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Total Maximum Daily Loads for the White Oak Creek Watershed

White Oak Creek at Miller Ring Road

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Acronyms and Abbreviations

AWS	agricultural water supply
BMP	best management practice
CWH	coldwater habitat
CWS	community water supply
DMR	discharge monitoring report
EWH	exceptional warmwater habitat
HSTS	home sewage treatment system
HUC	hydrologic unit code
IBI	Index of Biotic Integrity
ICI	Invertebrate Community Index
ILSAM	Illinois Streamflow Assessment Model
IRED	interim registration eligibility determination
IWS	industrial water supply
LA	load allocation
LRW	limited resource water
LTA	long term average
MDL	maximum daily limit
MOA	memorandum of agreement
MRLC	Multi-Resolution Land Characteristics (multiple federal agencies)
NASS	National Agricultural Statistics Service (U.S. Department of Agriculture)
NLCD	National Land Cover Database
NPDES	National Pollutant Discharge Elimination System
OAC	Ohio Administrative Code
ODNR	Ohio Department of Natural Resources
Ohio DOA	Ohio Department of Agriculture
Ohio EPA	Ohio Environmental Protection Agency
PCR	primary contact recreation
PWS	public water supply
QHEI	Qualitative Habitat Evaluation Index
RED	registration eligibility determination
RM	river mile
SCR	secondary contact recreation
SSO	sanitary sewer overflow
STEPL	Spreadsheet Tool for Estimating Pollutant Loads
SWCD	soil and water conservation district
TMDL	total maximum daily load
TSS	total suspended solids
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	wasteload allocation
WTP	water treatment plant
WWH	warmwater habitat
WWTP	wastewater treatment plant

1 INTRODUCTION

The White Oak Creek watershed drains approximately 234 square miles and consists of two 10-digit Assessment Units: *Headwaters White Oak Creek* (05090201 09) and *Sterling Run-White Oak Creek* (05090201 10). White Oak Creek, also referred to as Whiteoak Creek, is in southwestern Ohio near the Ohio-Kentucky border. In 2006 the Ohio Environmental Protection Agency (Ohio EPA) evaluated the biological health and water quality of White Oak Creek. The results indicate that most waterbody segments are in partial attainment or nonattainment of the warmwater habitat (WWH), exceptional warmwater habitat (EWH), and coldwater habitat (CWH) designated aquatic life uses. Additionally, several segments do not support the Primary Contact Recreation (PCR) use and one segment does not support its public water supply (PWS) designation. Physical habitat impairments were also determined using the Qualitative Habitat Evaluation Index (QHEI) scores, which measure the overall habitat and ecosystem health (Rankin 1989). Table 1 summarizes the impairment causes and sources reported on Ohio's most recent section 303(d) *Integrated Water Quality Monitoring and Assessment Report* (Ohio EPA 2008a).

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 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. The pollutant load is allocated among all sources in the watershed and voluntary (for nonpoint sources) and regulatory (for point sources) control measures are identified for attaining the source allocations. An implementation plan is also typically established to ensure that the control measures are effective at restoring water quality and all designated water uses.

The overall goals and objectives in developing the White Oak Creek TMDLs were to

- Assess the water quality within the White Oak Creek watershed and identify key issues associated with the impairments and potential pollutant sources.
- Use the best available science and available data to determine water quality conditions that will result in all streams fully supporting their designated uses.
- Prepare a final TMDL report that meets the requirements of the Clean Water Act and provides information to the key stakeholders that can be used to facilitate implementation activities to improve water quality.

The results of the TMDL process for the White Oak Creek watershed are documented in this report. Section 2 briefly describes the White Oak Creek watershed and applicable water quality standards, Section 3 summarizes the water quality characteristics of each impaired segment, Section 4 assesses the pollutant sources in the watershed, Section 5 describes the methodology used to estimate the current and allowable pollutant loads, and Section 6 presents the resulting TMDLs. Appendix A presents a discussion of streamflow estimation techniques, Appendix B presents the detailed TMDL reports for each station, Appendix C presents a discussion of the linear extrapolation of selected flow duration curves and linear interpolation of load duration curves, Appendix D presents a table of all Ohio EPA sample stations, Appendix E presents additional QHEI data, and Appendix F includes additional atrazine analyses. Appendix G presents supporting information for the implementation plan and Appendix H presents the justification for the 4B alternative for Town Run.

Table 1. Summary of section 303(d) listings in the White Oak Creek watershed

Assessment unit (HUC 10)[a]	Designated uses	Cause of impairments	Sources of impairments
Headwaters White Oak Creek (05090201 09) *Priority Points: 5*	Aquatic Life Use – **WWH** Recreation – **PCR** Water Supply – AWS, IWS, PWS[b]	■ Low Flow Alterations ■ Sedimentation/Siltation ■ Nutrient/Eutrophication Biological Indicators ■ Direct Habitat Alterations ■ Dissolved Oxygen ■ Ammonia (Total) ■ Phosphorus (Total)	■ Unrestricted Cattle Access ■ Manure Runoff ■ Crop Production (Crop Land or Dry Land) ■ Urban Runoff/Storm Sewers ■ Channelization ■ Loss of Riparian Habitat ■ On-Site Treatment Systems (Septic Systems or Similar Decentralized Systems)
Sterling Run - White Oak Creek (05090201 10) *Priority Points: 8*	Aquatic Life Use - **CWH**[c], **EWH**, **WWH** Recreation – PCR[c] Water Supply – AWS, IWS, **PWS**[d]	■ Nutrient/Eutrophication Biological Indicators ■ Low Flow Alterations ■ Sedimentation/Siltation ■ Dissolved Oxygen ■ Phosphorus (Total) ■ Atrazine	■ Upstream Source ■ Crop Production (Crop Land or Dry Land) ■ Sanitary Sewer Overflows (Collection System Failures) ■ Upstream Impoundments ■ Municipal Point Source Discharges

[a]White Oak Creek is also referred to as Whiteoak Creek.

[b]East Fork White Oak Creek is listed as a PWS in OAC-3745-1-17; however, the PWS is inactive. The revised rules reflect that the beneficial use applies but the PWS criteria do not.

