15]), fertilizer application, and storm water.

4.4.1.2 Turtle Creek at Nissen Road (S03K05; RM 11.62) subwatershed

The potential sources in the South Branch subwatershed are presented in the previous subsection (Section 4.4.1.1). The North Branch subwatershed is very similar to the South Branch subwatershed; the major differences are the presence of the White Rock Quarry, and the creek does not flow through any critical sewerage areas. However, Williston (critical sewerage area OT-02) is in the northern portion of the North Branch subwatershed, and part of the area drains to North Branch. Below the assessment site at Nissen Road, the creek flows through rural agricultural areas with unsewered residential properties and cultivated row crops. No feedlots or livestock operations are apparent in 2010 aerial imagery at any of the properties along the entire length of the Turtle Creek or its two branches.

Three facilities with individual NPDES permits were in the Turtle Creek subwatershed; however, only the White Rock Quarry (Ohio EPA ID 2IJ00037) discharges in the watershed. White Rock Quarry is a limestone quarry and discharges only water from its dewatering pit; the only permit limits are for flow, pH, and TSS. Allen Elementary School, formerly operated by the Genoa Area Local Schools district, was a small sewerage system that discharged wastewater to North Branch Turtle Creek. Since 2006 the facility had discharged low levels of *E. coli* and occasionally discharged elevated levels of ammonia. The permit did not include phosphorus limits. The facility was recently demolished and no longer discharges. Therefore, the potential sources of total phosphorus are: HSTS, animal waste (excluding CAFOs, which are not present in this subwatershed, and manure application, which does not occur in this subwatershed), fertilizer application, and storm water. Except for fertilizer application, the potential sources of *E. coli* are the same as those for total phosphorus. The potential sources of TSS are agricultural activities, point sources, and storm water.

4.4.2 Crane Creek – Frontal Lake Erie (HUC 04100010 07 02)

Figure 4-6. Crane Creek at Martin-Williston Road (2010).

Crane Creek generally flows northeast from Perrysburg Township (Wood County) to Lake Erie, just southeast of Toledo. The Crane Creek watershed is approximately 56.4 square miles in Wood, Ottawa and Lucas counties. This watershed is predominantly agricultural and has relatively little developed land in its drainage area (Table 4-5).

Predominant land uses are cultivated cropland (73 percent), developed open space (6 percent), low-intensity development (6 percent), and emergent

[15] Mike Libben, Ottawa SWCD, personal communications, December 23 & 30, 2011.

herbaceous wetlands (6 percent). Figure 4-6 shows Crane Creek at Martin-Williston Road (RM 8.83), which is in full attainment of its ALU. Ohio EPA listed the Crane Creek watershed as impaired, with the following causes: *E. coli*, sedimentation/siltation, and total phosphorus.

An evaluation of aerial imagery showed that the Crane Creek watershed is very similar to the Turtle Creek watershed. Crane Creek and Henry Creek headwaters are typically ditches running along crop fields or roadways with little forested riparian buffers along their headwaters. Both creeks flow through numerous rural residential properties, including the occasional MHP. Ayers Creek begins at the Metcalf Field airport (sewered) and flows through more dense residential areas (mostly sewered) than Henry Creek and the headwaters of Crane Creek. Ayers Creek flows through the village of Millbury (sewered) and discharges to Crane Creek at the Chippewa Golf Course.

Until recently, the Lemoyne and Stony Ridge areas in the upper portion of the Crane Creek watershed were unsewered and designated as critical areas (WCCGHD 2004, p. 56–57). At least one development uses a package treatment plant. The two areas will soon be connected to sewers that the Northwestern Water and Sewer District will own and operate (TMACOG 2011). WCCGHD had recommended the construction of public sewers for the Woodland Court subdivision south of Millbury and Johnson’s subdivision, near Henry Creek (WCCGHD 2004, p. 57) and the subdivision was sewered a few years ago. The communities of Curtice and Williston are served by package treatment plants, including the Luther Home of Mercy (Ohio EPA ID 2PS00013) and Wildflower Place Subdivision WWTP (Ohio EPA ID 2PW00010).

Seven facilities in this watershed are covered by individual NPDES permits (Table 4-7). These include WWTPs, package plants from MHP, and gas stations/fuel centers. Excluding regulated storm water, the only general NPDES permit is for petroleum bulk storage and is held by Petro Stopping Center, Inc., No 17 (Ohio EPA ID 2GB00002). This facility does not discharge bacteria loads.

Table 4-7. Point sources with individual NPDES permits in the Crane Creek watershed.

Ohio EPA ID	U.S. EPA ID	Facility	Permitee	Type	Size (mgd)	Waterbody
2II00050	OH0116041	Fuel Mart #641	Ports Petroleum Co Inc	Industrial	--[a]	Crane Creek
2PS00013	OH0126888	Luther Home of Mercy		Municipal	0.0325	Williston Ditch
2PY00014	OH0102687	Perrysburg Estates MHP	The Choice Group	Municipal	0.0624	ditch to Henry Creek
2IN00147	OH0116611	Pilot Travel Center No 012	Pilot Travel Centers LLC	Industrial	--[a]	miscellaneous
2II00032	OH0111368	Toledo Travel Center	TA Operating LLC	Industrial	--[a]	Crane Creek
2PY00008	OH0095117	Village Green MHP	David Nightingale	Municipal	0.045	unnamed tributary to Crane Creek
2PW00010	OH0126578	Wildflower Place Subdivision WWTP	Wildflower Place Subdivision Homeowners Association	Municipal	0.057	Crane Creek

Notes
a. Fuel Mart #641 (Ohio EPA ID 2II00050), Pilot Travel Center No 012 (Ohio EPA ID 2IN00014), and Toledo Travel Center (Ohio EPA ID 2II00032) have individual NPDES permits for storm water discharges.
b. Luther Home of Mercy (Ohio EPA ID 2PS00013) and Wildflower Place Subdivision WWTP (Ohio EPA ID 2PW00010) will be connected to public sewers by 2015.

Four facilities are permitted to discharge bacteria in their effluent: Luther Home of Mercy (Ohio EPA ID 2PS00013), Perrysburg Estates MHP (Ohio EPA ID 2PY00014), Village Green MHP (Ohio EPA ID 2PY00008) and Wildflower Place Subdivision WWTP (Ohio EPA ID 2PW00010). None of the facilities' permits include limits for total phosphorus. According to their permits, Perrysburg Estates MHP and Wildflower Place Subdivision WWTP have I/I issues and are required to improve their sanitary sewer systems.

The subwatersheds draining to three of Ohio EPA's sample sites are discussed in the following subsections. These sites are representative of the impairments to the Crane Creek watershed.

4.4.2.1 Henry Creek near mouth and Bradner Road (201118, RM 0.10) subwatershed

Henry Creek flows through crop fields and sewered and unsewered residential areas. Northwest of Stony Ridge, Ohio, Henry Creek flows adjacent to a residential development served by a package treatment plant (WO-40; TMACOG identifies facilities by county: WO represents Wood County). Stony Ridge is sewered, though portions had been unsewered and in a critical sewerage area (WO-08). Drainage ditches flow from the vicinity of Stony Ridge to Henry Creek. Downstream of the Stony Ridge area, Henry Creek flows through Johnson's subdivision (critical sewerage area WO-20) and then flows through rural areas, under I-80/90, by Wood Lake, and under I-280. Henry Creek discharges to Crane Creek within a dense, sewered residential area of Millbury, Ohio. Another unpermitted package treatment plant (WO-94) is near the I-280 interchange with Martin-Moline Road (OH-795); however, it might discharge to the Cedar Creek watershed. Two additional unpermitted package treatment plants (WO-36 and WO-91) and the BP Amoco Bulk Plant (Ohio EPA ID IN000174) are in this area but appear to discharge to the Cedar Creek watershed and not to Henry Creek. No feedlots or livestock operations are apparent in 2010 aerial imagery at any of the properties along the entire length of the creek. As discussed in Section 4.3.4, manure application occurs in northeast Wood County, but specific information in the Henry Creek subwatershed is not available.

The only individually NPDES-permitted facility in the Henry Creek subwatershed is Perrysburg Estates MHP (Ohio EPA ID 2PY00014). This facility has permit limits for ammonia, carbonaceous biochemical oxygen demand (CBOD), and dissolved oxygen but does not have limits for total phosphorus. The wastewater treatment works discharges to a pond, which then likely discharges to a roadside ditch or canal that connects to Henry Creek. TMACOG (2011) identifies two unpermitted package treatment plants in the subwatershed. Therefore, the potential sources of total phosphorus are point sources, HSTS, animal waste (excluding CAFOs), fertilizer application, storm water (highways, industrial facilities, and MS4s). Except for fertilizer application, the potential sources of *E. coli* are the same as those for total phosphorus. The potential sources of TSS are agricultural activities, point sources, and storm water.

4.4.2.2 Crane Creek at Hanley Road (S02P21, RM 18.82) subwatershed

Crane Creek begins in the vicinity of Dowling, an unsewered community (critical sewerage area WO-12), and the Tanglewood Golf Course. Similar to the other rural Lake Erie tributary watersheds, Crane Creek flows along and through crop fields and unsewered residential properties. It flows next to the Village Green MHP. In the vicinity of Lemoyne, the rural residences along Fremont Pike (US-20/23) and Lemoyne Road are sewered, as are the residences and businesses along Genoa Road and OH-420. The assessment site (S03P21; RM 18.82) is just north of the interchange between I-80/90 and I-280; the area includes commercial development. Toledo Travel Center, Pilot Travel Center and Fuel Mart are in this area; all three facilities have large, paved parking lots and individual NPDES permits for storm water. Hotels and other automobile travel related facilities are in the area.

No portion of the 2000 Census Urbanized Area is in the Crane Creek at Hanley Road subwatershed; therefore, no MS4s have storm water NPDES permits in the subwatershed.

Four individually NPDES-permitted facilities are in the upper Crane Creek subwatershed:

- Fuel Mart (#641) (Ohio EPA ID 2IL00050)
- Pilot Travel Center (#012) (Ohio EPA ID 2IN00147)
- Toledo Travel Center (Ohio EPA ID 2IL00032)
- Village Green MHP (Ohio EPA ID 2PY00008; package treatment plant WO-62

Fuel Mart and the Toledo Travel Center discharge to Crane Creek, and the Pilot Travel Center discharges to a ditch in the interchange area. The permits for Fuel Mart and Pilot Travel Center are for effluent from paved parking lots and oil/water separators. The permit for the Toledo Travel Center specifies that the effluent is discharged to storm sewers. The Village Green MHP discharges to an unnamed tributary of Crane Creek and its permit includes limits for ammonia, dissolved oxygen, and fecal coliform. Phosphorus data are not reported in the discharge monitoring report (DMR) for any of these facilities. Village Green MHP is the only continuously discharging facility. Besides the Village Green MHP (WO-62) another package treatment plant is in the subwatershed: WO-80 (TMACOG 2011). Therefore, the potential sources of total phosphorus are HSTS, animal waste (excluding CAFOs), fertilizer application, highway storm water, industrial storm water, and point sources. Except for fertilizer application, the potential sources of *E. coli* are the same as those for total phosphorus.

4.4.2.3 Crane Creek at Elliston Road (S03K01, RM 5.20) subwatershed

Crane Creek above Hanley Road is discussed in Section 4.4.2.2, and Henry Creek is discussed in Section 4.4.2.1. Before the confluence of Henry Creek, Crane Creek flows by commercial properties and parking lots adjacent to the I-80/90 toll exit, and some riparian buffers are upstream and downstream of the toll plaza. Downstream of the plaza (which is sewered) Crane Creek flows through dense, sewered, residential areas of the village of Millbury, which maintains forested riparian buffers until the confluence of Ayers Creek in the Chippewa golf course. Below Ayers Creek, Crane Creek flows through rural agricultural areas with larger riparian buffers; it does not flow through any more villages or MHPs. The lacustrine portion of lower Crane Creek is undeveloped. Livestock operations were not identified along any of the major creeks in this watershed.

Portions of the following Phase II MS4 entities are in this subwatershed: Ottawa County and Others (Allen Township and the county road authority), Lucas County and Others (Jerusalem Township), Wood County and Others (Lake Township and the county road authority), and ODOT.

Seven facilities with individual NPDES permits are listed in Table 4-7. The Luther Home of Mercy (Ohio EPA ID 2PS00013) and Wildflower Place Subdivision WWTP (Ohio EPA ID 2PW00010) are in the lower section of the creek, and both are permitted to discharge bacteria. These facilities are along a critical sewerage area, which was discussed at the beginning of Section 4.4.2. TMACOG (2011) does not identify any unpermitted package treatment plants. Thus, the potential sources of *E. coli* are point sources, HSTS, animal waste (excluding CAFOs), and storm water. The potential sources of TSS are agricultural activities, point sources, and storm water (including both agricultural and urban runoff).

4.4.3 Cedar Creek – Frontal Lake Erie (HUC 04100010 07 03)

Figure 4-7. Cedar Creek at East Broadway Road (2010).

The Cedar Creek watershed (57.9 square miles) is in Wood, Ottawa and Lucas counties, just southeast of Toledo. The watershed flows generally northeast from Perrysburg Township (Wood County) to Lake Erie. The watershed is predominantly agricultural (Table 4-5).

Predominant land uses are cultivated cropland (64 percent) and low-intensity development (12 percent). Figure 4-7 shows Cedar Creek at East Broadway Road (RM 17.32), which is in full attainment of its ALU. Ohio EPA listed the Cedar Creek watershed as impaired, with the following causes: ammonia, dissolved oxygen, *E. coli*, organic enrichment, sedimentation/siltation, and total phosphorus.

HSTS are throughout the Cedar Creek watershed. In 1999 OCGHD (2004, p. 34) used dye tests to determine that residential HSTS in the Curtice area were discharging to Cedar Creek. Water quality sampling along Cedar Creek also showed sewage contamination (OCGHD 2004). WCCGHD (2004) suspects that water quality in the watershed is degraded by HSTS that are inadequately treating sewage. WCCGHD identified Dunbridge, which is in the headwaters of the Cedar Creek watershed, and the development at Curtice Road and Bradner Road, near Dry Creek, as critical areas and recommended construction of public sewers (WCCGHD 2004, p. 54, 57). Before discharging to Lake Erie, Cedar Creek flows by critical sewerage area LU-27 and LU-28 (TMACOG identifies Lucas County sites as LU); additional critical sewerage areas are along the lake.

Five facilities with individual NPDES permits were identified in the Crane Creek watershed (Table 4-8*)*. Crazy Lady Inn (Ohio EPA ID 2PR00263) and Five Point MHP (Ohio EPA ID 2PY00073) are permitted to discharge bacteria in their effluent. While Crazy Lady Saloon is located in Curtice, the wastewater treatment works permitted at the Crazy Lady Inn have not been built. In August 2011, a general permit for non-contact cooling water (U.S. EPA ID OHN000004) was issued to Chrysler Group LLC's Toledo Machining Plant (Ohio EPA ID 2GN00024). None of the facilities' permits include limits for total phosphorus and all of the facilities' permits include limits for TSS.

Table 4-8. Point sources with individual NPDES permits in the Cedar Creek watershed

Ohio EPA ID	U.S. EPA ID	Facility	Permitee	Type	Size (mgd)	Waterbody
2IN00174	OH0122637	Bulk Plant Millbury	Gary Shumaker LLC	Industrial	-- [a]	I-280 ditch to Cedar Creek
2IJ00098	OH0135798	Cardinal Aggregates Inc		Industrial	2.88	unnamed tributary to Cedar Creek
2PR00263	OH0141798	Crazy Lady Inn [b]	Curtice Entertainment Group Rentals, LLC	Municipal	0.005	Cedar Creek
2IN00108	OH0095338	Evergreen Recycling & Disposal	Evergreen Landfill	Industrial	-- [a]	Otter Creek & Dry Creek
2PY00073	OH0141615	Five Point MHP	Michelle Myers	Municipal	0.0066	Cedar Creek
2IJ00052	OH0003573	Stoneco, Inc. Lime City Plant	Shelly Materials	Industrial	4.8	B&R Mills Ditch to Dry Creek

Note
a. These individual NPDES permit s are for storm water.
b. The wastewater treatment works permitted for the Crazy Lady Inn (Ohio EPA ID 2PR00263) were never built; the permit may be closed.

The subwatersheds draining to three of Ohio EPA's sample sites are discussed in the following subsections (refer to Appendix A for site information for each Ohio EPA station). These sites are representative of the impairments to the Cedar Creek watershed.

4.4.3.1 Dry Creek at East Broadway Road (S03S68, RM 7.00) subwatershed

Dry Creek runs along roads and along and through crop fields and unsewered rural residential properties. The creek begins near a Wal-Mart in Perrysburg, Ohio, and flows in a ditch through crop fields, through a culvert at Crossroads Parkway (a divided highway), into a pond near Arena Road, and under I-80/I-90 into another pond. Continuing through a mixed residential and commercial area, the creek flows under State Route 795 (a divided highway), through wooded lots, railroad rights of way, crop fields, and sewered subdivisions. The creek flows under many roads and through or along dense, sewered, residential areas (e.g., Walbridge, Northwood) and crop fields. As it flows through crop fields, its course runs near rural unsewered residential properties. Dry Creek flows through the southern portion of the Curtice and

Bradner area, which is critical sewerage area WO-17 (TMACOG 2011). No feedlots or livestock operations are apparent in 2010 aerial imagery at any of the properties along the entire length of the creek. As discussed in Section 4.3.4, manure application occurs in northeast Wood County, but specific information in the Dry Creek subwatershed is not available.

No facilities with individual NPDES permits or unpermitted package treatment plants are in the Dry Creek subwatershed (Ohio EPA 2010a; TMACOG 2011). Therefore, the potential sources of ammonia and total phosphorus are HSTS, animal waste (excluding CAFOs), fertilizer application, and storm water. Potential sources of TSS are agricultural operations and storm water.

4.4.3.2 Cedar Creek at Oregon Road (S03S34, RM 20.77) subwatershed

Cedar Creek runs along roads and along and through crop fields and unsewered rural residential properties. Approximately 0.4 mile east of crossing under I-75, Cedar Creek begins to flow as a meandering stream. In the vicinity of Five Point Road (Township Highway 102), it flows through or by many rural residential properties and then flows through crop fields until reaching Oregon Road. The lower half of the Crosswinds Golf Club drains to Cedar Creek just upstream of Oregon Road. A large industrial or commercial complex is also near Oregon Road and drains to Cedar Creek; this facility has storm water detention ponds. Only short segments of the creek have wooded riparian corridors. No feedlots or livestock operations are apparent in 2010 aerial imagery at any of the properties along the entire length of the creek. As discussed in Section 4.3.4, manure application occurs in northeast Wood County, but specific information in the Cedar Creek subwatershed is not available.

One facility with an individual NPDES permit is in this subwatershed: Five Points MHP (Ohio EPA ID 2PY00073). The facility is in an MHP at the intersection of Five Point Road and McCutchenville Road; Cedar Creek runs along the northern boundary of the wastewater treatment works. The facility processes domestic wastewater, and its permit includes limits for ammonia, dissolved oxygen, and fecal coliform. DMR data before August 2010 are not available. From August 1, 2010, through June 30, 2011, the facility discharged 2,250 gpd. Since then, the facility typically has discharged between 850 and 1,100 gpd.

Two unpermitted package treatment plants are in the watershed. WO-04 is near the on/off-ramps at Middleton Pike for I-75; the facility has two large structures, one small structure, asphalt and dirt parking areas. WO-45 is along I-75, north of WO-04; when its reported latitude and longitude plots are plotted in a geographic information system project, it appears in a large crop field near a number of farming or residential facilities. Additional information regarding these facilities is not available. Thus, the potential sources of total phosphorus are point sources, HSTS, animal waste (excluding CAFOs), and fertilizer application.

4.4.3.3 Cedar Creek at Yondota Road (S03S55, RM 4.27)

Below the confluence with Dry Creek, Cedar Creek flows through rural areas including Curtice, which is a critical sewerage area (OT-1) and tends to maintain a small forested riparian buffer. Little Cedar Creek begins at Metcalf Field airport and primarily flows through rural crop fields until near its confluence with Cedar Creek, which is dense residential (sewered).

There are five facilities with individual NPDES permits in this subwatershed; summaries of these facilities are presented in Table 4-8. The wastewater treatment works permitted for the Crazy Lady Inn (Ohio EPA ID 2PR00263) were never built and were to be located is in the lower reaches of Cedar Creek. TMACOG (2011) identifies a single unpermitted package treatment plant at a small development in the lower half of Cedar Creek. The Curtice (OT-01) and Curtice/Bradner (WO-17) critical sewerage areas are also in the lower half of Cedar Creek above Yondota Road. Thus, the potential sources of *E. coli* are point sources, HSTS, animal waste (excluding CAFOs), and storm water. The potential sources of TSS are point sources, agricultural operations and storm water.

4.4.4 Wolf Creek – Frontal Lake Erie (HUC 04100010 07 04) and Berger Ditch (HUC 04100010 07 05)

The Wolf Creek and Berger Creek watersheds are east of Toledo and flows generally northeast from Northwood to Lake Erie. The Wolf Creek watershed is adjacent to the Berger Creek watershed; both watersheds are in Lucas County; a small portion of the Wolf Creek watershed is also in Wood County. Figure 4-8 shows Berger Ditch near Maumee Bay State Park. The majority of the Wolf Creek watershed is within the jurisdictional boundaries of Oregon. Although near a major urban center, agriculture is the predominant land use of both watersheds, with cultivated crops covering 59 percent of the watershed group (Table 4-5). Significant land cover in the Wolf Creek watershed also includes emergent herbaceous wetlands; low-intensity development is considerable in the Berger Ditch watershed. Ohio EPA listed the Berger Ditch watershed as impaired, with the following causes: *E. coli*, organic enrichment, and sedimentation/siltation.

Figure 4-8. Berger Ditch near Maumee Bay State Park (2010).

The central and eastern portions of HUC 04100010 07 05 and most of HUC 04100010 07 04 are dominated by rural residential and crop fields. The lower reaches, in the lacustrine area, are sparsely populated. Much of the area in Lucas and Ottawa counties that is east of Oregon is not sewered (TMACOG 2011). Some portions of this unincorporated area were connected to public sewers in the past decade; however, many homes and businesses still use HSTS or package treatment plants. TMACOG (2011) identifies a number of small critical sewerage areas near the shores of Lake Erie in Lucas County; these critical sewerage areas are unsewered, and failed HSTS are suspected.

Two facilities in these watersheds hold individual NPDES permits (Table 4-9). Neither facility is permitted to discharge bacteria in the effluent. Oregon water treatment plant (WTP; Ohio EPA ID 2IW00220) is located downstream of the two sites that Ohio EPA evaluated in 2008.

Table 4-9. Point sources with individual NPDES permits in the Wolf Creek and Berger Ditch watersheds

Ohio EPA ID	U.S. EPA ID	Facility	Permitee	Type	Size (mgd)	Waterbody
2IH00111	OH0135666	Hirzel Canning Co		Industrial	0.150	Wolf Creek
2IW00220	OH0041815	Oregon WTP	City of Oregon	Industrial	--	Berger Ditch & Lake Erie

The subwatersheds draining to two of Ohio EPA's sample sites are discussed in the following subsections. These sites are representative of the impairments to the Berger Ditch watershed.

4.4.4.1 Wolf Creek upstream of Curtice Road (S02S50, RM 6.30) subwatershed

Wolf Creek begins as a ditch in crop fields in the city of Northwood. It flows east under I-280, through the Northwood School District complex, and through a dense sewered subdivision before flowing through agricultural lands again. Before flowing by Curtice Road (S02S50, RM 6.30), Wolf Creek flows through only developed, and sewered properties.

One point source with an individual NPDES permit is in the Wolf Creek and Berger Ditch subwatershed: Hirzel Canning Company (Ohio EPA ID 2IH00111). This facility operates four lagoons that collect process wastewater, storm water from the complex, and residual water from the fields on which they spray irrigate their wastewater (via a tile system). It has two outfalls on Wolf Creek, and its permit includes effluent limits on ammonia, CBOD, and dissolved oxygen. However, no discharge was recorded at outfalls 001, 002, and 801 since 2005; therefore, this facility cannot be a source of impairment. Prior to 2004, the facility only operated three lagoons. Spills used to occur because the three lagoons had insufficient capacity. No spills or discharge through the outfalls has occurred since the installation of the fourth lagoon. Thus, the potential sources of total phosphorus are HSTS, animal waste (excluding CAFOs and manure application), fertilizer application, and storm water. The potential sources of TSS are agricultural operations and storm water. The potential sources of bacteria are HSTS, animal waste (excluding CAFOs and manure application), and storm water.

4.4.4.2 Wolf Creek at Stadium Road (201111, RM 2.70) subwatershed

The area upstream of Curtice Road is discussed in Section 4.4.4.1. After Curtice Road, the creek flows along the Curtice/Bradner area (critical sewerage area WO-17 [TMACOG 2011]). The creek then flows along a mix of sewered residential properties and unsewered rural residential properties with row crop fields. The creek/ditch has a thin forested buffer. The Oregon School District complex is in the subwatershed, but the creek does not pass through its property.

The only facility covered by an individual NPDES permit in this subwatershed is Hirzel Canning Company (Ohio EPA ID 2IH00111); this facility is discussed in Section 4.4.4.1 and is not a source of bacteria. TMACOG (2011) identifies one package treatment plant (LU-26), but it is in a tributary drainage and is surrounded by sewered areas. Thus, the potential sources of total phosphorus are HSTS, animal waste (excluding CAFOs and manure application), fertilizer application, and storm water. The potential sources of bacteria are HSTS, animal waste (excluding CAFOs and manure application), and storm water.

4.4.5 Otter Creek – Frontal Lake Erie (HUC 04100010 07 06) and Duck Creek (HUC 04100009 09 04)

Duck and Otter creeks are in Lucas County, to the east of Toledo. Otter Creek is 7 miles long, its watershed includes portions of Toledo and Oregon, Ohio, and it flows to the Maumee Bay. Figure 4-9 shows Otter Creek at Consaul Road and Yarrow Street (RM 3.1), which is in nonattainment of its ALU. Just west of Otter Creek, Duck Creek flows through portions of Toledo for 4 miles to the Maumee River mouth and, ultimately, Maumee Bay. In total, the watershed group covers approximately 18 square miles. Significant portions of these drainages are developed (Table 4-5). Development (including low, medium, and high intensity) accounts for approximately 51 percent of the land coverage. In addition to development, cultivated crops account for nearly a third (25 percent) of the land in these drainages. Ohio

Figure 4-9. Otter Creek at Consaul Road and Yarrow Street (2010).

EPA listed the Otter Creek watershed (HUC 04100010 07 06) as impaired, with the following causes: contaminated sediments, *E. coli*, and sedimentation/siltation. The agency found Duck Creek to be impaired for the following causes: *E. coli* and sedimentation/siltation.

Identified sources of ALU impairment include channelization, non-irrigated crop production and on-site treatment systems such as septic systems and similar decentralized systems. The *Maumee Area of Concern Stage Two Restoration Plan* identifies urban runoff, sludge, removal of riparian vegetation, stream bank modification/destabilization, spills and contaminated sediment as additional sources of impairment (Maumee RAP and Duck and Otter Creek Partners, Inc. 2006).

Although Duck and Otter Creeks are relatively small drainages, a significant amount of attention is warranted because of chemical contamination caused by historical development. Serving as an industrial hub on Lake Erie for more than 100 years, effects have included habitat modifications, rerouting and channelizing streams, and contamination of sediment and surface waters of both Duck Creek and Otter Creek (U.S. EPA 2007a). The lower portion of both streams (miles that are most downstream) flow through heavily industrial areas (U.S. EPA 2007a).

The Otter and Duck creeks' drainages are sewered. Portions of Otter Creek have forested riparian buffers, which are generally residential areas. Other portions of the creek appear to be piped under industrial and commercial properties and one segment is a ditch along numerous rail lines. Driftmeyer and Amlosch ditches also flow through urban areas that are sewered, including dense residential and industrial areas (e.g., BP Husky LLC's Toledo Refinery); both ditches occasionally have forested riparian buffers. Duck Creek begins at Hecklinger Pond and flows through sewered, dense, residential areas and industrial areas; portions of the creek flow through small, undeveloped parcels.

TMACOG (2011) does not identify any critical sewerage areas in the Otter Creek or Duck Creek watersheds. Although isolated HSTS might be failing in these predominantly sewered watersheds, HSTS are not likely significant sources of bacteria load in either watershed.

Fourteen facilities with individual NPDES permits discharge to the Otter Creek watershed (excluding directly to Lake Erie and excluding regulated storm water) are presented in Table 4-10.

Table 4-10. Facilities (excluding the Toledo MS4) with individual NPDES permits in the Otter Creek watershed

Ohio EPA ID	U.S. EPA ID	Facility	Permitee	Type	Size	Waterbody
2IN00165	OH0122319	Asphalt Materials Inc		Industrial	-- [a]	Wynn Road Ditch
2IB00000	OH0002925	Bay Shore Plant	First Energy Generation Corporation	Industrial	-- [b]	Driftmeyer Ditch & Maumee Bay (Lake Erie) [b]
2II00108	OH0141593	Broadway Warehouse 605 Ltd		Industrial	-- [a]	Otter Creek
2II00106	OH0135470	Cedar Point Development LLC		Industrial	-- [a]	Heckman Ditch
2PT00051	OH0138819	East Broadway Middle School	Toledo Board of Education	Municipal	-- [a]	Otter Creek
2IN00013	OH0053864	Envirosafe Services of Ohio		Industrial	0.0394	*multiple* [c]
2IN00108	OH0095338	Evergreen Recycling & Disposal	Evergreen Landfill	Industrial	-- [a]	Otter Creek & Dry Creek
2IN00235	OH0141992	Fresenius Medical Care		Industrial	-- [a]	Driftmeyer Ditch
2IG00024	OH0078301	Oregon Terminal	Marathon Petroleum, LP	Industrial	--	Amlosch Ditch
2IN00020	OH0002445	Pilkington NA - E Broadway Rd Facility	Pilkington North America	Industrial	-- [a]	Otter Creek
2IG00003	OH0002763	Sunoco Inc R & M	Treated Water Outsourcing, LLC	Industrial	3.8	Otter Creek [d]
2II00019	OH0095451	Toledo Station	Buckeye Pipeline Company, LP	Industrial	0.0015	Otter Creek
2IG00021	OH0058793	Toledo Terminal	Citgo Petroleum Corp	Industrial	-- [a]	Driftmeyer Ditch
2IW00260	OH0030759	Toledo WTP	City of Toledo	Industrial	--	Duck Creek & Otter Creek

Notes
a. These individual NPDES permits are for storm water.
b Only outfall 002 discharges to Driftmeyer Ditch. The facility normally discharges via outfalls 001 (746 mgd) and 003 (2.3 mgd) to an effluent channel to Maumee Bay (Lake Erie). The only limit for outfall 002 is for pH.
c. Multiple outfalls discharge to unnamed ditches and storm sewers to Otter Creek, Driftmeyer Ditch, and Joehlin Ditch.
d. Outfall 001 is for emergency storm water overflow.

Only one facility is permitted to discharge bacteria in its effluent: Buckeye Pipeline Company, LP's Toledo Station (Ohio EPA ID 2II00019). The following three facilities are permitted to discharge arsenic: Broadway Warehouse 605 Ltd (Ohio EPA ID 2II00108), Envirosafe Services of Ohio (Ohio EPA ID 2IN00013), and Pilkington America's East Broadway Road Facility (Ohio EPA ID 2IN00020).

Excluding regulated storm water, two facilities with individual NPDES permits discharge to the Duck Creek subwatershed (Table 4-11); neither facility is permitted to discharge bacteria in its effluent. The Norco Pipeline Company's Toledo Station (Ohio EPA ID 2GH00007) has a general NPDES permit for discharging hydrostatic test water. FirstEnergy Generation Corporation has a general NPDES permit for petroleum-related corrective action (U.S. EPA ID OHU000005) for its Toledo Edison DuPont Road facility in Oregon (Ohio EPA ID 2GU00101).

Table 4-11. Facilities (excluding the Toledo MS4) with individual NPDES permits in the Duck Creek subwatershed

Ohio EPA ID	U.S. EPA ID	Facility	Permitee	Type	Size	Waterbody
2IN00218	OH0138525	Middleport Terminal, Toledo	Shell Liquid Division	Industrial	--	Duck Creek
2IW00260	OH0030759	Toledo water treatment plant	City of Toledo	Industrial	--	Duck Creek & Otter Creek

The subwatersheds draining to three of Ohio EPA's sample sites are discussed in the following subsections (refer to Appendix A for site information for each Ohio EPA station). These sites are representative of the impairments to the Duck Creek subwatershed and the Otter Creek watershed.

4.4.5.1 Duck Creek at York Street (P11S56, RM 2.52) subwatershed

The subwatershed is dominated by dense sewered residential developments, the Toledo water treatment plant, and Collins Park Golf Course. After discharging from Hecklinger Pond at I-280, Duck Creek flows through Ravine Park and has a forested riparian corridor. No agricultural activities (e.g., row crops, livestock operations) are evident in the 2010 aerial imagery in the subwatershed.

The only individually NPDES-permitted entities in this subwatershed are the Toledo MS4 and the Toledo water treatment plant (2IW00260). The Toledo water treatment plant has outfalls from its lagoons on Duck Creek. The facility is not permitted to discharge bacteria, but it has effluent limits for TSS. The subwatershed is sewered, and TMACOG (2011) does not identify known critical sewerage areas or failing HSTS. Therefore, the potential sources of *E. coli* are derived from urban runoff and the potential sources of TSS are point sources and urban runoff.

4.4.5.2 Otter Creek at Oakdale Avenue (S03P12, RM 5.92) subwatershed

The subwatershed is dominated by industrial development and row crop fields with some commercial and residential development. The developed areas are sewered, and TMACOG (2011) does not identify any critical sewerage areas or unpermitted package treatment plants. No livestock operations are evident in the 2010 aerial imagery.

Excluding regulated storm water, no individually permitted facilities are allowed to discharge bacteria in this subwatershed. Since critical sewerage areas, failing HSTS, and unpermitted package treatments were not identified, no livestock operations are present; the potential sources of *E. coli* and TSS are derived from urban runoff.

4.4.5.3 Otter Creek adjacent to CSX Road (S03S25, RM 0.40) subwatershed

Aerial imagery from 2010 and TMACOG (2011) shapefiles for critical sewerage areas and sewered areas were evaluated to determine the locations of potential sources of residential, commercial, and industrial runoff. The subwatershed above Oakdale Avenue is discussed in Section 4.4.5.2. The subwatershed below Oakdale Avenue contains a mix of commercial, industrial, and residential properties. Large refineries and petroleum storage facilities (e.g., BP Husky Refinery – Toledo Station), along with associated railroad lines, are in the lower portion of the subwatershed. TMACOG (2011) does not identify any critical sewerage areas or unpermitted package treatment plants; the developed areas are sewered.

Critical sewerage areas, failing HSTS, unpermitted package treatments, and agricultural properties were not identified. Information regarding inflow and infiltration of sanitary sewers and illicit connections to storm sewers are not available. Therefore, the potential sources of *E. coli* and TSS are derived from urban runoff.

4.5 Maumee River (Lower) Tributaries (HUC 04100009 09)

The Maumee River (lower) tributaries, which are a total of 76.5 square miles, include the following: Grassy Creek, Grassy Creek Diversion, Crooked Creek, and Delaware Creek (Figure 4-10). Because of proximity and similar watershed characteristics, Grassy Creek and Grassy Creek Diversion are grouped to form one watershed group. The grouping of Crooked Creek and Delaware Creek (excluding Duck Creek) form the second watershed of the Maumee River (lower) tributaries. Although Duck Creek is physically located in this 10-digit HUC, it was grouped with Otter Creek and previously discussed in Section 4.4.5.

Table 4-12. Maumee River (lower) tributaries (HUC 04100009 09)

HUC 04100009	Name	Area (acres)	Area (sq. mi.)
09 01	Grassy Creek Diversion	15,837	24.7
09 02	Grassy Creek	8,746	13.7
09 03	Crooked Creek – Maumee River	12,074	18.9
09 04	Delaware Creek – Maumee River	12,300	19.2
Total		**48,957**	**76.5**

Note: Areas were calculated in ArcGIS 10 using the North American Datum of 1983 for Ohio State Plane North (FIPS 3401) and were rounded to the nearest acre and one-tenth square mile.

Land cover varies across the Maumee River (lower) tributaries, as shown in Table 4-13. Urban area (summation of developed land classes) varies from 33 percent in the Grassy Creek and Grassy Creek Diversion watersheds to 66 percent in the Crooked Creek and Delaware Creek watershed. Grassland and agricultural lands range from 11 percent in the Crooked Creek and Delaware Creek watershed to 63 percent in the Grass Creek and Grassy Creek Diversion watershed group.

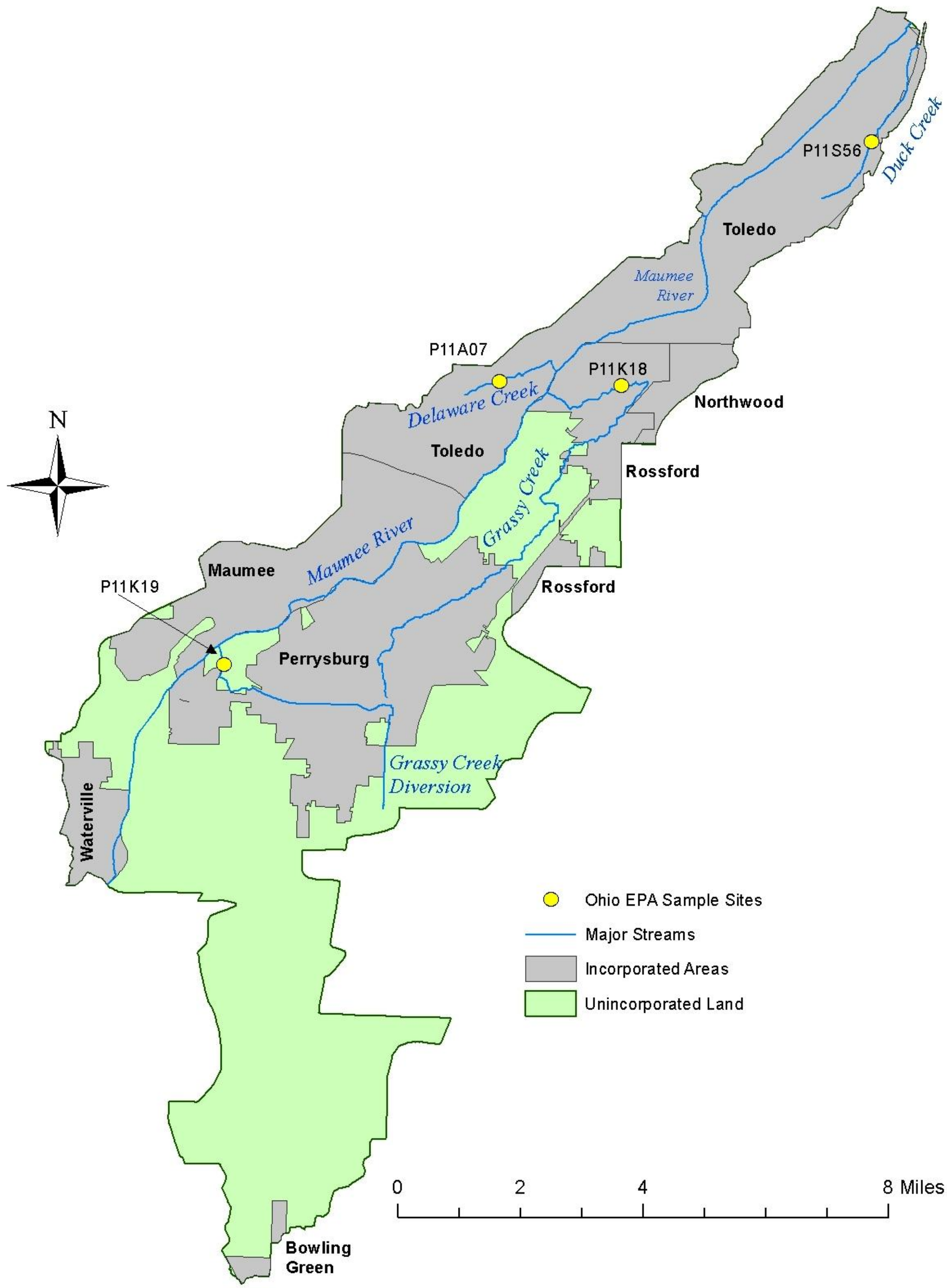


Figure 4-10. Maumee River (lower) tributaries (HUC 04100009 09).