[c]Town Run was designated limited resource water (LRW) and secondary contact recreation (SCR) in OAC-3745-1-17. Ohio EPA re-designated Town Run to CWH and PCR during the rule revisions that were adopted as final on July 9, 2009. Also, Ohio EPA has prepared a Category 4B decision document for the aquatic life use designation of this stream. See Appendix H.

[d]Sterling Run at river mile (RM) 6.47 (Mount Orab) is designated as PWS.

AWS = agricultural water supply, CWH = coldwater habitat; EWH = exceptional warmwater habitat; IWS = industrial water supply; PCR = primary contact recreation; PWS = public water supply; WWH = warmwater habitat

Bold designated uses are listed as impaired in the *2008 Ohio EPA Integrated Water Quality Monitoring and Assessment Report* (Ohio EPA 2008a).

2 DESCRIPTION OF THE WATERSHED AND WATERBODIES

This section provides a brief background of the White Oak Creek watershed and to present the water quality standards that will be used in TMDL development. Extensive descriptions of the watershed are also available in the *White Oak Creek Watershed Action Plan and Inventory* (Dragoo 2004) and *Biological and Water Quality Study of the White Oak Creek Watershed, 2006* (Ohio EPA 2008b).

2.1 Description of the White Oak Creek Watershed

White Oak Creek drains a 234-square-mile watershed in southwestern Ohio (Figure 1). The watershed is within the glaciated Interior Plateau (IP) ecoregion, which is relatively flat with fertile lowlands. The IP ecoregion is characterized by agriculture (50 percent) and forested land (37.7 percent). Developed land is limited to 8.6 percent of the ecoregion. Its underlying geology primarily consists of Mississippian- to Ordovician-age limestone, chert, sandstone, siltstone, and shale.

Flowing from north to south, White Oak Creek is divided between two counties and eventually meets the Ohio River near Higginsport. The watershed is within Brown and Highland counties. East Fork White Oak Creek, Little North Fork White Oak Creek, and North Fork White Oak Creek headwaters all originate in Highland County; Sterling Run's headwaters are within Brown County. Villages within the watershed include Georgetown, Mount Orab, Mowrystown, and Sardinia; there are numerous small, unincorporated communities. Grant Lake, in the Sterling Run subwatershed, is the only large lake in the White Oak Creek watershed. It is being filled with sediment, likely derived from agricultural practices, and the Ohio Division of Wildlife might let it to revert to a wetland (Ohio EPA 2008b).

The White Oak Creek mainstem is fed by several large tributaries: East Fork White Oak Creek (hereafter referred to as *East Fork*), North Fork White Oak Creek (hereafter referred to as *North Fork*), and Sterling Run. The watershed is divided into two 10-digit assessment units and further subdivided into seven 12-digit hydrologic unit code (HUC) subwatersheds as presented in Table 2.

Table 2. Assessment unit and 12-digit HUC designations for the White Oak Creek watershed

HUC 10	HUC 12	Watershed name	Drainage area (acres)	Drainage area (square miles)
05090201 09	01	Headwaters East Fork White Oak Creek	27,877	43.56
	02	Slabcamp Run-East Fork White Oak Creek	22,253	36.33
	03	Little North Fork-North Fork White Oak Creek	23,610	36.89
	04	Flat Run-North Fork White Oak Creek	19,451	30.39
05090201 10	01	Sterling Run	18,921	29.56
	02	Miranda Run-White Oak Creek	25,446	39.76
	03	Big Run-White Oak Creek	11,190	17.48
		Total	**149,748**	**233.97**

Note: White Oak Creek is also referred to as Whiteoak Creek.