Table 4-13. Land cover in the Maumee River (lower) tributaries (HUC 04100009 09)

Land cover class	Maumee River (lower) tributaries [a] (HUC 04110009 09)		Grassy Creek and Grassy Creek Diversion		Crooked Creek – Maumee River and Delaware Creek – Maumee River [b]	
	Acres	%	Acres	%	Acres	%
Open Water	3,466	7%	90	<1%	3,350	15%
Developed, Open	7,417	15%	2,957	12%	4,062	18%
Developed, Low	11,024	22%	3,801	15%	6,709	29%
Developed, Medium	4,531	9%	1,038	4%	3,131	14%
Developed, High	1,669	3%	410	2%	1,095	5%
Barren Land	292	<1%	133	<1%	156	<1%
Deciduous Forest	1,670	3%	578	2%	1,075	5%
Evergreen Forest	4	<1%	3	<1%	1	<1%
Grassland/Herbaceous	529	1%	343	1%	185	<1%
Pasture/Hay	51	0%	51	<1%	0	--
Cultivated Crops	17,409	36%	15,116	61%	2,294	10%
Woody Wetlands	45	<1%	29	<1%	16	<1%
Emergent Herbaceous Wetlands	850	2%	35	<1%	771	3%
Total	**48,957**	**100%**	**24,584**	**100%**	**22,845**	**100%**

Source: Land cover of the MRLC 2006.
Areas were calculated in ArcGIS 10 using the North American Datum of 1983 for Ohio State Plane North (FIPS 3401) and were rounded to the nearest acre and percent.
a. The values in the Maumee River (lower) tributaries include Duck Creek.
b. The values in the Crooked Creek – Maumee River and Delaware Creek – Maumee River exclude Duck Creek.

The levels of impervious cover vary considerably in HUC 04100009 09, with the highest levels in the Toledo-area as shown in Figure 4-11. The Grassy Creek Diversion watershed has the lowest watershed-scale impervious cover (4 percent), which is mostly limited to the northern fringes of the 12-digit HUC and the roadways throughout the watershed. The Delaware Creek-Maumee River watershed has the highest watershed impervious cover (36 percent).

Four individual and two general permitted facilities are presented in Figure 4-11; for excluded facilities, see Section 4.2.1. The facilities are further discussed in the following sections.

Although much of HUC 04100009 09 is sewered, Ohio EPA identified package treatment plants and HSTS as sources of impairment in some parts of the HUC. Figure 4-12 presents a map of areas that are covered by public sewers and of critical sewerage areas identified in TMACOG (2011). The critical sewerage areas are generally areas with failing HSTS or other non-public sewerage systems that are affecting surface waters.

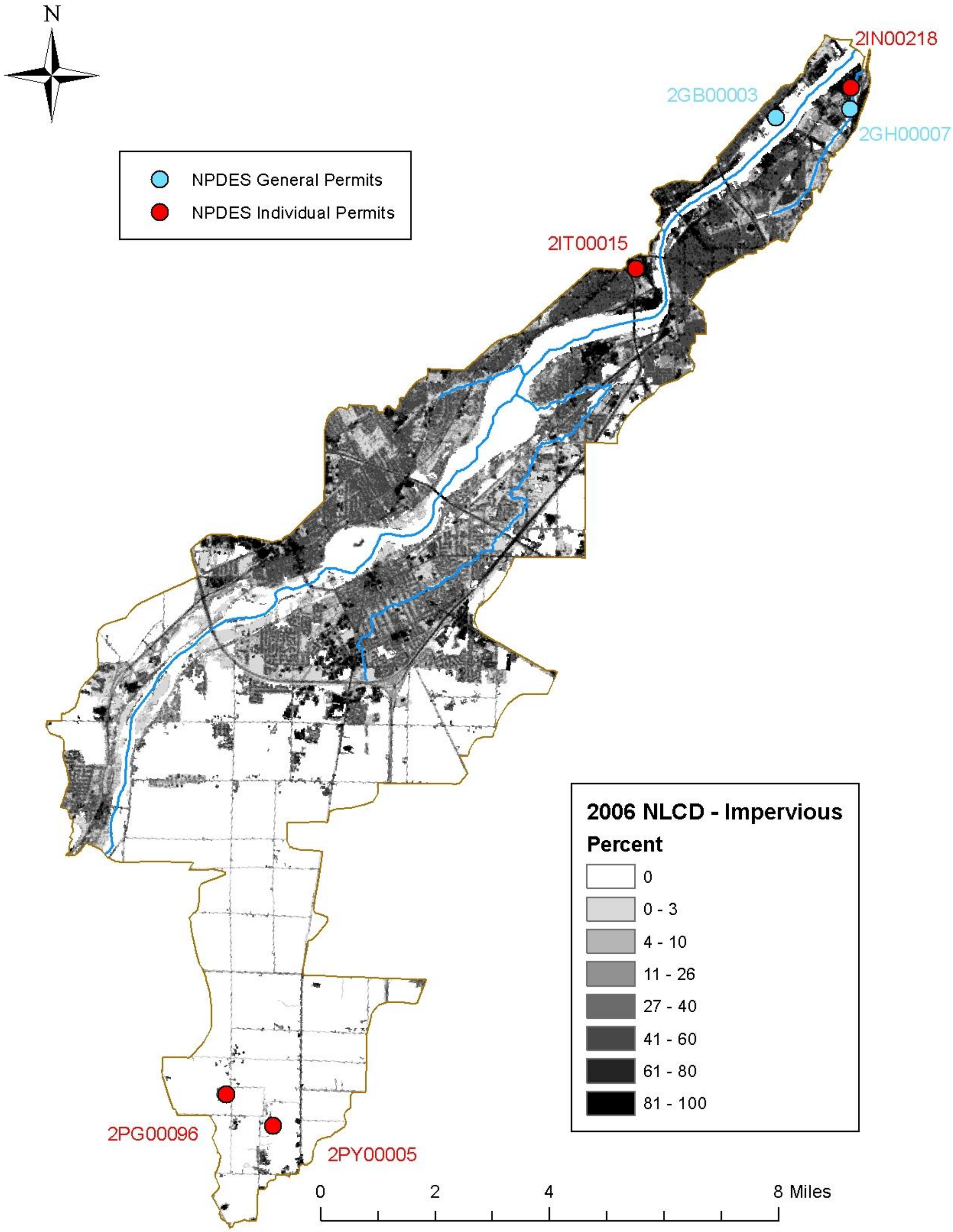
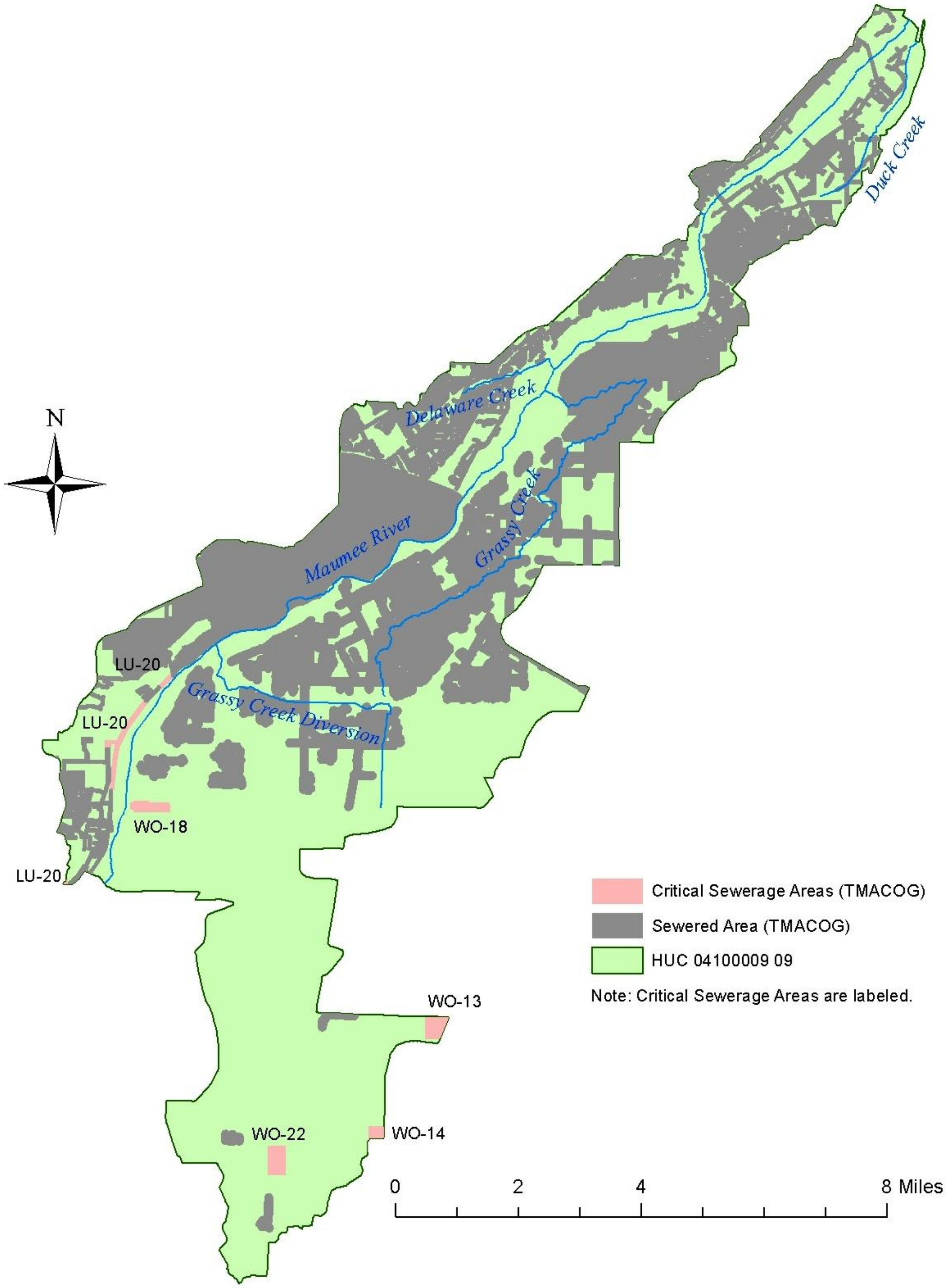


Figure 4-11. NPDES facilities and impervious cover in HUC 04100009 09.[16]

[16] NPDES general permits for storm water are not displayed in Figure 4-11.



Sources: Ohio EPA 2010 and TMACOG 2011.

Figure 4-12. Sewered areas and critical sewerage areas in HUC 0410009 09.

4.5.1 Grassy Creek (HUC 04100009 09 02) and Grassy Creek Diversion (HUC 0410009 09 01)

Figure 4-13. Grassy Creek at Buck Road (2010).

The Grassy Creek and Grassy Creek Diversion watersheds are in portions of Center, Middleton, Plain, and Perrysburg townships (Wood County) and the cities of Perrysburg and Rossford. In general, the Grassy Creek Diversion watershed (24.7 square miles) flows from east to west in Perrysburg Township and its confluence with the Maumee River upstream of the I-475/US-23 bridge. The Grassy Creek watershed (13.7 square miles) is east of, but adjacent to, the Grassy Creek Diversion watershed. Grassy Creek runs northeasterly through the cities of Perrysburg and Rossford. Its confluence with the Maumee River is near the downstream end of Grassy Island. Although the two watersheds are adjacent, land use varies greatly between the two; predominating land use in the Grassy Creek Diversion is cultivated; development (open space, low, medium and high) is predominant in the Grassy Creek watershed. Figure 4-13 shows Grassy Creek at Buck Road (RM 3.9) which is only in partial attainment of its ALU because of siltation. Ohio EPA listed these watersheds as impaired, with the following causes: *E. coli* and sedimentation/siltation.

HSTS are throughout the Grassy Creek and Grassy Creek Diversion watersheds. Much of the Grassy Creek watershed (HUC 04100009 09 02) is sewered (via the cities of Perrysburg and Rossford). In the Grassy Creek watershed, the unsewered area near Bates Road and East River Road, between Perrysburg and Rossford, is a critical area and WCCGHD recommends the construction of public sewers (WCCGHD 2004, p. 53). TMACOG (2011, p. 120) identifies the sewage pumping station—operated by the Northwestern Water and Sewer District at Colony Road along Grassy Creek—as having overflowed in the past.

Two facilities in the Grassy Creek Diversion watershed hold individual NPDES permits (Table 4-14). Both facilities are permitted to discharge bacteria. The permit for Maurer MHP required the facility to remove known overflows and bypasses; the MHP no longer has overflows or bypasses. There are no individual permits for facilities in the Grassy Creek watershed.

Table 4-14. Point sources with individual NPDES permits in the Grassy Creek Diversion watershed

Ohio EPA ID	U.S. EPA ID	Facility	Permitee	Type	Size (mgd)	Waterbody
2PG00096	OH0079197	Country Manor Estates [a]	Northwestern Water and Sewer District	Municipal	0.02	Hull Prairie Ditch
2PY00005	OH0078450	Maurer MHP	Maurer Mobile Home Court, Inc.	Municipal	0.03	Grassy Creek Diversion

Note
a. Country Manor Estates (Ohio EPA 2PG00096) is will be removed and the subdivision is connected to public sewers in June 2012.

The subwatersheds draining to two of Ohio EPA's sample sites are discussed in the following subsections. These sites are representative of the impairments to each watershed.

4.5.1.1 Grassy Creek Diversion at Grand Rapids Road (P11K19, RM 0.28) subwatershed

The Grassy Creek Diversion subwatershed is dominated by agricultural areas with numerous ditches and channelized streams. Except for the northern (downstream) areas, most of the subwatershed is unsewered. A few areas are served by small package treatment facilities (e.g., Maurer MHP). Much of the natural drainage has been modified for agriculture, and many ditches run along roads or row crop fields. No feedlots or livestock operations are apparent in 2010 aerial imagery.

Portions of the following Phase II MS4 entities are in this subwatershed: city of Perrysburg, Wood County and Others (Middleton and Perrysburg townships and the county road authority), and ODOT.

Subdivisions are being built in the northern portion of the subwatershed near the Maumee River and I-475/US-23. Commercial and industrial development is also occurring along State Route 25. An evaluation of aerial imagery from Google Earth™ shows that many of the subdivisions and development along I-475 were not present in 1994 and that a considerable amount of development occurred from 2000 through 2003. No significant development is evident in aerial imagery from 2006 to 2010.

Two individual NPDES-permitted facilities are in the Grassy Creek Diversion subwatershed: Country Manor Estates and Maurer MHP (see Table 4-14); however, Country Manor Estates package treatment plant will be removed in June 2012 when the subdivision is connected to public sewers. TMACOG (2011) does not identify any unpermitted package treatment plants in the subwatershed, but it does identify three critical sewerage areas: Dunbridge (WO-13), Maurer MHP (WO-22), and Sugar Ridge (WO-14). Dunbridge and Sugar Ridge are unsewered, and TMACOG (2011) recommends sewer installation. Maurer MHP previously had bypasses and overflows and may have been affected by inflow and infiltration. Therefore, the potential sources of *E. coli* are point sources, HSTS, animal waste (excluding CAFOs), and urban runoff (including industrial storm water and MS4s).

4.5.1.2 Grassy Creek at Glenwood Road (P11K18, RM 0.98) subwatershed

The evaluation of aerial imagery and TMACOG (2011) shapefiles identified locations of potential sources of *E. coli* and sedimentation: unsewered properties, agricultural areas, and urban runoff. The headwaters portion of the subwatershed is rural and agricultural, whereas the remainder of the subwatershed is developed. Row crop fields dominate the agricultural headwaters portion of the subwatershed; residences are unsewered. No feedlots or livestock operations are apparent in 2010 aerial imagery.

The developed portion of the subwatershed is dominated by dense residential developments in Perrysburg. Commercial and industrial properties are throughout the subwatershed with more industrial properties in the lower one-fourth of the subwatershed. The Ohio Turnpike (I-80/90) and I-75 run through the subwatershed, and four major interchanges are along those interstates. Row crop fields are also between I-75 and dense industrial properties along the Cedar Creek watershed.

No individually permitted facilities are in the subwatershed. TMACOG (2011) does not identify any critical sewerage areas or unpermitted package treatment plants. Therefore, the potential sources of *E. coli* are HSTS, animal waste (excluding CAFOs), and urban runoff (including industrial storm water and MS4s). TSS sources include channelization and urban runoff.

4.5.2 Crooked Creek – Maumee River (HUC 04100009 09 03) and Delaware Creek – Maumee River (HUC 04100009 04)

Figure 4-14. Delaware Creek near Rohr Drive (2010).

The Crooked Creek and Delaware Creek watersheds are along the borders of Lucas and Wood counties. Considerable portions of the watersheds are within the jurisdictional boundaries of Toledo. The Crooked Creek – Maumee River watershed drains approximately 18.8 square miles and the Delaware Creek – Maumee River watershed drains approximately 19.1 square miles. Development covers the majority of these subwatersheds, accounting for approximately 48 percent of the watershed group (Table 4-13). Figure 4-14 shows Delaware Creek at Rohr Drive (RM 0.30), which is in non-attainment of its ALU. Ohio EPA listed the Delaware Creek subwatershed as impaired, with the following causes: *E. coli*, nitrate plus nitrite, and total phosphorus.

This watershed group is dominated by urban development, and most of the area is sewered. HUC 04100009 09 03 was not assessed; thus, it is not further evaluated here. Much of HUC 04100009 09 04 is in Toledo, with dense residential areas and commercial and industrial areas. Delaware Creek flows through residential areas and a park, and the creek typically has a large forested riparian buffer. The mouth on the lower Maumee River is near Harvard Elementary School of Toledo Public Schools. Although much of the area of the watershed is sewered, certain areas are serviced by HSTS and package treatment plants. TMACOG (2011) does not identify any critical sewerage areas in the watershed.

ARC Terminals Toledo (Ohio EPA ID 2GB00003) has a general permit for a petroleum bulk storage facility. One facility has an individual NPDES permit in HUC 04100009 09 04 (Table 4-15), which does not discharge directly to the lower Maumee River; it is not permitted to discharge bacteria.

Table 4-15. Point source with an individual NPDES permit in HUC 04100009 09 04

Ohio EPA ID	U.S. EPA ID	Facility	Permitee	Type	Size (mgd)	Waterbody
2IT00015	OH0078514	Toledo M/W Shop	Norfolk Southern Corporation	Industrial	-- [a]	unnamed tributary to the Maumee River

Note
a. This individual NPDES permit is for storm water.

The subwatershed draining to the only one of Ohio EPA's sample sites in this 12-digit HUC is discussed in the following subsection.

4.5.2.1 Delaware Creek at Rohr Drive (P11A07, RM 0.38) subwatershed

The subwatershed is dominated by dense, sewered, residential developments. Because of the high level of development, it is difficult to observe the creek on the aerial imagery. The subwatershed includes large tracts of land for recreational uses (e.g., Heather Downs Country Club, Lucas County Recreational Center complex, Toledo Country Club) and multiple school complexes, some of which have athletic fields (e.g. Gateway Middle School, Maumee High School, Concord School). Multiple large roadways and divided highways (e.g., Ohio Turnpike [I-80/I-90]) cross the subwatershed. The segment below South Detroit Avenue (U.S. 24) to the mouth of the Maumee River has a wide forested riparian buffer that is surrounded by dense residential areas and schools. The creek flows through a park from the Rohr Drive crossing to the mouth, much of which is influenced by backwater from the Maumee River.

No NPDES-permitted facilities or unpermitted package treatment plants are in the Delaware Creek subwatershed, and the entire subwatershed is sewered (Ohio EPA 2010a; TMACOG 2011). The entire subwatershed is urban without any agriculture. Therefore, the potential sources of *E. coli*, nitrate/nitrite, and total phosphorus are derived from urban runoff.

5 Aquatic Life Use Linkage Analysis

The objective of a linkage analysis is to provide the link between pollutant sources and water quality targets. For this project, a weight-of-evidence approach was used to assess the degree that known sources are likely or unlikely contributors to the impairments. This section presents evaluations of water quality data and point source and nonpoint source contributions and their likely effect on the observed ALU impairments. Evaluations of all pollutants in all waterbodies (i.e., both impaired and attaining streams) are presented in the technical support document (TSD; Ohio EPA 2010a).

Because similar ALU impairments occur across watersheds, the impairments are evaluated by pollutant and source in this chapter.

5.1 Nitrogen, Phosphorus, and Related Impairments

Ammonia, dissolved oxygen, nitrate, organic enrichment, and total phosphorus are evaluated together because they are generally derived from similar sources including failing HSTS, non-irrigated crop production, or urban runoff. Streams that are in non-attainment of their ALU due to nutrient and related impairments are presented in Table 5-1.

Sewage that is not fully treated can contain elevated levels of nitrogen and phosphorus species. Failing or compromised HSTS can discharge elevated levels of nutrients into surface water and ground water, which threaten local public water supplies (TMACOG 2011). Chemical applications (e.g., fertilizers, pesticides) can contain phosphorus species and nitrogen species; runoff from crop fields or urban runoff from manicured lawns transports excess chemicals to the streams.

Table 5-1. Sources of impairments caused by ammonia, dissolved oxygen, nitrate plus nitrite, organic enrichment, and total phosphorus

Assessment site			Cause					Source			
Stream name	Site number	River mile	Ammonia	Dissolved Oxygen	Nitrate + Nitrite	Organic Enrichment	Total Phosphorus	Channelization	Non-irrigated crop production	On-site treatment system	Urban runoff and storm sewers
Turtle Creek – Frontal Lake Erie (HUC 04100010 07 01)											
South Branch Turtle Creek	S03K07	2.65	X	X			X			X	
Turtle Creek	S03K05	11.62					X	X	X		
Crane Creek – Frontal Lake Erie (HUC 04100010 07 02)											
Crane Creek	S03P21	18.82					X	X			X
Henry Creek	201118	0.10					X	X			X
Cedar Creek – Frontal Lake Erie (HUC 04100010 07 03)											
Cedar Creek	S03S34	20.77					X	X	X		
Dry Creek	S03S68	7.00	X	X		X	X	X	X	X	
Berger Ditch (HUC 04100010 07 05)											
Wolf Creek	201111	2.70				X	X	X		X	
Delaware Creek – Maumee River (HUC 04100009 09 04)											
Delaware Creek	P11A07	0.38			X		X				X

Source: Ohio EPA 2010a.

5.1.1 Ohio EPA Water Quality Data

The following two tables present summaries of water quality data collected by Ohio EPA. Ammonia and nitrate plus nitrite are presented in Table 5-2, and total phosphorus and dissolved oxygen are presented in Table 5-3. The subsequent subsections refer back to these tables.

Table 5-2. Ammonia and nitrate plus nitrite data collected in July and August 2008 from selected creeks (both in mg/L)

Location			Ammonia (as nitrogen)					Nitrate plus nitrite (as nitrogen)				
Site ID	Stream	River mile	No. of samples	Minimum	Maximum	Geometric mean	Exceed [a]	No. of samples	Minimum	Maximum	Geometric mean	Exceed
Turtle Creek – Frontal Lake Erie (HUC 04100010 07 01)												
201124	North Branch	0.80	4	0.03	0.10	0.04	0%	4	0.05	**4.62**	0.28	25%
S03K07	South Branch	2.65	4	0.11	**10.50**	1.30	33%	5	0.05	**9.19**	0.35	40%
S03K05	Turtle Creek	11.62	5	0.03	0.17	0.09	0%	5	0.05	**5.46**	0.30	20%
Crane Creek – Frontal Lake Erie (HUC 04100010 07 02)												
S03P21	Crane Creek	18.82	5	0.09	0.75	0.17	0%	5	0.11	**5.33**	0.50	40%
S03K02		15.38	5	0.06	0.14	0.09	0%	5	0.05	**4.99**	0.32	40%
S03G21		8.83	4	0.10	**2.14**	0.51	33%	4	0.80	**5.07**	**1.67**	75%
S03K01 [c]		5.20	5	0.03	0.11	0.04	0%	5	0.05	**6.45**	0.25	40%
S03S65	Henry Creek	3.73	5	0.13	0.33	0.22	0%	5	0.18	**5.27**	0.59	20%
201118		0.10	5	0.08	0.19	0.12	0%	5	0.05	**4.16**	0.35	20%
Cedar Creek – Frontal Lake Erie (HUC 04100010 07 03)												
S03S34	Cedar Creek	20.77	5	0.06	0.58	0.18	0%	5	0.05	**5.80**	0.41	20%
S03S60		17.32	5	0.06	0.14	0.09	0%	5	0.05	**5.82**	0.28	20%
S03S46		14.50	5	0.03	0.11	0.06	0%	5	0.05	**5.78**	0.30	20%
S03S44		9.59	5	0.06	0.10	0.07	0%	5	0.16	**6.44**	0.50	20%
S03S55		4.27	4	0.03	0.12	0.06	0%	4	0.05	**5.57**	0.34	25%
S03S68	Dry Creek	7.00	4	0.19	**1.34**	0.33	25%	5	0.33	**2.41**	0.72	40%
S03S48		0.01	3	0.05	0.20	0.08	0%	5	0.05	**2.82**	0.30	20%
Berger Ditch (HUC 04100010 07 05)												
S03S50	Wolf Creek	6.30	5	0.22	0.87	0.32	0%	5	**2.73**	**14.70**	**5.28**	100%
201111		2.70	5	0.09	0.24	0.17	0%	5	0.43	**3.96**	0.84	20%
Delaware Creek – Maumee River (HUC 04100009 09 04)												
P11A07 [d]	Delaware Creek	0.38	5	0.03	0.31	0.09	0%	6	1.20	**2.71**	**1.63**	100%

Notes
Bolded values violate the ammonia OMZA criteria or exceed the nitrate plus nitrite WWH target (1.0 mg/L for both headwaters and wading streams).
a. Percent of samples that exceed the ammonia OMZA criteria.
b. Percent of samples that exceed the nitrate plus nitrite WWH target (1.0 mg/L for both headwaters and wading streams).
c. Crane Creek at RM 5.2 (S03K01) is lacustrine.
d. Data were collected in June, July, and August 2006.

Table 5-3. Total phosphorus and dissolved oxygen data collected in July and August 2008 from selected creeks (both in mg/L)

Location			Total phosphorus (as phosphorus)					Dissolved oxygen				
Site ID	Stream	River mile	No. of samples	Minimum	Maximum	Geometric mean	Exceed	No. of samples	Minimum	Maximum	Geometric mean	Exceed
Turtle Creek – Frontal Lake Erie (HUC 04100010 07 01)												
201124	North Branch	0.80	4	0.02	**0.14**	0.06	50%	4	7.83	12.32	9.18	0%
S03K07	South Branch	2.65	5	**0.20**	**2.05**	**0.48**	100%	5	**1.95**	7.62	4.12	60%
S03K05	Turtle Creek	11.62	5	0.05	**0.22**	**0.13**	60%	5	5.32	8.65	7.40	0%
Crane Creek – Frontal Lake Erie (HUC 04100010 07 02)												
S03P21	Crane Creek	18.82	5	**0.12**	**0.20**	**0.15**	100%	5	4.14	7.33	5.62	0%
S03K02		15.38	5	0.08	**0.20**	**0.13**	80%	5	5.12	7.35	6.16	0%
S03G21		8.83	4	**0.16**	**0.87**	**0.38**	50%	4	6.87	8.02	7.41	0%
S03K01 [a]		5.20	5	0.15	0.20	0.17	--	5	5.76	7.38	6.57	0%
S03S65	Henry Creek	3.73	5	**0.18**	**0.47**	**0.29**	100%	5	5.43	7.39	6.45	0%
201118		0.10	5	**0.13**	**0.27**	**0.17**	100%	5	4.05	6.98	5.50	0%
Cedar Creek – Frontal Lake Erie (HUC 04100010 07 03)												
S03S34	Cedar Creek	20.77	5	0.06	**0.15**	**0.10**	60%	5	4.17	8.29	6.47	0%
S03S60		17.32	5	**0.08**	**0.15**	**0.11**	100%	5	4.53	8.35	6.55	0%
S03S46		14.50	5	0.06	**0.13**	0.08	20%	5	6.15	8.50	7.17	0%
S03S44		9.59	5	0.06	**0.13**	0.09	40%	5	5.99	8.43	7.23	0%
S03S55		4.27	4	0.03	**0.94**	**0.12**	50%	4	6.62	8.59	7.58	0%
S03S68	Dry Creek	7.00	5	**0.09**	**0.38**	**0.16**	100%	5	**3.65**	7.07	5.97	20%
S03S48		0.01	5	0.04	**0.14**	0.07	40%	5	6.16	8.00	7.06	0%
Berger Ditch (HUC 04100010 07 05)												
S03S50	Wolf Creek	6.30	5	**0.11**	**0.78**	**0.35**	100%	5	4.48	7.14	6.01	0%
201111		2.70	5	**0.15**	**0.26**	**0.19**	100%	5	6.47	8.29	7.12	0%
Delaware Creek – Maumee River (HUC 04100009 09 04)												
P11A07 [b]	Delaware Creek	0.38	6	**0.09**	**0.17**	**0.11**	100%	6	7.49	11.69	9.00	0%

Notes
Bolded values exceed the total phosphorus WWH target (headwaters: 0.08 mg/L; wading: 0.10 mg/L) or violate the dissolved oxygen OMZM (4.0 mg/L).
a. Crane Creek at RM 5.2 (S03K01) is lacustrine.
b. Data were collected in June, July, and August 2006.

5.1.2 South Branch Turtle Creek

The results in Table 5-2 and Table 5-3 show that South Branch Turtle Creek has elevated levels of ammonia and total phosphorus and low levels of dissolved oxygen. Additionally, Ohio EPA detected elevated levels of *E. coli* in South Branch Turtle Creek. Note that biochemical oxygen demand (BOD) and CBOD were not collected. Ohio EPA identified a potential for cross-connections between agricultural tiles and septic systems in this subwatershed. The agency concluded that HSTS and the unsewered community of Martin were the sources of impairment to South Branch Turtle Creek (Ohio EPA 2010a, p. 44). As discussed in Section 4.4.1.1, the potential sources of ammonia and total phosphorus are HSTS, animal waste (excluding CAFOs and manure application), fertilizer application, and storm water.

Cultivated crops fields are present throughout the subwatershed and along properties adjacent to the creek. Section 4.3.6.2 presents a summary of typical fertilizer application practices in Ottawa County, which contains the South Branch Turtle Creek subwatershed. Because anhydrous ammonia is not applied, fertilizers are not a probable source of the ammonia impairment. Phosphorus-containing fertilizers are applied in April and May but exceedances of the in-stream targets tended to occur during July and August. Therefore, fertilizers are not likely to be the source of the phosphorus impairment.

Rural, unsewered, residential properties are present throughout the subwatershed and adjacent to the creek along its entire length. An estimated 42 percent of the HSTS in Ottawa County are at or near their lifespan (OCGHD 2004, p. 24). Evaluations of load duration curves and field samples (Appendix C) show that a continual source of total phosphorus, similar to a point source, is present. The most likely explanation is that the pattern is caused by a concentrated group of residences with failing HSTS. An evaluation of a load duration curve for ammonia with field samples (Appendix C) leads to similar conclusions.

Since OCGHD (2004) and TMACOG (2011) have identified malfunctioning or failing HSTS, including in critical sewerage area OT-8 in Clay Township and in the town of Martin, failing individual HSTS and unsewered communities are the most probable sources of ammonia and total phosphorus to South Branch Turtle Creek. Agricultural runoff from crop fields with fertilizer application and animals (e.g., wildlife, hobby farms, pets) are other potential sources but secondary to that of failing HSTS and unsewered communities. Therefore, the ammonia and total phosphorus impairments are linked primarily to failing HSTS and unsewered communities. The sources will be addressed through ammonia and total phosphorus TMDLs.

The dissolved oxygen impairment will be addressed through the previously mentioned total phosphorus TMDL. Over the course of July and August in the South Branch of Turtle Creek, total phosphorus levels increased and dissolved oxygen levels generally decreased (this is depicted in Figure 5-1). A decreasing trend of dissolved oxygen would be expected if levels of nutrients increased and algal production increased. Also, Ohio EPA staff noted that the water was very green during sample collection on August 27, 2008. On that date the largest total phosphorous (2.05 mg/L) and ammonia (10.5 mg/L) concentrations and lowest dissolved oxygen concentration (1.95 mg/L) were detected at this site and in the entire Turtle Creek watershed. Thus, elevated nutrient levels are likely causing excessive algal production, which cause the green coloring of the water. As discussed in Sections 4.1.4 and 4.1.5, elevated levels of nutrients (specifically total phosphorus) can impair aquatic communities by increasing algal production that lowers dissolved oxygen levels, and the data collected in 2008 tend to confirm this. Because elevated levels of total phosphorus appear to cause low levels of dissolved oxygen, it is appropriate to address the dissolved oxygen impairment through a total phosphorus TMDL because implementing the total phosphorus TMDL would reduce algal growth and thus reduce in-stream oxygen depletion.

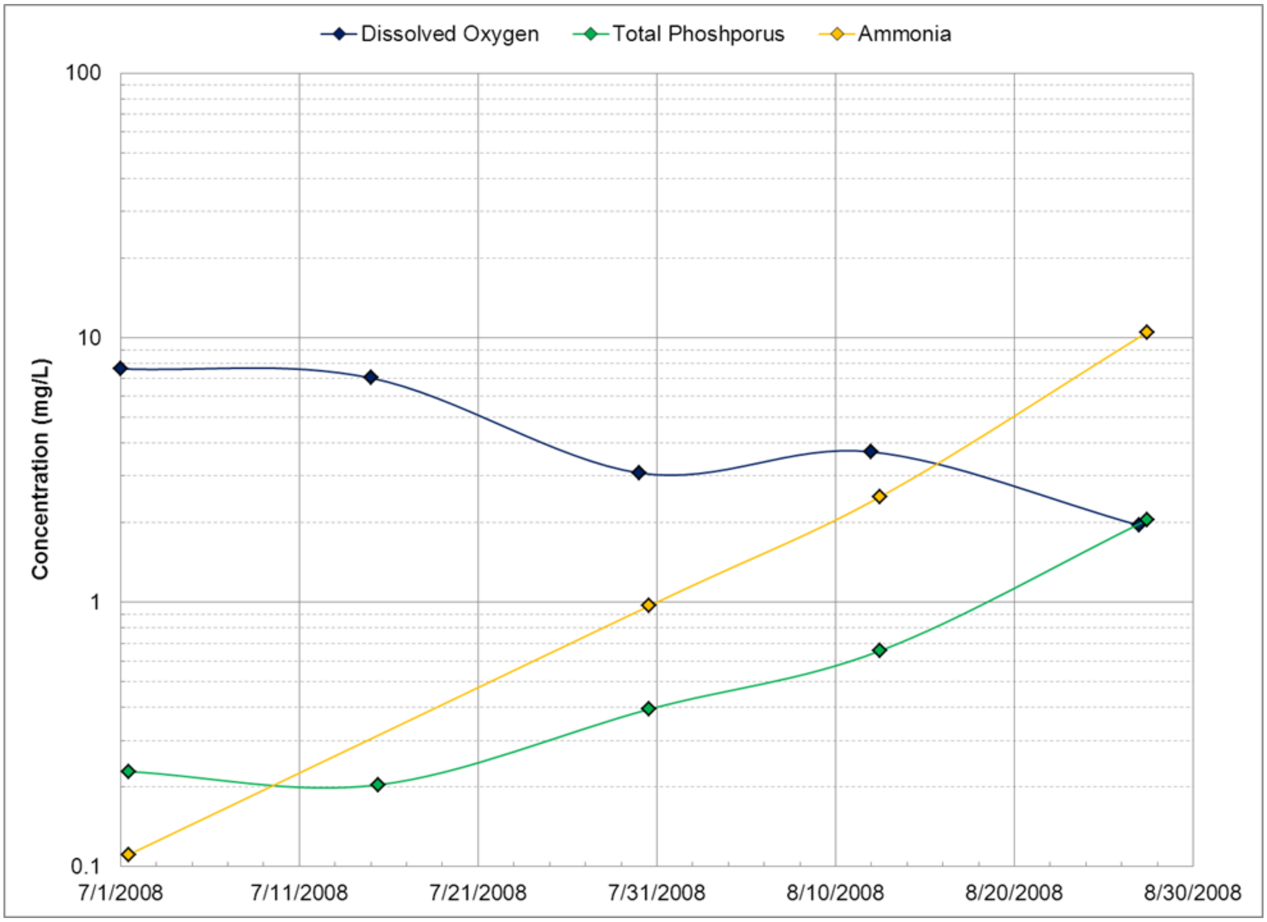


Figure 5-1. Dissolved oxygen, total phosphorus, and ammonia levels in South Branch Turtle Creek at Moline Road (S03K07, RM 2.65).

5.1.3 Turtle Creek

Elevated levels of total phosphorus were detected in Turtle Creek, as shown in Table 5-3. Ohio EPA found that the water quality of Turtle Creek was reflective of the contributions from North and South branches (Ohio EPA 2010a, p. 44). The assessment site at Nissen Road (S03K05, RM 11.62) is 0.3 river mile downstream of the confluence of the two branches. The creek is impaired by total phosphorus and sedimentation/siltation from channelization and non-irrigated crop production. The lower portion of Turtle Creek is lacustrine and affected by Lake Erie backwaters; the lacustrine segment is not evaluated in this report. As discussed in Section 4.4.1.2, the potential sources of total phosphorus are permitted point sources, HSTS, animal waste (excluding CAFOs and manure application), fertilizer application, and storm water.

Cultivated crop fields are present throughout the subwatershed and along properties adjacent to the creek. Section 4.3.6.2 presents a summary of typical fertilizer application practices in Ottawa County, where this subwatershed is located. Phosphorus-containing fertilizers are applied in April and May, but exceedances of the in-stream targets tended to occur during July and August. Therefore, fertilizers are not likely to be the source of the phosphorus impairment.

Two critical sewerage areas are in the subwatershed (refer back to Figure 4-4): Clay Township near Genoa (OT-08) along South Branch and Williston (OT-02) in the North Branch subwatershed. Rural unsewered residential properties are present throughout the subwatershed and directly adjacent to the creek along its entire length. An estimated 42 percent of the HSTS in Ottawa County are at or near their lifespan (OCGHD 2004, p. 24). One individually NPDES-permitted facility was in this subwatershed but is no longer operational (i.e., is not presently discharging): Allen Elementary School (Ohio EPA ID 2PT00042).

In-stream total suspended solids (TSS) and total phosphorus data were evaluated: Turtle Creek is reflective of the conditions of North Branch and South Branch. The South Branch of Turtle Creek clearly contributed large amounts of total phosphorus to Turtle Creek (Appendix D); in some cases, the total phosphorus load in South Branch exceeded the load in Turtle Creek at Nissen Road. No spatial or temporal patterns are apparent with TSS data, nor do TSS concentrations vary similarly with total phosphorus loads. Evaluations of load duration curves and field samples (Appendix C) show that total phosphorus loads exceeded the target loads in the moist through dry-flow zones but not the low-flow zone. The most likely explanation of this pattern is that total phosphorus is derived from multiple sources.

A weight-of-evidence analysis shows that multiple sources are likely contributing total phosphorus to Turtle Creek, including permitted point sources, HSTS and animal waste (excluding CAFOs and manure application). These probable total phosphorus sources will be addressed with a total phosphorus TMDL.

5.1.4 Henry Creek

The results in Table 5-2 and Table 5-3 show that Henry Creek has elevated levels of total phosphorus. Ohio EPA found Henry Creek at Bradner Road (201118, RM 0.01) to be in partial attainment due to a fair ICI score, which was caused by total phosphorus and siltation derived from urban runoff and channelization. As discussed in Section 4.4.1.1, the potential sources of total phosphorus are point sources, HSTS, animal waste (excluding CAFOs), fertilizer application, and storm water (highway, industrial facilities, and MS4s).

Cultivated crops fields are throughout the subwatershed and along properties adjacent to the creek. Section 4.3.6.3 presents a summary of typical fertilizer application practices in Wood County, where this subwatershed is located. Phosphorus-containing fertilizers are applied in the spring and early summer. Because exceedances of the in-stream targets tended to occur during July and August, fertilizers are a probable source of the phosphorus impairment.

Rural, unsewered, residential properties are throughout the subwatershed and directly adjacent to the creek along its entire length (refer back to Figure 4-4). Henry Creek is in Ottawa County and an estimated 42 percent of the HSTS in the county are at or near their lifespan (OCGHD 2004, p. 24). OCGHD (2004) and TMACOG (2011) have identified malfunctioning or failing HSTS, including critical sewerage area WO-20 (Johnson’s subdivision), and unpermitted package treatment plants. Therefore, HSTS, unsewered communities, and unpermitted package treatment plants are probable sources of the phosphorus impairments.

An evaluation of a load duration curve and field samples (Appendix C) shows that exceedances occur during all sampled flow conditions. The most likely explanation of this pattern is that total phosphorus is derived from multiple sources.

Storm water runoff from I-80/I-90, I-280, OH 795, transportation-related and commercial properties along the OH 795 corridor, and railway-related properties are also probable sources of phosphorus to Henry Creek. Other potential sources linked to urban runoff and storm sewers include the multiple industrial or commercial properties and roadways in the eastern portion of the subwatershed. These sources are likely primary sources of total phosphorus to Henry Creek.

The weight-of-evidence analysis shows that the following are probable sources of the in-stream total phosphorus impairment: urban runoff, runoff from crop fields with fertilizer or manure application, failing individual HSTS, and unsewered communities. Animals (e.g., wildlife, hobby farms, pets) and point sources are other potential sources but are likely secondary sources. The total phosphorus impairments that are linked primarily to urban runoff, failing HSTS, unsewered communities, and crop field runoff. The sources will be addressed through a total phosphorus TMDL.

5.1.5 Crane Creek

Crane Creek at Hanley Road (southeast of Walbridge, S03P21, RM 18.82) is impaired for total phosphorus and sedimentation/siltation from urban runoff/storm sewers and channelization. As shown in Table 5-3, every sample collected at this site exceeds the headwaters WWH target of 0.08 mg/L total phosphorus. As discussed in Section 4.4.2.2, the potential sources of total phosphorus are HSTS, animal waste (excluding CAFOs and manure application), fertilizer application, storm water (highway and industrial facilities), and point sources.

Cultivated crop fields are throughout the subwatershed and along properties adjacent to the creek. The Tanglewood Golf Course is also in the headwaters of Crane Creek. Section 4.3.6.3 presents a summary of typical agricultural fertilizer application practices in Wood County, where this subwatershed is located. Phosphorus-containing fertilizers are applied in the spring and early summer. Because exceedances of the in-stream targets tended to occur during July and August, fertilizers are a probable source of the phosphorus impairment.

Rural, unsewered, residential properties are throughout the subwatershed and directly adjacent to the creek along its entire length. Upper Crane Creek is in Wood County, and an estimated 40 percent of the HSTS in the county are not functioning properly (WCCGHD 2004, p. 4). It is probable that HSTS are contributing total phosphorus to Crane Creek.

Storm water runoff from the toll plaza (on I-80/I-90 at the interchange with I-280), toll road, and nearby transportation-related properties are a probable source of phosphorus to Crane Creek. Other potential sources linked to urban runoff and storm sewers include the multiple industrial or commercial properties and roadways in the eastern portion of the subwatershed. These sources are likely primary sources of total phosphorus to Crane Creek.

Evaluations of a load duration curve and field samples (Appendix C) shows that total phosphorus exceedances occur during all sampled flow conditions. The most likely explanation of this pattern is that total phosphorus is derived from multiple sources. An evaluation of total phosphorus and TSS data did not show any apparent trends, except that TSS tended to increase in the lacustrine area. Temporal and longitudinal evaluations showed that total phosphorus levels remained fairly consistent below the non-attainment site (S03P21; RM 18.82) and that a considerable increase occurred between the Collins Road crossing (S03K02, RM 15.38) and Martin-Williston Road crossing (S03G21, RM 8.83); Little Crane Creek and Ayers Creek discharge along this segment (Appendix D).

The most probable sources of elevated total phosphorus levels are urban runoff and storm sewers in the vicinity of the I-80/I-90 and I-280 interchange and toll plaza. Runoff from a golf course and crop fields treated with chemicals (e.g., fertilizers), failing individual HSTS and animals (e.g., wildlife, hobby farms, pets) are other probable sources but are likely secondary to that of urban runoff. The total phosphorus impairments will be addressed through a total phosphorus TMDL.

5.1.6 Dry Creek

The results in Table 5-2 and Table 5-3 show that Dry Creek has elevated levels of ammonia and total phosphorus and low levels of dissolved oxygen. Additionally, Ohio EPA detected elevated levels of *E. coli* in Dry Creek. Note that BOD and CBOD were not collected. The agency concludes that the creek was affected by septic system discharges (Ohio EPA 2010a, p. 44-45). As discussed in Section 4.4.3.1, the potential sources of ammonia and total phosphorus are HSTS, animal waste (excluding CAFOs and manure application), fertilizer application, and storm water.

Similar to most of the project area, cultivated crops fields are throughout the subwatershed and along properties adjacent to the creek. Section 4.3.6.3 presents a summary of typical agricultural fertilizer application practices in Wood County, where this subwatershed is located. Anhydrous ammonia and ammonia- and phosphorus-containing fertilizers are applied in the spring and early summer. Because exceedances of the in-stream targets tended to occur during July and August, fertilizers are a probable source of the ammonia and total phosphorus impairments.

Most of the dense residential areas in the Dry Creek subwatershed are sewered, but unsewered rural residential properties are throughout the subwatershed and directly along Dry Creek. The creek is in Wood County, and an estimated 40 percent of the HSTS in the county are not functioning properly (WCCGHD 2004, p. 4). Because WCCGHD (2004) and TMACOG (2011) identify malfunctioning or failing HSTS, including those in critical sewerage area WO-17 in the Curtice and Bradner area, failing individual HSTS and unsewered communities are probable sources of ammonia and total phosphorus to Dry Creek.

Evaluations of load duration curves and field samples (Appendix C) shows that total phosphorus exceedances occur during all flow conditions, and ammonia exceedances occur during dry conditions. Both parameters' loads increase during dry conditions.

The weight-of-evidence analysis shows that the following are probable sources of the in-stream total phosphorus impairment: runoff from crop fields with fertilizer or manure application, failing individual HSTS, and unsewered communities. Animals (e.g., wildlife, hobby farms, pets) are another potential sources but are likely a secondary source. The total phosphorus impairments are linked primarily to failing HSTS, unsewered communities, and crop field runoff. The sources will be addressed through ammonia and total phosphorus TMDLs.

Ohio EPA identifies organic enrichment and dissolved oxygen as causes of impairment (Ohio EPA 2010a). Failing HSTS are also the source of these impairments. A graphical evaluation of dissolved oxygen and total phosphorus concentrations showed that dissolved oxygen levels respond to total phosphorus levels in Dry Creek at East Broadway Road (S03K07, RM 7.00; see Appendix D). For example, on July 30, 2008, total phosphorus levels increase considerably to 0.38 mg/L, and dissolved oxygen levels drop to 3.65 mg/L. A similar pattern occurs with ammonia and dissolved oxygen levels. Data at the mouth of Dry Creek (S03S48, RM 0.01) show no discernible pattern; however, total phosphorus and ammonia levels are considerably smaller at this site.

The water quality results show that the depletion of dissolved oxygen coincides with elevated concentrations of total phosphorus. To a lesser degree, dissolved oxygen levels vary with ammonia levels. Because all the causes of impairment are linked to HSTS and unsewered areas and because dissolved oxygen levels vary with total phosphorus, it is appropriate to address the dissolved oxygen and organic enrichment impairments through a surrogate total phosphorus TMDL. Implementing both the total phosphorus and ammonia TMDLs will address failing HSTS and unsewered communities; thus, both TMDLs will reduce in-stream oxygen depletion and reduce organic enrichment.

5.1.7 Cedar Creek

Total phosphorus and sedimentation/siltation from non-irrigated crop production and channelization impair Cedar Creek at Oregon Road (S03S34; RM 20.77), which is in the headwaters of the Cedar Creek watershed (Ohio EPA 2010a). With the exception of elevated levels of *E. coli* because of the unsewered town of Curtice, Ohio EPA found that the water quality of Cedar Creek was fairly good (Ohio EPA 2010a, p. 45). As discussed in Section 4.4.3.2, the potential sources of total phosphorus are point sources, HSTS, animal waste (excluding CAFOs and manure application), fertilizer application, and storm water.

Similar to Dry Creek, cultivated crop fields are throughout the subwatershed and along properties adjacent to the creek. Fertilizers are potential sources of phosphorus species that can cause total phosphorus impairments in upper Cedar Creek. As discussed in Section 4.3.6, phosphorus may be applied in April through June. Because exceedances of the in-stream targets tended to occur during July and August, fertilizers are a probable source of the phosphorus impairment.

The entire subwatershed is unsewered. Although it is mostly rural residential and agricultural, a few commercial or industrial properties are there. The Dowling (WO-12) and Dunbridge (WO-13) critical sewerage areas are along the subwatershed boundaries and can contribute domestic wastewater to the upper Cedar Creek subwatershed through the various roadside ditches and agricultural field canals. The creek is in Wood County, and an estimated 40 percent of the HSTS in the county are not functioning properly (WCCGHD 2004, p. 4).

Evaluations of a load duration curve and field samples (Appendix C) show that total phosphorus exceedances occur during mid-range through low-flow conditions. The most likely explanation of this pattern is that total phosphorus is derived from multiple sources. Analyses of in-stream TSS and total phosphorus concentrations were inconclusive; examples of some analyses are presented in Appendix D.

The weight-of-evidence analysis shows that the following are probable sources of the in-stream total phosphorus impairment: runoff from crop fields with fertilizer application and failing individual HSTS. Animals (e.g., wildlife, hobby farms, pets) are another potential sources but are likely a secondary source. The total phosphorus impairments are linked primarily to crop field runoff and failing individual HSTS All of the previously mentioned sources will be addressed through a total phosphorus TMDL.

5.1.8 Wolf Creek, Wolf Ditch, and Berger Ditch

Ohio EPA (2010) reports elevated levels of phosphorus, ammonia, nitrate and *E. coli* along Wolf Creek and Wolf Ditch that might be in part from septic system discharges. The causes of impairment are organic enrichment (sewage) and total phosphorus from channelization and HSTS. The available ammonia, dissolved oxygen, and total phosphorus data are presented in Table 5-2 and Table 5-3; note that CBOD and BOD were not collected. None of the ammonia or dissolved oxygen data violated their respective numeric criteria; however, all the total phosphorus values exceed the target established in the *Associations* document (Ohio EPA 1999).

Ohio EPA field staff noted "heavy black sediment, septic odor, [and] abundant algae" at Wolf Creek at Curtice Road (RM 6.30, S03S50) during sampling on 9/3/1998. The total phosphorus in this sample was 1.41 mg/L, the BOD (5-day) was 72.0 mg/L, and the CBOD was 56.0 mg/L. Thus, in 1998, septic systems discharges were likely causing organic enrichment and algal blooms that impaired the stream.

Ohio EPA also found elevated levels of *E. coli* and nitrates and the agency concluded that the upper site (S03S50, RM 6.30) was "impacted by a nearby septic discharge(s)" (Ohio EPA 2010a, p. 45). As discussed in Section 4.4.4.2, the potential sources of total phosphorus are HSTS, animal waste (excluding CAFOs and manure application), fertilizer application, and storm water.

Similar to other subwatersheds, cultivated crop fields are throughout the subwatershed and along properties adjacent to the creek. Fertilizers are potential sources of phosphorus species that can cause total phosphorus impairments in Wolf Creek and Berger Ditch watersheds. As discussed in Section 4.3.6, phosphorus may be applied in March. In-stream phosphorus levels are elevated in July. Because subwatershed-specific fertilizer information is not available, fertilizers are probably not a source of the total phosphorus impairment.

Unsewered rural residential properties are throughout the subwatershed and directly along Wolf Creek and Wolf Ditch; many residential properties along major roads are sewered. Evaluations of load duration curves and field samples (Appendix C) shows that total phosphorus exceedances occur during all flow conditions. Such a pattern typically means that multiple sources are contributing pollutants.

Because TMACOG (2011) identifies malfunctioning or failing HSTS, including critical sewerage area WO-17 in the Curtice and Bradner area, failing individual HSTS and unsewered communities are the most probable sources of organic enrichment and total phosphorus to Wolf Creek. Agricultural runoff from crop fields with chemical application (e.g., fertilizers), wildlife, and hobby farms with a few livestock are other potential sources but secondary to that of HSTS and unsewered communities. The total phosphorus impairments are linked primarily to failing HSTS. All of the sources will be addressed with a total phosphorus TMDL.

Ohio EPA identified organic enrichment and dissolved oxygen as causes of impairment (Ohio EPA 2010a). Failing HSTS are also the source of these impairments. An evaluation of total phosphorus and dissolved oxygen data showed that dissolved oxygen levels respond to total phosphorus and ammonia levels in Wolf Creek. Generally, total phosphorus levels were higher and dissolved oxygen levels lower at the upstream sample site (Stadium Road, RM 6.30, S03S50) compared to the downstream site (Curtice Road, RM 2.70, 201111; see Appendix D). At the upper site (S03S50, RM 6.30), dissolved oxygen levels vary with total phosphorus; to a lesser degree, dissolved oxygen levels vary with ammonia.

The water quality results show that dissolved oxygen depletion is related to elevated concentrations of total phosphorus and ammonia. Because all of the causes of impairment are linked to HSTS and unsewered areas, it is appropriate to address the organic enrichment impairments through a surrogate total phosphorus TMDL. Implementing the total phosphorus TMDL will address failing HSTS and unsewered communities; thus the TMDL will reduce organic enrichment.

5.1.9 Delaware Creek

Delaware Creek is in non-attainment of its WWH designated use because of flow regime alterations, nitrate/nitrite, and total phosphorus. The sources of those impairments are urban runoff and storm sewers and channel erosion/incisions from upstream channel modification (Ohio EPA 2010a, p. 160). The agency also identified elevated levels of alpha-BHC (a pesticide), chloride, conductivity, and total dissolved solids in Delaware Creek (Ohio EPA 2010a, p. 46). As discussed in Section 4.5.2.1, the potential source of nitrate/nitrite and total phosphorus is from urban runoff.

Cultivated crop fields are not present, but chemical-application is a potential source because fertilizers and pesticides are likely applied to residential lawns, golf courses, athletic fields, and grassed areas at industrial, commercial, and institutional complexes. Storm water from fertilizer washoff contains elevated levels of nutrients (Shaver et al. 2007). As previously mentioned, Ohio EPA detected elevated levels of a-BHC, a pesticide, in addition to elevated levels of nutrients. Specific information regarding fertilizer and pesticide-application in the Delaware Creek subwatershed is not available; however, both types of chemicals are considered probable sources for the in-stream nitrate/nitrite and total phosphorus impairments.

The elevated levels of chloride, conductivity, and total dissolved solids that Ohio EPA found are probably derived from deicing agents applied during snow events. The constituents travel from roads, driveways, parking lots, and such through the storm sewer system and likely discharge to Delaware Creek. Ohio EPA also detected elevated levels of *E. coli*. Urban sources of bacteria that are also potential sources of total phosphorus and nitrate/nitrite are wildlife (e.g., deer, raccoons, geese) and pets. During precipitation events, animal waste is carried by storm water runoff into the storm sewer system. Potential sources of bacteria with nutrients from human waste are illicit connections to the storm water conveyance system and inflow and infiltration.

Evaluations of load duration curves and field samples (Appendix C) show that total phosphorus and nitrate/nitrite exceedances occur during all flow conditions. Typically, such results mean that multiple sources are contributing pollutants.

The suite of elevated and exceeding pollutants is typical of urban runoff that is conveyed to streams via storm sewers. Total phosphorus and nitrate/nitrite TMDLs are appropriate to address the multiple sources of urban runoff (e.g., fertilizers, pesticides, animal waste).

5.2 Sedimentation/Siltation

Increased rates of sedimentation and siltation affect aquatic communities. Stream-bottom substrates can become embedded as sedimentation and siltation occur, thus rendering the habitat ecologically nonfunctional (Shaver et al. 2007). For example, poor stream bed quality makes urban streams poor spawning environments (Schueler 2004). Sedimentation and siltation not only degrade habitat, but also directly affect aquatic life. For example, silt can clog fish gills. The cumulative effects of increased sedimentation (e.g., loss of high-quality habitat) affect aquatic communities by degrading community structure, reducing populations, and decreasing diversity. The effects of those negative effects on aquatic communities become evident in the poorer scores of the biological community health indices, which indicate that the waterbodies fail to meet their designated ALUs.

Ohio EPA (2010a) identifies sedimentation and siltation as a cause of impairment in seven watersheds; the sources of sedimentation and siltation are presented in Table 5-4. The sources of impairment include non-irrigated crop production typical for the Lake Erie tributaries (HUC 0410000 10) and urban runoff, storm sewers and related urban development for the Maumee River (lower) tributaries.

Channelization is a source of sedimentation/siltation throughout the entire project area. The Great Black Swamp was drained by building ditches and channelizing streams to allow for agricultural, and later urban, development. Roadside ditches are along many rural roads in the southern agricultural portion of the project area. Streams were also channelized and re-routed in the urban northern portion of the area, especially along major roadway and railway corridors.

Table 5-4. Sources of sedimentation and siltation impairments

HUC	Name	Channelization	Industrial parks and landfills	Impervious surfaces runoff	Non-irrigated crop production	Urban runoff and storm sewers
04100010 07 01	Turtle Creek – Frontal Lake Erie	X			X	
04100010 07 02	Cedar Creek – Frontal Lake Erie	X			X	
04100010 07 03	Crane Creek – Frontal Lake Erie	X				X
04100010 07 05	Berger Ditch	X			X	
04100010 07 06	Otter Creek – Frontal Lake Erie	X	X	X		X
04100009 09 02	Grassy Creek	X				X
04100009 09 04	Delaware Creek – Maumee River	X				X

Source: Ohio EPA 2010a, p. 154.

5.2.1 In-stream Water Quality Data

Ohio EPA evaluated water quality samples collected during the 2006 and 2008 field surveys for TSS; a summary of the data is presented in Table 5-5. At all but two of the sedimentation/siltation- impaired sites, TSS samples exceeded the 24 mg/L TSS target derived from the *Associations* document (Ohio EPA 1999) by 20 to 100 percent. The two exceptions are Otter Creek adjacent to CSX Road (RM 0.40, S03S25) and Duck Creek at York Street (RM 2.52, P11S56).

Table 5-5. TSS data (mg/L) collected in 2006 and 2008 from the project area

HUC	Site ID	Stream	RM	Size	No. of samples	Min	Max	Geomean	Exceed [a]
Lake Erie tributaries (HUC 04100010 07)									
01	**201124**	North Branch	0.80	H	4	n.d.	**29**	10	25%
	S03K07	South Branch	2.65	H	5	5	**46**	16	20%
	S03K05	Turtle Creek	11.62	W	5	13	**36**	22	40%
02	**S03P21**	Crane Creek	18.82	H	5	16	**49**	**28**	60%
	S03K02		15.38	W	5	10	**34**	21	40%
	S03G21		8.83	W	4	7	**32**	13	25%
	S03K01[b]		5.20	W	5	**29**	**49**	**38**	--[b]
	S03S65	Henry Creek	3.73	H	5	15	**71**	**36**	60%
	201118		0.10	H	5	17	**31**	23	40%
03	**S03S34**	Cedar Creek	20.77	H	5	**30**	**52**	**39**	100%
	S03S60		17.32	H	5	11	**50**	22	40%
	S03S46		14.50	W	5	5.5	**58**	16	20%
	S03S44		9.59	W	5	7	**58**	20	40%
	S03S55		4.27	W	4	6	**48**	12	25%
	S03S68	Dry Creek	7.00	H	5	**28**	**53**	**33**	100%
	S03S48		0.01	H	5	6	**83**	21	40%
04	201144	Wolf Creek/Williams Ditch	1.70	H	4	20	**31**	**26**	75%
05	S03S50	Wolf Creek	6.30	H	5	6	**93**	20	40%
	201111		2.70	H	4	12	**116**	**46**	75%
06	**S03P12**	Otter Creek	5.92	H	8	n.d.	**60**	8	13%
	S03P08		2.95	H	8	6	**62**	17	38%
	S03P05		2.13	H	7	13	**37**	**25**	57%
	S03S25		0.40	H	2	8	19	12	0%
Maumee River (lower) tributaries (HUC 04100009 09)									
01	P11K19	Grassy Creek Diversion	0.28	H	7	n.d.	20	9	0%
02	P11A05	Grassy Creek	4.85	H	7	n.d.	18	6	0%
	P11K18 [c]		0.98	H	6	6	**31**	10	17%
04	P11A07	Delaware Creek	0.38	H	6	n.d.	**60**	8	17%
	300376	Duck Creek	4.00	H	4	n.d.	6	3	0%
	P11K22		3.10	H	2	8	**46**	19	50%
	P11S56		2.52	H	2	n.d.	8	4	0%

Notes

Bolded red represents sites that Ohio EPA determined to be impaired by sedimentation/siltation.

Bolded blue represents values that exceed the 24.0 mg/L, which is the 75th percentile TSS data for both headwaters and wading reference streams (excluding urban and physically modified sites) in the HELP ecoregion (Ohio EPA 1999, Appendix I, p. 24).

The detection limit for TSS was 5.0 mg/L; 2.5 mg/L was used for non-detects in the calculation of the geometric mean.

Geomean = geometric mean; H = headwaters stream; HUC = hydrologic unit code; max = arithmetic maximum; min = arithmetic minimum; n.d. = non-detect; RM = river mile; W = wading stream.

a. Percent of individual samples at a site that exceed 24.0 mg/L, which is the 75th percentile TSS data for both headwaters and wading reference streams (excluding urban and physically modified sites) in the HELP ecoregion (Ohio EPA 1999, Appendix I, p. 24).

b. Crane Creek at RM 5.2 (S03K01) is lacustrine; the TSS target does not apply.

c. Ohio EPA found Grassy Creek at Buck Road (RM 3.85; P11Q07) to only be in partial attainment of its WWH designation because of sedimentation/siltation. However, no TSS data are available for this site. The impaired site is between the two displayed sites (P11A05 and P11K18) and can affect the downstream site (P11K18).

5.2.2 QHEI Data

Summaries of QHEI scores across the project area are presented in Figure 5-2 and Table 5-8. Explanations of the color-coding shown in Table 5-8 are presented in Table 5-6 and Table 5-7.

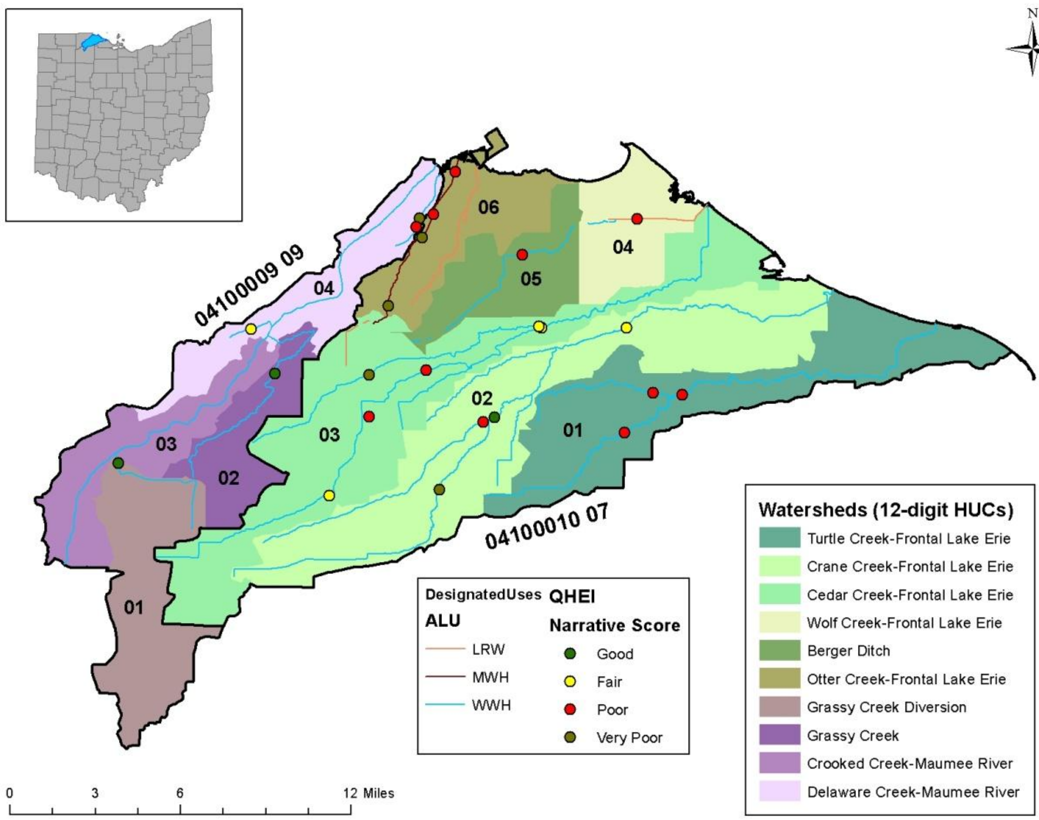


Figure 5-2. QHEI and ALU designated uses in the project area.

Table 5-6. QHEI scoring scheme

Narrative score	Headwaters streams	Wading streams and rivers
Excellent	≥ 70	≥ 75
Good	55–69	60–74
Fair	43–54	45–59
Poor	30–42	30–44
Very Poor	< 30	< 30

Source: Ohio EPA 2006.

Table 5-7. Metric score color coding

Color	Percent of maximum score [a]
	0%–49%
	50%–74%
	75%–100%

Note
a. The percent of maximum potential metric score is calculated as individual metric score divided by the maximum potential score and converted to a percentage.

Table 5-8. QHEI and metric scores

HUC	Stream	RM	Year	Type	QHEI	Substrate (20)	Instream cover (20)	Channel morphology (20)	Bank erosion and riparian zone (10)	Pool/glide (12)	Riffle/run (8)	Gradient (10)
Lake Erie tributaries (04100010 07)												
01	North Branch Turtle Creek	**0.8**	2008	W	31.5	1.5	8	8	3	4	1	6
	South Branch Turtle Creek	2.6	2008	W	39.5	5.5	10	8	5.5	3	1.5	6
	Turtle Creek	**11.6**	2008	W	30.5	0.5	10	6.5	4.5	5	0	4
02	Henry Creek	**0.2**	2008	H	34	3.5	11	7	4	4	0.5	4
	Crane Creek	**18.9**	2008	H	29.5	2.5	10	6	3	3	1	4
		15.4	2008	H	55	11.5	11	14	6	5	1.5	6
		8.8	2008	W	52.5	10.5	12	12	4	6	2	6
03	Dry Creek	7.0	2008	H	26.5	0	6	6	3.5	5	2	4
		0.1	2008	H	50	6.5	12	14	4.5	5	2	6
	Cedar Creek	**20.8**	2008	H	45	6.5	9	10	4.5	3	2	10
		17.3	2008	H	33	1.5	10	7	5	4	1.5	4
		14.5	2008	W	38	2.7	10	8	5.5	6	0	6
		9.6	2008	W	51.5	7.5	11	13	4.5	6	3.5	6
04	Wolf Creek/Williams Ditch	1.7	2008	L	31	-2	13	6	4	8	0	2
05	Wolf Ditch/Berger Ditch	**2.7**	2008	H	34.5	0	10	12	3.5	5	0	4
06	Otter Creek	**6.0**	2006	H	23	1	10	8	4	3	0	6
		3.1	2006	H	25.5	2.5	4	6	5	4	0	4
		2.2	2006	H	30	1	4	8	7	8	0	2
		0.5	2006	L	35	2.5	1	5.5	7	8	0	2
Maumee River (lower) tributaries (04100009 09)												
01	Grassy Creek Diversion Channel	0.3	2006	H	66.5	17	15	7.5	6	10	3	8
02	Grassy Creek	**3.9**	2006	H	59.5	14	10	14	5.5	12	0	4
04	Delaware Creek	0.3	2006	H	45	11	9	12	7	4	0	2
	Duck Creek	**3.1**	2008	H	30	0	9	11	4	4	0	2
		2.4	2008	H	22	0	6	6	4	4	0	2

Notes
Bolded red represents sites that Ohio EPA determined to be impaired by sedimentation/siltation.
H = headwaters (drainage area less than 20 square miles); W = wading (drainage area 20 to 100-200 square miles [the upper limit depends on sampling method]).

5.2.3 Turtle Creek – Frontal Lake Erie (HUC 04100010 07 01)

In the Turtle Creek – Frontal Lake Erie HUC, Ohio EPA identified channelization as the source of impairments caused by sedimentation/siltation. As discussed in Section 4.4.1, point sources and runoff from agricultural operations (including row crops or small livestock operations) are additional potential sources of impairment.

Turtle Creek (6.5) and North and South Branches (8 each) scores for the channel morphology metric indicate the channel condition is poor (Table 5-8). In each creek, the channel sinuosity was low and the channels were poorly developed. Each creek either had recent channelization or was recovering from channelization. These three sites had moderate to heavy silt in their substrate and moderate to extensive substrate embeddedness. High levels of embeddedness suggest that suspended sediment was once present but has since been deposited (U.S. EPA 2012).

Excluding storm water, permitted point sources are not the source of sedimentation/siltation. The only individual NPDES-permitted facility is the White Rock Quarry (Ohio EPA ID 2IJ00037), which discharges to an unnamed tributary of the North Branch of Turtle Creek. Ninety percent of DMR records report a daily flow rate; when discharging, the flow rate varied from 0.0004 to 3.46 mgd, with a median of 0.56 mgd. TSS concentrations were reported for 118 of 235 water quality samples and ranged from 1 to 57 mg/L, with a median of 5 mg/L. From February 2002 through September 2009, the Quarry only discharged TSS in excess of 24 mg/L on three occasions (25, 30, and 57 mg/L). Without corresponding TSS loads from the North Branch of Turtle Creek, the impact of this Quarry upon the creek cannot be fully evaluated. However, based upon the limited data, it appears that the White Rock Quarry typically contributes a relatively small TSS load to the North Branch of Turtle Creek and is not causing the sedimentation/siltation impairment.

An evaluation of the load duration curve and field samples using TSS as the surrogate pollutant for sedimentation/siltation (Appendix C) shows that exceedances occur during moist and mid-range conditions. Though the number of samples and representativeness are limited, the evaluation did not show any impacts from a continually-discharging point source. Results indicate that runoff (agricultural) is a likely contributor of sediment loads as well as in-stream sources such as bank erosion and channelization due to high flow conditions.

5.2.4 Crane Creek – Frontal Lake Erie (HUC 04100010 07 02)

In the Crane Creek – Frontal Lake Erie HUC, Ohio EPA identified channelization and urban runoff and storm sewers as the sources of impairment caused by sedimentation/siltation. As discussed in Section 4.4.2, point sources and runoff from agricultural operations (including row crops or small livestock operations) are additional potential sources of impairment.

An evaluation of QHEI data shows that the upper portion of the watershed had worse channel morphology metric scores than the lower portion of the watershed (Table 5-8). Crane Creek at Hanley Road (RM 18.90) and Henry Creek near the mouth (RM 0.01) had channel morphology metric scores of 6 and 7 (respectively) and both sites are impaired for sedimentation/siltation. Crane Creek at Martin-Williston Road (RM 8.83) and at Collins Road (RM 15.38) scored 12 and 14, respectively. The sinuosity attribute scores were low (except for a moderate score for Crane Creek at Martin-Williston Road) and the development scores were poor (except for a good score for Crane Creek at Collins Road). Crane Creek at Hanley Road and Henry Creek near the mouth were recently channelized; no channelization was present at the two downstream Crane Creek sites. Channelized streams and ditches are apparent along segments of Crane Creek and its tributaries in the 2010 aerial imagery.

Substrate embeddedness at these four sites was moderate to extensive. Substrate siltation was moderate to heavy at each site except for Crane Creek at Collins Road, which had low to moderate siltation. Riffle/run substrate was unstable to moderately stable, and riffle/run embeddedness was moderate to extensive. These QHEI attribute scores indicate that sedimentation/siltation affect Crane and Dry creeks.

All seven facilities with individual NPDES permits (refer back to Table 4-7 in Section 3) are allowed to discharge TSS; three facilities have individual permits for storm water with monitoring requirements only. TSS detections at Luther Home of Mercy (Ohio EPA ID 2PS00013) ranged from 0.5 to 197 mg/L (n = 136, median = 5 mg/L), and TSS detections at Wildflower Place Subdivision (Ohio EPA ID 2PW00010) ranged from 0.16 to 2,400 mg/L (n = 282, median = 4 mg/L). Luther Home of Mercy and Wildflower Place Subdivision are scheduled to be closed and the areas will be connected to public sewers.

Both Perrysburg Estates MHP (Ohio EPA ID 2PY00014; 444 detections, range = 0.5 to 53 mg/L, median = 3 mg/L), and Village Green MHP (Ohio EPA ID 2PY0008; 463 detections, range = 1 to 20 mg/L, median = 6 mg/L) contributed TSS loads. Due to the low concentrations that are typically discharged from each facility and the fact that their combined WLA is only 11 percent of the loading capacity of Crane Creek, it is apparent that neither facility was the primary cause of the impairment.

DMR data for the three facilities with individual NPDES permits for storm water show that these facilities may be a significant source of TSS during certain flow conditions. Fuel Mart #641 (Ohio EPA ID 2II00050; 445 detections, range = 2 to 1,174 mg/L, median = 16 mg/L), Pilot Travel Center (Ohio EPA ID 2IN00147; 130 detections, range = 3.13 to 370 mg/L, median = 10 mg/L), and Toledo Travel Center (Ohio EPA ID 2II00030; 64 detections, range = 1.4 to 434 mg/L, median = 45 mg/L) each discharged at high sediment concentrations. Combined, the DMR data for these facilities include 104 records at concentrations in excess of 60 mg/L, including 47 records in excess of 100 mg/L. Further analysis, including in-stream samples to be collected just downstream of these facilities, is necessary to determine the impact these three facilities are having on Crane Creek.

An evaluation of a load duration curve and field samples using TSS as the surrogate pollutant for sedimentation/siltation (Appendix C) shows that exceedances occurred during the mid-range flow condition. Though the number of samples and representativeness are limited, the evaluation did not show any impacts from continually-discharging point sources. TSS exceedances occurring during mid-range flow conditions indicate storm water runoff as a likely source.

The conclusion of the weight-of-evidence analysis is that channelization and urban runoff are the primary sources of sediment loads; these sources will be addressed through a TSS TMDL.

5.2.5 Cedar Creek – Frontal Lake Erie (HUC 04100010 07 03)

In the Cedar Creek – Frontal Lake Erie HUC, Ohio EPA identified channelization and non-irrigated crop production as the sources of impairment caused by sedimentation siltation. As discussed in Section4.4.3, point sources, runoff from agricultural operations (including row crops or small livestock operations) and urban development are additional potential sources of impairment.

There are no apparent spatial trends with the QHEI scores for the channel morphology metric at the four sampled sites on Cedar Creek and two sampled sites on Dry Creek. All the sites had low channel sinuosity (except Dry Creek at the mouth [RM 0.01]) and poor or fair channel development. Recent channelization occurred on Cedar Creek at East Broadway Road (RM 17.73) and Dry Creek at East Broadway Road (RM 7.00). The stream channels were scored as recovering on Cedar Creek at Lemoyne Road (RM 14.50) and at Oregon Road (RM 20.77). No channelization was recorded on Cedar Creek at

Billman Road (RM 9.59) or Dry Creek at the mouth. In addition to the assessed sites, channelized streams and ditches along tributaries to Cedar Creek are apparent throughout the watershed in 2010 aerial imagery. No trends are apparent with substrate siltation and embeddedness attribute scores or riffle/run substrate and embeddedness scores.

All six permitted facilities in this watershed may discharge TSS in their effluent. Bulk Plant Millbury (Ohio EPA ID 2IN00174) and Evergreen Recycling and Disposal (Ohio EPA ID 2IN00108) have individual NPDES permits that are only for storm water. Bulk Plant Millbury only has a monitoring requirement, and of its 20 samples, 3 were non-detect and 15 samples were below 24 mg/L; this facility is not a major source of TSS to Cedar Creek. Evergreen Recycling and Disposal is also not a major source of TSS; of the 19 detections, the range was 4 to 36.8 mg/L with a median of 19 mg/L.

Two package treatment plants are permitted to discharge in the watershed: Crazy Lady Inn (Ohio EPA ID 2PR00263) and Five Point MHP (Ohio EPA ID 2PY00073). The wastewater treatment works permitted at the Crazy Lady Inn were never built and Five Point MHP has always discharged less than 10 mg/L; thus, neither facility is a major source of TSS to Cedar Creek.

Two quarries discharge in the Cedar Creek watershed: Cardinal Aggregates Inc (Ohio EPA ID 2IJ00098) and Stoneco, Inc Lime City Plant (Ohio EPA ID 2IJ00052). TSS ranged from 2 to 40 mg/L (n = 267, median = 9 mg/L) at Cardinal Aggregates Inc and from 0 to 86 mg/L (n = 83, median = 6 mg/L) at Stoneco, Inc. Both facilities had over 2,000 flow records, with median flows of 0.14 mgd for Cardinal Aggregates Inc and 0.09 mgd for Stoneco Inc. At larger flows, the creeks become effluent-dominated channels. Without corresponding TSS loads from downstream sites, the impacts of these quarries on the creeks cannot be fully evaluated. However, based upon the limited data, it appears that both quarries typically contributes a relatively small TSS load and are not causing the sedimentation/siltation impairment.

An evaluation of a load duration curve and field samples (Appendix C) using TSS as the surrogate pollutant for sedimentation/siltation shows that exceedances occurred in the mid-range condition. Though the number of samples and representativeness are limited, the evaluation did not show any impacts from a continually-discharging point source. Results also indicate that runoff is a likely contributor of sediment loads as well as in-stream sources such as bank erosion and channelization due to high flow conditions.

DMR data show that the facilities with individual NPDES permits are not contributing significant sediment loads. The conclusion of the weight-of-evidence analysis is that channelization, non-irrigated crop production, and storm water are the primary sources of sediment loads.

5.2.6 Berger Ditch (HUC 04100010 07 05)

In the Berger Ditch watershed, Ohio EPA identified channelization as the source of impairment caused by sedimentation/siltation. As discussed in Section 4.4.4, runoff from agricultural operations (including row crops or small livestock operations) and point sources are additional potential sources of impairment.

A single site was assessed for QHEI in the Berger Ditch watershed on Wolf Creek upstream of Curtice Road (RM 2.70). The site’s substrate had heavy siltation and extensive embeddedness; no riffle/runs were present to be evaluated. The creek channel had low sinuosity and poor development. No channelization was observed at this site; however, this watershed drains to Berger Ditch, which was constructed along North Curtice Road (County Road 202).

Hirzel Canning Company (Ohio EPA ID 2IH00111) has not recorded a discharge since a fourth lagoon was installed in 2005. Therefore, this facility is not currently contributing to the sediment/siltation impairment, nor did it contribute in 2008 during Ohio EPA's field survey. The Oregon WTP (Ohio EPA ID 2IW00220, outfalls 001 and 002) has contributed TSS; the DMR detections (n = 484) range from 0.01 to 45 mg/L with a median of 5 mg/L. While it discharges below the permit limit of 45 mg/L, it contributes a relatively large load because the in-stream target is 24 mg/L. The Oregon WTP's WLA is 85 percent of the loading capacity of Berger Ditch for the low flow zone; thus, in low flow conditions, this point source is the major source of TSS to Berger Ditch.

An evaluation of a load duration curve and field samples (Appendix C) using TSS as the surrogate pollutant for sedimentation/siltation shows that one exceedance occurred in the mid-range condition. Though the number of samples and representativeness are limited, the evaluation did show that TSS loads were fairly consistent across flow conditions, which may be indicative of the influence of a continually-discharging point source.

The DMR data generally show that Hirzel Canning Company does not contribute TSS to Berger Ditch and that the Oregon WTP occasionally contributes larger loads The conclusion of the weight-of-evidence analysis is that channelization and agricultural runoff are the primary sources of sediment loads.

5.2.7 Otter Creek – Frontal Lake Erie (HUC 04100010 07 06) and Duck Creek

In the Otter Creek – Frontal Lake Erie HUC, Ohio EPA identified channelization, impervious surfaces, and commercial/industrial districts as the sources of impairment caused by sedimentation/siltation. For Otter Creek, no other potential sources, beyond urban runoff, were identified during the source assessment (Section 4.4.5). Ohio EPA identified channelization and urban runoff and storm sewers as the sources of impairment in the Duck Creek watershed; point sources were also identified as potential sources in the source assessment (Section 4.4.5).