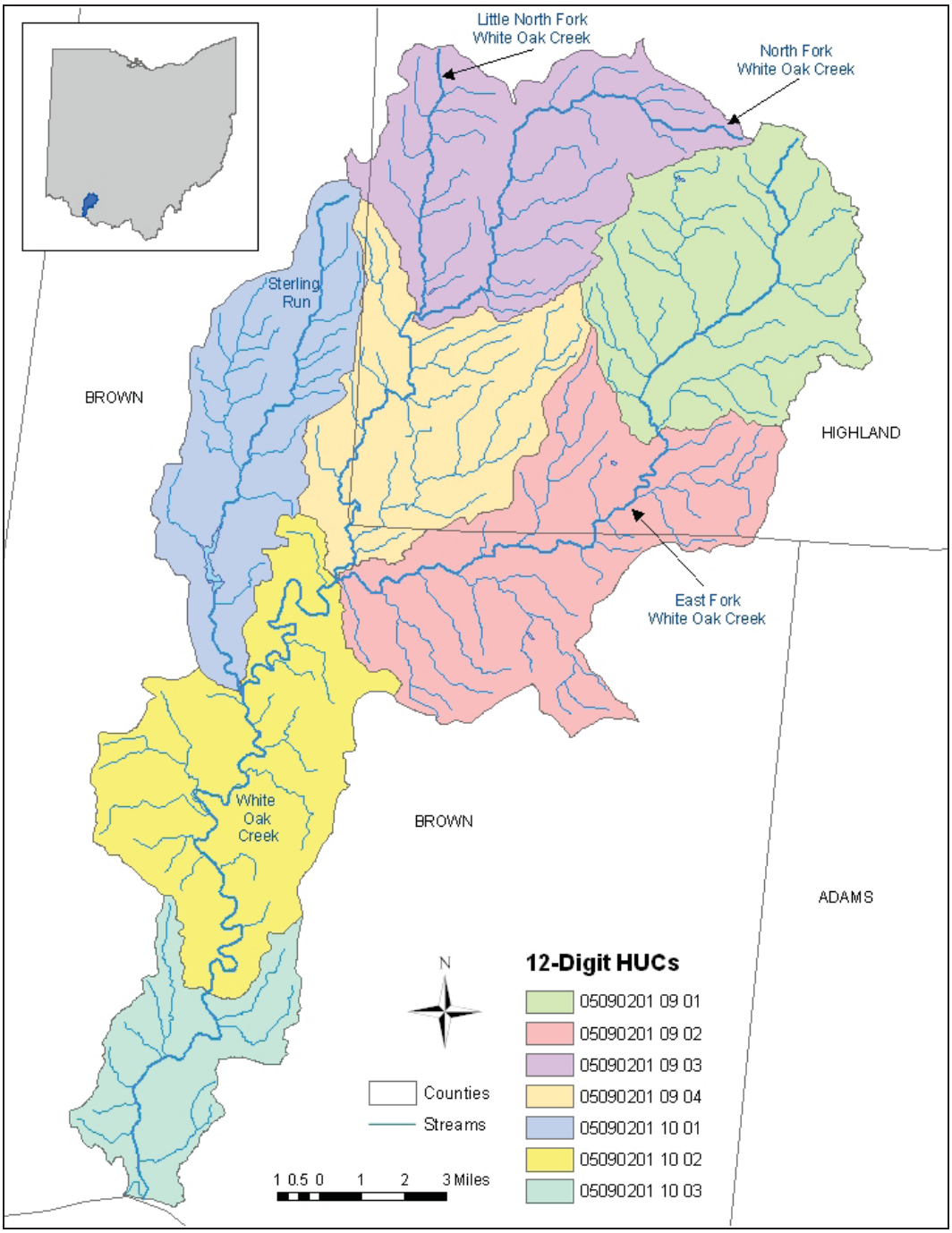

Figure 1. White Oak Creek watershed.

2.2 Land Use and Land Cover within the White Oak Creek Watershed

The land use/land cover for the White Oak Creek watershed was extracted from the Multi-Resolution Land Characteristics (MRLC) Consortium 2001 National Land Cover Database (Table 3). Figure 2 shows that land use in each 12-digit HUC subwatershed varies significantly.

Table 3. Land use and land cover characteristics of the White Oak Creek watershed

Land cover/Land use	Area (acres)	Area (square miles)	Percent of watershed
Open Water	401	0.63	0.3%
Developed, Open Space	7,063	11.04	4.7%
Developed, Low Intensity	2,360	3.69	1.6%
Developed, Medium Intensity	560	0.87	0.4%
Developed, High Intensity	196	0.31	0.1%
Barren Land (Rock/Sand/Clay)	50	0.08	0.0%
Deciduous Forest	37,296	58.27	24.9%
Evergreen Forest	413	0.64	0.3%
Mixed Forest	648	1.01	0.4%
Shrub/Scrub	304	0.48	0.2%
Grassland/Herbaceous	758	1.18	0.5%
Pasture/Hay	16,538	25.84	11.0%
Cultivated Crops	83,122	129.88	55.5%
Emergent Herbaceous Wetlands	39	0.06	0.0%
Total	**149,749**	**233.98**	**100.00%**

Note: Area was rounded to the nearest acre and one-hundredth of a square mile, and percentages were rounded to the nearest tenth of a percent; the summations of land cover/land use might not equal the value reported in the final row because of rounding.

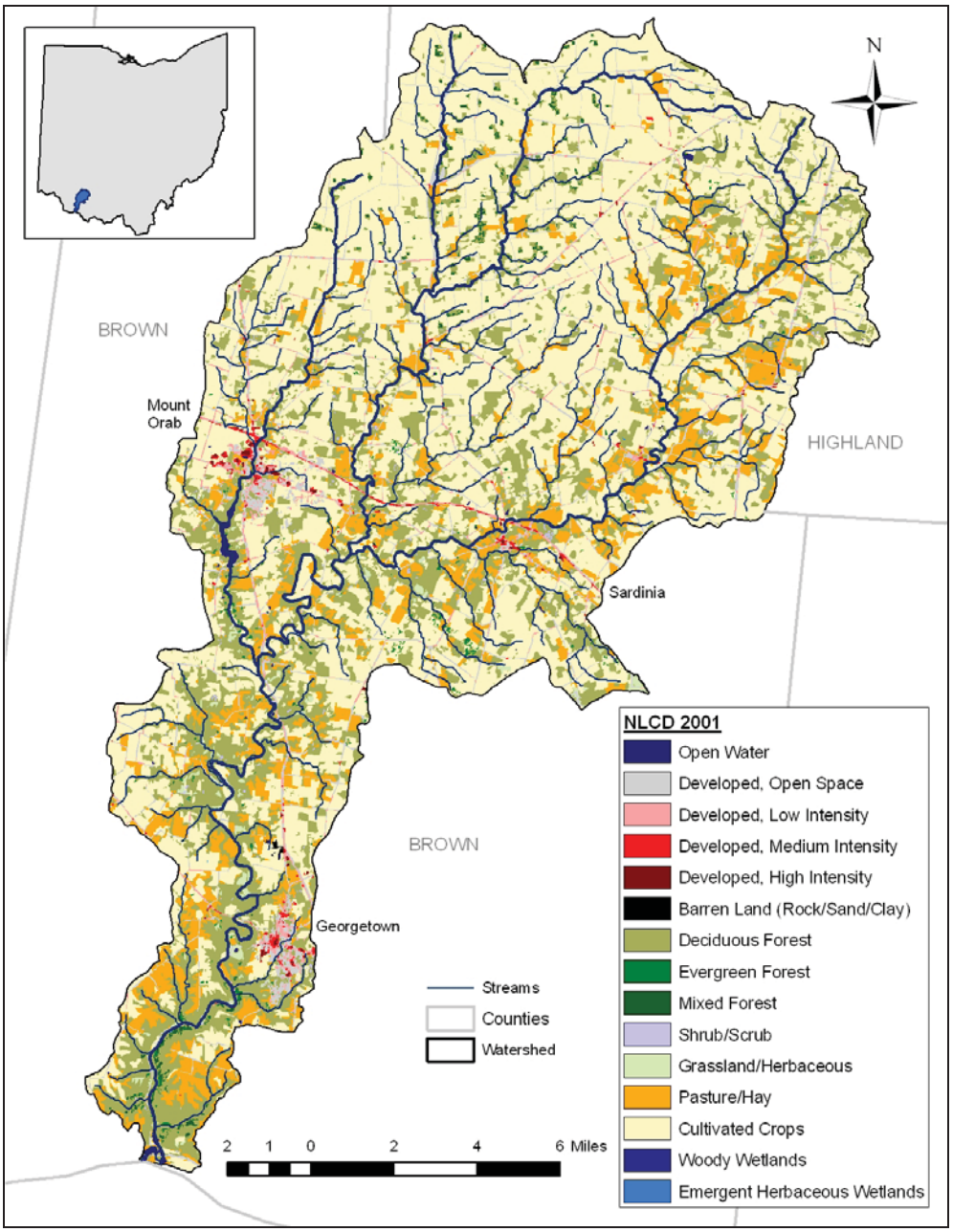

Figure 2. Land use and land cover within the White Oak Creek watershed.

Further investigation of each 12-digit HUC indicates that land use significantly varies in each subwatershed (Table 4 and Table 5). None of the segments of White Oak Creek are heavily influenced by developed land cover (open space and low-, medium-, and high-intensity). With the exception of *Big Run-White Oak Creek* (HUC 05090201 10 03), the two most dominant land covers in the subwatersheds are cultivated crops (range: 18 to 78 percent) and deciduous forest (range: 11 to 46 percent). In *Big Run-White Oak Creek*, the three most dominant land covers are deciduous forest (46 percent), pasture/hay (22 percent), and cultivated crops (18 percent). This subwatershed also has the highest percentages of evergreen forest (0.7 percent) and mixed forest (1.6 percent), which tend to be present along the mainstem of White Oak Creek and some of the tributaries. The mainstem's and tributaries' riparian corridors tend to be more forested in the southern part of the watershed. The subwatershed (*Big Run-White Oak Creek*)

with the highest percentage of cultivated crops (78 percent) has the lowest percentages of deciduous forest (11.3 percent) and pasture/hay (3.7 percent).

The major tributaries to White Oak Creek include East Fork, North Fork, and Sterling Run. East Fork has a diverse distribution of land cover, with 69 percent agricultural (crop cultivation and pasture/hay), 24 percent forested (deciduous, evergreen and mixed), and 6 percent developed land. The North Fork (including Little North Fork) has the highest amount of agriculture (77 percent), the least amount of forested land (17 percent), and the least amount of developed land (6 percent, tied with East Fork). Sterling Run has the highest amount of developed land (11 percent), because of the village of Mount Orab, and second-lowest amount of forested land (23 percent).

Table 4. 2001 NLCD land use by subwatershed (square miles)

	05020901 09		**05020901 10**	
Land cover/Land use	**East Fork (01 & 02)**	**Little North Fork & North Fork (03 & 04)**	**Sterling Run (01)**	**White Oak Creek (02 & 03)**
Open Water	0.07	0.02	0.29	0.24
Developed, Open Space	3.44	2.90	1.74	2.95
Developed, Low-Intensity	1.08	0.77	0.98	0.85
Developed, Medium-Intensity	0.19	0.13	0.31	0.25
Developed, High-Intensity	0.06	0.02	0.13	0.10
Barren Land (Rock/Sand/Clay)	0.01	--	0.00	0.07
Deciduous Forest	18.89	10.96	6.48	**21.95**
Evergreen Forest	0.26	0.07	0.09	0.24
Mixed Forest	0.01	0.61	0.09	0.30
Shrub/Scrub	0.22	0.09	0.05	0.11
Grassland/Herbaceous	0.37	--	0.10	0.72
Pasture/Hay	11.14	3.53	1.83	9.34
Cultivated Crops	**44.14**	**48.18**	**17.47**	20.08
Emergent Herbaceous Wetlands	0.01	0.00	0.00	0.05
Total	79.89	67.28	29.56	57.24

Note: **Bolded** area represents the largest relative area for the subwatershed. The summations of land cover/land use might not equal the value reported in the final row because of rounding.

Table 5. 2001 NLCD land use by subwatershed (percent of total area)

Land cove/Land use	05090201 09		05090201 10	
	East Fork (01 & 02)	Little North Fork & North Fork (03 & 04)	Sterling Run (01)	White Oak Creek (02 & 03)
Open Water	0.1%	0.0%	1.0%	0.4%
Developed, Open Space	4.3%	4.3%	5.9%	5.2%
Developed, Low-Intensity	1.4%	1.1%	3.3%	1.5%
Developed, Medium-Intensity	0.2%	0.2%	1.0%	0.4%
Developed, High-Intensity	0.1%	0.0%	0.4%	0.2%
Barren Land (Rock/Sand/Clay)	0.0%	--	0.0%	0.1%
Deciduous Forest	23.6%	16.3%	21.9%	**38.3%**
Evergreen Forest	0.3%	0.1%	0.3%	0.4%
Mixed Forest	0.0%	0.9%	0.3%	0.5%
Shrub/Scrub	0.3%	0.1%	0.2%	0.2%
Grassland/Herbaceous	0.5%	--	0.3%	1.3%
Pasture/Hay	13.9%	5.2%	6.2%	16.3%
Cultivated Crops	**55.2%**	**71.6%**	**59.1%**	35.1%
Emergent Herbaceous Wetlands	0.0%	0.00	0.0%	0.1%
Total	100.0%	100.0%	100.0%	100.0%

Note: **Bolded** area represents the largest relative area for the subwatershed. The summations of land cover/land use might not equal the value reported in the final row because of rounding.

3 WATER QUALITY STANDARDS AND WATERBODY IMPAIRMENTS

This section presents the water quality standards for the pollutants of concern in the White Oak Creek watershed and then summarizes the waterbody impairments.

3.1 Water Quality Standards

The purpose of developing a TMDL is to identify the pollutant loading that a waterbody can receive while still meeting water quality standards. Under the Clean Water Act, every state must adopt water quality standards to protect, maintain, and improve the quality of the nation's surface waters. These standards represent a level of water quality that will support the Clean Water Act's goal of *swimmable/fishable* waters. Water quality standards consist of three components: designated uses, numeric or narrative criteria, and an antidegradation policy. Ohio's water quality standards are summarized in Table 6 and explained in greater detail below.