The QHEI channel morphology metric scores for the four sampled sites on Otter Creek ranged from 5.5 to 8 (Table 5-8), which indicates poor channel condition. Otter Creek has low to no channel sinuosity and poor channel development. The creek is channelized or recovering from channelization. Channelized streams are apparent in 2010 aerial imagery, especially along the railway lines to the west of the BP Husky Refinery.

The substrate at all four sites on Otter Creek had heavy siltation and the embeddedness was extensive. No riffle/runs were present along the assessed segments of Otter Creek. The QHEI data indicate the habitat condition is impacted by sedimentation/siltation.

Both sites assessed for the QHEI in Duck Creek lacked channel sinuosity and had poor development. Duck Creek at York Street (RM 2.52) had recent channelization, while the creek at Consaul Road (RM 3.1) was not channelized. The substrate at both sites had heavy siltation and was extensively embedded; riffles/runs were not present at either site. The poor habitat condition is due in part to sedimentation/siltation.

Six outfalls at the Toledo WTP (Ohio EPA ID 2IW00260) discharge to Otter Creek. The detections across all six outfalls range from 0.001 to 68 mg/L (n = 969, median = 3.4 mg/L). Its WLA is the largest of all permitted point sources in this watershed and is approximately 82 percent of the loading capacity of Otter Creek during low flow conditions. Non-storm water effluent is also discharged from Envirosafe Services of Ohio (Ohio EPA ID 2IN00013, outfall 001) and Buckeye Pipeline's Toledo Station (Ohio EPA ID 2II00019, outfall 003). TSS ranged from 1to 1,870 mg/L (n = 343, median = 13) at Envirosafe Services of Ohio and from 2 to 400 mg/L (n = 120, median = 9 mg/L) at the Toledo Station. None of these three facilities are a major source of TSS to Otter Creek.

Storm water is discharged from six facilities in the Otter Creek watershed. TSS detections at Broadway Warehouse 605 Ltd (Ohio EPA ID 2II00108) ranged from 5 to 1,350 mg/L at outfall 001 (n = 33, median = 32 mg/L). At East Broadway Middle School (Ohio EPA ID 2PT00051), TSS detections ranged from 7 to 30 mg/L (n = 6, median = 11 mg/L). Storm water is also discharged at Envirosafe Services of Ohio in outfalls 002, 006, 009, and 011; TSS ranged from 1 to 1,500 mg/L (n = 130, median = 12 mg/L). Outfall 004 of Evergreen Recycling and Disposal (Ohio EPA ID IN00108) ranged from 3 to 1,640 mg/L (n = 89, median = 26 mg/L). Outfalls 001 and 002 at the Toledo Station has TSS data ranging from 2 to 400 (n = 117, median = 9 mg/L). TSS data for storm water effluent outfalls at Pilkington N.A. (Ohio EPA ID 2IN00020) are not available. Typically, all of these facilities discussed in this section contribute TSS loads to Otter Creek and each facility only occasionally contributes large loads that could be the major source of TSS causing the impairment. Together, these storm water permitted facilities contribute a large TSS load to Otter Creek.

Two permitted facilities discharge to Duck Creek: the Toledo WTP (Ohio EPA ID 2IW00260, outfall 003) and Middleport Terminal (Ohio EPA ID 2IN00218, storm water). No discharge has been reported at the Middleport Terminal. TSS detections have ranged from 0.2 to 19.7 mg/L (n = 101, median = 2 mg/L) at outfall 003 at the Toledo WTP. This facility is the dominant source of flow, especially during low flow conditions, and its WLA ranges from 63 to 83 percent of the loading capacity of Duck Creek across the five flow zones.

Evaluations of load duration curves and field samples (Appendix C), collected at all four Ohio EPA sample sites on Otter Creek, using TSS as the surrogate pollutant for sedimentation/siltation shows that exceedances occurred in high through dry conditions. No exceedances occurred at the site adjacent to CSX Road (S03S25, RM 0.40); however, only two samples were collected at this site. Eight samples each were collected at the other three sites. Four of the eight samples exceeded at the site at Millard Avenue (S03P04, RM 2.13); the observed loads followed the load duration curve, which may be indicative of land cover derived sources of sediment (i.e., urban runoff). Evaluations of data collected from Duck Creek were inconclusive.

The DMR data show that the only point sources that are major contributors of TSS to Otter or Duck creeks are the water treatment plants, except on infrequent occasions when large concentrations of TSS are discharged from other facilities. Without corresponding in-stream data, the impact upon these creeks from the facilities cannot be fully assessed. The conclusion of the weight-of-evidence analysis is that channelization, point sources, and urban runoff are the primary sources of sediment loads. These sources will be addressed through TSS TMDLs on Otter and Duck creeks.

5.2.8 Grassy Creek (HUC 04100009 09 02)

In the Grassy Creek watershed, Ohio EPA identified channelization and urban runoff and storm sewers as the sources of impairment caused by sedimentation/siltation. No other potential sources, beyond urban runoff, were identified during the source assessment (Section 4.5.1).

A single site was assessed for QHEI in the Grassy Creek watershed on Grassy Creek at Buck Road (RM 3.85). Its substrate had moderate levels of siltation and embeddedness and its riffle/run substrate was unstable and extensive embedded. The channel morphology metric score at this site was 14 (Table 5-8); however, this single site may not be representative of the habitat conditions throughout the watershed. The creek channel had moderate sinuosity and fair development. Channelization was not observed when the QHEI was assessed. Channelized streams are evident in the 2010 aerial imagery to the southeast of the I-75 and I-475 interchange in Perrysburg, OH. For example, a stream is channelized into a roadside ditch along Schelder Road (Township Road 299).

An evaluation of a load duration curve and field samples (Appendix C) using TSS as the surrogate pollutant for sedimentation/siltation shows that one exceedance occurred in the high flow condition. Though the number of samples and representativeness are limited, the evaluation did show that observed loads generally followed the load duration curve, which may be indicative of land cover derived sources of sediment (i.e., urban runoff).

Since there are no individually permitted point sources, sediment is derived from nonpoint sources. The conclusion of the weight-of-evidence analysis is that channelization and urban runoff are the primary sources of sediment loads; these sources will be addressed through a TSS TMDL.

5.3 Contaminated Sediments

Urban streams tend to have impervious surfaces that alter the hydrologic regime (e.g., higher magnitude flows, more frequent high flows), which then increases the erosion of the streambed and banks and increases re-suspension of bed sediment (U.S. EPA 2012). Sediment quality can be affected by contamination from urban sources. Shaver et al. (2007) found that sediment contaminated with pollutants from storm water runoff detrimentally affected benthic organisms. In Ohio, watersheds with streams impacted by contaminated sediments are placed on Ohio's 303(d) list.

The Otter Creek – Frontal Lake Erie watershed (HUC 041100010 07 06) is on Ohio's 303(d) list for impairments from contaminated sediments. Otter Creek was found to be in non-attainment of MWH biocriteria during Ohio EPA's 2006 biosurvey (Ohio EPA 2010a). The agency found the macroinvertebrate community health to be very poor and the fish community health in the upper one-half of the creek was in poor. The sediments were contaminated by the following pollutants:

Metals	**Organic compounds**
Arsenic	4,4'-dichlorodiphenyldichloroethane (4,4'-DDD)
Cadmium	4,4'- dichlorodiphenyldichloroethylene (4,4'-DDE)
Chromium	Chlordane
Copper	Polychlorinated Biphenyls (PCBs)
Lead	Total PAHs
Mercury	
Zinc	

TMDLs are not developed for Otter Creek because there are ongoing efforts to characterize the contamination of Otter Creek that will lead to initiatives to clean-up and restore the creek. Therefore, the objective of this section is to present and summarize recent activities.

5.3.1 Previous Studies

Contaminated sediments in the industrial areas along the mouth of the Maumee River (lower) at Maumee Bay have been identified by numerous entities, including the U.S. EPA and Ohio EPA; for example, contaminated sediments are discussed in the *Maumee Area of Concern Stage 2 Watershed Restoration Plan, Volume 1* (Maumee RAP and Duck and Otter Creek Partners, Inc. 2006). Summaries of two recent studies are presented in this section.

5.3.1.1 Screening and Baseline Ecological Risk Assessment, Duck and Otter Creeks, Toledo and Oregon, Ohio

U.S. EPA's Great Lakes National Program Office (GLNPO) completed human health and ecological risk assessments for Duck and Otter creeks (Tetra Tech 2008). The objective of the ecological risk assessment was to evaluate the potential exposure of sediment to ecological receptors in Duck and Otter creeks. The potential risks of contaminated sediments to benthic invertebrates, benthic-coupled fish, and piscivorous birds and mammals were evaluated. Exposure pathways for benthic organisms were dermal contact with interstitial water and sediment particles, contact of the gills with interstitial water, and ingestion of sediment; the pathways for wildlife were dermal contact and ingestion of contaminated sediment and food.

To assess potential risk, each creek was divided into five segments. The potential risks of each segment were assessed using the following methods:

- Evaluation of sediment and surface water concentrations with Ohio-specific sediment reference values (Ohio EPA 2003), Ohio water quality standards and U.S. EPA Region 5 Ecological Screening Levels (ESLs) (2003)
- Evaluation of total PAH concentrations with criteria for forming lesions on bottom-dwelling fish
- 20-day sediment bioassays with invertebrate midges (*Chironomous tentans*)
- Evaluation of acid volatile sulfides and simultaneously extractable metals data to assess how metals in the sediment affect toxicity
- Food chain models for piscivorous birds and mammals (represented by belted kingfishers and minks)

Otter Creek is impaired for its ALU by contaminated sediments. The results of the ecological risk assessment (Tetra Tech 2008) showed that the ecological system is stressed. Sediment and surface water concentrations varied by segment with many constituents exceeding targets or criteria. The sediment concentrations exceeded all the screening criteria for bottom-dwelling fish. The mean percent survival of 11 of 12 sites on Otter Creek were statistically different from the control (i.e., the sediment from Otter Creek was toxic to the midges). The acid volatile sulfides and simultaneously extractable metals data indicate a high probability that most metals in the sediments could be bound to sulfides and, thus, are not bioavailable.

5.3.1.2 Duck and Otter Creeks Great Lakes Legacy Data Gap Investigation Report (CardnoEntrix 2012)

A multiple lines of evidence approach was used to determine the potential impacts of toxic substances to Duck and Otter creeks (CardnoEntrix 2012). The objective of this study was to fill the data gaps identified by the Duck and Otter Creek Industrial Partners and U.S. EPA GLNPO. Bulk sediment chemistry, sediment pore water, and tissue samples were evaluated. Field data collection included: surface and subsurface sediment cores, sediment pore water, benthic macroinvertebrates (via U.S. EPA's Rapid Bioassessment Protocols), tissue samples from fish and benthic invertebrates, and QHEI. Sediment toxicity was evaluated with 10-day sediment bioassays with invertebrate midges (*Chironomus dilutus*). The multiple lines of evidence approach included evaluations of the impaired Duck and Otter creeks along with evaluations of Grassy Creek and Amlosch Ditch.

Sediment was thickest in the lower, lacustrine segments of Duck and Otter Creek, where silt and clay were typically the dominant particle sizes. Most of the observed sediment was silt with clay, sand, gravel, and peat was observed infrequently. Sediment was grey, brown, or black and sometimes contained shells or fragments of shells. "During sample collection field crews recorded observations of visible sheens and odors that were believed to be petroleum in several sampling locations" (CardnoEntrix 2012, p. E-2).

PAHs in sediment pore water may be contributing to the observed sediment toxicity in lower Otter Creek because elevated levels of PAH from sediment pore waters occurred at the same locations where midge growth was inhibited during sediment toxicity testing. Gasoline-range organic hydrocarbons were detected in Otter Creek and Amlosch Ditch while diesel-range and residual range organic hydrocarbons were detected in all four urban streams.

"The concentrations of 16 priority pollutant PAHs in bulk sediments exceeded the probable effects concentration in Amlosch Ditch" and several locations along Otter Creek but not in either Duck or Grassy creeks (CardnoEntrix 2012, p. E-3). PCBs and semi-volatile organic compounds were detected at levels below conservative benchmarks, while metals concentrations exceeded conservative benchmarks in Duck and Otter Creeks. "The concentrations of metals in sediment pore water, which is generally accepted as the biologically-available fraction, and a primary route of exposure for sediment-dwelling organisms, did not exceed the respective ambient water quality criteria" (CardnoEntrix 2012, p. E-5). PCBs, metals, pyrethroid pesticides, and non-PAH semi-volatile organic compounds were not sources of toxicity because their concentrations were not generally elevated and were not bioavailable. Ammonia concentrations in sediment pore water were elevated at several locations but were not toxic to the midges during sediment toxicity testing.

The QHEI scores ranged from very poor to poor, which were caused, in part, by "siltation; low gradient; lack of natural; in-stream structures; lack of riparian vegetation; and channelization (CardnoEntrix 2012, p. E-6). They recommended "in-stream enhancements such as adding woody structures" and storm water retention to help restore the urban streams (CardnoEntrix 2012, p. 4-6). Tolerant species dominated the biological communities, which was consistent with the poor habitat quality.

The report concluded that sediment contamination and toxicity issues are not present in Duck Creek or the segments of Otter Creek south of (upstream of) Millard Avenue. The lowest segment of Otter Creek that is downstream of Millard Avenue may be affected by contaminated sediments because of the reduced midge survival and growth during the bioassay, presence of elevated PAH levels in sediment pore waters, and the presence of elevated petroleum hydrocarbon levels in subsurface sediment samples.

5.3.2 Water and Sediment Quality Data

Multiple entities, including federal and state agencies, over the past few decades have collected sediment chemistry data. Since this report was developed primarily from data collected by Ohio EPA staff during the 2006 and 2008 field seasons (Ohio EPA 2010a), an evaluation of data collected from Otter Creek is presented here.

Ohio EPA collected sediment samples from eight locations on tributaries to Lake Erie (HUC 04100010 07) and four locations on tributaries to the lower Maumee River (HUC 04100009 09). Metals, nutrients and PAHs were detected in all samples with the most common detections and largest concentrations detected in streams flowing through urban areas. Strontium was detected above the Ohio-specific sediment reference values (Ohio EPA 2008) at almost every site.

The sediment from Otter Creek (HUC 04100010 07 06) was extremely contaminated (Ohio EPA 2010a, p. 92). Detections and exceedances are presented in the TSD (Ohio EPA 2010a, pp. 100, 106). The metals results are also briefly summarized with the Ohio-specific SRVs below in Table 5-9. The PAH results are summarized in Table 5-10 with ESLs (U.S. EPA 2003). Total PCBs and other synthetic compounds were also detected above the ESLs.

Table 5-9. Sediment metal results (mg/kg) collected from Otter Creek in 2006 that exceed SRV targets

Parameter	SRV [a]	Oakdale Rd RM 6.00	Consaul St. RM 3.10	Millard Rd. RM 2.13	CSX Bridge RM 0.50
Arsenic	11	**25.9**	**24.5**	**12.4**	**11.4**
Cadmium	0.96	0.913	**1.25**	0.724	**1.02**
Chromium	51	39	**191**	**174**	**81**
Copper	42	**43.8**	**156**	**73.0**	**89.7**
Lead	47	**61**	**130**	**94**	**85**
Mercury	0.12	0.106	**0.327**	**0.463**	**0.273**
Nickel	36	32	36	< 28	< 34
Selenium	1.4	**< 1.52**	**10.4**	< 1.39	**< 1.70**
Strontium	250	**251**	216	**500**	**260**
Zinc	190	**236**	**330**	152	**231**

Modified from Ohio EPA 2010a (p. 100, Table 12).
Notes
All values are reported in mg/kg.
Bolded values exceed the SRV.
a. SRVs from Ohio EPA 2008. Lead and mercury SRVs are for the entire state; all other parameters are for the HELP ecoregion.

Table 5-10. Sediment PAHs results (mg/kg) collected from Otter Creek in 2006

Parameter	ESL [a]	Oakdale Rd RM 6.00	Consaul St. RM 3.10	Millard Rd. RM 2.13	CSX Bridge RM 0.50
Anthracene	0.0572	n.d.[b]	**1.19**	n.d.[b]	n.d.[b]
Benz(a)anthracene	0.108	**3.12**	**2.20**	**1.41**	**1.52**
Benzo(a)pyrene	0.150	**3.79**	**2.91**	**1.49**	**1.93**
Chrysene	0.166	**5.29**	**3.90**	**2.90**	**3.20**
Fluoranthene	0.423	**9.60**	**5.17**	**2.22**	**3.05**
Phenathrene	0.204	**4.11**	**2.90**	**1.53**	**2.12**
Pyrene	0.195	**7.57**	**6.07**	**4.35**	**3.71**

Modified from Ohio EPA (2010, p. 106, Table 15).
Notes
All values are reported in mg/kg.
Bolded values exceed the ESL.
a. Ecological Screening Levels (ESL) for sediments (U.S. EPA 2003).
b. Parameter was not detected.

Ohio EPA collected water column samples from Otter Creek when sediment samples were collected. The pollutants that led to the contaminated sediments impairment were also analyzed in the water column samples collected from Otter Creek. Cadmium, chromium, copper, and mercury were not detected in any water column sample. Lead and zinc were detected in water column samples; a summary of the data is presented in Table 5-11. None of the lead or zinc samples exceed their respective criteria.

Table 5-11. Lead and zinc detections in Otter Creek in 2006

Location		Lead					Zinc				
Site	RM	No. of samples	No. of detections	Minimum	Maximum	Geometric mean [a]	No. of samples	No. of detections	Minimum	Maximum	Geometric mean [a]
S03P12	5.92	8	1	5.3			8	4	11	50	21
S03P08	2.95	7	7	2.2	6.4	3.4	7	6	15	31	19
S03P05	2.13	8	5	2.6	5.4	3.9	8	5	10	21	15
S03S25	0.40	2	1	2.3			2	0	--		

Notes
All values are reported in mg/L.
The detection limits are 2.0 mg/L for lead and 10 mg/L for zinc.
a. The geometric mean was calculated using only detections.

Ohio EPA also collected water column organic compounds samples from Otter Creek. 4,4’-DDD and 4,4’-DDE were not detected in any samples from Otter Creek.

As presented here and fully discussed in the TSD (Ohio EPA 2010a), pollutants in the sediment collected from Otter Creek are at concentrations in excess of Ohio’s sediment reference values. Concurrently collected water column samples contain some of these pollutants at concentrations below the numeric criteria, while other pollutants were not detected in water column samples. Thus, at this time, these data do not sufficiently characterize the contamination of Otter Creek such that a load duration curve approach TMDL could address the contamination, once implemented. The additional ongoing characterization efforts will drive future initiatives to address the sediment contamination in Otter Creek.

6 Recreation Use Linkage Analysis

The objective of this linkage analysis is to provide the link between bacteria sources and the observed water quality impairments. For this project area, a weight-of-evidence approach was used to assess the degree that known sources are likely or unlikely contributors to the recreation use impairments. This section presents evaluations of water quality data and point source and nonpoint source contributions of bacteria and their likely effect on the observed recreation use impairments. Further evaluation of the bacteria samples is presented in the TSD (Ohio EPA 2010a); summaries of the data are presented in Table 6-1 and Table 6-2 .

Table 6-1. *E. coli* samples collected in 2008 from the Lake Erie tributaries (HUC 04100010 07)

HUC	Site ID	Stream	RM	PCR class	No. of samples	Min	Max	Geomean
01	S03K06	North Branch Turtle Creek	3.00	B	5	760	2,300	**1,395**
	201124		0.80		4	290	1,200	**551**
	S03K07	South Branch Turtle Creek	2.65		5	610	10,000[a]	**2,046**
	S03K05	Turtle Creek	11.62		5	570	2,200	**911**
02	S03P21	Crane Creek	18.82	B	5	440	2,600	**1,043**
	S03K02		15.38		5	440	5,800	**1,244**
	S03G21		8.83		4	1,200	2,500	**1,782**
	S03K01		5.20		5	92	1,200	**343**
	S03S65	Henry Creek	3.73		5	340	1,300	**647**
	201118		0.10		5	200	2,800	**842**
	S03K04	Ayers Creek	0.60		3	860	31,000	**2,895**
	S03K03	UT to Crane Cr. [b]	0.42		5	180	42,000	**2,202**
03	S03S34	Cedar Creek	20.77	B	5	340	2,300	**1,003**
	S03S60		17.32		5	110	2,200	**600**
	S03S46		14.50		5	190	1,300	**436**
	S03S44		9.59		5	210	1,050	**573**
	S03G22		7.90		5	560	2,300	**1,113**
	S03S55		4.27		4	140	760	**382**
	S03S68	Dry Creek	7.00		6	1,400	41,000	**5,496**
	S03S48		0.01		5	280	490	**358**
	S03G23	UD to Cedar Cr. [c]	0.01		5	4,000	200,000[d]	**42,341**
04	201144	Wolf Creek/Williams Ditch	1.70	SCR	4	140	250	186
05	S03S50	Wolf Creek	6.30	C	5	90	10,000	**852**
	201111		2.70	B	5	730	3,200	**1,556**
06	S03P12	Otter Creek [e]	5.92	C	8	430	10,000[a]	1,343
	S03P08		2.95	B	8	450	10,000[a]	1,987
	S03P05		2.13		7	27	2,950	313
	S03S25		0.40		2	11	4,100	212

Notes
Bolded values exceed the seasonal geometric mean criteria.
a. The maximum detection limit is 10,000 counts per 100 mL; this value was used in the calculation of the geometric mean.
b. Unnamed tributary to Crane Creek at RM 12.00.
c. Unnamed ditch to Cedar Creek at RM 7.91.
d. The maximum detection limit is 200,000 counts per 100 mL; this value was used in the calculation of the geometric mean.
e. Data were collected in June, July, and August 2006.

Table 6-2. *E. coli* samples collected in 2006 from the lower Maumee River tributaries (HUC 04100009 09)

HUC	Site ID	Stream	RM	PCR class	No. of samples	Min	Max	Geomean
01	P11K19	Grassy Creek Diversion	0.28	B[a]	8	360	1,200	**644**
02	P11A05	Grassy Creek	4.85	B	7	290	10,000[b]	**1,521**
	P11K18		0.98		8	700	10,000[b]	**1,582**
04	300376	Duck Creek [c]	4.00	B	4	15	150	54
	P11K22		3.10		2	610	770	**685**
	P11S56		2.52		2	700	1,300	**954**
	P11A07	Delaware Creek	0.38		8	290	10,000 [b]	**1,614**

Notes
Values are reported in counts per 100 mL.
Bolded values exceed the seasonal geometric mean criteria.
a. Grassy Creek Diversion is undesignated; the displayed use was recommended in the TSD (Ohio EPA 2010a).
b. The maximum detection limit is 10,000 counts per 100 mL; this value was used in the calculation of the geometric mean.
c. Data were collected in 2008.

6.1 Turtle Creek – Frontal Lake Erie (HUC 04100010 07 01)

In the Turtle Creek watershed, Ohio EPA identified HSTS and package treatment plants as the sources of bacteria and specifically noted that the unsewered village of Martin is a source for the South Branch of Turtle Creek (Ohio EPA 2010a, p. 80, 86). Additional potential sources of bacteria load that were identified in Section 4.4.1 are agricultural runoff (e.g., livestock operations, hobby farms), runoff from residential (e.g., pets) and other developed properties, and wildlife.

Four of six facilities with individual NPDES permits (refer back to Table 4-6 in Section 4.4.1) are allowed to discharge bacteria. A summary of their DMR data is presented in Appendix B. The three marinas (2PR00130, 2PY00074, and 2PS00011) are downstream of the assessment location at Nissen Road; therefore, these facilities did not cause the non-attainment observed by Ohio EPA. It is noteworthy that the Turtle Creek Marina and Campground (Ohio EPA ID 2PS000111) did not discharge above 100 fecal coliform counts per 100 mL before 2010 (the facility has since discharged at higher levels).

The Allen Elementary School (Ohio EPA ID 2PT00042) was not likely a significant contributor to the recreation use impairment in Turtle Creek because of the low levels of bacteria the facility discharged. During the 2008 field survey season, the facility discharged between 10 and 13 counts of fecal coliform per 100 mL. The facility was demolished since Ohio EPA sampled in 2008 and it no longer discharges.

As discussed in Section 4.4.1, Turtle Creek flows through unsewered, rural, residual areas and row crops. Agricultural (e.g., livestock on hobby farms) and residential (e.g., pets) runoff, along with wildlife, contribute to the bacteria impairments in the Turtle Creek watershed, but the significance of their contributions is likely limited. The results of studies by OCGHD (2004) and TMACOG (2011), as presented in Section 4.4.1, show that old and failing HSTS are present along both branches and the mainstem of Turtle Creek and are likely contaminating the creek and its tributaries. Public sewer system issues including illicit connections and inflow and infiltration can also contribute bacteria loads; however, TMACOG (2011) does not identify them as a significant problem in the Turtle Creek watershed.

The DMR data show that facilities with individual NPDES permits might contribute bacteria loads to Turtle Creek and its tributaries but are not the primary source of bacteria loads. Similarly, agricultural and rural residential runoff, and wildlife contribute bacteria loads, but their loads are likely relatively small. Because the creek and its tributaries flow through unsewered, rural, residential areas, including critical sewerage areas with known failing HSTS, the conclusion of the weight-of-evidence analysis is that failing HSTS are the most probable source of bacteria loads. The sources will be addressed by an *E. coli* TMDL on Turtle Creek at North Lickett Harder Road (RM 5.3).

6.2 Crane Creek – Frontal Lake Erie (HUC 04100010 07 02)

In the Crane Creek watershed, Ohio EPA identifies unsewered, rural, residential areas (i.e., HSTS) and package treatment plants as the sources of bacteria and specifically notes the unsewered town of Williston (Ohio EPA 2010a, p. 80, 86). Ohio EPA field staff noted a "septic odor" on July 1, 2008, when sampling Crane Creek at Martin-Williston Road (S03G21, RM 8.83), which is adjacent to the unsewered Williston area (critical sewerage area OT-02 on Figure 4-4). Additional potential sources of bacteria load that were identified in Section 3 are agricultural runoff (e.g., livestock operations, hobby farms), urban storm water, and wildlife.

Four of seven facilities with individual NPDES permits (refer back to Table 4-7 in Section 3) are allowed to discharge bacteria. A summary of their DMR data is presented in Appendix B. The Luther Home of Mercy (Ohio EPA ID 2PS00013) discharges to Williston Ditch, a tributary to Crane Creek upstream of Martin-Williston Road (S03K01, RM 5.20). Between 2003 and 2009, the facility discharged fecal coliform in excess of 1,000 counts per 100 mL on five occasions. However, the effluent loads were in the range of 4.0 to 4.5 billion fecal coliform counts per day, which are significantly lower than the monitored in-stream loads. In 2010 and 2011, only two detections (2 and 8 counts fecal coliform per 100 mL) occurred at this facility. In the past, this facility might have contributed significantly to the non-attainment of Crane Creek, but in 2010 and 2011 its bacteria contributions to Crane Creek were insignificant. The Luther Home of Mercy will be connected to public sanitary sewers by 2015, and thus, will not be a potential source of bacteria load to Crane Creek in the future.

Package treatment plants serving two MHPs (Ohio EPA ID 2PY00008 and 2PY00014; refer back to Table 4-7) are in the Crane Creek headwaters, and neither facility has discharged fecal coliform in excess of 1,000 counts per 100 mL. The facilities are not likely significantly contributing to the bacteria impairments in the Crane Creek watershed.

Fecal coliform samples from the package treatment plant at the Wildflower Place Subdivision (Ohio EPA ID 2PW00010) were considerably larger in 2008 through 2010 with 8 of 26 samples in excess of 1,000 fecal coliform counts per 100 mL. *E. coli* data are available for the year 2011: three of the five samples were flagged as too numerous to count, and the remaining two samples were 49 and 1,400 *E. coli* counts per 100 mL, yielding loads of 70 million and 2 billion counts *E. coli* per day, respectively. Although the bacteria concentrations are occasionally elevated, the facility discharges at small volumes (median: 0.035 mgd); thus, effluent is not likely a significant contributor to the in-stream impairment, except during low-flow periods. The permit identifies structural issues including infiltration and inflow. This facility will be connected to public sanitary sewers by 2015 and will no longer discharge to Crane Creek.

As discussed in Section 4.4.2, Crane Creek flows through unsewered, rural, residual areas and row crops. Agricultural (e.g., livestock on hobby farms) and residential (e.g., pets) runoff, along with wildlife, contribute to the bacteria impairments in the Crane Creek watershed, but the significance of their contributions is likely limited. The results of studies by TMACOG (2011) and WCCGHD (2004), as presented in Section 4.4.2, show that unsewered communities with failing HSTS are along creeks in the Crane Creek watershed and are likely contaminating Crane Creek and its tributaries. Public sewer system issues including illicit connections and infiltration/inflow can also contribute bacteria loads; however, TMACOG (2011) does not identify them as a significant problem in the Crane Creek watershed.

The DMR data show that facilities with individual NPDES permits contribute bacteria loads to Crane Creek and its tributaries and can contribute significantly during low-flow periods. Agricultural and rural residential runoff and wildlife also contribute bacteria loads, but their loads are likely relatively small. The creek and its tributaries flow through unsewered, rural, residential areas, including critical sewerage areas with known failing HSTS. Thus, the weight-of-evidence analysis shows that failing HSTS (isolated and in communities) and facilities with individual NPDES permits are the most probable sources of bacteria loads to Crane Creek and its tributaries. The sources will be addressed by an *E. coli* TMDL on Crane Creek at Nissen Road (RM 6.5).

6.3 Cedar Creek – Frontal Lake Erie (HUC 04100010 07 03)

In the Cedar Creek watershed, Ohio EPA identifies HSTS and package treatment plants as the sources of bacteria and specifically notes that the unsewered town of Curtice affects Cedar Creek and unsewered, residential and industrial areas affect Dry Creek (Ohio EPA 2010a, p. 80, 86). Ohio EPA field staff noted a “slight septic odor” on July 1, 2008, when field sampling Dry Creek at the mouth (S03S48, RM 0.01), which is one river mile downstream of the unsewered Curtice and Bradner area (critical sewerage area WO-17 on Figure 4-4). Field staff also reported a “raw sewage discharge upstream right bank” on July 30, 2008, while sampling Dry Creek at East Broadway Street (S03S68, RM 7.00). Although no critical sewerage areas are upstream of this site, unsewered residential and industrial areas are upstream of the assessment site. Additional potential sources of bacteria load that were identified in Section 3 are agricultural runoff (e.g., livestock operations, hobby farms), urban storm water, and wildlife.

Two of five facilities with individual NPDES permits (refer back to Table 4-8 in Section 3) are allowed to discharge bacteria. A summary of their DMR data is presented in Appendix B. Neither facility has DMR data from during the 2006 and 2008 field seasons; therefore, it is not possible to evaluate if the facilities affected in-stream water quality when Ohio EPA evaluated recreation use attainment. The wastewater treatment works permitted for the Crazy Lady Inn (Ohio EPA ID 2PR00263) were never built and no DMR data were ever reported. Therefore, this facility is not considered to be contributing to the bacteria impairment on Cedar Creek.

Only one of the samples collected at the Five Point MHP (Ohio EPA ID 2PY00073) had a concentration greater than 400 counts fecal coliform per 100 mL: 10,000 counts per 100 mL on August 3, 2011. This sample yields a load of 350 million counts per day, and the load in Cedar Creek exceeds this value 99 percent of the time. The facility discharges between 725 and 2,250 gpd with a median of 2,250 gpd; the median flow in Cedar Creek at Yondota Road (RM 4.27) is 6,722 gpd. Additionally, inflow and infiltration were not identified as a problem at the Five Points MHP. Because this facility typically discharges effluent at less than 400 counts fecal coliform per 100 mL, it is not likely the primary source of impairment to Cedar Creek.

As discussed in Section 4.4.3, Cedar Creek flows through unsewered, rural, residual areas; row crops; and sewered dense residential areas. Agricultural (e.g., livestock on hobby farms) and residential (e.g., pets) runoff, along with wildlife, contribute to the bacteria impairments in the Cedar Creek watershed, but the significance of their contributions is likely limited. The results of studies by OCGHD (2004), TMACOG (2011), and WCCGHD (2004), as presented in Section 4.4.3, show that unsewered communities with failing HSTS are along creeks in the Cedar Creek watershed and are likely contaminating Cedar Creek and its tributaries.

The DMR data show that facilities with individual NPDES permits contribute bacteria loads to Cedar Creek and its tributaries but are not the primary source of bacteria loads. Similarly, agricultural and rural residential runoff and wildlife also contribute bacteria loads, but their loads are likely relatively small. The creek and its tributaries flow through both sewered and unsewered areas, including a few critical sewerage areas with known failing HSTS; therefore, the weight-of-evidence analysis shows that failing

HSTS are the most probable source of bacteria loads. The sources will be addressed by an *E. coli* TMDL on Cedar Creek at Yondota Road (RM 4.27; S03S55).

6.4 Wolf Creek (HUC 04100010 07 04) and Berger Ditch (HUC 04100010 07 05)

The Wolf Creek watershed is in full attainment of its recreation use. In the Berger Ditch watershed, Ohio EPA identified HSTS as the source of bacteria and specifically noted that unsewered residential areas affect Wolf Creek (upstream of the diversion to Berger Ditch) and Wolf Ditch (Ohio EPA 2010a, p. 80, 87). Additional potential sources of bacteria load that were identified in Section 3 include agricultural runoff (e.g., livestock on hobby farms), and residential urban runoff (e.g., pets).

Neither of the facilities in this watershed group with individual NPDES permits (refer back to Table 4-9 in Section 3) is allowed to discharge bacteria. TMACOG (2011) does not identify any critical sewerage areas along impaired streams. A portion of critical sewerage area WO-17 (Curtice/Bradner) is in the subwatershed draining to Stadium Road; additionally, old and failing HSTS are probably in this watershed group.

As discussed in Section 4.4.4, Wolf Creek and Ditch, Williams Ditch, and Berger Ditch flow through unsewered rural residual areas; row crops; and sewered, dense, residential areas. Agricultural (e.g., livestock on hobby farms) and residential (e.g., pets) runoff, along with wildlife, contribute to the bacteria impairments in the watershed, but the significance of their contributions is likely limited.

Evaluations of load duration curves and field samples (Appendix C) show *E. coli* exceedances occur during most flow conditions. In the subwatershed draining to Curtice Road (S03S60, RM 6.30), considerably elevated bacteria loads were in the moist conditions through the dry flow conditions; the single load in the low-flow zone was below the target. All the loads exceeded the target loads in the subwatershed draining to Stadium Road (201111, RM 2.70). That trend indicates that multiple bacteria sources are likely causing the impairment.

No facilities with individual NPDES permits are authorized to discharge bacteria to the Berger Ditch HUC. The creeks and ditches flow through both sewered and unsewered areas, including a few critical sewerage areas with known failing HSTS; therefore, the weight-of-evidence analysis shows that failing HSTS are the most probable source of bacteria loads. An *E. coli* TMDL on Berger Ditch upstream of Cedar Point Road (RM 0.75) will address sources of impairment above Curtice Road (PCR Class C) and above Stadium Road (PCR Class B).

6.5 Otter Creek – Frontal Lake Erie (HUC 04100010 07 06) and Duck Creek

In the Otter Creek watershed, Ohio EPA identifies HSTS and package treatment plants as the sources of bacteria and specifically notes that unknown sources also affect Otter Creek (Ohio EPA 2010a, p. 80, 87). Ohio EPA identifies HSTS and a golf course as the sources of bacteria in the Duck Creek watershed (Ohio EPA 2010a, p. 88). Additional potential sources of bacteria load that were identified in Section 3 are urban runoff (e.g., residential pets, wildlife), and illicit connections to storm sewers.

No facilities with individual NPDES permits (refer back to Table 4-11 in Section 3) are authorized to discharge bacteria to Duck Creek. Only one of the 15 facilities with individual NPDES permits (refer back to Table 4-10 in Section 3) that discharge to Otter Creek, Amlosch Ditch, or Driftmeyer Ditch is authorized to discharge bacteria. Facilities discharging to the Maumee River or Maumee Bay (i.e., Lake Erie) are not evaluated in this report. Buckeye Pipeline Company LP's Toledo Station (Ohio EPA ID 2II00019) sampled fecal coliform 12 times (5 detections) between May 14, 2009, and October 29, 2009, and concentrations ranged from 3 to 4,000 counts per 100 mL (geometric mean: 20 counts per 100 mL).

The sample from May 19, 2009, was 4,000 counts per 100 mL (5.6 billion counts per day[17]); every sample since May 28, 2009, was 12 counts per 100 mL or less. Therefore, this facility is not likely causing the bacteria impairment in Otter Creek, except that it can contribute significantly during low-flow periods.

As discussed in Section 4.4.5, Otter and Duck creeks and Driftmeyer and Amlosch ditches flow through sewered urban areas, including dense residential and industrial. TMACOG (2011) does not identify any critical sewerage areas along impaired streams; however, limited numbers of old and failing HSTS are probably present.

Urban runoff, which includes such sources as residential pets and wildlife, probably contribute to the bacteria impairments. For example, in the Duck Creek at York Street (P11S56, RM 2.52) subwatershed, precipitation events likely wash off deposited animal waste from pets or wildlife that are present at Collins Park Golf Course and Ravine Park.

Evaluations of load duration curves and field samples (Appendix C) show that *E. coli* exceedances occur during all flow conditions. Typically such results mean that multiple sources are contributing pollutants. For the Duck Creek at York Street analysis, only two field samples were collected in 2008 (one each in the moist and mid-range flow zones); thus, a trend analysis is not possible. The eight samples collected at Otter Creek at Oakdale Avenue yielded *E. coli* loads in the high through mid-range flow zones, and all loads exceeded targets considerably. Only two samples were collected at Otter Creek at CSX Road (both in the mid-range flow zone) and one load exceeded its target by a factor of 30.

The DMR data show that a facility with an individual NPDES permit contributes bacteria loads to Otter Creek but is not the primary source of bacteria loads, except during low-flow periods. Non-attainment in both Otter and Duck creeks is primarily caused by runoff from multiple urban sources (e.g., residential pets, wildlife). The sources will be addressed through *E. coli* TMDLs on Otter Creek adjacent to CSX Road (RM 0.40; S03S25) and on Duck Creek at York Street (RM 2.52; P11S56).

6.6 Grassy Creek Diversion (HUC 04100009 09 01) and Grassy Creek (HUC 04100009 09 02)

In the Grassy Creek Diversion and Grassy Creek watersheds, Ohio EPA identifies HSTS and urban areas as the sources of bacteria (Ohio EPA 2010a, p. 88). Animal waste (excluding CAFOs and manure application) is another potential source of *E. coli* loads that was identified in Section 3.

No facilities with individual NPDES permits are in the Grassy Creek watershed (refer back to Table 4-14 in Section 3). Both of the facilities with individual NPDES permits in the Grassy Creek Diversion watershed are permitted to discharge bacteria. A summary of their DMR data is presented in Appendix B. From 2002 through 2006, at least a few samples per year at Country Manor Estates (Ohio EPA ID 2PG00096) exceeded 1,000 counts fecal coliform per 100 mL; since 2006, only one of 28 samples has exceeded 270 counts per 100 mL. In 2006, loads at the facility ranged from 1.6 to 1.3 billion counts per day; observed loads in Grassy Creek Diversion at Grand Rapids Road (RM 0.28) during 2006 ranged from 8 billion to 185 billion counts per day. Because the facility discharges to Hull Prairie Ditch and because it contributes a relatively small bacteria load, was not likely the primary source of the bacteria impairment in Grassy Creek Diversion, except during low flow conditions. Country Manor Estates will be removed in 2012 as the subdivision is connected to public sanitary sewers.

[17] Toledo Station did not report flow rate on 5/19/2011. The facility discharged at 36,971 gallons per day on 5/16/2009 and 5/26/2009, and that flow was used to calculate the load.

At the Maurer MHP (Ohio EPA ID 2PY00005), 30 of 57 samples were non-detect for fecal coliform. Effluent samples collected during 2006, which is the same year that Ohio EPA sampled Grassy Creek Diversion, had concentrations less than or equal to 40 counts fecal coliform per 100 mL. Thus, during 2006, this facility does not appear to have contributed significantly to the bacteria impairment on Grassy Creek Diversion. However, Maurer MHP occasionally discharges at elevated concentrations (e.g., 7,200 counts per 100 mL on August 23, 2007). Such occasional elevated concentrations yield loads in the billions of counts per day. Because of the typically low effluent concentrations and relatively small flow rate, Maurer MHP effluent generally is not significantly contributing to the bacteria impairment on Grassy Creek Diversion; however, occasional elevated effluent loads do contribute during dry and low-flow periods. Additionally, the NPDES permit cites inflow and infiltration issues; inflow and infiltration can contribute to the bacteria impairment in the Grassy Creek Diversion watershed.

Most of the Grassy Creek Diversion watershed and the headwaters portion of the Grassy Creek watershed are unsewered. Critical sewerage areas were identified in the headwaters portion of the Grassy Creek watershed, which are in Wood County (refer back to Figure 4-12). An estimated 40 percent of the HSTS in the Wood County are not functioning properly (WCCGHD 2004, p. 4).

Urban runoff, which includes such sources as residential pets and wildlife, probably contribute to the bacteria impairments. Typical urban wildlife, which might live in the parks and other green space, include waterfowl (e.g., Canada geese), deer, and small riparian mammals (e.g. beaver). Wildlife are likely more abundant in rural portions of both watersheds.

Evaluations of load duration curves and field samples (Appendix C) show that *E. coli* exceedances occur from high through dry-flow conditions (no samples were collected during low flow conditions). Such a pattern typically indicates that multiple sources of bacteria are driving the impairment. For Grassy Creek Diversion, the bacteria loads tended to be 4 to 10 times the target load, whereas the loads were 7 to 17 times the size of the target loads for the Grassy Creek watershed.

WCCGHD (2004) and TMACOG (2011) identified malfunctioning or failing HSTS, package treatment plants (see Section 4.5.1.1), and point sources as probable sources of *E. coli* to Grassy Creek Diversion. Urban runoff from residential subdivisions and commercial and industrial development along the I-475 corridor are also probable sources of *E. coli* in the Grassy Creek Diversion watershed. In the Grassy Creek watershed, where no critical sewerage areas, unpermitted package treatment plants, or individually permitted point sources are identified, urban runoff is the probable source of bacteria impairment. The sources in these two watersheds will be addressed through *E. coli* TMDLs on Grassy Creek Diversion at Grand Rapids Road (RM 0.28; P11K19) and on Grassy Creek at Glenwood Road (RM 0.98; P11K8).

6.7 Delaware Creek – Maumee River (HUC 04100009 09 04)

In the Delaware Creek-Maumee River watershed, Ohio EPA identifies HSTS as a source of bacteria (Ohio EPA 2010a, p. 88). In the source assessment Section 4.5.2, urban runoff was identified as another potential source of bacteria.

As discussed in Section 4.5.2, the following sources are not present: facilities with individual NPDES permits (excluding NPDES permits for storm water), livestock operations, and row crops. An evaluation of geographic information system data from TMACOG (2011) shows that the subwatershed is sewered, and critical sewerage areas (i.e., known failing HSTS) and unpermitted package treatment plants are not present (refer back to Figure 4-11 in Section 3). The discussion of nitrate/nitrite and total phosphorus sources from Section 5.1.9 showed that urban runoff and storm sewers are the sources of nutrients and bacteria.

Urban sources of bacteria are wildlife (e.g., deer, raccoons, geese) and pets. During precipitation events, animal waste will be carried by storm water runoff into the storm sewer system. Potential sources of bacteria from human waste are illicit connections to the storm water conveyance system and inflow and infiltration.

Evaluations of load duration curves and field samples (Appendix C) show that *E. coli* exceedances occur from high conditions through dry-flow conditions (no samples were collected during low flow conditions). The elevated loads during high and moist flow conditions are consistent with urban runoff (e.g., pet waste). A large increase of loads occurs in the mid-range to dry flow conditions. This would typically indicate that a point source is contributing bacteria loads; however, no NPDES-permitted point sources are in the Delaware Creek at Rohr Road (RM 0.38; P11A07) subwatershed, nor are unsewered communities that might act similar to a point source. Illicit connections to the storm sewer system are a potential explanation of this trend.

Because TMACOG (2011) does not identify failing HSTS and package treatment plants, no point sources are in the subwatershed, and the subwatershed is sewered, urban runoff and illicit connections to the storm sewer system are the probable sources of *E. coli* to Delaware Creek. The bacteria sources will be addressed through an *E. coli* TMDL on Delaware Creek at Rohr Road (RM 0.38; P11A07).

7 TMDL and Allocations

A TMDL is the total amount of a pollutant that a receiving waterbody can assimilate while still achieving water quality standards. TMDLs can be expressed in terms of mass per time or by other appropriate measures. TMDLs are composed of the sum of individual wasteload allocations (WLA)s for point sources and load allocation s(Las) for nonpoint sources and natural background levels. In addition, the TMDL must include a margin of safety (MOS), either implicitly or explicitly, that accounts for the uncertainty in the relationship between pollutant loads and the quality of the receiving waterbody. When future growth (FG) is a concern and can be quantified, it is also included. Conceptually, this is defined by the following equation:

$$TMDL = \sum WLA + LA + MOS + FG$$

The TMDL was calculated at the target, which is typically the most conservative numeric criterion for a given constituent, multiplied by the flow and converted to appropriate units. All loads are reported on a daily time-scale. TMDLs are calculated at the flow duration interval that represents the midpoint of the flow zone (e.g., for the high-flow zone [0 to 10th percentile], the TMDL was calculated at the 5th percentile).

This section presents the development of the TMDLs via the load duration curve methodology and the allocation of loads, waste loads, MOS, and FG. It also discusses seasonality and critical conditions.

7.1 Load Duration Curves

Allowable pollutant loads in the Maumee River (lower) and Lake Erie tributaries project area were determined using load duration curves. Discussions of load duration curves are in *An Approach for Using Load Duration Curves in the Development of TMDLs* (U.S. EPA 2007b). This approach involves calculating the allowable loadings over the range of flow conditions expected to occur in the impaired stream by taking the following steps:

1. A flow duration curve for the stream is developed by generating a flow frequency table and plotting the data points to form a curve. The data reflect a range of natural occurrences from extremely high flows to extremely low flows. TMDL subwatersheds and flows for this project were estimated using StreamStats for Ohio (Koltun et al. 2006).[18] The estimated flows at selected percentiles are used to derive flow duration curves.

2. The flow curve is translated into a load duration (or TMDL) curve by multiplying each flow value (in cubic feet per second) by the water quality standard/target for a contaminant (mg/L or count/100 mL), then multiplying by conversion factors to get results in the proper unit (i.e., pounds per day or count per day). The resulting points are plotted to create a load duration curve.

3. Water quality samples collected by Ohio EPA are plotted as points on the TMDL graphs and can be compared to the water quality standard/target, or load duration curve. Ohio EPA did not monitor flow when collecting water quality samples. The flow percentile from the nearby Ottawa River at the University of Toledo (USGS 04177000) gage's flow duration curve for each date of Ohio EPA sampling in the project area was used to determine a corresponding flow at the sample site[19]. This flow

[18] Available online at: http://streamstats.usgs.gov/ohio.html. StreamStats for Ohio (Koltun et al. 2006) uses basin characteristics power equations to estimate flow statistics (Koltun and Whitehead 2002; Koltun 2003).

[19] The gage on the Ottawa River at University of Toledo (04177000; 150 square miles) was found to be more representative of conditions in the project area tributaries than any other continuously recording USGS gage within or near the project area.. Gages on Wolf Creek at Oregon (04194082) and Berger Ditch near Oregon (04194085) are impacted by the seiche effect in Lake Erie. The gages on the Maumee River at Waterville (04193500; 6,330 square miles) and Portage River at Woodville (04195500; 428 square miles) are considerably larger than the project area tributaries.

was then multiplied by the water quality standard/target and conversion factors to calculate loads for Ohio EPA's samples.

4. Points plotting above the curve represent deviations from the water quality standard/target and the daily allowable load. Those plotting below the curve represent compliance with standards and the daily allowable load. Further, it can be determined which flow conditions contribute loads above or below the water quality standard/target.

5. The area below the TMDL curve is interpreted as the loading capacity of the stream. The difference between this area and existing load is the load that must be reduced to meet water quality standards/targets.

6. The final step is to determine where reductions need to occur. Those exceedances at the right side of the graph occur during low-flow conditions and can be derived from sources such as point sources, septic systems and illicit sewer connections. Exceedances on the left side of the graph occur during higher flow events and can be derived from sources such as runoff. Using the load duration curve approach allows Ohio EPA to determine which implementation practices are most effective for reducing loads on the basis of flow regime.

The stream flows displayed on a load duration curve can be grouped into various flow regimes to aid with interpreting the load duration curves. The flow regimes are typically divided into 10 groups, which can be further categorized into the following five *hydrologic zones* (Cleland 2005, 2007):

- High-flow zone: flows that plot in the 0 to 10 percentile range, related to flood flows
- Moist zone: flows in the 10 to 40 percentile range, related to wet-weather conditions
- Mid-range zone: flows in the 40 to 60 percentile range, median stream flow conditions
- Dry zone: flows in the 60 to 90 percentile range, related to dry-weather flows
- Low-flow zone: flows in the 90 to 100 percentile range, related to drought conditions

The load duration approach also considers critical conditions and seasonal variation in the TMDL development as required by the CWA and U.S. EPA's implementing regulations. Because the approach establishes loads on the basis of a representative flow regime, it inherently considers seasonal variations and critical conditions attributed to flow conditions. An underlying premise of the duration curve approach is correlation of water quality impairments to flow conditions. The duration curve alone does not consider specific fate and transport mechanisms, which can vary depending on watershed or pollutant characteristics.

7.2 Allocations

Load duration analyses were conducted for impaired HUCs (at a site in the watershed upstream of the lacustrine zone) and selected sites with a sufficient number of samples. In-stream water quality data were obtained from Ohio EPA. Data were used only if Ohio EPA accepted them as level 3 credible via the Ohio Credible Data Program. TMDLs were not generated in the lacustruaries because the ebb and flow makes the loadings less predictable. Additionally, the objective of developing TMDLs is to address sources of pollution in the impaired streams, the objective does not include addressing any pollutants present in Lake Erie backwaters.

Most TMDLs were generated at individual assessment sites. Subwatersheds draining to these assessment sites were delineated using StreamStats for Ohio (Koltun 2006). In most cases, only one sample was collected in each flow zone. In cases where more than one sample was collected, the sample requiring the most reduction was selected. For TMDLs at assessment sites, the necessary percent reductions were calculated as the TMDL minus the observed load divided by the observed load; this calculation generates the portion of the observed load that must be reduced to achieve the TMDL. For TMDLs at sites that were not sampled by Ohio EPA, the necessary percent reduction was calculated at the downstream-most assessment site with data, using the previously discussed methodology.

The load duration approach helps to identify the issues surrounding the impairment and to roughly differentiate between sources. Table 7-1 summarizes the relationship between the five hydrologic zones and potential contributing source areas (Cleland 2005, 2007).

Table 7-1. Relationship between load duration curve zones and contributing sources

Contributing source area	Duration curve zone				
	High	Moist	Mid-range	Dry	Low
Point source				M	H
Livestock direct access to streams				M	H
HSTS	M	M-H	H	H	H
Riparian areas		H	H	M	
Storm water: Impervious		H	H	H	
Storm water: Upland	H	H	M		

Note: Potential relative importance of source area to contribute loads under hydrologic conditions (H: High; M: Medium; L: Low)

A summary of the allowable loads and allocations for all parameters in the Maumee River (lower) tributaries and Lake Erie tributaries project area is presented in this chapter. Section 7.3presents the allocations for the ALU impairments and Section 7.4 presents the allocations for the recreation use impairments.

7.2.1 Margin of Safety

The CWA requires that a TMDL include an MOS to account for uncertainty in the relationship between LAs and WLAs and water quality. U.S. EPA guidance explains that the MOS may be implicit (i.e., incorporated into the TMDL through conservative assumptions in the analysis) or explicit (i.e., expressed in the TMDL as loadings set aside for the MOS).

Explicit and implicit MOS are presented for each TMDL in Table 7-2.

Table 7-2. Summary of margin of safeties by parameter

Parameter	Explicit MOS description	Implicit MOS description
Ammonia	5%	Targets selected on the basis of numeric criteria that varies by temperature and pH with most restrictive criteria selected
E. coli	5%	Numeric criteria (seasonal geometric means) used as daily targets
Nitrate plus nitrite	10%	The recommendations in the *Associations* document (Ohio EPA 1999) were applied as daily targets.
TP	10%	
TSS	10%	

Notes
MOS = margin of safety; TP = total phosphorus; TSS = total suspended solids.

The MOS for ammonia is both implicit and explicit. The numeric criteria for ammonia vary by designated use, season, temperature, and pH. The TMDL target was conservatively selected from the available temperature and pH data, with the most restrictive target of temperature and pH combinations selected. A supplemental explicit MOS was also included, which was 5 percent of the TMDL.

The MOS for *E. coli* is both implicit and explicit. The geometric mean criteria for Bathing Waters and PCR Class A (126 counts/100 mL) and Class B (161 counts/100 mL) were used as the daily TMDL targets. This target selection itself provides an implicit MOS because the geometric mean criteria were conservatively applied on a daily timescale. Implicit MOS for *E. coli* TMDLs applies because the load duration analysis does not address the die-off of pathogens. A supplemental explicit MOS was also included, which was 5 percent of the TMDL.

The nitrate plus nitrite, total phosphorus, and TSS targets were derived from recommendations in the *Associations* document (Ohio EPA 1999) that were based upon analyses of normal, summer and fall low flow conditions. The averaging period of these recommendations was not reported. The recommendations were conservatively applied as daily targets. A supplemental explicit MOS of 10 percent of the TMDL was also included for these three pollutants. This moderate explicit MOS was specified because the use of the load duration curves is expected to provide reasonably accurate information on the loading capacity of the stream, but the estimate of the loading capacity could be subject to potential error associated with the method used to estimate flows in the watershed.

7.2.2 Future Growth

Allocations for FG were assigned to all TMDLs on the basis of the largest measured growth in the project area. An evaluation of 2000 and 2010 Census data showed that Lucas County and Toledo are losing population (Table 7-3). The change in population between the 2000 and 2010 Censuses for Wood County was used to calculate the FG allocation for all TMDL locations. Because the FG reserve accounts for growth beyond population changes (e.g., expansion of a permitted point source), the largest population growth (Wood County, 3.7 percent) was applied to TMDL locations in other counties even if population declined.

Table 7-3. Population statistics

Location	2000 population	2010 population	Change
Lucas County	455,056	441,815	–2.9%
Ottawa County	40,985	41,428	+1.1%
Toledo	313,619	298,446	–4.9%
Wood County	121,062	125,488	+3.7%

Source: U.S. Census Bureau 2011.

7.2.3 Critical Conditions and Seasonality

The CWA requires that TMDLs take into account critical conditions for stream flow, loading, and water quality parameters as part of the analysis of loading capacity. Through the load duration curve approach, it has been determined that load reductions are needed for specific flow conditions; however, the critical conditions (the periods when the greatest reductions are required) vary by location and are inherently addressed by specifying different levels of reduction according to flow.

When calculated, the allocation of point source loads (i.e., the WLA) will also take into account critical conditions by assuming that the facilities will always discharge at their maximum design flows. In reality, many facilities discharge below their design flows.

The CWA also requires that TMDLs be established with consideration of seasonal variations. Seasonal variations are addressed in this TMDL by assessing conditions only during the season when the water quality standard applies (May 1 through October 30) for *E. coli*. The load duration approach also accounts for seasonality by evaluating daily allowable loads over the entire range of observed flows and by presenting daily allowable loads that vary by flow.

7.3 Aquatic Life Use

Seventeen assessment sites were not in full attainment of their ALU. Eleven TMDLs were generated for phosphorus species and nitrogen species and six TMDLs were generated for TSS to address the impairments at these 17 sites. The locations of the TMDLs are listed in Table 7-4 and shown in Figure 7-2. Load duration curves were developed for each waterbody-pollutant combination (i.e., 17 load duration curves). TMDLs were generated for both the watersheds (upstream of the lacustrine zone) and headwaters areas, which are subject to different targets and tended to have different causes of impairment than downstream impaired sites. Since three TMDL locations are not Ohio EPA assessment sites (identified with a double dash [“--"] in the Site ID field in Table 7-4), additional load duration curves were developed for the closest Ohio EPA assessment site that is upstream of the TMDL site.

Table 7-4. Summary of ALU TMDLs

Site ID	Site name	RM	Size	Parameter	Target
Turtle Creek – Frontal Lake Erie (HUC 04100010 07 01)					
S03K07	South Branch Turtle Creek at Moline Road	2.65	H	Ammonia	1.6 mg/L as N
				Total phosphorus [a]	0.08 mg/L as P
--	Turtle Creek at North Lickett Harder Road	5.3	W	Total phosphorus	0.10 mg/L as P
Crane Creek – Frontal Lake Erie (HUC 04100010 07 02)					
S03P21	Crane Creek at Hanley Road	18.82	H	Total phosphorus	0.08 mg/L as P
201118	Henry Creek near Bradner Road	0.10	H	Total phosphorus	0.08 mg/L as P
--	Crane Creek at Nissen Road	6.5	W	Total phosphorus	0.10 mg/L as P
				TSS	24 mg/L
Cedar Creek – Frontal Lake Erie (HUC 04100010 07 03)					
S03S34	Cedar Creek at Oregon Road	20.77	H	Total phosphorus	0.08 mg/L as P
S03S68	Dry Creek at East Broadway Road	7.00	H	Ammonia	0.5 mg/L as N
				Total phosphorus [a,b]	0.08 mg/L as P
S03S55	Cedar Creek at Yondota Road	4.27	W	Total phosphorus	0.10 mg/L as P
Berger Ditch (HUC 04100010 07 05)					
--	Berger Ditch upstream of Cedar Point Road	0.75	H	Total phosphorus [b]	0.08 mg/L as P
				TSS	24 mg/L
Otter Creek – Frontal Lake Erie (HUC 04100010 07 06)					
S03S25	Otter Creek adjacent to CSX Road	0.40	H	TSS	24 mg/L
Delaware Creek – Maumee River (HUC 04100009 09 04)					
P11A07	Delaware Creek at Rohr Drive	0.38	H	Nitrate plus nitrite	1.0 mg/L as N
				Total phosphorus	0.08 mg/L as P
P11S56	Duck Creek at York Street	2.52	H	TSS	24 mg/L

Notes
All streams and HUCs are in the HELP level IV ecoregion and are warmwater habitat.
ALU = aquatic life use; H = headwaters (less than 20 square miles); HUC = hydrologic unit code (i.e., the TMDL will cover the entire HUC) mg/L = milligram per liter; N = nitrogen; P = phosphorus; RM = river mile; TSS = total suspended solids; W = wading (greater than 20 square miles and smaller than requiring a boat).
a. The total phosphorus TMDL also serves as a surrogate for a dissolved oxygen impairment.
b. The total phosphorus TMDL also serves as a surrogate for an organic enrichment impairment.

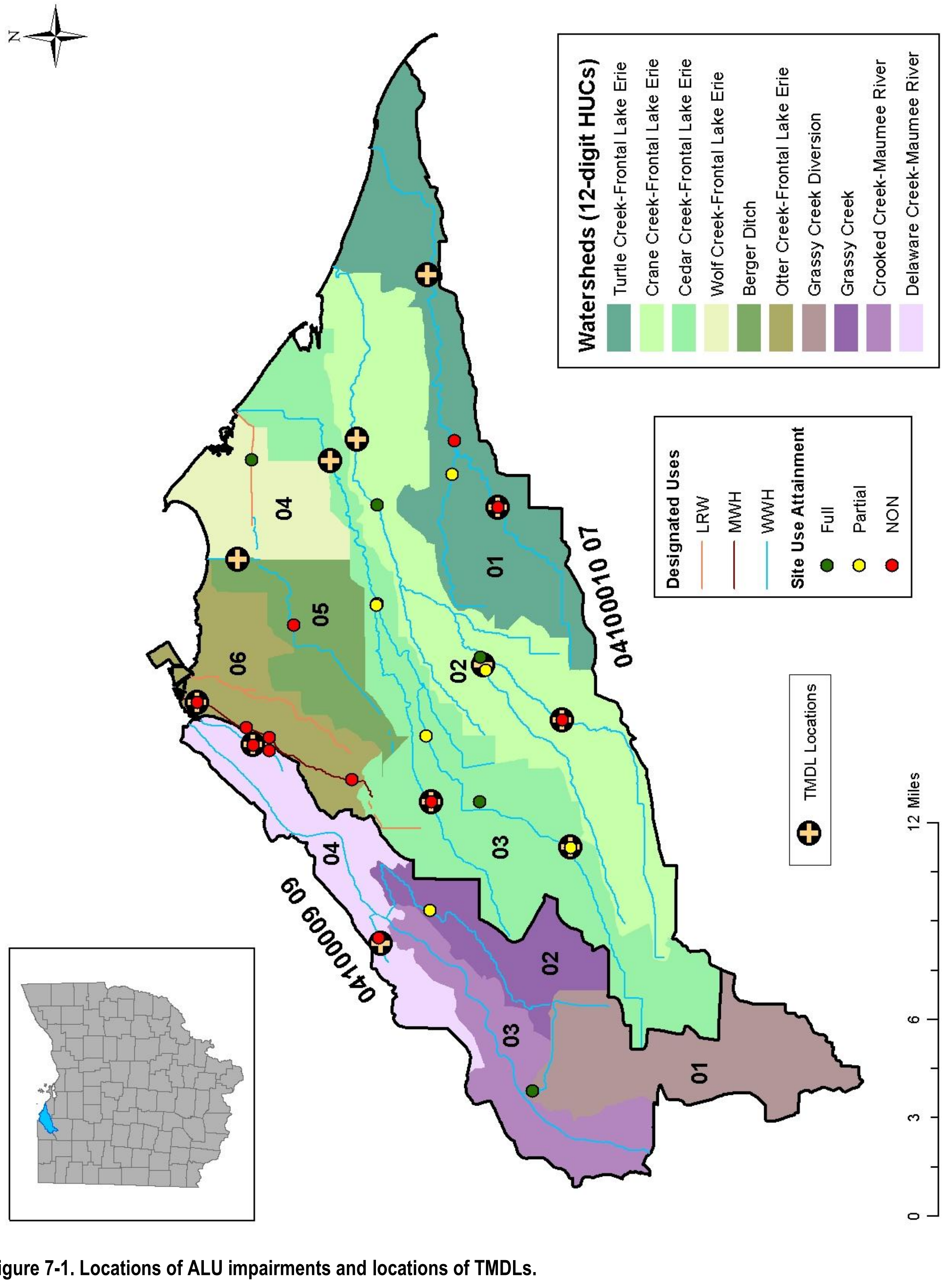


Figure 7-1. Locations of ALU impairments and locations of TMDLs.

7.3.1 TMDL Targets

TMDL targets for total phosphorus, nitrate plus nitrite, and TSS were derived from the *Associations* document (Ohio EPA 1999). All of the impaired streams were either headwaters or wading size. The total phosphorus targets were 0.08 mg/L as phosphorus for headwaters streams and 0.10 mg/L as phosphorus for wading streams (refer back to Table 7-4.). Only one stream (i.e., Delaware Creek) was impaired by nitrate plus nitrite; its target was 1.0 mg/L as nitrogen. The TSS target is 24 mg/L for both headwaters and wading streams.

The ammonia target for South Branch Turtle Creek was 1.6 mg/L, which is equivalent to the OMZA criteria for a WWH waterbody for March through November with pH of 7.7 standard units and a temperature of 25 degrees Celsius. The ammonia target for Dry Creek was 0.5 mg/L, which is equivalent to the OMZA criteria for a WWH waterbody for March through November with a pH of 8.5 standard units and a temperature of 19 degrees Celsius. In each case, the most restrictive pairing of pH and temperature was used to select the ammonia target.

7.3.2 Waste Load Allocations

Waste loads were allocated for permitted point sources, including facilities with individual NPDES permits and regulated storm water (MS4s, construction and industrial). In each allocation table in this section, the row labeled “WLA” is the summation of all WLAs, which are indented within subsequent rows.

7.3.2.1 Facilities with Individual NPDES Permits

The WLAs for facilities with individual NPDES permits (excluding storm water) were calculated by multiplying the design flow by the TMDL target and converting to proper units (Table 7-5 and Table 7-6). The WLA for facilities with individual NPDES permits for storm water were calculated on the basis of the area of each facility as a proportion to the area of the watershed (Appendix E).

No facilities with individual NPDES permits (excluding the Toledo MS4) are located in Delaware Creek subwatershed; thus, no individually permitted facilities’ WLAs were calculated for nitrate plus nitrite. Additionally, no individually NPDES-permitted facilities are allowed to discharge ammonia in their effluent in the Dry Creek at East Broadway Road (S03S68, RM 7.00) and South Branch Turtle Creek at Martin-Moline Road (S03K07, RM 2.65) subwatersheds; thus, ammonia WLAs were not calculated for individual NPDES permits.

Table 7-5. Total phosphorus WLAs for NPDES facilities

Facility name	Ohio EPA ID	Design flow (mgd)	Allowable effluent concentration (mg/L as P)	WLA (lb/d)
Allen Elementary School [a]	2PT00042	0	--	0
Crazy Lady Inn	2PR00263	0.005	3	0.13
Five Points MHP	2PY00073	0.0066	3	0.17
Hirzel Canning Co. [c]	2IH00111	0.15	0.08	0.10
Perrysburg Estates MHP	2PY00014	0.0624	0.33	0.17
Luther Home of Mercy [d]	2PS00013	0.0325	--	0
Village Green MHP	2PY00008	0.045	0.37	0.14
Wildflower Subdivision WWTP [d]	2PY00008	0.045	--	0

Note
a. Allen Elementary School (Ohio EPA ID 2PT00042) is no longer operational and cannot discharge.
b. The wastewater treatment works permitted for the Crazy Lady Inn (Ohio EPA ID 2PR00263) were never built; the permit may be closed.
c. WLA is applicable in only the high and moist flow conditions; the WLA is zero in mid-range, dry, and low-flow conditions.
d. Luther Home of Mercy (Ohio EPA ID 2PS00013) and Wildflower Place Subdivision WWTP (2PW00010) will be connected to public sewers by 2015 and will not be permitted to discharge to surface waters.

Table 7-6. TSS WLAs for NPDES facilities

Facility name	Ohio EPA ID	Design flow (mgd)	Allowable effluent concentration (mg/L)	WLA (lb/d)
Envirosafe Services of Ohio	2IN00013	0.0394	24	7.9
Hirzel Canning Co. [a]	2IH00111	0.15	24	30
Perrysburg Estates MHP	2PY00014	0.0624	18	9.4
Oregon WTP [b]	2IW00220	0.30	24	60
Stoneco, Inc. Lime City Plant	2IJ00052	4.80	24	961
Toledo Station (Buckeye Pipeline Company)	2II00019	0.0015	18	0.23
Toledo WTP [c]	2IW00260	5.91 Duck	20	1,586
		29.5 Otter		4,924
Village Green MHP	2PY00008	0.045	18	6.8

Note
a. WLA is applicable in only the high and moist flow conditions; the WLA is zero in mid-range, dry, and low-flow conditions.
b. The WLA for Oregon WTP (Ohio EPA ID 2IW00220) is a summation for outfalls 001 and 002, each with a design flow of 0.15 mgd. Outfall 003 is excluded from this WLA; it does not discharge to Berger Ditch.
c. The Toledo WTP (Ohio EPA ID 2IW00260) discharges to Duck Creek (outfall 003) and Otter Creek (outfalls 004, 005, 006, 007, and 010). Outfall 001 is closed and outfall 002 is not used; they are excluded from the facility's WLAs.

7.3.2.2 Construction Storm Water

Construction storm water was assigned a gross allocation that is applicable to all construction storm water permitees. The WLAs are calculated on the basis of the average area of the watershed that is regulated under Ohio's general permit for construction site storm water (OHC000003) from 2006 through 2011. The average annual summation of construction areas was calculated for each county's portion of the project area. The WLA for each TMDL subwatershed was calculated using the county ratios and the areas of each county in the TMDL subwatershed.

7.3.2.3 Industrial Storm Water

Regulated industrial storm water facilities are assigned a gross WLA, covering 51 permits in the project area. The WLAs were calculated on the basis of the area of each facility that is regulated under the Ohio Multi-Sector General Permit (OHR00005). Each of the permitted facilities was located with geographic information system information, and county parcel data[20] were used to calculate the area of each facility. The WLA was calculated as the proportion of the subwatershed that is industrial facilities (i.e., the summation of the areas of parcels for the industrial facilities).

7.3.2.4 Municipal Separate Storm Sewer System Storm Water

One Phase I and 12 Phase II regulated MS4s are in the project area. Individual WLAs were established for each MS4 on the basis of the area of the regulated entity. The jurisdictional areas of cities and villages were used as a surrogate for the regulated area of each MS4, except for the city of Oregon. The areas of developed land within the jurisdictional areas of the city of Oregon and unincorporated areas of co-permitees (e.g., Allen Township of Ottawa County) were used to calculate MS4 WLA. Since a large portion of the city of Oregon is agricultural, the area of developed land within city limits was used, instead of the incorporated area, to calculate its WLA. Developed area is defined as the developed land cover classes (developed, open; developed, low intensity; developed, medium intensity; and developed, high intensity) of the 2006 NLCD. The area for each entity was assigned a WLA according to the proportion of the total drainage area of the subwatershed.

For regulated MS4 road authorities (Lucas County, ODOT, OTC, Ottawa County, and Wood County), the regulated area was determined using the length of applicable roads[21] in the 2000 Census Urbanized Area and an estimated right of way width. WLAs for the county MS4s which include township co-permitees are based on the summations of the unincorporated land area and county road area in each subwatershed.

Several of the subwatersheds are completely contained within regulated MS4 jurisdictions (e.g., Duck Creek); a tiered approach was used to allocate storm water WLAs. Construction and industrial storm water (a gross WLA for each) and storm water for facilities with individual NPDES permit were allocated first. The remaining capacity was then allocated to regulated MS4s. In these cases, there is no LA.

7.3.3 Turtle Creek – Frontal Lake Erie (HUC 04100010 07 01)

Three TMDLs were generated for the Turtle Creek watershed (HUC 0410010 07 01). A TMDL was generated for total phosphorus for the watershed upstream of the lacustrine zone (Table 7-7; Appendix C). Samples collected on Turtle Creek at Nissen Road (S03K05, RM 11.62) require total phosphorus reductions of 48 to 54 percent in the moist through dry-flow zones and no reduction in the low-flow zone (Appendix C).

The TMDLs for South Branch Turtle Creek at Moline Road (S03K07, RM 2.65; in Table 7-8 and Table 7-9) require reductions of 85 percent for ammonia in the low-flow zone and 61 to 80 percent for total phosphorus (Appendix C).

[20] Parcel GIS data were provided by the Auditor's Offices in Lucas, Ottawa, and Wood counties in January 2012.
[21] Road centerline GIS shapefiles were provided by the Engineers' Offices in Lucas, Ottawa, and Wood counties in January 2012.

Table 7-7. Total phosphorus allocations (lb/d) for Turtle Creek at North Lickett Harder Road (RM 5.3)

Duration Interval	High 5%	Moist 25%	Mid-range 50%	Dry 75%	Low 95%
TMDL	**50.0**	**10.9**	**3.78**	**1.41**	**0.341**
LA	40.1	8.73	3.03	1.132	0.273
WLA	3.1	0.67	0.23	0.086	0.021
Allen Elementary School (2PT00042) [a]	0	0	0	0	0
Construction storm water (general permit)	0.026	0.0056	0.0020	0.00073	0.00018
Industrial storm water (general permit)	0.078	0.017	0.0059	0.0022	0.00053
Ottawa County & Others MS4 (2GQ00022)	2.8	0.60	0.21	0.078	0.019
Wood County & Others MS4 (2GQ00028)	0.16	0.036	0.012	0.0046	0.0011
ODOT MS4 (4GQ00000)	0.030	0.0066	0.0023	0.00085	0.00021
FG (3.7%)	1.8	0.40	0.14	0.052	0.013
MOS (10%)	5.0	1.1	0.38	0.14	0.034

Note
a. Allen Elementary School (Ohio EPA ID 2PT00042) was closed down and demolished.

Table 7-8. Ammonia allocations (lb/d) on South Branch Turtle Creek at Martin-Moline Road (S03K07, RM 2.65)

Duration Interval	High 5%	Moist 25%	Mid-range 50%	Dry 75%	Low 95%
TMDL	**207**	**50**	**18**	**7.2**	**1.9**
LA	170.1	41	14.7	5.887	1.555
WLA	19.2	4.7	1.71	0.683	0.181
Construction storm water (general permit)	0.13	0.032	0.012	0.0046	0.0012
Ottawa County & Others MS4 (2GQ00022)	18	4.4	1.6	0.64	0.17
Wood County & Others MS4 (2GQ00028)	0.96	0.23	0.085	0.034	0.0088
ODOT MS4 (4GQ00000)	0.11	0.027	0.010	0.0039	0.0010
FG (3.7%)	7.7	1.8	0.68	0.27	0.070
MOS (5%)	10	2.5	0.91	0.36	0.094

Table 7-9. Total phosphorus allocations (lb/d) for South Branch Turtle Creek at Martin-Moline Road (S03K07, RM 2.65)

Duration Interval	High 5%	Moist 25%	Mid-range 50%	Dry 75%	Low 95%
TMDL	**10.4**	**2.48**	**0.915**	**0.360**	**0.0943**
LA	8.1	1.908	0.708	0.279	0.073
WLA	0.92	0.23	0.081	0.032	0.0084
Construction storm water (general permit)	0.0063	0.0015	0.00055	0.00022	0.000057
Ottawa County & Others MS4 (2GQ00022)	0.86	0.21	0.076	0.030	0.0079
Wood County & Others MS4 (2GQ00028)	0.046	0.011	0.0040	0.0016	0.00041
ODOT MS4 (4GQ00000)	0.0054	0.0013	0.00047	0.00019	0.000049
FG (3.7%)	0.38	0.092	0.034	0.013	0.0035
MOS (10%)	1.0	0.25	0.092	0.036	0.0094

7.3.4 Crane Creek – Frontal Lake Erie (HUC 04100010 07 02)

Four TMDLs were generated for the Crane Creek watershed (HUC 0410010 07 02). A TMDL was generated for total phosphorus for the watershed upstream of the lacustrine zone (Table 7-12; Appendix C). Ohio EPA did not collect data at this site. The nearest upstream site that Ohio EPA sampled was at Martin-Williston Road (S03G21, RM 8.83); this site requires reductions of 38 to 88 percent in the moist through low flow zones (Appendix C).

A TSS TMDL was also generated for the watershed upstream of the lacustrine zone at Nissen Road (Table 7-11, Appendix C). The TMDL at Nissen Road addresses the sedimentation/siltation impairments at the following upstream sites: Crane Creek at Hanley Road (S03P21, RM 18.82) and Henry Creek near the mouth (201118, RM 0.10). Samples collected at Martin-Williston Road (S03G21, RM 8.83) require TSS reductions of 25 percent in the mid-range zones and no reductions are necessary in the moist, dry, and low flow zones.

The total phosphorus TMDL for Crane Creek at Hanley Road (S03P21, RM 18.82; Table 7-13) requires reductions of 44 to 59 percent in the moist through low-flow zones (Appendix C). The total phosphorus TMDL for Henry Creek at Bradner Road (201118; RM 0.25; Table 7-13) requires reductions of 44 to 71 percent in the moist through low-flow zones (Appendix C).

Table 7-10. Total phosphorus allocations (lb/d) for Crane Creek at Nissen Road (RM 6.5)

	High	Moist	Mid-range	Dry	Low
Duration Interval	5%	25%	50%	75%	95%
TMDL	**66.4**	**14.8**	**5.23**	**2.06**	**0.588**
LA	48.4	10.52	3.58	1.239	0.167
WLA	8.9	2.23	0.94	0.535	0.34
Luther Home of Mercy (2PS00013) [a]	0	0	0	0	0
Perrysburg Estates MHP (2PY00014)	0.17	0.17	0.17	0.17	0.17
Village Green MHP (2PY00008)	0.14	0.14	0.14	0.14	0.14
Wildflower Place Subdivision WWTP (2PS00013) [a]	0	0	0	0	0
Construction storm water (general permit)	0.068	0.015	0.0050	0.0018	0.00024
Industrial storm water (general permit)	0.074	0.016	0.0055	0.0019	0.00026
Fuel Mart #641 storm water (2II00050) [b]	0.0023	0.00053	0.00018	0.000062	0
Pilot Travel Center storm water (2IN00147) [b]	0.0010	0.00023	0.00008	0.000027	0
Toledo TravelCenter storm water (2II00032) [b]	0.0070	0.0016	0.00056	0.00019	0
Village of Millbury MS4 (2GQ00007)	1.2	0.26	0.090	0.031	0.0042
Lucas County & Others MS4 (2GQ00006)	0.023	0.0050	0.0017	0.00059	0.000078
Ottawa County & Others MS4 (2GQ00022)	1.8	0.40	0.13	0.047	0.0063
Wood County & Others MS4 (2GQ00028)	5.3	1.2	0.39	0.14	0.018
ODOT MS4 (4GQ00000)	0.062	0.014	0.0046	0.00161	0.00022
FG (3.7%)	2.5	0.55	0.19	0.076	0.022
MOS (10%)	6.6	1.5	0.52	0.21	0.059

Notes
a. Luther Home of Mercy (Ohio EPA ID 2PS00013) and Wildflower Subdivision WWTP (Ohio EPA ID 2PS00013) will be connected to public sewers by 2015 (TMACOG 2011) and the facilities will not be permitted to discharge to surface waters.
b. These storm water WLAs for individual permits were set in the TMDL for Crane Creek at Hanley Road (S03P21; RM 18.82).

Table 7-11. TSS allocations (lb/d) for Crane Creek at Nissen Road (RM 6.5)

Duration Interval	High 5%	Moist 25%	Mid-range 50%	Dry 75%	Low 95%
TMDL	**15,924**	**3,541**	**1,255**	**495**	**141**
LA	11,647.8	2,578.7	904	349	89.7
WLA	2,095.2	477.3	179	78	32.1
Luther Home of Mercy (2PS00013)[a]	0	0	0	0	0
Perrysburg Estates MHP (2PY00014)	9.4	9.4	9.4	9.4	9.4
Village Green MHP (2PY00008)	6.8	6.8	6.8	6.8	6.8
Wildflower Subdivision WWTP (2PS00013)[a]	0	0	0	0	0
Construction storm water (general permit)	16	3.6	1.3	0.49	0.13
Industrial storm water (general permit)	18	4.0	1.4	0.53	0.14
Fuel Mart #641 storm water (2II00050)	3.0	0.66	0.23	0.089	0.023
Pilot Travel Center storm water (2IN00147)	1.3	0.29	0.10	0.039	0.010
Toledo TravelCenter storm water (2II00032)	9.2	2.0	0.71	0.28	0.071
Village of Millbury (2GQ00007)	293	65	23	8.8	2.3
Lucas County & Others (2GQ00006)	5.5	1.2	0.43	0.16	0.042
Ottawa County & Others MS4 (2GQ00022)	438	97	34	13	3
Wood County & Others MS4 (2GQ00028)	1,280	284	100	38	10
ODOT MS4 (4GQ00000)	15	3.3	1.2	0.45	0.12
FG (3.7%)	589	131	46	18	5.2
MOS (10%)	1,592	354	126	50	14

Note
a. Luther Home of Mercy (Ohio EPA ID 2PS00013) and Wildflower Subdivision WWTP (Ohio EPA ID 2PS00013) will be connected to public sewers by 2015 (TMACOG 2011) and the facilities will not be permitted to discharge to surface waters.

Table 7-12. Total phosphorus allocations (lb/d) for Crane Creek at Hanley Road (S03P21, RM 18.82)

Duration Interval	High 5%	Moist 25%	Mid-range 50%	Dry 75%	Low 95%
TMDL	**12.3**	**2.99**	**1.13**	**0.491**	**0.162**
LA	10.47	2.43	0.836	0.283	0.001
WLA	0.17	0.15	0.142	0.141	0.14
Village Green MHP (2PY00008)	0.14	0.14	0.14	0.14	0.14
Construction storm water (general permit)	0.015	0.0034	0.0012	0.0004	0 [a]
Fuel Mart #641 storm water (2II00050)	0.0023	0.00053	0.00018	0.000062	0 [a]
Pilot Travel Center storm water (2IN00147)	0.00099	0.00023	0.000079	0.000027	0 [a]
Toledo TravelCenter storm water (2II00032)	0.0070	0.0016	0.00056	0.00019	0 [a]
FG (3.7%)	0.46	0.11	0.042	0.018	0.005 [a]
MOS (10%)	1.2	0.30	0.11	0.049	0.016

Note
a. WLAs for storm water were set to zero and the FG is less than 3.7 percent of the loading capacity in the low flow zone to allow for allocation to Village Green MHP (Ohio EPA ID 2PY00008), MOS, and LA.