Table 6. Ohio water quality standards

Component	Description
Designated Use	Designated use reflects how the water can potentially 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).[a]
Numeric Criteria	Chemical criteria are the allowable concentrations of pollutants that can be present while still protecting the designated use of the waterbody. Biological criteria indicate the health of the in-stream biological community. Three indices (composed of aggregated metrics) are used in Ohio: ▪ Index of Biotic Integrity (IBI) (measures fish health). ▪ Modified Index of well being (MIwb) (measures fish health). ▪ Invertebrate Community Index (ICI) (measures benthic macroinvertebrate 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 may 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. For more information, see http://www.epa.ohio.gov/dsw/wqs/index.aspx.

[a]According to OAC 3745-1-07(A)(1) each waterbody is assigned a designated use. Any streams in Ohio are undesignated still must attain the chemical criteria associated with warm water habitat designation. There is no similar protection for recreational use.

3.1.1 Designated Uses

White Oak Creek and its tributaries (except Town Run) are designated by Ohio EPA as either WWH or EWH. Similarly, all the streams in the White Oak Creek watershed (except Town Run) are designated as PCR (OAC 3745-1-17). Ohio EPA recently revised some of the designations through a rule revision that was formally adopted on July 9, 2009. Town Run is now designated as CWH and PCR and Ohio EPA has prepared a Category 4B decision document for the aquatic life use designation of this stream (Appendix H). Total phosphorus and nitrate plus nitrite TMDL analyses for Town Run are included in this report.

Water Supply Uses for all waterbodies in the watershed are designated as Agricultural Water Supply (AWS) and Industrial Water Supply (IWS). Sterling Run river mile (RM) 6.47 (X02K14) is designated as

PWS because it is the location of the village of Mount Orab water treatment plant's (WTP's) PWS intake. An additional PWS for the village of Sardinia was formerly designated on East Fork; however, the PWS is historic and Ohio EPA's recent rule revision noted the inactivity. The beneficial use still applies, though the PWS criteria do not.

3.1.2 Numeric Criteria

This section presents the numeric criteria for the pollutants of concern in the White Oak Creek watershed.

3.1.2.1 Fecal coliform and *Escherichia Coli*

Numeric criteria exist in Ohio to protect contact recreation designated uses. Standards have been established to protect three different designated uses: bathing waters, primary contact, and secondary contact. The impaired streams discussed in this report are designated as PCR:

> *Primary contact*: these are waters that, during the recreation season, are suitable for full-body contact recreation such as, but not limited to, swimming, canoeing, and scuba diving with minimal threat to public health as a result of water quality (Ohio EPA 2008e, OAC-3745-1-07(B)(4)(b))

Table 7 shows that the primary contact *E. coli* criterion of 126 colony forming units per 100 milliliters (cfu/100 mL) is identical to the bathing water *E. coli* criterion as a geometric mean. However, this is not the case for fecal coliform. Ohio EPA's regulations (Ohio EPA 2008e, OAC 3745-1-07, Table 7-13) state

> For each designation at least one of the two bacteriological standards (fecal coliform or *E. coli*) must be met.

Therefore, when both fecal coliform and *E. coli* data are available from the same sample, if at least one of the two standards is met, the waterbody is in attainment of the recreational use. If data for only one of the two bacteria groups are available, the available group must be solely used to determine exceedances of recreational standards. Note that the standards apply only during the recreation season (May 1 to October 15).

Table 7. Fecal coliform and *E. coli* standards for Ohio (applicable May 1 through October 15)

Parameter	Bathing waters		Primary contact		Secondary contact
	Geometric mean[a]	Instantaneous[b]	Geometric mean[a]	Instantaneous[b]	Instantaneous[b]
Fecal Coliform	200/100 mL	400/100 mL	1,000/100 mL	2,000/100 mL	5,000/100 mL
E. coli	126/100 mL	235/100 mL	126/100 mL	298/100 mL	576/100 mL

[a]Geometric mean bacteria content should not exceed this standard based on not less than five samples within a 30-day period.
[b]Bacteria content should not exceed this standard in more than 10 percent of the samples taken in any 30-day period.

3.1.2.2 Ammonia

The TMDL target for ammonia is 1.0 milligram per liter (mg/L) and applies only to Bells Run (the only stream listed as impaired by ammonia). Bells Run is designated as WWH and has very limited data. Ammonia is a regulated parameter, as discussed in Rule 7 of the *State of Ohio Water Quality Standards* (Ohio EPA 2008d). The target chosen was the most restrictive of targets derived from three sets of data using the *State of Ohio Water Quality Standards* (Ohio EPA 2008d, Tables 7-1 and 7-5). The target of 1.0 mg/L represents the outside mixing zone 30-day average for WWH streams during March to November with a temperature of 25 degrees Celsius and a pH of 8.0 standard units.

3.1.2.3 Atrazine

The target for atrazine is a daily maximum of 35 micrograms per liter (µg/L). This target applies to the PWS in Sterling Run at RM 6.47 (OH0801011) and Ohio EPA's water quality sample station at the PWS, Sterling Run RM 6.47 (X02K14). This value, 35 µg/L, represents a target necessary to ensure that atrazine concentrations do not exceed a 90-day rolling average of 3.0 µg/L. The value of 3.0 µg/L is based on numeric criteria established by Ohio for waters within 500 yards of a PWS intake (Ohio EPA 2008e, 3745-1-34(C)(2)(A) and Table 34-1). The value is also consistent with U.S. EPA maximum contaminant levels for atrazine in drinking water (U.S. EPA 2003a, p. 1). A maximum daily limit (MDL) of 35 µg/L was calculated using the following formula:

$$MDL = LTA \times e^{[(z \times \sigma) - (0.5 \times \sigma^2)]}$$

where LTA is the long term average, e is the base of the natural logarithm, z is the z-score associated with the target recurrence interval, and σ^2 is the natural logarithm of the quantity of the square of the coefficient of variation plus one (U.S. EPA 2007b). For the calculation, see Appendix F.