Table 7-13. Total phosphorus allocations (lb/d) for Henry Creek at Bradner Road (201118, RM 0.25)

Duration Interval	High 5%	Moist 25%	Mid-range 50%	Dry 75%	Low 95%
TMDL	**13.7**	**3.31**	**1.25**	**0.560**	**0.195**
LA	9.79	2.26	0.772	0.262	0.005
WLA	2.0	0.60	0.312	0.221	0.17
Perrysburg Estates MHP (2PY00014)	0.17	0.17	0.17	0.17	0.17
Construction storm water (general permit)	0.016	0.0038	0.0013	0.00044	0 [a]
Village of Millbury (MS42GQ00007)	0.0070	0.0016	0.00054	0.00019	0 [a]
Wood County & Others MS4 (2GQ00028)	1.8	0.41	0.14	0.05	0 [a]
FG (3.7%)	0.51	0.12	0.046	0.021	0 [a]
MOS (10%)	1.4	0.33	0.12	0.056	0.020

Note
a. WLAs for storm water and FG were set to zero in the low flow zone to allow for allocation to Perrysburg Estates MHP (Ohio EPA ID 2PY00014), MOS, and LA.

7.3.5 Cedar Creek – Frontal Lake Erie (HUC 04100010 07 03)

Four TMDLs were generated for the Cedar Creek watershed (HUC 0410010 07 03). A TMDL was generated for total phosphorus for the watershed upstream of the lacustrine zone (Table 7-14; Appendix C); this site requires a reduction of 23 percent reduction in the mid-range flow zone and a 7 percent reduction in the dry flow zone.

The total phosphorus TMDL for Cedar Creek at Oregon Road (S03S43, RM 20.77; Table 7-15) requires reductions of 20 percent in the low-flow zone and 48 percent in the mid-range flow zone (Appendix C). The TMDLs for Dry Creek (Table 7-16 and Table 7-17) require reductions of 75 percent for ammonia in the dry-flow zone and 10 to 79 percent for total phosphorus in the moist through low-flow zones.

Table 7-14. Total phosphorus allocations (lb/d) for Cedar Creek at Yondota Road (S03S55, RM 4.27)

Duration Interval	High 5%	Moist 25%	Mid-range 50%	Dry 75%	Low 95%
TMDL	**72.6**	**16.0**	**5.62**	**2.18**	**0.562**
LA	40	8.66	2.95	1.033	0.139
WLA	22.6	5.15	1.9	0.846	0.346
Crazy Lady Inn (2PR00263) [a]	0.13	0.13	0.13	0.13	0.13
Five Point MHP (2PY00073)	0.13	0.13	0.13	0.13	0.13
Construction storm water (general permit)	0.11	0.023	0.0078	0.0028	0.00040
Industrial storm water (general permit)	1.7	0.36	0.12	0.044	0.0063
Bulk Plant Millbury storm water (2IN00174)	0.0062	0.0014	0.00046	0.00016	0.000023
Evergreen storm water (2IN000108) [b]	0.26	0.068	0.026	0.013	0.0044
City of Northwood MS4 (2GQ00002)	4.5	0.98	0.33	0.12	0.017
City of Oregon MS4 (2GQ00001)	0.0060	0.0013	0.00044	0.00016	0.000022
City of Rossford MS4 (2GQ00017)	1.6	0.35	0.12	0.042	0.0060
Village of Walbridge MS4 (2GQ00003)	2.2	0.49	0.17	0.058	0.0083
Lucas County & Others MS4 (2GQ00006)	0.14	0.032	0.011	0.0038	0.00053
Ottawa County & Others MS4 (2GQ00022)	0.60	0.13	0.044	0.016	0.0022
Wood County & Others MS4 (2GQ00028)	11	2.4	0.79	0.28	0.040
ODOT MS4 (4GQ00000)	0.19	0.042	0.014	0.0050	0.00071
OTC MS4 (3GQ00022)	0.012	0.0026	0.00089	0.00031	0.000044
FG (3.7%)	2.7	0.59	0.21	0.081	0.021
MOS (10%)	7.3	1.6	0.56	0.22	0.056

Note
a. The wastewater treatment works permitted for the Crazy Lady Inn (Ohio EPA ID 2PR00263) were never built; the permit may be closed.
b. This storm water WLA for an individual permit was set in the TMDL for Dry Creek at East Broadway Road (S03S48; RM 7.00).

Table 7-15. Total phosphorus allocations (lb/d) for Cedar Creek at Oregon Road (S03S34; RM 20.77).

Duration Interval	High 5%	Moist 25%	Mid-range 50%	Dry 75%	Low 95%
TMDL	**15.3**	**3.64**	**1.34**	**0.542**	**0.150**
LA	13.082	3.0158	1.0296	0.3332	0.00199
WLA	0.148	0.1342	0.1314	0.1348	0.13001
Five Point MHP (2PY00073)	0.13	0.13	0.13	0.13	0.13
Construction storm water (general permit)	0.018	0.0042	0.0014	0.00048	3.7×10^{-6}
FG (3.7%)	0.57	0.13	0.049	0.020	0.003 [a]
MOS (10%)	1.5	0.36	0.13	0.054	0.015

Note
a. FG is less than 3.7 percent of the loading capacity in the low flow zone to allow for allocation to Five Point MHP (Ohio EPA ID 2PY00073), MOS, and LA.

Table 7-16. Ammonia allocations (lb/d) for Dry Creek at East Broadway Road (S03S48, RM 7.00)

Duration Interval	High 5%	Moist 25%	Mid-range 50%	Dry 75%	Low 95%
TMDL	**68**	**17**	**6.8**	**3.2**	**1.1**
LA	29.1	6.98	2.96	1.33	0.458
WLA	33	8.50	3.25	1.59	0.544
Construction storm water (general permit)	0.087	0.022	0.0087	0.0042	0.0014
Industrial storm water (general permit)	2.9	0.74	0.29	0.14	0.048
Evergreen storm water(2IN00108)	1.7	0.45	0.17	0.083	0.029
City of Rossford MS4 (2GQ00017)	8.6	2.2	0.85	0.41	0.14
Wood County & Others MS4 (2GQ00028)	19	5.0	1.9	0.93	0.32
ODOT MS4 (4GQ00000)	0.25	0.065	0.025	0.012	0.0042
OTC MS4 (3GQ00022)	0.058	0.015	0.0057	0.0027	0.00095
FG (3.7%)	2.5	0.65	0.25	0.12	0.042
MOS (5%)	3.4	0.87	0.34	0.16	0.056

Table 7-17. Total phosphorus allocations (lb/d) for Dry Creek at East Broadway Road (S03S48, RM 7.00)

Duration Interval	High 5%	Moist 25%	Mid-range 50%	Dry 75%	Low 95%
TMDL	**10.9**	**2.80**	**1.09**	**0.520**	**0.180**
LA	4.4	1.12	0.44	0.229	0.1223
WLA	5.0	1.3	0.50	0.22	0.033
Construction storm water (general permit)	0.013	0.0034	0.0013	0.00063	0.00022
Industrial storm water (general permit)	0.44	0.11	0.044	0.021	0.0072
Evergreen storm water (2IN00108)	0.26	0.068	0.026	0.013	0.0044
City of Rossford MS4 (2GQ00017)	1.3	0.33	0.13	0.042[a]	0.0060[a]
Wood County & Others MS4 (2GQ00028)	2.9	0.76	0.29	0.14	0.014[b]
ODOT MS4 (4GQ00000)	0.038	0.0098	0.0038	0.0018	0.00063
OTC MS4 (3GQ00022)	0.0087	0.0022	0.00087	0.00031[a]	0.000044[a]
FG (3.7%)	0.40	0.10	0.040	0.019	0.0067
MOS (10%)	1.1	0.28	0.11	0.052	0.018

Notes

a. These WLAs were assigned the loading capacity in Cedar Creek at Yondota Road (RM 4.27; S03S55). In the Cedar Creek subwatershed, these regulated MS4s are completely contained within the Dry Creek subwatershed.

b. This WLA was assigned as 34.167 percent of the corresponding WLA for Cedar Creek at Yondota Road (RM 4.27; S03S55). The portion of the Wood County and Others area in the Dry Creek subwatershed is 34.167 percent of the Wood County and Others portion in the Cedar Creek subwatershed.

7.3.6 Berger Ditch (HUC 04100010 07 05)

Two TMDLs were generated for the Wolf Creek and Berger Ditch watershed. The organic enrichment impairment was addressed with a total phosphorus TMDL (Table 7-18). Samples collected on Wolf Creek at Stadium Road (201111, RM 2.70) need reductions of 48 to 69 percent in the moist through low-flow zones. A TSS TMDL was also generated (Table 7-19, Appendix C).

The TMDL generated for Berger Ditch at Cedar Point Road (RM 0.75) addresses the sedimentation/siltation impairment for the upstream site located on Wolf Creek at Stadium Road (201111, RM 2.70). Samples collected on Wolf Creek at Stadium Road (201111, RM 2.70) need reductions of 23 to 79 percent in the mid-range through low flow zones; no reductions are necessary in the moist zone.

Table 7-18. Total phosphorus allocations (lb/d) for Berger Ditch upstream of Cedar Point Road (RM 0.75)

	High	Moist	Mid-range	Dry	Low
Duration Interval	**5%**	**25%**	**50%**	**75%**	**95%**
TMDL	**20.0**	**4.93**	**1.81**	**0.794**	**0.243**
LA	11.44	2.76	1.043	0.456	0.139
WLA	5.82	1.50	0.52	0.23	0.071
Hirzel Canning Co. (2IH00111)	0.10	0.10	0	0	0
Construction storm water (general permit)	0.17	0.041	0.015	0.0068	0.0021
City of Northwood MS4 (2GQ00002)	2.0	0.49	0.18	0.080	0.025
City of Oregon MS4 (2GQ00001)	3.3	0.80	0.30	0.13	0.040
Lucas County & Others MS4 (2GQ00006)	0.14	0.033	0.013	0.0055	0.0017
Wood County & Others MS4 (2GQ00028)	0.053	0.013	0.0048	0.0021	0.00064
ODOT MS4 (4GQ00000)	0.054	0.013	0.0049	0.0022	0.00066
FG (3.7%)	0.74	0.18	0.067	0.029	0.0090
MOS (10%)	2.0	0.49	0.18	0.079	0.024

Table 7-19. TSS allocations (lb/d) for Berger Ditch upstream of Cedar Point Road (RM 0.75)

Duration Interval	High 5%	Moist 25%	Mid-range 50%	Dry 75%	Low 95%
TMDL	**6,054**	**1,540**	**602**	**298**	**133**
LA	3,336	736	233	58	2.1
WLA	1,889	593	287	199	113
Hirzel Canning Co. (2IH00111)	56	56	0	0	0
Oregon WTP (2IW00220)[a]	113	113	113	113	113
Construction storm water (general permit)	51	13	5.1	2.5	0[b]
City of Northwood MS4 (2GQ00002)	604	149	61	30	0[b]
City of Oregon MS4 (2GQ00001)	992	244	100	49	0[b]
Lucas County & Others (2GQ00006)	41	10	4.2	2.1	0[b]
Wood County & Others MS4 (2GQ00028)	16	3.9	1.6	0.79	0[b]
ODOT MS4 (4GQ00000)	16	4.0	1.6	0.82	0[b]
FG (3.7%)	224	57	22	11	4.9
MOS (10%)	605	154	60	30	13

Note
a. The WLA for the Oregon WTP (Ohio EPA ID 2IW00220) is for outfall 001 and 002, with a combined design flow of 0.30 mgd.
b. The storm water WLAs were set to zero to allow for the allocation of the Oregon WTP (Ohio EPA ID 2IW00220), MOS, FG, and LA.

7.3.7 Otter Creek – Frontal Lake Erie (HUC 04100010 07 06)

A single TMDL was generated for the Otter Creek watershed (HUC 0410010 07 06). A TMDL was generated for TSS at the Ohio EPA sample site adjacent to CSX Road (Table 7-20; Appendix C). The TMDL at this site also addresses the sedimentation/siltation impairments of three upstream sites on Otter Creek: at Millard Avenue (S03P04, RM 2.13), at Consaul Road (S03P08, RM 2.95), and at Oakdale Avenue (S03P12, RM 5.92).

Otter Creek adjacent to CSX Road (S03S25, RM 0.40) requires a reduction of 0 percent in the mid-range flow zone and no data are available for the other flow zones. It should be noted that only two samples were collected from Otter Creek adjacent to CSX Road (S03S35, RM 0.40), which may not be representative of conditions in Otter Creek. Additionally, TSS is used as a surrogate pollutant for the sedimentation/siltation impairment and, as in this case, TSS may be a poor surrogate.

Table 7-20. TSS allocation (lb/d) for Otter Creek adjacent to CSX Road (S03S25, RM 0.40)

Duration Interval	High 5%	Moist 25%	Mid-range 50%	Dry 75%	Low 95%
TMDL	**9,454**	**6,853**	**6,288**	**6,103**	**5,986**
LA	265	79	38	27	18
WLA	7,894	5,835	5,388	5,240	5,148
Envirosafe (2IN00013)	15	15	15	15	15
Toledo Station (2IN00019)	0.23	0.23	0.23	0.23	0.23
Toledo WTP (2IW00260)[a]	4,924	4,924	4,924	4,924	4,924
Construction storm water (general permit)	23	6.9	3.5	2.3	1.6
Industrial storm water (general permit)	238	72	36	24	17
Broadway Warehouse storm water (2II00108)	24	7.3	3.7	2.5	1.7
E. Broadway Middle School storm water (2PT00108)	25	7.6	3.8	2.6	1.8
Evergreen storm water (2IN00108)	168	51	26	17	12
Envirosafe storm water (2IN00013)	75	23	11	7.6	5.3
Pilkington N.A. storm water (2IN00020)	96	29	15	9.8	6.8
Toledo Station storm water (2IN00019)	3.5	1.1	0.54	0.36	0.25
City of Northwood MS4 (2GQ00002)	619	187	94	63	44
City of Oregon MS4 (2GQ00001)	937	284	142	95	66
City of Rossford MS4 (2GQ00017)	5.1	1.6	0.78	0.52	0.36
City of Toledo MS4 (2PI00003)	388	118	59	40	27
Lucas County & Others (2GQ00006)	44	13	6.7	4.5	3.1
Wood County & Others MS4 (2GQ00028)	287	87	43	29	20
ODOT MS4 (4GQ00000)	22	6.5	3.3	2.2	1.5
FG (3.7%)	350	254	233	226	221
MOS (10%)	945	685	629	610	599

Note

a. The Toledo WTP (Ohio EPA ID 2IW00260) discharges to Duck Creek (outfall 003) and Otter Creek (outfalls 004, 005, 006, 007, and 010). Outfall 001 is closed and outfall 002 is not used. This WLA addresses the outfalls on Otter Creek.

7.3.8 Grassy Creek (HUC 04100009 09 02)

A single TMDL was generated for the Grassy Creek watershed (HUC 0410009 09 02). A TMDL was generated for TSS at the Ohio EPA sample site at Glenwood Road (Table 7-21; Appendix C). Data collected at Glenwood Road (P11K18, RM 0.98) require a reduction of 23 percent reduction in the high flow zone and no reductions are necessary in the moist through dry flow zones.

Though sedimentation/siltation was not a listed cause of impairment for the sites at Glenwood Road (P11K18, RM 0.98) and at Ford Road (P11A05, RM 4.85), sedimentation/siltation does impair the site at Buck Road (P11Q07, RM 3.85). The TMDL at Glenwood Road (P11K18, RM 0.98; Table 7-21) addresses the sedimentation/siltation impairment at Buck Road (P11Q07, RM 3.85).

Table 7-21. TSS allocations (lb/d) for Grassy Creek at Glenwood Road (P11K18, RM 0.98)

Duration Interval	High 5%	Moist 25%	Mid-range 50%	Dry 75%	Low 95%
TMDL	**5,453**	**1,411**	**551**	**256**	**85**
LA	1,576	407	159.8	72.5	24.3
WLA	3,130	811	316.2	148	49
Construction storm water (general permit)	6.6	1.7	0.67	0.31	0.10
City of Northwood MS4 (2GQ00002)	35	9.0	3.5	1.6	0.54
City of Perrysburg MS4 (2GQ00018)	1,228	318	124	58	19
City of Rossford MS4 (2GQ00017)	547	142	55	26	8.5
Wood County & Others MS4 (2GQ00028)	1,234	319	125	58	19
ODOT MS4 (4GQ00000)	73	19	7.4	3.4	1.1
OTC MS4 (3GQ00022)	6.1	1.6	0.62	0.29	0.10
FG (3.7%)	202	52	20	9.5	3.2
MOS (10%)	545	141	55	26	8.5

7.3.9 Delaware Creek – Maumee River (HUC 04100009 09 04)

Three TMDLs were generated for the Delaware Creek – Maumee River HUC (04100009 09 04). For Delaware Creek, the nitrate plus nitrite TMDL (Table 7-22) needs reductions of 17 to 63 percent and the total phosphorus TMDL (Table 7-23) needs reductions of 7 to 52 percent (Appendix C).

A TSS TMDL was generated for Duck Creek at York Street (P11S56, RM 2.52); this TMDL also addressed the sedimentation/siltation impairment at the upstream site at Consaul Road (P11K22; RM 3.10). The TMDL at York Street (P11S56, RM 2.52; Table 7-24) needs reductions of 0 percent (Appendix C); however, it should be noted that only two samples were collected from Duck Creek at York Street (P11S56, RM 2.52), which may not be representative of conditions in Duck Creek. Additionally, TSS is used as a surrogate pollutant for the sedimentation/siltation impairment and, as in this case, TSS may be a poor surrogate.

Table 7-22. Nitrate plus nitrite allocations (lb/d) on Delaware Creek at Rohr Drive (P11A07, RM 0.38)

Duration Interval	High 5%	Moist 25%	Mid-range 50%	Dry 75%	Low 95%
TMDL	**69.9**	**19.0**	**7.71**	**3.66**	**1.25**
LA [a]	0	0	0	0	0
WLA	60	16.4	6.62	3.25	1.081
Construction storm water (general permit)	0.68	0.19	0.075	0.036	0.012
City of Maumee MS4 (2GQ00012)	22	6.0	2.4	1.2	0.40
City of Toledo MS4 (2MS00000)	35	9.6	3.9	1.9	0.63
Lucas County & Others MS4 (2GQ00006)	1.1	0.29	0.12	0.055	0.019
ODOT MS4 (4GQ00000)	0.69	0.19	0.076	0.036	0.012
OTC MS4 (3GQ00022)	0.41	0.11	0.045	0.022	0.0074
FG (3.7%)	2.9	0.70	0.32	0.04 [b]	0.039 [b]
MOS (10%)	7.0	1.9	0.77	0.37	0.13

Note
a. The LA is set to zero in all flow zones because the entire subwatershed consists of regulated MS4s that received WLAs.
b. FG is less than 3.7 percent of the loading capacity to allow for allocation to storm water and MOS.

Table 7-23. Total phosphorus allocations (lb/d) on Delaware Creek at Rohr Drive (P11A07, RM 0.38)

Duration Interval	High 5%	Moist 25%	Mid-range 50%	Dry 75%	Low 95%
TMDL	**5.59**	**1.52**	**0.617**	**0.293**	**0.100**
LA [a]	0	0	0	0	0
WLA	4.83	1.312	0.525	0.255	0.0871
Construction storm water (general permit)	0.055	0.015	0.0060	0.0029	0.00098
City of Maumee MS4 (2GQ00012)	1.8	0.48	0.19	0.093	0.032
City of Toledo MS4 (2MS00000)	2.8	0.77	0.31	0.15	0.051
Lucas County & Others MS4 (2GQ00006)	0.084	0.023	0.0093	0.0044	0.0015
ODOT MS4 (4GQ00000)	0.055	0.015	0.0061	0.0029	0.00098
OTC MS4 (3GQ00022)	0.033	0.0090	0.0036	0.0017	0.00059
FG (3.7%)	0.20	0.058	0.030	0.009	0.0029
MOS (10%)	0.56	0.15	0.062	0.029	0.010

Note
a. The LA is set to zero in all flow zones because the entire subwatershed consists of regulated MS4s that received WLAs.

Table 7-24. TSS allocations (lb/d) for Duck Creek at York Street (P11S56, RM 2.52)

Duration Interval	High 5%	Moist 25%	Mid-range 50%	Dry 75%	Low 95%
TMDL	**1,564**	**1,292**	**1,228**	**1,207**	**1,192**
LA [a]	0	0	0	0	0
WLA	1,351	1,115	1,061	1,043	1,029
Toledo WTP (2IW00260)[b]	985	985	985	985	985
Construction storm water (general permit)	4.1	1.5	0.85	0.64	0.50
Middleport Terminal storm water (2IN00218)	40	14	8.2	6.2	4.8
City of Oregon MS4 (2GQ00001)	13	4.5	2.6	2.0	1.5
City of Toledo MS4 (2PI00003)	300	107	62	47	36
Lucas County & Others (2GQ00006)	7.4	2.6	1.5	1.2	0.90
ODOT MS4 (4GQ00000)	1.0	0.36	0.21	0.16	0.12
FG (3.7%)	57	48	44	44	44
MOS (5%)	156	129	123	120	119

Notes

a. The LA is set to zero in all flow zones because the entire subwatershed consists of regulated MS4s that received WLAs.

b. The Toledo WTP (Ohio EPA ID 2IW00260) discharges to Duck Creek (outfall 003) and Otter Creek (outfalls 004, 005, 006, 007, and 010). Outfall 001 is closed and outfall 002 is not used. This WLA addresses the outfalls on Duck Creek.

7.4 Recreation Use

Thirty-four assessment sites were in non-attainment of their recreation use. Nine TMDLs for *E. coli* were generated using load duration curves to address the 34 sites in non-attainment and the locations of these TMDLs are presented in Table 7-25 and shown in Figure 7-2. Section 7.4.1 discusses the targets. Section 7.4.3 presents the allocation tables for the five TMDLs on the Lake Erie tributaries, and Section 7.4.4 presents the allocation tables for the four TMDLs on the Maumee River (lower) tributaries. Since three TMDL locations are not Ohio EPA assessment sites (identified with a double dash [“--"] in the Site ID field in Table 7-25), additional load duration curves were developed for the closest Ohio EPA assessment site that is upstream of the TMDL site.

Table 7-25. TMDL locations for recreation use impairments

Site ID	Site Name	River mile	Recreation use [a]	Upstream impaired sites [b]
Turtle Creek – Frontal Lake Erie (HUC 04100010 07 01)				
--	Turtle Creek at North Lickett Harder Road	5.3	B	201124 S03K06 203K05 S03K07
Crane Creek – Frontal Lake Erie (HUC 04100010 07 02)				
--	Crane Creek at Nissen Road	6.5	B	201118 S03K02 S03P21 S03G21 S03K03 S03S65 S03K01 S03K04
Cedar Creek – Frontal Lake Erie (HUC 04100010 07 03)				
S03S55	Cedar Creek at Yondota Road	4.27	B[c]	S03G22 S03S44 S03S60 S03G23 S03S46 S03S68 S03S34 S03S48
Berger Ditch (HUC 04100010 07 05)				
--	Berger Ditch upstream of Cedar Point Road	0.75	B[c]	S03S50 20111
Otter Creek – Frontal Lake Erie (HUC 04100010 07 06)				
S03S25	Otter Creek adjacent to CSX Road	0.40	B[c]	S03P12 S03P05 S03P08
Grassy Creek Diversion (HUC 04100009 09 01)				
P11K19	Grassy Creek Diversion at Grand Rapids Road	0.28	B[d]	*none*
Grassy Creek (HUC 04100009 09 02)				
P11K18	Grassy Creek at Glenwood Road	0.98	B[d]	P11A05
Delaware Creek – Maumee River (HUC 04100009 09 04)				
P11A07	Delaware Creek at Rohr Drive	0.38	B[d]	*none*
P11S56	Duck Creek at York Street	2.52	B[c]	P11K22

Based on Ohio EPA 2010a.
Notes
a. All TMDL locations are primary contact recreation; the class is displayed.
b. Assessment sites upstream of TMDL location that are also in non-attainment of the displayed recreation use. The TMDL displayed in this table will address the non-attainment of the designated recreation use for the upstream sites presented herein.
c. TMDL locations are within 5 miles of Lake Erie, which has a Bathing Water designated use, and are therefore subject to the Bathing Water *E. coli* criteria to protect the downstream designated use.
d. TMDL locations are within 5 miles of the Maumee River, which has a PCR Class A designated use, and are therefore subject to the PCR Class A *E. coli* criteria to protect the downstream designated use.

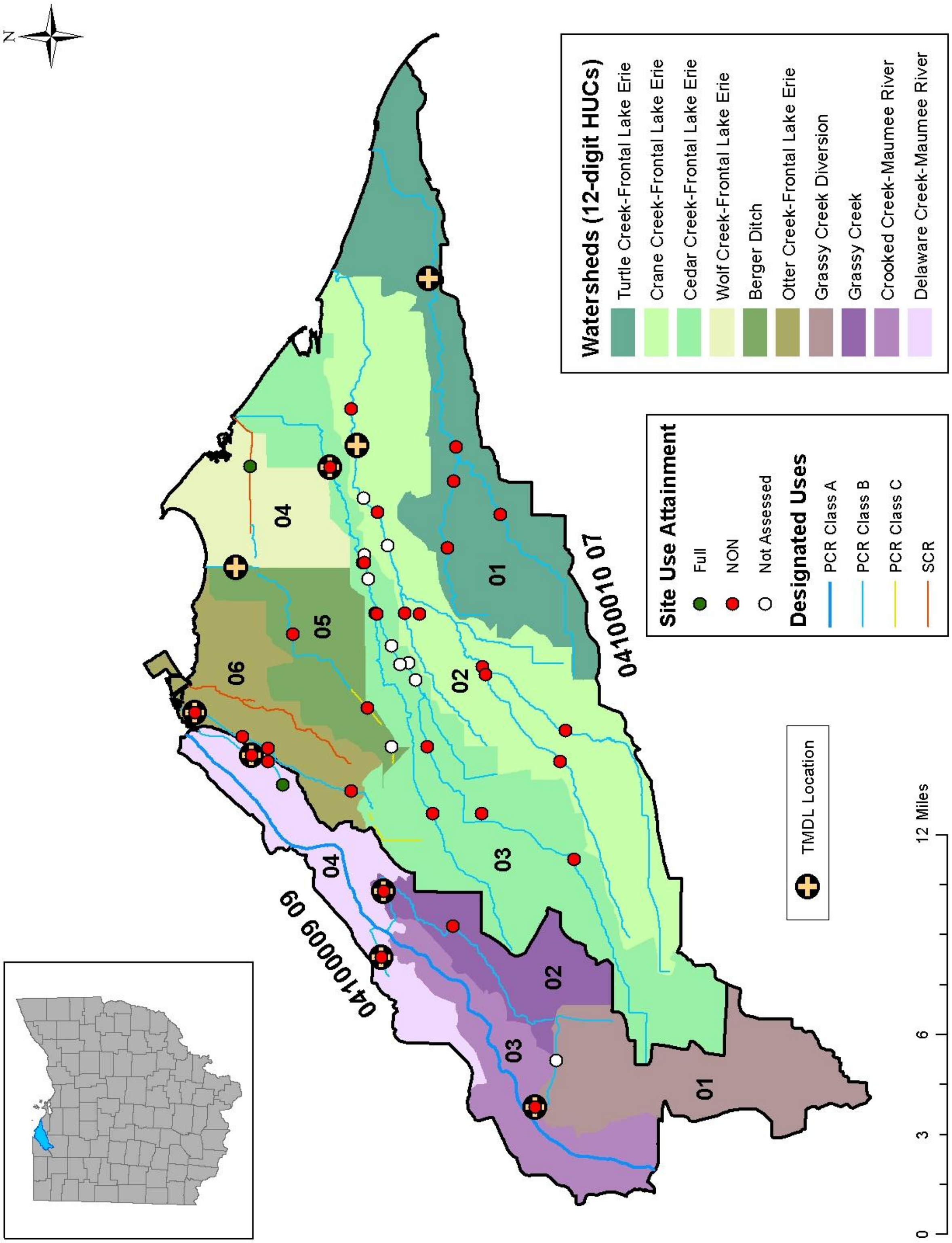


Figure 7-2. Locations recreation use impairments and locations of *E. coli* TMDLs.

7.4.1 TMDL Targets

All TMDLs were on PCR Class B waterbodies and were within 5 miles of Lake Erie (bathing water) or the lower Maumee River (PCR Class A); therefore, the target for all TMDLs was 126 counts per 100 mL. For a discussion of the seasonal geometric mean criteria, see Section 2.2.2.1.

7.4.2 Wasteload Allocations

Wasteloads were allocated for permitted point sources, including facilities with individual NPDES permits, for MS4s, and for industrial storm water. In each allocation table in this section, the row labeled "WLA" is the summation of all individual and bulk WLAs, which are indented within subsequent rows.

7.4.2.1 Facilities with Individual NPDES Permits

WLAs for individual NPDES permitted sources, excluding regulated storm water, were calculated by multiplying the design flow by the TMDL target and converting to proper units. The TMDL target was 161 counts per 100 mL unless the facility was within 5 miles of Lake Erie or the lower Maumee River. A target of 126 counts per 100 mL was assigned to such facilities to protect the downstream designated uses. The *E. coli* WLAs for the Lake Erie tributaries are presented in Table 7-26, and the *E. coli* WLAs for the Maumee River (lower) tributaries are presented in Table 7-27.

Table 7-26. *E. coli* WLAs for the Lake Erie tributaries (HUC 04100010 07)

HUC	Ohio EPA ID	U.S. EPA ID	Facility	Size (mgd)	TMDL Target	WLA (count/d)
07 01	2PT00042 [a]	OH0132438	Allen Elementary School	0	161	0
07 02	2PS00013 [b]	OH0126888	Luther Home of Mercy	0.0325	161	0
	2PY00014	OH0102687	Perrysburg Estates MHP	0.0624	161	3.80E+08
	2PY00008 [b]	OH0095117	Village Green MHP	0.045	161	2.74E+08
	2PW00010	OH0126578	Wildflower Place Subdivision WWTP	0.057	161	0
07 03	2PR00263 [c]	OH0141798	Crazy Lady Inn	0.005	161	3.05E+07
	2PY00073	OH0141615	Five Point MHP	0.0066	161	4.02E+07
07 06	2II00019	OH0095451	Buckeye's Toledo Station	0.0015	126	7.15E+06

Notes
The TMDL targets are reported in counts per 100 mL.
a. Allen Elementary School (Ohio EPA ID 2PT00042) is no longer operational and cannot discharge.
b. Luther Home of Mercy (Ohio EPA ID 2PS00013) and Wildflower Place Subdivision WWTP (2PW00010) will be connected to public sewers by 2015 and will not be permitted to discharge to surface waters.
c. The wastewater treatment works permitted for the Crazy Lady Inn (Ohio EPA ID 2PR00263) were never built; the permit may be closed.

Table 7-27. *E. coli* WLAs for the lower Maumee River tributaries (HUC 04100009 09)

HUC	Ohio EPA ID	U.S. EPA ID	Facility	Size (mgd)	TMDL Target	WLA (count/d)
09 01	2PG00096	OH0079197	Country Manor Estates [a]	0	0	0
	2PY00005	OH0078450	Maurer MHP	0.03	161	1.83E+08

Notes
The TMDL targets are reported in counts per 100 mL.
a. Country Manor Estates (Ohio EPA ID 2PG00096) will be removed in June 2012 and the subdivision will be connected to public sanitary sewers.

The Fenwick Marina (Ohio EPA ID 2PR00130), Inland Marina and Mobile Home Park (Ohio EPA ID 2PY00074), and Turtle Creek Marina and Campground (Ohio EPA ID 2PS00011) discharge to Turtle Creek near its mouth on Lake Erie (in the lacustrine zone) and are potential sources of bacteria. However, these sites are located downstream of the TMDL location, and thus, did not receive WLA.

7.4.2.2 Regulated Storm Water

WLAs for MS4s, industrial facilities with general permits, and facilities with individual permits for storm water were calculated using area ratios following the same methodology for ALU regulated storm water WLAs. Storm water WLAs for individually permitted facilities are described in Section 7.3.2.1; WLAs for industrial storm water are described in Section 7.3.2.3; and MS4 WLAs are described in Section 7.3.2.4. For additional information about storm water WLAs, see Appendix E.

7.4.3 Lake Erie Tributaries (HUC 04100010 07)

E. coli TMDL allocations for the Turtle Creek watershed (HUC 04100010 07 01) are presented in Table 7-28. The TMDL addresses the nonattainment of the PCR Class B use at the following four upstream sites:

- North Branch Turtle Creek at Genoa Clay Center Road (RM 3.00)
- North Branch Turtle Creek at Opfer-Lentz Road (RM 0.80)
- South Branch Turtle Creek at Moline Road (RM 2.65)
- Turtle Creek at Nissen Road (RM 11.62)

Samples collected on Turtle Creek at Nissen Road (S03K05; RM 11.62) need reductions of 75 to 93 percent in the moist through low-flow zones (Appendix C).

Table 7-28. *E. coli* allocations (counts/day) for Turtle Creek at North Lickett Harder Road (RM 5.3)

	High	Moist	Mid-range	Dry	Low
Duration Interval	**5%**	**25%**	**50%**	**75%**	**95%**
TMDL	**3.6E+11**	**8.0E+10**	**2.8E+10**	**1.0E+10**	**2.5E+09**
LA	2.9E+11	6.4E+10	2.2E+10	8.3E+09	2.0E+09
WLA	2.2E+10	4.8E+09	1.7E+09	6.2E+08	1.5E+08
Allen Elementary School (2PT00042) [a]	0	0	0	0	0
Industrial storm water (general permit)	5.7E+08	1.2E+08	4.3E+07	1.6E+07	3.9E+06
Ottawa County & Others MS4 (2GQ00022)	2.0E+10	4.4E+09	1.5E+09	5.7E+08	1.4E+08
Wood County & Others MS4 (2GQ00028)	1.2E+09	2.6E+08	9.0E+07	3.4E+07	8.1E+06
ODOT MS4 (4GQ00000)	2.2E+08	4.8E+07	1.7E+07	6.2E+06	1.5E+06
FG (3.7%)	1.4E+10	2.9E+09	1.0E+09	3.8E+08	9.2E+07
MOS (5%)	3.6E+10	8.0E+09	2.8E+09	1.0E+09	2.5E+08

Note
a. Allen Elementary School (Ohio EPA ID 2PT00042) was closed down and demolished.

The allocations of the *E. coli* TMDL for the Crane Creek watershed (HUC 04100010 07 02) are presented in Table 7-29. The TMDL addresses the nonattainment of the PCR Class B use at the following seven upstream sites:

- Ayers Creek at Billman Road (RM 0.60)
- Crane Creek at Hanley Road (RM 18.82)
- Crane Creek at Collins Road (RM 15.38)
- Crane Creek at Martin-Williston Road (RM 8.83)
- Henry Creek at Cummins Road (RM 3.73)
- Henry Creek near mouth (RM 0.10)
- Unnamed tributary to Crane Creek at Billman Road (RM 0.42)

Samples collected on Crane Creek at Martin-Williston Road (S03G21; RM 8.83) need reductions of 88 to 94 percent in the moist, through low-flow zones (Appendix C).

Table 7-29. *E. coli* allocations (counts/day) for Crane Creek at Nissen Road (RM 6.5)

Duration Interval	High 5%	Moist 25%	Mid-range 50%	Dry 75%	Low 95%
TMDL	**4.8E+11**	**1.1E+11**	**3.8E+10**	**1.5E+10**	**4.3E+09**
LA	3.5E+11	7.8E+10	2.7E+10	1.0E+10	2.6E+09
WLA	6.3E+10	1.5E+10	5.5E+09	2.5E+09	1.1E+09
Luther Home of Mercy (2PS00013) [a]	0	0	0	0	0
Perrysburg Estates MHP (2PY00014)	3.8E+08	3.8E+08	3.8E+08	3.8E+08	3.8E+08
Village Green MHP (2PY00008)	2.7E+08	2.7E+08	2.7E+08	2.7E+08	2.7E+08
Wildflower Place Subdivision WWTP (2PW00010) [a]	0	0	0	0	0
Industrial storm water (general permit)	5.4E+08	1.2E+08	4.2E+07	1.6E+07	4.0E+06
Fuel Mart #641 storm water (2II00050)	9.1E+07	2.0E+07	7.0E+06	2.7E+06	6.6E+05
Pilot Travel Center storm water (2IN00147)	3.9E+07	8.7E+06	3.1E+06	1.2E+06	2.9E+05
Toledo TravelCenter storm water (2II00032)	2.8E+08	6.2E+07	2.2E+07	8.3E+06	2.0E+06
Village of Millbury MS4 (2GQ00007)	8.9E+09	2.0E+09	6.9E+08	2.6E+08	6.5E+07
Lucas County & Others MS4 (2GQ00006)	1.7E+08	3.7E+07	1.3E+07	4.9E+06	1.2E+06
Ottawa County & Others MS4 (2GQ00022)	1.3E+10	2.9E+09	1.0E+09	3.9E+08	9.7E+07
Wood County & Others MS4 (2GQ00028)	3.9E+10	8.6E+09	3.0E+09	1.2E+09	2.9E+08
ODOT MS4 (4GQ00000)	4.6E+08	1.0E+08	3.5E+07	1.4E+07	3.4E+06
FG (3.7%)	1.8E+10	4.0E+09	1.4E+09	5.6E+08	1.6E+08
MOS (5%)	4.8E+10	1.1E+10	3.8E+09	1.5E+09	4.3E+08

Note

a. Luther Home of Mercy (Ohio EPA ID 2PS00013) and Wildflower Place Subdivision WWTP (2PW00010) will be connected to public sewers by 2015 and will not be permitted to discharge to surface waters.

The allocations of the *E. coli* TMDL for the Cedar Creek watershed (HUC 04100010 07 03) are presented in Table 7-30. The TMDL addresses the non-attainment of the PCR Class B use at the following nine sites:

- Cedar Creek at Oregon Road (RM 20.77)
- Cedar Creek at East Broadway Road (RM 17.32)
- Cedar Creek at Lemoyne Road (RM 14.50)
- Cedar Creek at Billman Road (RM 9.59)
- Cedar Creek at Wildacre Road (RM 7.90)
- Cedar Creek at Yondota Road (RM 4.27)
- Ditch to Cedar Creek (RM 7.91) adjacent to railroad (RM 0.01)
- Dry Creek at East Broadway (RM 7.00)
- Dry Creek at mouth (RM 0.01)

Samples collected on Cedar Creek at Yondota Road (S03S55; RM 4.27) need reductions of 10 to 83 percent in moist through low-flow zones (Appendix C).

Table 7-30. *E. coli* allocations (counts/day) for Cedar Creek at Yondota Road (S03S55, RM 4.27)

Duration Interval	High 5%	Moist 25%	Mid-range 50%	Dry 75%	Low 95%
TMDL	**4.1E+11**	**2.1E+08**	**1.3E+10**	**2.1E+08**	**9.0E+10**
LA	2.4E+11	7.8E+07	7.3E+09	7.8E+07	5.3E+10
WLA	1.3E+11	1.1E+08	4.1E+09	1.1E+08	2.9E+10
Crazy Lady Inn (2PR00263) [a]	3.0E+07	3.0E+07	3.0E+07	3.0E+07	3.0E+07
Five Points MHP (2PY00073)	4.0E+07	4.0E+07	4.0E+07	4.0E+07	4.0E+07
Industrial storm water (general permit)	1.0E+10	3.2E+06	3.0E+08	3.2E+06	2.2E+09
Bulk Plant Millbury storm water (2IN00174)	3.8E+07	1.2E+04	1.1E+06	1.2E+04	8.3E+06
Evergreen storm water (2IN000108)	1.9E+09	6.1E+05	5.8E+07	6.1E+05	4.2E+08
City of Northwood MS4 (2GQ00002)	2.7E+10	8.7E+06	8.2E+08	8.7E+06	6.0E+09
City of Oregon MS4 (2GQ00001)	3.7E+07	1.2E+04	1.1E+06	1.2E+04	8.0E+06
City of Rossford MS4 (2GQ00017)	9.9E+09	3.1E+06	3.0E+08	3.1E+06	2.1E+09
Village of Walbridge MS4 (2GQ00003)	1.4E+10	4.3E+06	4.1E+08	4.3E+06	3.0E+09
Lucas County & Others MS4 (2GQ00006)	8.8E+08	2.8E+05	2.6E+07	2.8E+05	1.9E+08
Ottawa County & Others MS4 (2GQ00022)	3.6E+09	1.2E+06	1.1E+08	1.2E+06	7.9E+08
Wood County & Others MS4 (2GQ00028)	6.6E+10	2.1E+07	2.0E+09	2.1E+07	1.4E+10
ODOT MS4 (4GQ00000)	1.2E+09	3.7E+05	3.5E+07	3.7E+05	2.6E+08
OTC MS4 (3GQ00022)	7.3E+07	2.3E+04	2.2E+06	2.3E+04	1.6E+07
FG (3.7%)	1.5E+10	7.8E+06	4.6E+08	7.8E+06	3.3E+09
MOS (5%)	2.1E+10	1.0E+07	6.3E+08	1.0E+07	4.5E+09

Note
a. The wastewater treatment works permitted for the Crazy Lady Inn (Ohio EPA ID 2PR00263) were never built; the permit may be closed.