Ohio EPA has also identified a "Community Action Level" of a daily maximum of 3.0 µg/L because 3.0 µg/L is the de facto daily standard used by the Mount Orab WTP. The WTP does not pump water from Sterling Run when samples exceed 3.0 µg/L or are anticipated to exceed 3.0 µg/L[1]. Maintaining atrazine levels below this target will result in reduced treatment costs for the community, reduced risk to human health, and allowing the drinking water system to fully utilize the Sterling Run water source. For a description of the atrazine sampling at the PWS intake, see Section 3.4.

For the remainder of this report, the TMDL daily target is 35 µg/L and the community action level daily target is 3.0 µg/L.

3.1.3 Narrative Criteria

Only narrative criteria are available for nutrient-related causes of impairment. TMDL targets are therefore needed to compare existing water quality conditions to desired water quality conditions and to derive *maximum daily loads*. Ohio EPA (1999) has established proposed water quality targets for nutrients that were applied for TMDL development purposes in the White Oak Creek watershed (Table 8).

Table 8. Nutrient TMDL target values for the White Oak Creek watershed

Water quality parameter	Drainage area	WWH target (mg/L)	EWH target (mg/L)
Nitrate Nitrogen	Headwaters (< 20 square miles)	1.0	0.5
	Wadeable (20 ≥ to < 200 square miles)	1.0	0.5
Total Phosphorus	Headwaters (< 20 square miles)	0.08	0.05
	Wadeable (20 ≥ to < 200 square miles)	0.10	0.05

TMDL targets for water quality parameters not specifically addressed in Ohio EPA's water quality standards were derived from state reference site statistics (Ohio EPA 1999).

[1] John Van Harlingen, operator, Mount Orab WTP, telephone conversation and email correspondence, August 2008.

The total phosphorus target for Town Run is 0.1 mg/L. Normally, a CWH stream would be subject to the EWH target; however, in this case, Ohio EPA has decided that 0.1 mg/L is appropriate for Town Run; refer to Section 6.2.3 for a discussion of this decision.

The guideline values for total suspended solids (TSS) are shown in Table 9. The TSS TMDLs presented in Section 6 use statewide reference site 75th percentile statistics for TSS targets (Ohio EPA 1999).

Table 9. Suggested TSS targets for White Oak Creek derived from state reference site statistics

Water quality parameter	Reference site statistic	Drainage area	Target value (mg/L)
Total Suspended Solids	75th percentile	Headwaters (< 20 square miles)	16
		Wadeable (20 ≥ to < 200 square miles)	24.75
		Boating (≥ 200 square miles)	39

Using TSS as an indicator of sediment in streams 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 be 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. Because of the lack of bed load and other sediment data throughout the White Oak Creek watershed, TSS has been used as a surrogate for the sediment impairment. QHEI and metric scores will be used to supplement the sediment analyses.

3.2 Waterbody Impairments

Ohio EPA identified ten segments in the White Oak Creek watershed that require TMDLs. The segments are present in HUCs listed as impaired in the *2008 Integrated Water Quality Monitoring and Assessment Report* (hereafter referred to as the *Integrated Report*; Ohio EPA 2008a) for one or more of the following impairments: atrazine, ammonia, habitat, nitrate, or total phosphorus (Table 10). Water quality bacteria data for four additional segments were in excess of standards, and, therefore, TMDLs were also generated for these segments.

Ohio EPA listed three types of habitat impairment: direct habitat alterations, low flow alterations, and siltation. All the habitat-impaired segments included siltation impairment; therefore, TSS data were used as a surrogate parameter to represent siltation. Only segments that do not fully meet their designated uses are discussed in this section. Data collected from segments that fully meet their designated uses are presented for comparison purposes only. Throughout this section, stations are displayed in figures with headwaters on the left and downstream stations to the right, and stations are displayed in tables with the headwaters on the top and downstream stations below. For descriptions of Ohio EPA sample stations, see the table in Appendix D. For a full description of water quality sampling and results, see the *Biological and Water Quality Study of the White Oak Creek Watershed, 2006* (Ohio EPA 2008b).

Table 10. Impairments for White Oak Creek

12-Digit HUC (05090201)	Waterbody[a]	Designated uses[b]	TMDL parameters	Data source (2006 unless indicated)[c]
09 01	East Fork White Oak Creek	PCR	Fecal coliform	Ohio EPA – DES
	Tributary to East Fork White Oak Creek @ RM 15.52	PCR	Fecal coliform	Ohio EPA – DES
09 02	Bells Run	WWH	Ammonia, Dissolved Oxygen[d], Habitat[e], Total Phosphorus	Ohio EPA – DES Ohio EPA – EAS
		PCR	Fecal coliform	Ohio EPA – DES
	Slabcamp Run	WWH	Habitat[e,f]	Ohio EPA – EAS
		PCR	Fecal coliform	Ohio EPA – DES Sardinia WWTP (2003–2006)
09 03	North Fork White Oak Creek	WWH	Habitat[e,f,g], Nitrate	Ohio EPA – DES Ohio EPA – EAS
		PCR	Fecal coliform	Ohio EPA – DES
	Little North Fork White Oak Creek	WWH	Habitat[e,f,g], Total Phosphorus	Ohio EPA – DES Ohio EPA – EAS
09 04	Flat Run	WWH	Habitat[e,f]	Ohio EPA – EAS
10 01	Sterling Run	WWH	Dissolved, Oxygen[d], Habitat[e,f], Total Phosphorus	Ohio EPA – DES Ohio EPA – EAS
		PCR	Fecal coliform	Ohio EPA – DES
		PWS	Atrazine[c]	Ohio EPA – DES (2006, 2008) Syngenta (2004–2008)
	Tributary to Sterling Run @ RM 6.68	WWH	Dissolved, Oxygen[d], Habitat[e,f,g], Total Phosphorus	Ohio EPA – DES Ohio EPA – EAS
	Snapping Turtle Run	PCR	Fecal coliform	Ohio EPA – DES Mount Orab WWTP (2003–2006)
10 02	White Oak Creek	EWH	Habitat[e], Nitrate	Ohio EPA – DES Ohio EPA – EAS
10 03	Town Run	CWH	Ammonia[h], Nitrate, Total Phosphorus	Ohio EPA – DES

Notes:

CWH = cold water habitat, DES = Division of Environmental Services, EAS = Division of Surface Water Ecological Assessment Unit, EWH = exceptional warmwater habitat, PCR = primary contact recreation, PWS = public water supply, SCR = secondary contact recreation WWH = warmwater habitat, WWTP = wastewater treatment plant

[a]Streams and segments that fully meet their designated uses are not displayed.

[b]Only the designated uses that are not in full attainment are displayed.

[c]All data meet Level 3 specifications under Ohio's credible data law. Syngenta Crop Protection, Inc., collected data through the Mt. Orab WTP as part of an intensive monitoring program of community water systems. This sampling work was required by the January 2003 Atrazine Re-registration Eligibility Decision and subsequent Memorandum of Agreement (MOA) between U.S. EPA and the atrazine registrants (including Syngenta).

[d]Dissolved oxygen (DO) is listed as a cause of impairment in the *Integrated Report* (Ohio EPA 2008a). A TMDL will not be performed because improvements regarding nutrients and habitat will be beneficial toward improving DO.

[e]The habitat impairment is siltation.

[f]The habitat impairment is low flow alterations.

[g]The habitat impairment is direct habitat alteration.

[h]Ohio EPA has prepared a Category 4B decision document for the aquatic life use designation of this stream. See Appendix H.

Nine segments in *Headwater White Oak Creek* (HUC 05090201 09) do not fully attain their designated uses. All the streams in this HUC are designated as PCR and WWH. All the Ohio EPA data included in the analysis below were collected between July 2006 and September 2006. Personnel from the Sardinia wastewater treatment plant (WWTP) collected samples at stations upstream and downstream of the plant's effluent outfalls. Pertinent WWTP data (i.e., fecal coliform data from the discharge monitoring report [DMR]) were collected annually or semiannually between June 2003 and October 2006). DMR data were used when no Ohio EPA-collected bacteria data were available. The Highland County Southwest WWTP was recently constructed, and no data are available for this facility.

In *Sterling Run-White Oak Creek* (HUC 05090201 10) five segments did not fully attain their designated uses. All of the streams in this HUC are designated as PCR, and all but two are designated as WWH. Sterling Run RM 6.47 (X02K14) is designated as PWS. The previously mentioned exception is Town Run, which is designated as CWH. For a discussion of Town Run, see Section 3.1.1. The other exception is White Oak Creek, which is designated as EWH. All the Ohio EPA data were collected between February 2006 and December 2006 with additional atrazine sampling in May 2008 and June 2008. Syngenta data were collected at the PWS intake between June 2004 and September 2008. Personnel from Mount Orab WWTP collected samples at stations upstream and downstream of the plant's effluent outfalls. Pertinent WWTP data (i.e., fecal coliform data from the DMR) were collected annually or semiannually between June 2003 and October 2006. DMR data were used when no Ohio EPA-collected bacteria data were available.

Ohio EPA collected *E. coli* and fecal coliform at 21 stream stations across both 10-digit HUCs. At most stations, five fecal coliform samples were collected during a one-week time period. Thus, comparisons could be made to both the geometric mean and instantaneous components of the fecal coliform standards.

3.2.1 HUC 05090201 09 01

Ohio EPA did not identify any impaired segments that required TMDLs in this HUC 12, which was not listed for a water quality impairment in the *Integrated Report* (Ohio EPA 2008a); however, Tetra Tech determined that bacteria samples from two segments exceeded standards: East Fork RM 16.5 (X02K41) and East Fork (RM 15.52) Tributary RM 2.10 (XO2K40). There are nine Ohio EPA sample stations in this subwatershed (Figure 3). The data analysis for East Fork is presented in Section 3.2.2.2.

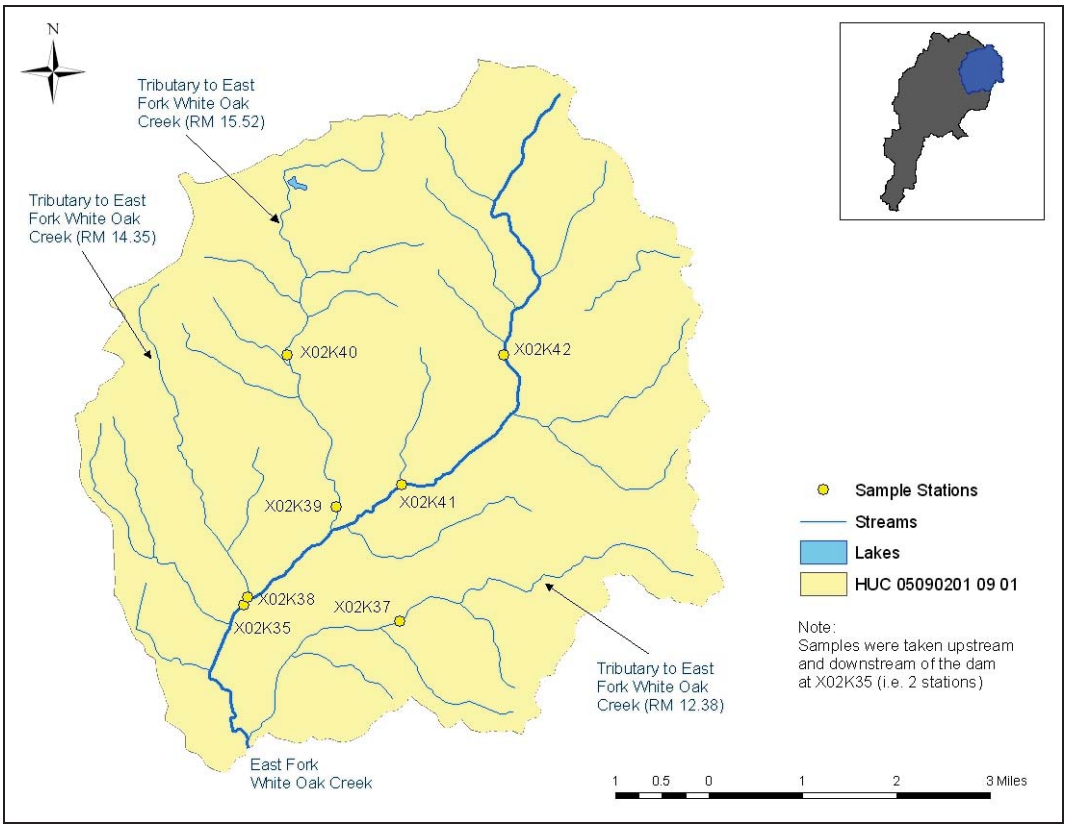

Figure 3. Sample stations in HUC 05090201 09 01.