The allocations of the *E. coli* TMDL for the Berger Creek watershed (HUC 04100010 07 05) are presented in Table 7-31. The TMDL addresses the non-attainment at the following two upstream sites:

- Wolf Creek upstream of Curtice Road (RM 6.30), non-attainment of PCR Class C
- Wolf Creek at Stadium Road (RM 2.70), non-attainment of PCR Class B

Samples collected on Wolf Creek at Stadium Road (201111; RM 2.70) need reductions of 83 to 96 percent in moist through low-flow zones (Appendix C).

Table 7-31. *E. coli* allocations (counts/day) for Berger Ditch upstream of Cedar Point Road (RM 0.75)

	High	Moist	Mid-range	Dry	Low
Duration Interval	**5%**	**25%**	**50%**	**75%**	**95%**
TMDL	**1.4E+11**	**3.5E+10**	**1.3E+10**	**5.7E+09**	**1.7E+09**
LA	8.3E+10	2.0E+10	7.5E+09	3.3E+09	1.0E+09
WLA	4.0E+10	9.7E+09	3.6E+09	1.6E+09	4.9E+08
City of Northwood MS4 (2GQ00002)	1.4E+10	3.5E+09	1.3E+09	5.8E+08	1.8E+08
City of Oregon MS4 (2GQ00001)	2.4E+10	5.8E+09	2.2E+09	9.5E+08	2.9E+08
Lucas County & Others MS4 (2GQ00006)	9.9E+08	2.4E+08	9.0E+07	4.0E+07	1.2E+07
Wood County & Others MS4 (2GQ00028)	3.8E+08	9.2E+07	3.5E+07	1.5E+07	4.6E+06
ODOT MS4 (4GQ00000)	3.9E+08	9.5E+07	3.6E+07	1.6E+07	4.8E+06
FG (3.7%)	5.3E+09	1.3E+09	4.8E+08	2.1E+08	6.4E+07
MOS (5%)	1.4E+10	3.5E+09	1.3E+09	5.7E+08	1.7E+08

The allocations of the *E. coli* TMDLs for the Otter Creek watershed are presented in Table 7-32. HUC 04100010 07 06 is in non-attainment because of the non-attainment of four sites on Otter Creek (see below); therefore, the TMDL addresses Otter Creek and not the other waterbodies (e.g., Amlosch ditch) in the HUC.

- Otter Creek at Oakdale Avenue (RM 5.92), non-attainment of PCR Class C
- Otter Creek at Consaul Road (RM 2.95), non-attainment of PCR Class B
- Otter Creek at Millard Avenue (RM 2.13), non-attainment of PCR Class B
- Otter Creek adjacent to CSX Road (RM 0.40), non-attainment of PCR Class B

Samples collected on Otter Creek adjacent to CSX Road (S03S25; RM 0.40) need reductions of 97 percent in mid-range flow zone (Appendix C). Samples were not collected from any other flow zone.

Table 7-32. *E. coli* allocations (counts/day) for Otter Creek adjacent to CSX Road (S03S25, RM 0.40)

Duration Interval	High 5%	Moist 25%	Mid-range 50%	Dry 75%	Low 95%
TMDL	**8.4E+10**	**2.2E+10**	**8.9E+09**	**4.4E+09**	**1.6E+09**
LA	6.4E+09	1.7E+09	6.7E+08	3.4E+08	1.2E+08
WLA	7.0E+10	1.9E+10	7.4E+09	3.7E+09	1.4E+09
Toledo Station (2IN00019)	7.2E+06	7.2E+06	7.2E+06	7.2E+06	7.2E+06
Industrial storm water (general permit)	5.7E+09	1.5E+09	6.0E+08	3.0E+08	1.1E+08
Broadway Warehouse storm water (2II00108)	5.8E+08	1.5E+08	6.1E+07	3.0E+07	1.1E+07
East Broadway Middle School storm water (2PT00108)	6.0E+08	1.6E+08	6.3E+07	3.2E+07	1.2E+07
Evergreen storm water (2IN00108)	4.0E+09	1.1E+09	4.2E+08	2.1E+08	7.8E+07
Envirosafe storm water (2IN00013)	1.8E+09	4.7E+08	1.9E+08	9.4E+07	3.5E+07
Pilkington North America storm water (2IN00020)	2.3E+09	6.1E+08	2.4E+08	1.2E+08	4.5E+07
Toledo Station storm water (2IN00019)	8.5E+07	2.2E+07	8.9E+06	4.5E+06	1.6E+06
City of Northwood MS4 (2GQ00002)	1.5E+10	3.9E+09	1.6E+09	7.8E+08	2.9E+08
City of Oregon MS4 (2GQ00001)	2.3E+10	6.0E+09	2.4E+09	1.2E+09	4.4E+08
City of Rossford MS4 (2GQ00017)	1.2E+08	3.3E+07	1.3E+07	6.5E+06	2.4E+06
City of Toledo MS4 (2MS00000)	9.4E+09	2.5E+09	9.8E+08	4.9E+08	1.8E+08
Lucas County & Others MS4 (2GQ00006)	1.1E+09	2.8E+08	1.1E+08	5.6E+07	2.1E+07
Wood County & Others MS4 (2GQ00028)	6.9E+09	1.8E+09	7.3E+08	3.6E+08	1.3E+08
ODOT MS4 (4GQ00000)	5.2E+08	1.4E+08	5.5E+07	2.7E+07	1.0E+07
FG (3.7%)	3.1E+09	8.3E+08	3.3E+08	1.6E+08	6.1E+07
MOS (5%)	4.2E+09	1.1E+09	4.4E+08	2.2E+08	8.2E+07

7.4.4 Maumee River (Lower) Tributaries (HUC 04100009 09)

The allocations of the *E. coli* TMDL for the Grassy Creek Diversion watershed (HUC 04100009 09 01) are presented in Table 7-33. Samples were collected on Grassy Creek Diversion at Grand Rapids Road (P11K19; RM 0.28), and reductions of 72 to 90 percent are necessary (Appendix C).

Table 7-33. *E. coli* allocations (counts/day) for Grassy Creek Diversion at Grand Rapids Road (P11K19, RM 0.28)

Duration Interval	High 5%	Moist 25%	Mid-range 50%	Dry 75%	Low 95%
TMDL	**1.9E+11**	**4.7E+10**	**1.8E+10**	**7.6E+09**	**2.3E+09**
LA	1.4E+11	3.5E+10	1.3E+10	5.6E+09	1.6E+09
WLA	3.1E+10	7.9E+09	3.1E+09	1.4E+09	5.1E+08
Country Manor Estates (2PG00096)[a]	0	0	0	0	0
Maurer MHP (2PY00005)	1.8E+08	1.8E+08	1.8E+08	1.8E+08	1.8E+08
Industrial storm water (general permit)	1.6E+08	3.8E+07	1.4E+07	6.0E+06	1.6E+06
City of Perrysburg MS4 (2GQ00018)	1.7E+10	4.2E+09	1.6E+09	6.6E+08	1.8E+08
Wood County & Others MS4 (2GQ00028)	1.4E+10	3.4E+09	1.3E+09	5.2E+08	1.4E+08
ODOT MS4 (4GQ00000)	2.2E+08	5.5E+07	2.1E+07	8.6E+06	2.4E+06
FG (3.7%)	7.0E+09	1.7E+09	6.6E+08	2.8E+08	8.6E+07
MOS (5%)	9.5E+09	2.4E+09	9.0E+08	3.8E+08	1.2E+08

Note
a. Country Manor Estates (Ohio EPA ID 2PG00096) will be removed in June 2012 and the subdivision will be connected to public sanitary sewers.

The allocations of the *E. coli* TMDL for the Grassy Creek watershed (HUC 04100009 09 02) are presented in Table 7-34. The TMDL addresses non-attainment of PCR Class B uses at two sites: Grassy Creek at Glenwood Road (RM 0.98) and Grassy Creek at Ford Road (RM 4.85). Samples were collected at Grassy Creek at Glenwood Road (P11K18; RM 0.98), and reductions of 86 to 99 percent are necessary to meet the TMDL (Appendix C).

Table 7-34. *E. coli* allocations (counts/day) for Grassy Creek at Glenwood Road (P11K18, RM 0.98)

Duration Interval	High 5%	Moist 25%	Mid-range 50%	Dry 75%	Low 95%
TMDL	**1.3E+11**	**3.4E+10**	**1.3E+10**	**6.1E+09**	**2.0E+09**
LA	4.0E+10	1.0E+10	4.0E+09	1.9E+09	6.2E+08
WLA	7.9E+10	2.0E+10	8.0E+09	3.7E+09	1.2E+09
City of Northwood MS4 (2GQ00002)	8.8E+08	2.3E+08	8.9E+07	4.1E+07	1.4E+07
City of Perrysburg (2GQ00018)	3.1E+10	8.0E+09	3.1E+09	1.5E+09	4.8E+08
City of Rossford MS4 (2GQ00017)	1.4E+10	3.6E+09	1.4E+09	6.5E+08	2.2E+08
Wood County & Others MS4 (2GQ00028)	3.1E+10	8.1E+09	3.1E+09	1.5E+09	4.9E+08
ODOT MS4 (4GQ00000)	1.8E+09	4.8E+08	1.9E+08	8.6E+07	2.9E+07
OTC MS4 (3GQ00022)	1.5E+08	4.0E+07	1.6E+07	7.2E+06	2.4E+06
FG (3.7%)	4.8E+09	1.2E+09	4.9E+08	2.3E+08	7.5E+07
MOS (5%)	6.5E+09	1.7E+09	6.6E+08	3.1E+08	1.0E+08

The allocations of the *E. coli* TMDLs for the Delaware Creek – Maumee River HUC (04100009 09 04) are presented in Table 7-35 and Table 7-36. Samples collected on Delaware Creek at Rohr Road (P11A07, RM 0.38) need reductions of 71 to 99 percent (Appendix C).

The *E. coli* TMDL on Duck Creek at York Street (P11S56, RM 2.52; Table 7-36) addresses the non-attainment of the PCR Class B use at the upstream site at Consaul Road (P11K22, RM 3.10). Samples collected on Duck Creek at York Street (P11S56, RM 2.52) need reductions of 82 to 90 percent in the moist and mid-range flow zones (Appendix C); samples were not collected in the other flow zones.

Table 7-35. *E. coli* allocations (counts/day) for Delaware Creek at Rohr Drive (P11A07, RM 0.38)

Duration Interval	High	Moist	Mid-range	Dry	Low
	5%	25%	50%	75%	95%
TMDL	**4.0E+10**	**1.1E+10**	**4.4E+09**	**2.1E+09**	**7.2E+08**
LA	0	0	0	0	0
WLA	3.6E+10	9.9E+09	4.0E+09	1.9E+09	6.5E+08
City of Maumee MS4 (2GQ00012)	1.4E+10	3.7E+09	1.5E+09	7.1E+08	2.4E+08
City of Toledo MS4 (2PI00003)	2.2E+10	5.9E+09	2.4E+09	1.1E+09	3.9E+08
Lucas County & Others MS4 (2GQ00006)	6.5E+08	1.8E+08	7.1E+07	3.4E+07	1.2E+07
ODOT MS4 (4GQ00000)	4.2E+08	1.1E+08	4.6E+07	2.2E+07	7.5E+06
OTC MS4 (3GQ00022)	2.5E+08	6.9E+07	2.8E+07	1.3E+07	4.5E+06
FG (3.7%)	1.5E+09	4.0E+08	1.6E+08	7.7E+07	2.6E+07
MOS (5%)	2.0E+09	5.4E+08	2.2E+08	1.0E+08	3.6E+07

Table 7-36. *E. coli* allocations (counts/day) for Duck Creek at York Street (P11S56, RM 2.52)

Duration Interval	High	Moist	Mid-range	Dry	Low
	5%	25%	50%	75%	95%
TMDL	**9.1E+09**	**2.6E+09**	**1.1E+09**	**6.1E+08**	**2.5E+08**
LA	0	0	0	0	0
WLA	8.3E+09	2.4E+09	1.0E+09	5.5E+08	2.3E+08
Middleport Terminal storm water (2IN00218)	9.1E+08	2.6E+08	1.1E+08	6.1E+07	2.5E+07
City of Oregon MS4 (2GQ00001)	2.9E+08	8.4E+07	3.6E+07	1.9E+07	8.1E+06
City of Toledo MS4 (2PI00003)	6.9E+09	2.0E+09	8.4E+08	4.6E+08	1.9E+08
Lucas County & Others MS4 (2GQ00006)	1.7E+08	4.9E+07	2.1E+07	1.1E+07	4.8E+06
ODOT MS4 (4GQ00000)	2.3E+07	6.6E+06	2.8E+06	1.5E+06	6.4E+05
FG (3.7%)	3.4E+08	9.7E+07	4.1E+07	2.2E+07	9.4E+06
MOS (5%)	4.6E+08	1.3E+08	5.5E+07	3.0E+07	1.3E+07

8 Water Quality Improvement Strategy

Restoration methods to bring an impaired waterbody into attainment with water quality standards generally involve an increase in the waterbody' s capacity to assimilate pollutants, a reduction of pollutant loads to the waterbody, or some combination of both. A water quality improvement strategy has been developed to idenfity the priority activities that can be undertaken to achieve water quality improvements, and eventually attainment of the designated use.

Several sources of pollutants were identified in the project area; they are summarized in Table 8-1 and Table 8-2. The sources of pollutants are further discussed in Source Assessment (Section 4) and linkage analyses (Section 5 and Section 6).

- Point sources (package treatment plants, wastewater facilities)
- Failing HSTS and unsewered communities
- Agricultural runoff (non-irrigated crop production and livestock operations)
- Urban runoff and storm sewers

Recommended implementation activities, by pollutant source, are presented in the following sections.

Table 8-1. Lake Erie tributaries (HUC 04100010 07) TMDL summary

Watershed (04100010)	TMDL pollutant	Pollutant reduction requirements (%)	Pollutant sources
Turtle Creek – Frontal Lake Erie (07 01)	*E. coli*	75%–93% (S03K05)	▪ Unsewered communities (Martin) ▪ Failing HSTS
	Ammonia (total)	85% (S03K07)	▪ Point sources ▪ Failing HSTS ▪ Unsewered communities (Martin) ▪ Livestock operations
	Phosphorus (total)	48%–54% (S03K05) 61%–80% (S03K07)	
Crane Creek – Frontal Lake Erie (07 02)	*E. coli*	88%–94% (S03G21)	▪ Unsewered communities (Williston) ▪ Point sources (Wildflower Place subdivision WWTP) ▪ Failing HSTS
	Phosphorus (total)	34%–59% (S03P21) 44%–71% (201118) 50%–88% (S03G21)	▪ Urban runoff and storm sewers ▪ Unsewered communities ▪ Failing HSTS
	TSS	50% (S03G21)	▪ Urban runoff and storm sewers ▪ Channelization
Cedar Creek – Frontal Lake Erie (07 03)	*E. coli*	10%–83% (S03S55)	▪ Failing HSTS
	Ammonia (total)	75% (S03S48)	▪ Non-irrigated crop production ▪ Failing HSTS
	Phosphorus (total)	20%–48% (S03S34) 10%–79% (S03S68) 7%–23% (S03S55)	
Berger Ditch (07 05)	*E. coli*	83%–96% (201111)	▪ Failing HSTS
	Phosphorus (total)	48%–69% (201111)	▪ Failing HSTS
	TSS	23%–79% (201111)	▪ Channelization
Otter Creek – Frontal Lake Erie (07 06)	*E. coli*	97% (S03S25)	▪ Point sources ▪ Urban runoff and storm sewers ▪ Failing HSTS
	TSS	0% [b] (S03S25)	▪ Industrial runoff ▪ Channelization

Notes
HSTS = home sewage treatment system; TSS = total suspended solids.
a. A range is presented with the site at which the range was calculated. The range was calculated at the most downstream site with data. For reductions for specific flow zones, refer to Appendix C. Note that flow zones requiring no reduction or without data are not summarized in this table.
b. Only two samples were collected from Otter Creek adjacent to CSX Road (S03S35, RM 0.40), which may not be representative of conditions in Otter Creek. Additionally, TSS is used as a surrogate pollutant for the sedimentation/siltation impairment and, as in this case, TSS may be a poor surrogate.

Table 8-2. Lower Maumee River tributaries (HUC 04100009 09) TMDL summary

Watershed (04100009)	Cause(s) of impairment	Pollutant reduction requirements (%)[a]	Source(s) of impairment
Grassy Creek Diversion (09 01)	*E. coli*	72%–90% (P11K19)	▪ Urban runoff and storm sewers ▪ Failing HSTS ▪ Point sources
Grassy Creek (09 02)	*E. coli*	86%–99% (P11K18)	▪ Urban runoff
	TSS	23% (P11K18)	▪ Urban runoff ▪ Channelization
Delaware Creek – Maumee River (09 04)	*E. coli*	71%–99% (P11A07) 82%–90% (P11S56)	▪ Urban runoff and storm sewers (illicit connections)
	Phosphorus (total)	7%–52% (P11A07)	▪ Urban runoff and storm sewers
	Nitrate/nitrite	17%–63% (P11A07)	

Notes
HSTS = home sewage treatment system.
a. A range is presented with the site at which the range was calculated. The range was calculated at the most downstream site with data. Note that flow zones requiring no reduction or without data are not summarized in this table.

8.1 Point Sources

This section summarizes recommendations that can be implemented using Ohio EPA's regulatory authority to address point sources, excluding regulated storm water.

Additional total phosphorus reductions will be necessary at several facilities according to calculated TMDLs in locations where total phosphorus contributes to ALU impairment. Recommendations for NPDES permits, according to calculated TMDLs, are summarized by discharger and watershed in Table 8-3. Ohio EPA will work with permit holders to accomplish any needed reductions in loadings. Existing permit conditions involving total phosphorus for facilities not listed in Table 8-3 should remain unchanged.

These facilities do not have total phosphorus monitoring requirements or effluent limits. Thus, the potential load contribution from these facilities to the impaired streams is unknown. The first phase of the recommended permit conditions is monthly effluent sampling to determine total phosphorus effluent loads. Depending on the results of the quarterly sampling, the sampling requirements can be continued or altered and total phosphorus limits of 1 mg/L can be incorporated into the permit.

All the non-storm water point sources discharging wastewater have effluent limits on bacteria and TSS; however, several facilities have exceedances of permitted effluent limits and discharge at rates exceeding the permit design flow. For *E. coli*, wastewater treatment facilities, in particular package treatment plants, might require upgrades or expansions to provide for appropriate levels of treatment and to comply with the TMDL WLAs. Recommendations for NPDES permits, according to calculated TMDLs, are summarized by discharger and watershed for *E. coli* in Table 8-4 and Table 8-5 and for TSS in Table 8-6 and Table 8-7. Existing permit limits for *E. coli* and TSS were retained (i.e., no changes were recommended) for facilities with non-storm water individual NPDES permits.

Sanitary sewer overflows due to inflow and infiltration were documented at two permitted facilities: Perrysburg Estates MHP (Ohio EPA ID 2PY00014) and Wildflower Place Subdivision WWTP (Ohio EPA ID 2PW00010). Under the guidance of Ohio EPA, Perrysburg Estates MHP is required to perform a sewer system evaluation survey and implement the survey's recommendations. The Wildflower Place

Subdivision WWTP must implement the recommendations from *Investigation and Report of Sanitary Sewer System for The Wildflower Place Subdivision*. When both facilities address their I/I issues and improve sanitary sewer infrastructure, the potential for sanitary sewer overflows will be reduced considerably.

Table 8-3. Recommended implementation actions through the NPDES program for total phosphorus

HUC (041100010)	Permitee	Ohio EPA ID	Receiving stream	Design Flow (mgd)	WLA (lb/d)	WLA (mg/L)	Recommended permit conditions (1st phase / 2nd phase)		Explanation for difference
07 02	Bulk Plant Millbury	2IN00174	Ditch to I-280	storm water [a]	2.3E-5 to 6.2E-3	0.08	Monitor 1x per season	None; evaluate at renewal	--
07 02	Crazy Lady Inn [b]	2PR00263	Cedar Creek	0.005	0.13	3.0	Monitor 1x per month	Average monthly limit of 3.0 mg/l	The WLA is based on statewide average data. Facility data will guide implementation.
07 03	Evergreen Recycling and Disposal	2IN00108	Dry Creek and Otter Creek	storm water [a]	0.0044 to 0.26	0.08	Monitor 1x per season	None; evaluate at renewal	--
07 03	Five Points MHP	2PY00073	Cedar Creek	0.0066	0.13	2.3	Monitor 1x per month	Average monthly limit of 2.3 mg/l	The WLA is based on statewide average data. Facility data will guide implementation.
07 02	Fuel Mart #641	2II00050	Crane Creek	storm water [a]	0 to 0.0023	0.08	Monitor 1x per season	None; evaluate at renewal	--
07 05	Hirzel Canning Co. [c]	2IH00111	Wolf Creek	0.15	0.10	0.08	Monitor 1x per season	None; evaluate at renewal	--
07 02	Luther Home of Mercy [d]	2PS00013	Williston Ditch	0.0325	0	0	n/a	n/a	--
07 02	Perrysburg Estates MHP	2PY00014	ditch to Henry Creek	0.0624	0.17	0.33	Monitor 1x per month	Average monthly limit of 1.0 mg/l	The WLA is based on statewide average data. Facility data will guide implementation. A permit limit of 1.0 mg/l will likely be a significant reduction. Biology should be re-assessed after a permit limit of 1.0 mg/l is implemented.
07 02	Pilot Travel Center	2IN00147	miscellaneous	storm water [a]	0 to 0.00099	0.08	Monitor 1x per season	None; evaluate at renewal	--

HUC (041100010)	Permitee	Ohio EPA ID	Receiving stream	Design Flow (mgd)	WLA (lb/d)	WLA (mg/L)	Recommended permit conditions (1st phase / 2nd phase)		Explanation for difference
07 02	Toledo TravelCenter	2II00032	Crane Creek	storm water [a]	0 to 0.0070	0.08	Monitor 1x per season	None; evaluate at renewal	--
07 02	Village Green MHP	2PY00008	Unnamed tributary to Crane Creek	0.045	0.14	0.37	Monitor 1x per month	Average monthly limit of 1.0 mg/l	The WLA is based on statewide average data. Facility data will guide implementation. A permit limit of 1.0 mg/l will likely be a significant reduction. Biology should be re-assessed after a permit limit of 1.0 mg/l is implemented.
07 02	Wildflower Place Subdivision WWTP [d]	2PY00008	Crane Creek	0.045	0	0	n/a	n/a	--

Notes

a. These facilities discharge storm water and their WLAs are calculated based upon flow condition in the receiving stream. The range of WLA loads is displayed; for individual WLA loads per flow conditions, refer back to Section 7.3.4 and Section 7.3.5. Some facilities cannot discharge storm water effluent during low flow conditions.

b. The wastewater treatment works permitted for the Crazy Lady Inn (Ohio EPA ID 2PR00263) were never built; the permit may be closed.

c. Hirzel Canning Company (Ohio EPA ID 2IH00111) was assigned the in-stream headwaters WWH target (0.08 mg/L). The WLA is only applicable in the high and moist flow zones.

d. Luther Home of Mercy (Ohio EPA ID 2PS00013) and Wildflower Place Subdivision WWTP (2PW00010) will be connected to public sewers by 2015 and will not be permitted to discharge to surface waters.

Table 8-4. Recommended implementation actions through the NPDES program for *E. coli* for the Lake Erie tributaries (041100010 07) except for Otter Creek (HUC 041100010 07 06)

HUC	Permitee	Ohio EPA ID	Receiving stream	Design flow (mgd)	WLA (count/day)	WLA (count/100 mL)	Recommended permit conditions
07 02	Bulk Plant Millbury	2IN00174	Ditch to I-280	storm water [a]	8.3E+06 to 3.8E+07	161	None; evaluate at renewal
07 03	Crazy Lady Inn [b]	2PR00263	Cedar Creek	0.005	3.1E+07	161	Average monthly limit of 161 count/ 100 mL
07 03	Five Point MHP	2PY00073	Cedar Creek	0.0066	4.0E+07	161	Average monthly limit of 161 count/ 100 mL
07 02	Fuel Mart #641	2II00050	Crane Creek	storm water [a]	6.6E+05 to 9.1E+07	161	None; evaluate at renewal
07 02	Luther Home of Mercy [c]	2PS00013	Williston Ditch	0.0325	0	0	--
07 02	Perrysburg Estates MHP	2PY00014	ditch to Henry Creek	0.0624	3.8E+08	161	Average monthly limit of 161 count/ 100 mL
07 02	Pilot Travel Center	2IN00147	miscellaneous	storm water [a]	2.9E+05 to 3.9E+07	161	None; evaluate at renewal
07 06	Toledo Station	2II00019	Otter Creek	0.0015	7.2E+06	126	Average monthly limit of 126 count/ 100 mL
07 02	Toledo TravelCenter	2II00032	Crane Creek	storm water [a]	2.0E+06 to 2.8E+08	161	None; evaluate at renewal
07 02	Village Green MHP	2PY00008	Unnamed tributary to Crane Creek	0.045	2.7E+08	161	Average monthly limit of 161 count/ 100 mL
07 02	Wildflower Place Subdivision WWTP [c]	2PW00010	Crane Creek	0.057	0	0	--

Notes
HUC = hydrologic unit code; mgd = million gallons per day; MHP = mobile home park; mL = milliliter; WLA = wasteload allocation; WWTP = wastewater treatment plant.
a. These facilities discharge storm water and their WLAs are calculated based upon flow condition in the receiving stream. The range of WLA loads is displayed; for individual WLA loads per flow conditions, refer back to Section 7.4.3.
b. The wastewater treatment works permitted for the Crazy Lady Inn (Ohio EPA ID 2PR00263) were never built; the permit may be closed.
c. Luther Home of Mercy (Ohio EPA ID 2PS00013) and Wildflower Place Subdivision WWTP (2PW00010) will be connected to public sewers by 2015 and will not be permitted to discharge to surface waters.

Table 8-5. Recommended implementation actions through the NPDES program for *E. coli* for Otter Creek (HUC 041100010 07 06) and the Maumee River (lower) tributaries (HUC 041100009 09)

HUC	Permitee	Ohio EPA ID	Receiving stream	Design flow (mgd)	WLA (count/day)	WLA (count/100 mL)	Recommended permit conditions
Otter Creek (HUC 04100010 07 06)							
07 06	Broadway Warehouse	2II00108	Otter Creek	storm water [a]	1.1E+07 to 5.8E+08	126	None; evaluate at renewal
07 06	East Broadway Middle School	2PT00108	Otter Creek	storm water [a]	1.2E+07 to 6.0E+08	126	None; evaluate at renewal
07 06	Evergreen Recycling and Disposal	2IN00108	Dry Creek and Otter Creek	storm water [a]	7.8E+07 to 4.0E+09	126	None; evaluate at renewal
07 06	Envirosafe	2IN00013	multiple [b]	storm water [a]	3.5E+07 to 1.8E+09	126	None; evaluate at renewal
07 06	Pilkington N.A.	2IN00020	Otter Creek	storm water [a]	4.5E+07 to 2.3E+09	126	None; evaluate at renewal
07 06	Toledo Station (Buckeye Pipe Line Co.)	2IN00019	Otter Creek	storm water [a]	1.6E+06 to 8.5E+07	126	None; evaluate at renewal
Maumee River (lower) Tributaries (HUC 04100009)							
09 01	Country Manor Estates [c]	2PG00096	Hull Prairie Ditch	0.02	0	0	--
09 01	Maurers MHP	2PY00005	Grassy Creek Diversion	0.03	1.8E+08	161	Average monthly limit of 161 count/ 100 mL
09 04	Middleport Terminal	2IN00218	Duck Creek	storm water [a]	2.5E+07 to 9.1E+08	126	None; evaluate at renewal

Notes
HUC = hydrologic unit code; mgd = million gallons per day; MHP = mobile home park; mL = milliliter; WLA = wasteload allocation.
a. These facilities discharge storm water and their WLAs are calculated based upon flow condition in the receiving stream. The range of WLA loads is displayed; for individual WLA loads per flow conditions, refer back to Section 7.4.3.
b. Multiple outfalls discharge to unnamed ditches and storm sewers to Otter Creek, Driftmeyer Ditch, and Joehlin Ditch.
c. Country Manor Estates (Ohio EPA ID 2PG00096) will be removed in June 2012 and the subdivision will be connected to public sanitary sewers.

Table 8-6. Recommended implementation actions through the NPDES program for TSS for the Lake Erie tributaries (041100010 07) except for Otter Creek (HUC 041100010 07 06)

HUC	Permitee	Ohio EPA ID	Receiving stream	Design flow (mgd)	WLA (lb/d)	WLA (mg/L)	Recommended permit conditions
07 02	Fuel Mart #641	2II00050	Crane Creek	storm water [a]	0.023 to 3.0	24	None; evaluate at renewal.
07 05	Hirzel Canning Co. [b]	2IH00111	Wolf Creek	0.15	56	45	Maximum daily limit of 45 mg/L
07 05	Oregon WTP	2IW00220	Berger Ditch	0.30	113	45	Maximum daily limit of 45 mg/L
07 02	Perrysburg Estates MHP	2PY00014	ditch to Henry Creek	0.0624	9.4	18	Maximum daily limit of 18 mg/L
07 02	Pilot Travel Center	2IN00147	miscellaneous	storm water [a]	0.010 to 1.3	24	None; evaluate at renewal.
07 02	Toledo TravelCenter	2II00032	Crane Creek	storm water [a]	0.071 to 9.2	24	None; evaluate at renewal.
07 02	Village Green MHP	2PY00008	Unnamed tributary to Crane Creek	0.045	6.8	18	Maximum daily limit of 18 mg/L

Notes

HUC = hydrologic unit code; lb/d = pounds per day; mgd = million gallons per day; mg/L = milligram per liter; MHP = mobile home park; WLA = wasteload allocation; WTP = water treatment plant.

a. These facilities discharge storm water and their WLAs are calculated based upon flow condition in the receiving stream. The range of WLA loads is displayed; for individual WLA loads per flow conditions, refer back to Section 7.3.4 and Section 7.3.5. Some facilities cannot discharge storm water effluent during low flow conditions..

b. Hirzel Canning Company (Ohio EPA ID 2IH00111) was assigned the in-stream headwaters WWH target (0.08 mg/L). This facility may discharges canning operations wastewater and storm water, not sanitary wastewater. The WLA is only applicable in the high and moist flow zones; the WLA is set to 0 in the mid-range through low flow zones.

Table 8-7. Recommended implementation actions through the NPDES program for TSS for Otter Creek (HUC 041100010 07 06) and the Maumee River (lower) tributaries (HUC 041100009 09)

HUC	Permitee	Ohio EPA ID	Receiving stream	Design flow (mgd)	WLA (lb/d)	WLA (mg/L)	Recommended permit conditions
Otter Creek (HUC 04100010 07 06)							
07 06	Broadway Warehouse	2II00108	Otter Creek	storm water [a]	1.7 to 24	24	None; evaluate at renewal.
07 06	East Broadway Middle School	2PT00108	Otter Creek	storm water [a]	1.8 to 25	24	None; evaluate at renewal.
07 06	Evergreen Recycling and Disposal	2IN00108	Dry Creek and Otter Creek	storm water [a]	12 to 168	45	None; evaluate at renewal.
07 06	Envirosafe	2IN00013	multiple [b]	0.0394	15	45	Maximum daily limit of 45 mg/L
				storm water [a]	5.3 to 75	24	None; evaluate at renewal.
07 06	Pilkington N.A.	2IN00020	Otter Creek	storm water [a]	6.8 to 96	24	None; evaluate at renewal.
07 06	Toledo Station (Buckeye Pipe Line Co.)	2IN00019	Otter Creek	0.0015	0.23	18	Maximum daily limit of 18 mg/L
				storm water [a]	0.25 to 3.5	24	None; evaluate at renewal.
07 06	Toledo WTP	2IW00260	Otter Creek	29.5	4,924	20	Maximum daily limit of 20 mg/L
Maumee River (lower) Tributaries (HUC 04100009)							
09 04	Middleport Terminal	2IN00218	Duck Creek	storm water [a]	4.8 to 40	45	None; evaluate at renewal.
09 04	Toledo WTP	2IW00260	Duck Creek	5.9	985	20	Maximum daily limit of 20 mg/L

Notes
HUC = hydrologic unit code; lb/d = pounds per day; mgd = million gallons per day; mg/L = milligram per liter; WLA = wasteload allocation; WTP = water treatment plant
a. These facilities discharge storm water and their WLAs are calculated based upon flow condition in the receiving stream. The range of WLA loads is displayed; for individual WLA loads per flow conditions, refer back to Section 7.4.3.
b. Multiple outfalls discharge to unnamed ditches and storm sewers to Otter Creek, Driftmeyer Ditch, and Joehlin Ditch.
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Table 8-8. Recommended implementation actions through the NPDES program for regulated MS4s

Permitee	Ohio EPA ID	HUC [a]	Receiving subwatershed	WLA [b]				
				Ammonia (lb/d as N)	*E. coli* (count/day)	Nitrate plus nitrite (lb/d as N)	Total phosphorus (lb/d as P)	TSS (lb/d)
City of Maumee	2GQ00012	09 04	Delaware Creek	--	2.4E+08 – 1.4E+10	0.40 - 22	0.032 – 1.8	--
City of Northwood	2GQ00002	07 03	Cedar Creek	--	6.0E+09 – 2.7E+10	--	0.017 – 4.5	--
		07 05	Berger Ditch	--	1.8E+08 – 1.4E+10	--	0.025 – 2.0	0 – 604
		07 06	Otter Creek	--	2.9E+08 – 1.5E+10	--	--	44 – 619
		09 02	Grassy Creek	--	1.4E+07 – 8.8E+08			0.54 – 35
City of Oregon	2GQ00001	07 03	Cedar Creek	--	8.0E+06 – 3.7E+07	--	0.000022 – 0.0060	--
		07 05	Berger Ditch	--	2.9E+08 – 2.4E+10	--	0.040 – 3.3	0 – 992
		07 06	Otter Creek	--	4.4E+08 – 2.3E+10	--	--	66 – 937
		09 04	Duck Creek	--	8.1E+06 – 2.9E+08	--	--	1.5 – 13
City of Perrysburg	2GQ00018	09 01	Grassy Creek Diversion	--	1.8E+08 – 1.7E+10	--	--	--
		09 02	Grassy Creek	--	4.8E+08 – 3.1E+10	--	--	19 – 1,228
City of Rossford	2GQ00017	07 03	Cedar Creek	--	2.1E+09 – 9.9E+09	--	0.0060 – 1.6	--
			Dry Creek	0.14 – 8.6	--	--	0.0060 – 1.3	--
		07 06	Otter Creek	--	2.4E+06 – 1.2E+08	--	--	0.36 – 5.1
		09 02	Grassy Creek	--	2.2E+08 – 1.4E+10	--	--	8.5 – 547
City of Toledo	2PI00003	07 06	Otter Creek	--	1.8E+08 – 9.4E+09	--	--	27 – 388
		09 04	Delaware Creek	--	3.9E+08 – 2.2E+10	0.63 - 35	0.051 – 2.8	--
			Duck Creek	--	1.9E+08 – 6.9E+09	--	--	36 - 300
Lucas County and Others	2GQ00006	07 02	Crane Creek	--	1.2E+06 – 1.7E+08	--	0.000078 – 0.023	0.042 – 5.5
		07 03	Cedar Creek	--	1.9E+08 – 8.8E+08	--	0.00053 – 0.14	--
		07 05	Berger Ditch	--	1.2E+07 – 9.9E+08	--	0.0017 – 0.14	0 – 41
		07 06	Otter Creek	--	2.1E+07 – 1.1E+09	--	--	3.1 – 44
		09 04	Delaware Creek	--	1.2E+07 – 6.5E+08	0.019 – 1.1	0.0015 – 0.084	--
			Duck Creek	--	4.8E+06 – 1.7E+08	--	--	0.90 – 74
ODOT	4GQ00000	07 01	Turtle Creek	--	1.5E+06 – 2.2E+08	--	0.00021 – 0.030	--
			SB Turtle Creek	0.0010 – 0.11	--	--	0.000049 – 0.0054	--
		07 02	Crane Creek	--	3.4E+06 – 4.6E+08	--	0.00022 – 0.062	0.12 – 15
		07 03	Cedar Creek	--	2.6E+08 – 1.2E+09	--	0.00071 – 0.19	--
			Dry Creek	0.0042 – 0.25	--	--	0.00063 – 0.038	--
		07 05	Berger Ditch	--	4.8E+06 – 3.9E+08	--	0.00066 – 0.054	0 – 16

Permitee	Ohio EPA ID	HUC [a]	Receiving subwatershed	WLA [b]				
				Ammonia (lb/d as N)	*E. coli* (count/day)	Nitrate plus nitrite (lb/d as N)	Total phosphorus (lb/d as P)	TSS (lb/d)
		07 06	Otter Creek	--	1.0E+07 – 5.2E+08	--	--	1.5 – 22
		09 01	Grassy Creek Diversion	--	2.4E+06 – 2.2E+08	--	--	--
		09 02	Grassy Creek	--	2.9E+07 – 1.8+09	--	--	1.1 – 73
		09 04	Delaware Creek	--	7.5E+06 – 4.2E+08	0.012 – 0.69	0.00098 – 0.055	--
			Duck Creek	--	6.4E+06 – 2.3E+07	--	--	0.12 – 1.0
OTC	3GQ00022	07 03	Cedar Creek	--	1.6E+07 – 7.3E+07	--	0.000044 – 0.012	--
			Dry Creek	0.00095 – 0.058	--	--	0.000044 – 0.0087	--
		09 02	Grassy Creek	--	2.4E+06 – 1.5E+08	--	--	0.10 – 6.1
		09 04	Delaware Creek	--	4.5E+06 – 1.5E+09	0.0074 – 0.41	0.00059 – 0.033	--
Ottawa County and Others	2GQ00022	07 01	Turtle Creek	--	1.4E+08 – 2.0E+10	--	0.019 – 2.8	--
			SB Turtle Creek	0.17 – 18	--	--	0.0079 – 0.86	--
		07 02	Crane Creek	--	9.7E+07 – 1.3E+10	--	0.0063 – 1.8	3 – 438
		07 03	Cedar Creek	--	7.9E+08 – 3.6E+09	--	0.0022 – 0.60	--
Village of Millbury	2GQ00007	07 02	Crane Creek	--	6.5E+07 – 8.9E+09	--	0.0042 – 1.2	2.3 – 293
			Henry Creek	--	--	--	0 – 0.0070	--
Village of Walbridge	2GQ00003	07 03	Cedar Creek	--	3.0E+09 – 1.4E+10	--	0.0083 – 2.2	--
Wood County and Others	2GQ00028	07 01	Turtle Creek	--	8.1E+06 – 1.2E+09	--	0.0011 – 0.16	--
			SB Turtle Creek	0.088 – 0.96	--	--	0.00041 – 0.046	--
		07 02	Crane Creek	--	2.9E+08 – 3.9E+10	--	0.018 – 5.3	10 – 1,280
			Henry Creek	--	--	--	0 – 1.8	--
		07 03	Cedar Creek	--	1.4E+10 – 6.6E+10	--	0.040 - 11	--
			Dry Creek	0.32 – 19	--	--	0.049 – 2.9	--
		07 05	Berger Ditch	--	4.6E+06 – 3.8E+08	--	0.00064 – 0.053	0 – 16
		07 06	Otter Creek	--	1.3E+08 – 5.2E+08	--	--	20 – 287
		09 01	Grassy Creek Diversion	--	1.4E+08 – 1.4E+10	--	--	--
		09 02	Grassy Creek	--	4.9E+08 – 3.1E+10	--	--	19 – 1,234

Notes
HUC = hydrologic unit code; lb/d = pound per day (as N = as nitrogen; as P = as phosphorus); ODOT = Ohio Department of Transportation; OTC = Ohio Turnpike Commission; SB = South Branch; TSS = total suspended solids; WLA = wasteload allocation.
a. Lake Erie tributaries (HUC 04100010 07) begin with “07” and Maumee River (lower) tributaries (04100009 09) begin with “09”.
b. These facilities discharge storm water and their WLAs are calculated based upon flow condition in the receiving stream. The range of WLA loads is displayed; for individual WLA loads per flow conditions, refer back to Section 7.3 and Section 7.4.

8.2 Failing HSTS and Unsewered Communities

Improper wastewater treatment from HSTS and unsewered communities are the most common sources of pollutants in the project area. Recommended activities to address these sources of pollutants are maintaining and replacing failing HSTS and connecting to public WWTPs. Appendix F presents additional information on activities to address impairments from untreated wastewater.

8.2.1 Connecting to Public WWTP

Unsewered communities cause bacteria and nutrient impairments throughout the project area. Connecting to sanitary sewers or constructing a new WWTP might be more beneficial than replacing and upgrading unsewered communities with malfunctioning and failing HSTS. TMACOG, the county health departments, and other agencies have worked together to identify areas with failing HSTS and unsewered communities. These areas are presented as critical sewerage areas in *Areawide Water Quality Management Plan* (TMACOG 2011). The plan provides recommendations for each area, which include extending sanitary sewer coverage to unsewered communities or areas with dense, failing HSTS.

8.2.2 Properly Maintaining and Replacing HSTS

HSTS are sources of impairment in 8 of the 10 HUCs. HSTS that are not operating properly or have failed are resulting in the elevated in-stream levels of ammonia, bacteria, nitrate/nitrite, and total phosphorus. Chapter 5 of the *Areawide Water Quality Management Plan* (TMACOG 2011) is devoted to on-site sewage treatment and includes discussions of state and county regulations, financial assistance, and recommended implementation practices.

Septic tanks with tile leaching fields are the most common type of HSTS in the project area (TMACOG 2011, p. 275). The most effective BMP for managing loads from septic systems is regular maintenance. When not maintained properly, septic systems can release pathogens and excess nutrients into surface water. Good housekeeping measures relating to septic systems are listed below (Goo 2004):

- Inspect the system annually and pump the system every 3 to 5 years, depending on the tank size and number of residents per household.
- Refrain from trampling the ground or using heavy equipment above a septic system (to prevent pipe collapse).
- Prevent septic system overflow by conserving water, not diverting storm drains or basement pumps into septic systems, and not disposing of trash through drains or toilets.

Education is a crucial component of reducing pollution from septic systems. Education can occur through public meetings, mass mailings, and radio and television advertisements.

An inspection program would help identify those systems that are connected to tile drain systems and identify maintenance recruitments. All tanks discharging to tile drainage systems should be disconnected immediately.

Some communities choose to formally regulate HSTS by creating a database of all systems in an area. Such a database usually contains information on the size, age, and type of system. All inspections and maintenance records are maintained in the database through cooperation with licensed maintenance and repair companies. The databases allow the communities to detect problem areas and ensure proper maintenance.

TMACOG, the county health departments, and other agencies have worked together to identify areas with failing HSTS. These areas are presented as critical sewerage areas in *Areawide Water Quality Management Plan* (TMACOG 2011). The document also provides the requirements each county has for installing and repairing HSTS.

8.3 Agricultural Runoff

Runoff derived from agricultural activities including non-irrigated crop production and livestock operations is a source of multiple pollutants. For example, runoff from non-irrigated crop production is a source of impairment for sedimentation/siltation. Sources of total phosphorus such as fertilizer and manure application and bacteria are also the result of crop production. Chapter 6 of the *Areawide Water Quality Management Plan* (TMACOG 2011) is devoted to agricultural runoff and includes discussions of resources available from federal, state, and county agencies and recommended BMPs.

Recommended activities to address pollutants associated with agricultural runoff include conservation tillage and installing and maintaining filter strips, grassed waterways, and riparian buffers. Appendix F presents additional activities that can be used to address agricultural runoff.

8.3.1 Conservation Tillage

Conservation tillage practices and residue management are commonly used to control erosion and surface transport of pollutants from fields used for crop production. The residue provides erosion control and a nutrient source to growing plants. Continued use of conservation tillage results in a more productive soil with higher organic and nutrient content. Several practices are commonly used to maintain surface residues:

- **No-till** systems disturb only a small row of soil during planting and typically use a drill or knife to plant seeds below the soil surface.
- **Strip till** operations leave the areas between rows undisturbed but remove residual cover above the seed to allow for proper moisture and temperature conditions for seed germination.
- **Ridge till** systems leave the soil undisturbed between harvest and planting: cultivation during the growing season is used to form ridges around growing plants. During or before the next planting, the top half inch to two inches of soil, residuals, and weed seeds are removed, leaving a relatively moist seed bed.
- **Mulch till** systems are any practice that results in at least 30 percent residual surface cover, excluding no-till and ridge till systems.

Corn residue is more durable and capable of sustaining 30 percent cover required for conservation tillage. Soybeans generate less residue that degrades more quickly, and supplemental measures or special care might be necessary to meet the 30 percent cover requirement (University of Minnesota Extension 1996).

Conservation tillage practices are also a high-priority recommendation in the *Areawide Water Quality Management Plan* because sediment-bound phosphorus derived from agricultural production contributes to phosphorus loading in Lake Erie (TMACOG 2011). In Ottawa County, almost all wheat production is no-till, about four-fifths of soybean production is no-till, and about half of corn production is no-till.[22] Various tilling methods are used throughout Lucas and Wood counties.

[22] Mike Libben, Ottawa SWCD, personal communications, December 23 & 30, 2011.

8.3.2 Installing and Maintaining Filter Strips, Grassed Waterways, and Riparian Buffers

Agricultural runoff can be slowed and treated when routed through linear vegetated surfaces including filter strips, grassed waterways, and riparian buffer. It should be noted that the effectiveness of filter strips and riparian buffers is limited in areas served by drain tiles because the agricultural runoff can discharge directly to streams and bypasses the BMPs. Cropland drainage should be evaluated prior to the installation of any BMP.

Filter strip sizing is dependent on site-specific features such as climate and topography, but at a minimum, the area of a filter strip should be 2 percent of the drainage area for agricultural land (OSU Extension 1994). The minimum filter strip width suggested by the Natural Resources Conservation Service (NRCS 2002) is 30 feet. They are most effective on sites with mild slopes of generally less than 5 percent, and to prevent concentrated flow, the upstream edge of a filter strip should follow one elevation contour (North Carolina Department of Environmental and Natural Resources 2005). Filter strips will require maintenance, including grading and seeding, to ensure distributed flow across the filter and protection from erosion. Periodic removal of vegetation will encourage plant growth and uptake and remove nutrients stored in the plant material. The strips are assumed to function properly with annual maintenance for 30 years before requiring soil and vegetation replacement.

Grassed waterways convey runoff across fields while preventing erosion, reducing runoff velocities, allowing for infiltration, and filtering out particulate pollutants. Grassed waterways are also used in animal operations to divert clean water away from pastures, feedlots, and manure storage areas.

Vegetated riparian corridors are a critical component of aquatic ecosystems and local hydrologic cycles. Stream bank vegetation provides habitat to many terrestrial and aquatic species. For example, riparian trees benefit aquatic communities by providing leaf litter and woody debris as habitat and as a source of energy for the community food webs (Cappiella et al. 2005). Trees along stream banks reduce channel erosion by stabilizing stream banks (via their root systems), by adding organic matter, and by dispersing rainfall energy via dispersing the raindrop energy across the canopy (Cappiella et al. 2005).

8.4 Urban Runoff and Storm Sewers

Urban runoff, including runoff that is regulated through Ohio EPA general permits (i.e. MS4, construction, and industrial), has been identified as a primary source of pollutants including *E. coli*, nutrients and sediment in the project area. In addition to runoff, illicit connections between sanitary and storm sewers are also a potential source of pollutants in the urban environment. Chapter 7 of the *Areawide Water Quality Management Plan* (TMACOG 2011) is devoted to storm water management and includes discussions of regulations/policy, illicit connections, funding and infrastructure.

Recommended activities to address these sources include storm water management and education and outreach programs. Appendix F presents additional information on these and other activities that are recommended to address sources of impairment derived from urban runoff and storm sewers.

8.4.1 Storm Water Management

Storm water management, including best management practices retrofitting and planning for future development, can be used to address the sources of pollutants derived from urban runoff and storm sewers. In addition, education and outreach is an integral component of a comprehensive storm water management program that can address diffuse sources of pollutants such as pet waste and lawn maintenance activities.

Retrofitting urban areas with storm water best management practices, especially those practices that reduce the volume of runoff from urban areas, can address pollutant loads from existing developed areas. Controlling runoff associated with development typically consists of end-of-pipe measures such as storm water detention and retention. Those controls abate flooding and reduce erosion, thus providing some water quality protection. However, studies show that water quality degradation occurs in developing watersheds despite those controls because of the altered hydrologic regime (Brabec et al. 2002; Booth 2005).

On-site, or decentralized, storm water management increases infiltration and reduces runoff generation by decreasing imperviousness. That is accomplished through appropriate planning, such as that used for low impact development (LID). LID is based on maximizing contiguous open space, protecting sensitive areas—namely floodplains, ground water recharge areas, and wetlands—and preserving existing vegetation (especially trees). Yoder et al. (2000) found that riparian buffers in Ohio can preserve or enhance in-stream habitat and thus mitigate the detrimental effects of high levels of urbanization. A Web-based resource for LID is http://www.lowimpactdevelopment.org/. In LID, houses are closer to one another, roadways are narrower, and bioretention and infiltration techniques are used. LID reduces runoff and can provide cost savings in storm water infrastructure. Additional non-environmental benefits include above average increases in property values.

Decentralized best management practices that promote infiltration and filtration, also referred to as green infrastructure, include bioretention, bioswales, rain gardens, green roofs, infiltration basins and trenches, underground storage, permeable pavement, and storm water wetlands. In addition, rainwater harvesting from using rain barrels and cisterns can reduce the volume of runoff being generated and provide other benefits such as reduced potable water supply demand.

Watersheds that retain relatively large areas of forest are able to better mitigate the effects of increasing imperviousness than those with little forest cover (Booth 2005). Procuring conservation easements and establishing parkland and nature preserves can help retain some of the existing forest cover and facilitate the conversion from open land to forest. Although land preservation alone is not likely to occur at a level necessary to mitigate development effects, it will augment other measures that are taken (e.g., LID or discrete, on-site storm water management).

At the scale of individual residences or business, diverting drainage from rooftops, driveways, and other impervious surfaces away from a centralized collection system (e.g., outlets to either curb-and-gutter drains or storm water sewer lines) to green infrastructure techniques can be used to retain runoff and provide water quality treatment. Minimizing the extent of impervious surfaces by limiting their size or substituting them with permeable surfaces will also achieve the benefit of reduced storm water runoff.

In cases where stream channels are directly altered by development, green infrastructure and regional practices that reduce storm water runoff might not be sufficient to restore biological integrity. In-stream restoration activities, such as stream bank stabilization or dam removal, are used to restore stream channels to more natural conditions and will vary depending on which physical features are impairing aquatic life.

8.4.2 Education and Outreach

Successful implementation of the TMDLs will rely heavily on effective public education and outreach activities that will encourage participation and produce changes in behavior. It is imperative to raise stakeholders' awareness about issues in the watershed and develop strategies to change their behavior in a manner that will promote voluntary participation. Changes in awareness and behavior are surrogate indicators for longer term changes in water quality.

Ideally, a public education and outreach campaign would address all target audiences and their related behaviors through a comprehensive outreach campaign spearheaded by one entity serving as an outreach campaign organizer. The outreach campaign organizer would be responsible for coordinating all outreach efforts conducted by multiple partners to ensure an efficient use of resources, avoid duplicative activities, and promote targeted messaging to specific audiences. A Maumee River (lower) tributaries and Lake Erie tributaries public outreach campaign should involve representatives from all agencies and organizations that play a role in conducting outreach, including Duck and Otter Creek Partnership, Partners for Clean Streams (Maumee RAP), TMACOG, the county soil and water conservation districts, and the MS4 communities.

Awareness can be increased through signage, brochures, radio and television advertisements, websites, ordinance enforcement, and a pledge program. The effectiveness of the program could be evaluated through surveys (online or mail-in), focus groups, and evaluating the number of bags used at pet waste stations at parks.

8.4.3 Characterization of Otter Creek

TMDLs were not developed for Otter Creek to address impairments caused by sediment contamination. After the impairments are fully characterized, restoration efforts will begin. At this time, efforts to characterize Otter Creek are ongoing. A list of recent projects is provided below.

- Cardno ENTRIX. 2012. Duck and Otter Creeks Great Lakes Legacy Act Data Gap Investigation Report. Prepared by Cardno ENTRIX. Prepared for Duck and Otter Creek Industrial Partners. April 2012.
- Weston Solutions. 2012. Data Evaluation Report for Duck and Otter Creeks Confluence Sediment Investigation, Toledo, Lucas County, Ohio (Revision 1). Prepared for US EPA. Prepared by Weston Solutions. Feb 10, 2012.
- Department of the Army US Army Engineers. 2011. Acute Toxicity Evaluation of Duck and Otter Creek Sediments with *Chironomus dilutus* (part of Data Gap Investigation). Prepared for US EPA. Prepared by Department of the Army US Army Engineer Research and Development Center Environmental Laboratory. April 1, 2011.
- Department of the Army US Army Engineers. 2011. Acute Toxicity Evaluation of Duck and Otter Creek Sediments with *Chironomus dilutus* (part of Confluence Study Investigation). Prepared for US EPA. Prepared by Department of the Army US Army Engineer Research and Development Center Environmental Laboratory. Feb 25, 2011.
- Tetra Tech EMI. 2008. Human Health Risk Assessment; Duck and Otter Creeks, Toledo and Oregon, Ohio. Prepared for Partners For Clean Streams, Inc., Bowling Green, Ohio. Prepared by Tetra Tech EMI. Chicago, Illinois. December 2008.
- Tetra Tech EMI. 2008. Screening and Baseline Ecological Risk Assessment; Duck and Otter Creeks, Toledo and Oregon, Ohio. Prepared for Partners For Clean Streams, Inc., Bowling Green, Ohio. Prepared by Tetra Tech EMI. Chicago, Illinois. December 2008.
- SulTRAC. 2007. Sediment Sampling Report for Duck and Otter Creeks, Toledo and Oregon, Ohio. Prepared for US EPA Great Lakes National Program Office. December 2007.
- ChemRisk. 1999. Sediment Quality Assessment for Duck and Otter Creeks, Toledo, Ohio. March 31, 1999.

8.5 Watershed-specific Recommendations

Table 8-9 and Table 8-10 show an overview of all of the watersheds that contain sites with partial and non-attainment of aquatic life and recreation uses. Causes of impairment are shown within parentheses following each source that might contribute to that cause. Table 8-11 and Table 8-12 present the recommendations for the Maumee River (lower) tributaries and Lake Erie tributaries, respectively. For each watershed, specific actions are recommended.

These actions are intended to be inclusive of possible methods to improve water quality in the watershed based on identified causes and sources of impairment. Because Ohio EPA recognizes that actions taken in any individual subwatershed may depend on a number of factors (including socioeconomic, political and ecological factors), these recommendations are not intended to be prescriptive of actions to be taken, and any number or combination might contribute to improvement, whether applied at sites where actual impairment was noted or other locations where sources contribute indirectly to water quality impairment. Further details about individual practices can be found in Appendix F.

Table 8-9. Recommendations for improving water quality in impaired areas in the Maumee River (lower) tributaries (04100009 09)

Location Description (10-digit HUC) Location Description (12-digit HUC) Sources (Causes)	Restoration Categories: Bank & Riparian Restoration	Stream Restoration	Wetland Restoration	Conservation Easements	Dam Modification or Removal	Levee or Dike Modification or Removal	Abandoned Mine Land Reclamation	Home Sewage Planning and Improvement	Education and Outreach	Agricultural Best Management Practices	Storm Water Best Management Practices	Regulatory Point Source Controls
Grassy Creek – Maumee River (04100009 09)												
Grassy Creek Diversion (09 01)												
Failing HSTS (bacteria)								x	x			x
Urban/residential runoff (bacteria)									x		x	x
Grassy Creek (09 02)												
Channelization (sedimentation)	x			x							x	x
Urban runoff/storm sewers (sedimentation)									x		x	x
Failing HSTS (bacteria)								x	x			x
Urban/residential runoff (bacteria)									x		x	x
Delaware Creek – Maumee River (09 04) (includes Duck Creek)												
Channelization (sedimentation)	x										x	x
Urban runoff/storm sewers (sedimentation, nitrate/nitrite, phosphorus)									x		x	x
Channel erosion/incision from upstream hydromodifications (other flow regime modifications)	x										x	x
Illicit connections to storm sewers (bacteria)									x			x
Golf course (bacteria)											x	x
Failing HSTS (bacteria)	Already addressed											
Urban/residential runoff (bacteria)											x	x

Notes
HSTS = home sewage treatment systems; HUC = hydrologic unit code; WWTP = wastewater treatment plant.

Table 8-10. Recommendations for improving water quality in impaired areas in the Lake Erie tributaries (HUC 04100010 07)

Location Description (10-digit HUC) Location Description (12-digit HUC) Sources (Causes)	Restoration Categories											
	Bank & Riparian Restoration	Stream Restoration	Wetland Restoration	Conservation Easements	Dam Modification or Removal	Levee or Dike Modification or Removal	Abandoned Mine Land Reclamation	Home Sewage Planning and Improvement	Education and Outreach	Agricultural Best Management Practices	Storm Water Best Management Practices	Regulatory Point Source Controls
Cedar Creek – Frontal Lake Erie (04100010 07)												
Turtle Creek – Frontal Lake Erie (07 01)												
Channelization (sedimentation)	x	x	x	x					x	x	x	x
Non-irrigated crop production (phosphorus, habitat alterations)	x	x	x						x	x		
Failing HSTS (low D.O., ammonia, phosphorus, bacteria)								x	x			x
Package WWTP (bacteria)												x
Agricultural runoff (bacteria)									x	x		
Urban/residential runoff (bacteria)									x		x	x
Crane Creek – Frontal Lake Erie (07 02)												
Urban runoff/storm sewers (phosphorus, sedimentation, bacteria)									x		x	x
Channelization (sedimentation)	x	x	x	x					x	x	x	x
Package WWTP (bacteria)												x
Failing HSTS (bacteria)								x	x			x
Agricultural runoff (bacteria)									x	x		
Cedar Creek – Frontal Lake Erie (07 03)												
Channelization (sedimentation)	x	x	x	x					x	x	x	x
Non-irrigated crop production (sedimentation, phosphorus)	x	x	x						x	x		
Failing HSTS (organic enrichment, low D.O., ammonia, phosphorus, bacteria)								x	x			x

Location Description (10-digit HUC) Location Description (12-digit HUC) Sources (Causes)	Restoration Categories: Bank & Riparian Restoration	Stream Restoration	Wetland Restoration	Conservation Easements	Dam Modification or Removal	Levee or Dike Modification or Removal	Abandoned Mine Land Reclamation	Home Sewage Planning and Improvement	Education and Outreach	Agricultural Best Management Practices	Storm Water Best Management Practices	Regulatory Point Source Controls
Package WWTP (bacteria)												x
Agricultural runoff (bacteria)									x	x		
Urban/residential runoff (bacteria)									x		x	x
Berger Ditch (07 05)												
Channelization (sedimentation)	x	x	x	x					x	x	x	x
Failing HSTS (phosphorus, organic enrichment, bacteria)								x	x			x
Agricultural runoff (bacteria)									x	x		
Urban/residential runoff (bacteria)									x		x	x
Otter Creek – Frontal Lake Erie (07 06)												
Channelization (sedimentation)	x	x	x	x					x	x	x	x
Impervious surface runoff (sedimentation)									x		x	x
Commercial/industrial districts (sedimentation, contaminated sediments)	x										x	x
Sediment re-suspension (contaminated sediments)	See narrative text											
Landfills (contaminated sediments)	See narrative text											
Failing HSTS (bacteria)								x	x			
Package WWTP (bacteria)												x
Illicit connections to storm sewers (bacteria)									x			x
Urban/residential runoff (bacteria)									x		x	x

Notes
D.O. = dissolved oxygen; HSTS = home sewage treatment systems; HUC = hydrologic unit code; WWTP = wastewater treatment plant.

Table 8-11. Recommended implementation actions in the Maumee River (lower) tributaries (HUC 04100009 09)

Restoration categories		Specific restoration activities	Grassy Creek Diversion (09 01)	Grassy Creek (09 02)	Delaware Creek-Maumee River (09 04)
Bank & Riparian Restoration	constructed	Restore streambank using bio-engineering		x	x
		Restore streambank by recontouring or regrading		x	x
	planted	Plant grasses in riparian areas		x	x
		Plant prairie grasses in riparian areas			
		Remove/treat invasive species		x	x
		Plant trees or shrubs in riparian areas		x	x
Stream Restoration		Restore flood plain			
		Restore stream channel			
		Install in-stream habitat structures			
		Install grade structures			
		Construct 2-stage channel			
		Restore natural flow			
Wetland Restoration		Reconnect wetland to stream			
		Reconstruct & restore wetlands			
		Plant wetland species			
Conservation Easements		Acquire conservation easements		x	
Dam Modification or Removal		Remove dams			
		Modify dams			
		Remove associated dam support structures			
		Install fish passage and/or habitat structures			
		Restore natural flow			
Levee or Dike Modification or Removal		Remove levees			
		Breach or modify levees			
		Remove dikes			
		Modify dikes			
		Restore natural flood plain function			
Abandoned Mine Land Reclamation	treatment	Construct lime dosers			
		Install slag leach beds			
		Install limestone leach beds			
		Install limestone channels			
		Install successive alkalinity producing systems			
		Install settling ponds			
		Install vertical flow ponds			
		Install limestone drains (anoxic and/or oxic)			
		Construct acid mine drainage wetland			
	flow diversion	Repair subsidence sites			
		Reclaim pit impoundments			

Restoration categories		Specific restoration activities	Grassy Creek Diversion (09 01)	Grassy Creek (09 02)	Delaware Creek-Maumee River (09 04)
		Reclaim abandoned mine land			
		Eliminate stream captures			
		Eliminate mine drainage discharges			
		Restore positive drainage			
		Cover toxic mine spoils			
Home Sewage Planning and Improvement		Develop HSTS plan			
		Inspect HSTS	x	x	
		Repair or replace traditional HSTS	x	x	
		Repair or replace alternative HSTS	x	x	
Education and Outreach		Host meetings, workshops, and/or other events	x	x	x
		Distribute educational materials	x	x	x
Agricultural Best Management Practices	farmland	Plant cover/manure crops			
		Implement conservation tillage practices			
		Implement grass/legume rotations			
		Convert to permanent hayland			
		Install grassed waterways			
		Install vegetated buffer areas/strips			
		Install location-specific conservation buffer			
		Install / restore wetlands			
	nutrients / agro-chemicals	Conduct soil testing			
		Install nitrogen reduction practices			
		Develop nutrient management plans			
	drainage	Install sinkhole stabilization structures			
		Install controlled drainage system			
		Implement drainage water management			
		Construct over-wide ditch			
		Construct 2-stage channel			
	livestock	Implement prescribed & conservation grazing practices			
		Install livestock exclusion fencing			
		Install livestock crossings			
		Install alternative water supplies			
		Install livestock access lanes			
	manure	Implement manure management practices			
		Construct animal waste storage structures			
		Implement manure transfer practices			
		Install grass manure spreading strips			
	misc. infrastructure	Install chemical mixing pads			
		Install heavy use feeding pads			

Restoration categories		Specific restoration activities	Grassy Creek Diversion (09 01)	Grassy Creek (09 02)	Delaware Creek-Maumee River (09 04)
	and management	Install erosion & sediment control structures			
		Install roof water management practices			
		Install milkhouse waste treatment practices			
		Develop whole farm management plans			
Storm Water Best Management Practices	planning	Develop/implement local ordinances/resolutions		x	x
		Develop local comprehensive land use plans			
	construction practices	Implement erosion controls		x	x
		Implement sediment controls		x	x
		Implement non-sediment controls		x	x
	post construction practices	Reduce pollutant(s) through treatment			
		Reduce pollutant(s) through flow/volume management		x	x
	post development/ storm water retrofit	Implement erosion controls		x	x
		Implement sediment controls		x	x
		Implement non-sediment controls	x	x	x
		Reduce pollutant(s) through treatment	x		
		Reduce pollutant(s) through flow/volume management	x	x	x
Regulatory Point Source Controls (includes Storm Water, Sanitary, and Industrial)	planning	Develop long-term control plan (CSOs)			
		Develop/implement local ordinances/resolutions	x		
		Develop water quality management/208 plans			
	collection and new treatment	Install sewer systems in communities			
		Implement long-term control plan (CSOs)			
		Eliminate SSOs/CSOs/by-passes			
	enhanced treatment	Issue permit(s) and/or modify permit limit(s)			
		Improve quality of effluent			
	monitoring	Establish ambient monitoring program	x		
		Increase effluent monitoring			
	alternatives	Establish water quality trading			
	construction practices	Issue permit(s) and/or modify permit limit(s)			
		Implement erosion controls		x	x
		Implement sediment controls		x	x
		Implement non-sediment controls		x	x
	post construction practices	Issue permit(s) and/or modify permit limit(s)			
		Reduce pollutant(s) through treatment			
		Reduce pollutant(s) through flow/volume management		x	x
	post development/ storm water	Issue permit(s) and/or modify permit limit(s)			
		Implement erosion controls		x	x
		Implement sediment controls		x	x

Restoration categories		Specific restoration activities	Grassy Creek Diversion (09 01)	Grassy Creek (09 02)	Delaware Creek-Maumee River (09 04)
	retrofit	Implement non-sediment controls		x	x
		Reduce pollutant(s) through treatment			
		Reduce pollutant(s) through flow/volume management		x	x
		Reduce volume to CSOs			

Notes
CSO = combined sewer overflow; HSTS = home sewage treatment system; SSO= sanitary sewer overflow.

TMACOG has developed a 208 plan (i.e., TMACOG 2011) covering this 10-digit HUC that will implement storm water best management practices. In addition, illicit connections should be investigated, identified and eliminated.

Table 8-12. Recommended implementation actions in the Lake Erie tributaries (HUC 04100010 07)

Restoration categories		Specific restoration activities	Turtle Creek-Frontal Lake Erie (07 01)	Crane Creek-Frontal Lake Erie (07 02)	Cedar Creek-Frontal Lake Erie (07 03)	Berger Ditch (07 05)	Otter Creek-Frontal Lake Erie (07 06)
Bank & Riparian Restoration	constructed	Restore streambank using bio-engineering	x	x	x	x	x
		Restore streambank by recontouring or regrading	x	x	x	x	x
	planted	Plant grasses in riparian areas	x	x	x	x	x
		Plant prairie grasses in riparian areas	x	x	x	x	x
		Remove/treat invasive species	x	x	x	x	x
		Plant trees or shrubs in riparian areas	x	x	x	x	x
Stream Restoration		Restore flood plain	x	x	x	x	x
		Restore stream channel	x	x	x	x	x
		Install in-stream habitat structures	x	x	x	x	x
		Install grade structures	x	x	x	x	x
		Construct 2-stage channel	x	x	x	x	x
		Restore natural flow	x	x	x	x	x
Wetland Restoration		Reconnect wetland to stream	x	x	x	x	x
		Reconstruct & restore wetlands	x	x	x	x	x

Restoration categories		Specific restoration activities	Turtle Creek-Frontal Lake Erie (07 01)	Crane Creek-Frontal Lake Erie (07 02)	Cedar Creek-Frontal Lake Erie (07 03)	Berger Ditch (07 05)	Otter Creek-Frontal Lake Erie (07 06)
		Plant wetland species	x	x	x	x	x
Conservation Easements		Acquire conservation easements	x	x	x	x	x
Dam Modification or Removal		Remove dams					
		Modify dams					
		Remove associated dam support structures					
		Install fish passage and/or habitat structures					
		Restore natural flow					
Levee or Dike Modification or Removal		Remove levees					
		Breach or modify levees					
		Remove dikes					
		Modify dikes					
		Restore natural flood plain function					
Abandoned Mine Land Reclamation	treatment	Construct lime dosers					
		Install slag leach beds					
		Install limestone leach beds					
		Install limestone channels					
		Install successive alkalinity producing systems					
		Install settling ponds					
		Install vertical flow ponds					
		Install limestone drains (anoxic and/or oxic)					
		Construct acid mine drainage wetland					
	flow diversion	Repair subsidence sites					
		Reclaim pit impoundments					
		Reclaim abandoned mine land					
		Eliminate stream captures					
		Eliminate mine drainage discharges					
		Restore positive drainage					
		Cover toxic mine spoils					
Home Sewage Planning and Improvement		Develop HSTS plan			x	x	
		Inspect HSTS	x	x	x	x	x
		Repair or replace traditional HSTS	x	x	x	x	x
		Repair or replace alternative HSTS	x	x	x	x	x
Education and Outreach		Host meetings, workshops, and/or	x	x	x	x	x

Restoration categories		Specific restoration activities	Turtle Creek-Frontal Lake Erie (07 01)	Crane Creek-Frontal Lake Erie (07 02)	Cedar Creek-Frontal Lake Erie (07 03)	Berger Ditch (07 05)	Otter Creek-Frontal Lake Erie (07 06)
		other events					
		Distribute educational materials	x	x	x	x	x
Agricultural Best Management Practices	farmland	Plant cover/manure crops	x	x	x	x	x
		Implement conservation tillage practices	x	x	x	x	x
		Implement grass/legume rotations					
		Convert to permanent hayland					
		Install grassed waterways	x	x	x	x	x
		Install vegetated buffer areas/strips	x	x	x	x	x
		Install location-specific conservation buffer	x	x	x	x	x
		Install / restore wetlands	x	x	x	x	x
	nutrients / agro-chemicals	Conduct soil testing					
		Install nitrogen reduction practices					
		Develop nutrient management plans			x		
	drainage	Install sinkhole stabilization structures					
		Install controlled drainage system					
		Implement drainage water management					
		Construct over-wide ditch	x	x	x	x	x
		Construct 2-stage channel	x	x	x	x	x
	livestock	Implement prescribed & conservation grazing practices					
		Install livestock exclusion fencing					
		Install livestock crossings					
		Install alternative water supplies					
		Install livestock access lanes					
	manure	Implement manure management practices	x	x	x	x	
		Construct animal waste storage structures	x	x	x	x	
		Implement manure transfer practices	x	x	x	x	
		Install grass manure spreading strips	x	x	x	x	
	misc. infrastructure and management	Install chemical mixing pads					
		Install heavy use feeding pads					
		Install erosion & sediment control structures	x	x	x	x	x
		Install roof water management					

Restoration categories		Specific restoration activities	Turtle Creek-Frontal Lake Erie (07 01)	Crane Creek-Frontal Lake Erie (07 02)	Cedar Creek-Frontal Lake Erie (07 03)	Berger Ditch (07 05)	Otter Creek-Frontal Lake Erie (07 06)
		practices					
		Install milkhouse waste treatment practices					
		Develop whole farm management plans	x	x	x	x	x
Storm Water Best Management Practices	planning	Develop/implement local ordinances/resolutions	x	x	x	x	x
		Develop local comprehensive land use plans	x	x	x	x	x
	construction practices	Implement erosion controls	x	x	x	x	x
		Implement sediment controls	x	x	x	x	x
		Implement non-sediment controls	x	x	x	x	x
	post construction practices	Reduce pollutant(s) through treatment	x	x	x	x	x
		Reduce pollutant(s) through flow/volume management	x	x	x	x	x
	post development/ storm water retrofit	Implement erosion controls	x	x	x	x	x
		Implement sediment controls	x	x	x	x	x
		Implement non-sediment controls	x	x	x	x	x
		Reduce pollutant(s) through treatment	x	x	x	x	x
		Reduce pollutant(s) through flow/volume management	x	x	x	x	x
Regulatory Point Source Controls (includes Storm Water, Sanitary, and Industrial)	planning	Develop long-term control plan (CSOs)					
		Develop/implement local ordinances/resolutions					
		Develop water quality management/208 plans					
	collection and new treatment	Install sewer systems in communities					
		Implement long-term control plan (CSOs)					
		Eliminate SSOs/CSOs/by-passes					
	enhanced treatment	Issue permit(s) and/or modify permit limit(s)	x	x	x		x
		Improve quality of effluent	x	x	x		x
	monitoring	Establish ambient monitoring program	x	x	x		x
		Increase effluent monitoring	x	x	x		x
	alternatives	Establish water quality trading					
	construction practices	Issue permit(s) and/or modify permit limit(s)	x	x	x	x	x
		Implement erosion controls	x	x	x	x	x

Restoration categories		Specific restoration activities	Turtle Creek-Frontal Lake Erie (07 01)	Crane Creek-Frontal Lake Erie (07 02)	Cedar Creek-Frontal Lake Erie (07 03)	Berger Ditch (07 05)	Otter Creek-Frontal Lake Erie (07 06)
		Implement sediment controls	x	x	x	x	x
		Implement non-sediment controls	x	x	x	x	x
	post construction practices	Issue permit(s) and/or modify permit limit(s)		x	x	x	x
		Reduce pollutant(s) through treatment	x	x	x	x	x
		Reduce pollutant(s) through flow/volume management	x	x	x	x	x
	post development/ storm water retrofit	Issue permit(s) and/or modify permit limit(s)	x	x	x	x	x
		Implement erosion controls	x	x	x	x	x
		Implement sediment controls	x	x	x	x	x
		Implement non-sediment controls	x	x	x	x	x
		Reduce pollutant(s) through treatment	x	x	x	x	x
		Reduce pollutant(s) through flow/volume management	x	x	x	x	x
		Reduce volume to CSOs					

Notes
CSO = combined sewer overflow; HSTS = home sewage treatment system; SSO= sanitary sewer overflow.

In the Otter Creek watershed (HUC 04100010 07 06), levees are being modified near Lake Erie to reconnect natural hydrology (e.g., restoring wetlands). The levee modification will likely reduce impacts from channelization. In addition, illicit connections should be investigated, identified and eliminated.

8.6 Reasonable Assurances

The recommendations made in this TMDL report will be carried out if the appropriate entities work to implement them. In particular, activities that do not fall under regulatory authority require that state and local agencies, governments, and private groups mount a committed effort to carry out or facilitate such actions. For successful implementation, adequate resources must also be available.

When a TMDL is developed for waters impaired by point sources only, the issuance of a NPDES permit(s) provides the reasonable assurance that the WLAs contained in the TMDL will be achieved. This is because title 40 of the *Code of Federal Regulations* section 122.44(d)(1)(vii)(B) requires that effluent limits in permits be consistent with the assumptions and requirements of any available WLA in an approved TMDL.

When a TMDL is developed for waters impaired by both point and nonpoint sources and the WLA is based on an assumption that nonpoint source load reductions will occur, U.S. EPA's 1991 TMDL guidance states that the TMDL should provide reasonable assurances that nonpoint source control measures will achieve expected load reductions. To that end, Appendix F discusses organizations and programs that have an important role or can provide assistance for meeting the goals and recommendations of this TMDL. Efforts specific to this watershed are described below.

8.6.1 Local Zoning and Regional Planning

Local zoning is typically controlled at the county or municipality level. Local zoning can be a useful tool for implementing some recommendations of the TMDL, such as stream bank setbacks for developing land. Local governments typically conduct planning to meet the sewage disposal needs of the community. Ohio EPA has established guidelines for planning that are useful in the context of Section 208 and the State Water Quality Management Plan. Local governments that follow these guidelines are more likely to have the results of their planning work incorporated into the Section 208 plan prepared by Ohio EPA. The Areawide Planning Agencies have established their own operating protocols, committees and processes to involve local governments in shaping their 208 plans.

Planning should account for long-range sewer and treatment needs by looking at projections for community growth and development. Comprehensive land use planning, where available, is an excellent tool that can help those assessing the sewage disposal needs of a community or group of communities. In highly populated areas, regional solutions involving several communities have proven to be a cost-effective means to solve sewage disposal problems.

TMACOG is one of Ohio's areawide agencies; it has a local role in developing areawide water quality plans—the entire project area is in their service area. TMACOG's website (http://www.tmacog.org/enviro_body.htm) describes the role of the Environmental Council, which oversees and manages the environmental planning functions of TMACOG:

> The Council recommends regional environmental policies and procedures to define and achieve TMACOG's mission for adoption by the Board of Trustees. Through these policies, the strategic, long-term Environmental Council goals of TMACOG are established, and the methods to achieve short-term tactical objectives are determined. The Environmental Council also establishes the administrative support necessary to achieve these goals and objectives.

8.6.2 Local Watershed Groups

Duck and Otter Creek Partnership, the Partners for Clean Streams (Maumee RAP), TMACOG and its many partners have been active in engaging the public in protecting the tributaries to the lower Maumee River and Lake Erie. These organizations emphasize educating stakeholders, and planning and implementing projects to control nonpoint source pollution from agricultural and rural home sewage sources.

8.6.3 Past and Ongoing Water Resource Evaluation

Ohio EPA has surveyed various sections of the project area. The Maumee River (lower) tributaries (HUC 04100009 09) excluding Duck Creek and including Otter Creek were evaluated in 2006, and the Lake Erie tributaries (HUC 04100010 07) excluding Otter Creek and including Duck Creek were evaluated in 2008. The *Biological and Water Quality Study of the Portage River Basin, Select Lake Erie Tributaries, and Select Maumee River Tributaries, 2006 - 2008* provides the results (Ohio EPA 2010a). Sampling in the Maumee River (lower) tributaries also occurred in 1992, 1997, and 1998 and sampling in the Lake Erie tributaries occurred in 1994 and 1998; the data were collected by Ohio EPA.

According to the *Ohio 2010 Integrated Water Quality Monitoring and Assessment Report* (Ohio

EPA 2010c), the next scheduled Ohio EPA evaluation of this watershed is in 2023. Because of a number of factors, schedules are subject to change.

All NPDES-permitted wastewater treatment facilities are required to routinely sample their effluent as a condition of their permits. Monitoring parameters and frequencies vary and are dictated by individual permit requirements according to pollutants of concern, plant design flow, and other considerations. In many cases, entities are also required to collect ambient water quality samples upstream and downstream of their discharge location to provide data regarding potential effects on stream water quality. NPDES-permitted dischargers are required to report their self-monitoring results to Ohio EPA monthly as a condition of their permits.

Multiple watershed restoration initiatives are ongoing in the Maumee Area of Concern (AOC) and are being coordinated by Partners for Clean Streams and their many community partners, such as Duck and Otter Creeks Partnership, TMACOG, Toledo Area Metroparks, The Nature Conservancy, and Western Lake Erie Waterkeeper. Projects range from stream restoration to wetland mitigation and sediment remediation studies to green storm water infrastructure. Agricultural incentives for nutrient and sediment reduction are led by the Natural Resources Conservation Service and the county soil and water conservation districts. In addition, numerous projects are identified in the Maumee AOC Stage 2 Watershed Restoration Plan (2006).

Early communications should take place between Ohio EPA and any potential collaborators to discuss research interests and objectives. Areas of overlap should be identified, and ways to make all parties' research efforts more efficient should be discussed. Ultimately, important questions can be addressed by working collectively and through pooling resources, knowledge, and data.

8.6.4 Adaptive Management

The watershed would benefit from an adaptive management approach to restoring water quality. An adaptive management approach allows for changes in the management strategy if environmental indicators suggest that the strategy is inadequate or ineffective. Adaptive management is recognized as a viable strategy for managing natural resources (Baydack et al. 1999).

If chemical water quality does not show improvement or waterbodies are still not attaining water quality standards after the improvement strategy has been carried out, a TMDL revision would be initiated. Ohio EPA would initiate the revision if no other parties wish to do so.

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