The East Fork (RM 15.52) Tributary RM 2.10 (XO2K40) is designated as PCR. This segment is not in a HUC listed for any parameters in the *Integrated Report* (Ohio EPA 2008a), but water quality samples collected in 2006 exceeded both the instantaneous and geometric mean standards for *E. coli* and fecal coliform. Two stations were sampled on this tributary: East Fork (RM 15.52) Tributary RM 0.26 (XO2K39) and East Fork (RM 15.52) Tributary RM 2.10 (XO2K40) (see Figure 3). Bacteria samples were not collected at East Fork (RM 15.52) Tributary RM 0.26 (XO2K39). Table 11 summarizes the pertinent water quality data on this tributary.

Table 11. Bacteria samples collected at East Fork (RM 15.52) Tributary RM 0.26 (X02K40)

Parameter	# of samples	Begin date	End date	Min[a]	Max[a]	Geometric mean[a]	Exceed target[b]
E. coli	5	8/14/2006	8/18/2006	1,900	54,000	5,470	100%
Fecal coliform	5	8/14/2006	8/18/2006	3,000	70,000	11,100	100%

[a]The units for *E. coli* and fecal coliform are cfu/100 mL.

Displayed value is the percentage of individual samples that exceeded the instantaneous standards. For a discussion of targets, see Section 3.1.

A spatial analysis of the data for this stream is not possible because only one station was sampled. Ohio EPA reports that it observed unrestricted cattle access in this stream during the time of the sampling. This likely explains why all bacteria concentrations were in excess of the standards.

3.2.2 HUC 05090201 09 02

Two segments in this HUC 12 do not meet the designated uses, and the HUC 12 is listed in the *Integrated Report* (Ohio EPA 2008a): Bells Run, and Slabcamp Run. In addition, Tetra Tech determined that bacteria samples from two segments exceeded standards: East Fork, and Slabcamp Run. There are 12 Ohio EPA sample stations in this subwatershed (Figure 4).

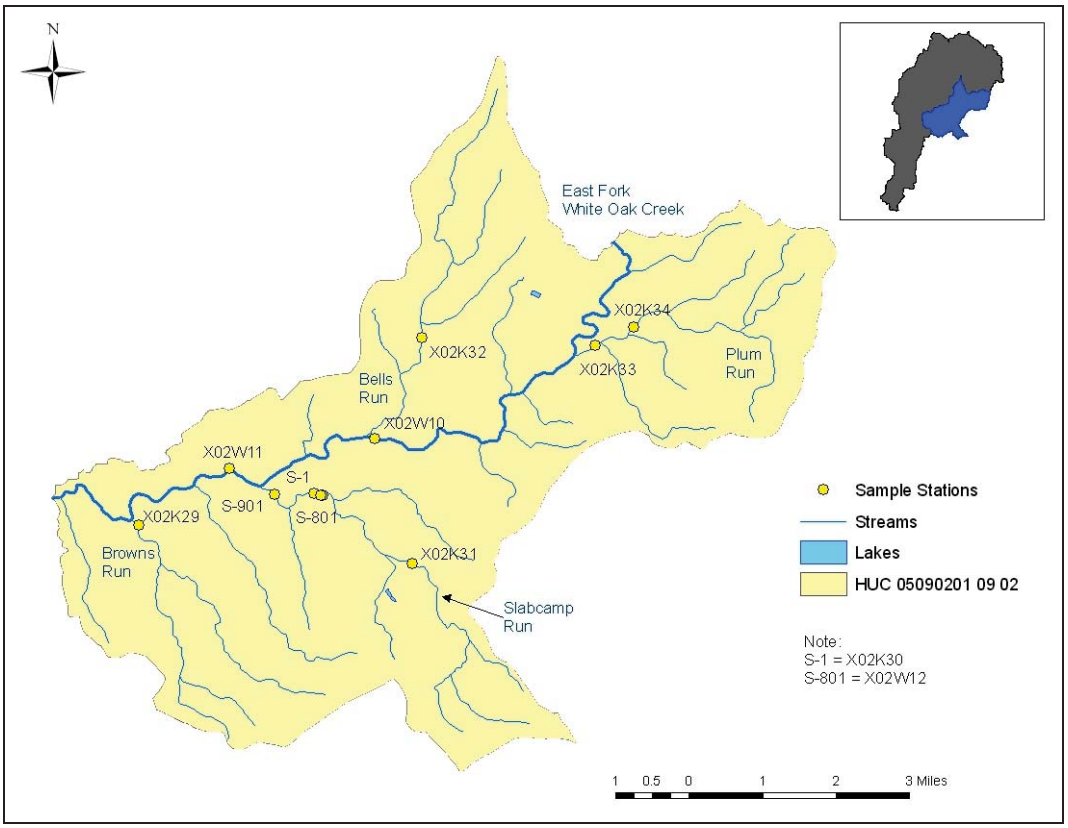

Figure 4. Sample stations in HUC 05090201 09 02.

3.2.2.1 Bells Run RM 1.97 (X02K32)

Bells Run is a tributary to East Fork and is designated as WWH and PCR. Ohio EPA identified three parameters that require TMDLs in Bells Run: ammonia, habitat (siltation), and total phosphorus. Water quality samples collected in 2006 exceeded the instantaneous standards for *E. coli* and fecal coliform and the geometric mean standard for *E. coli*. Table 12 summarizes the pertinent water quality data at the only station in Bells Run: Bells Run RM 1.97 (X02K32). This station encompasses a 4.0-square-mile drainage area.

Table 12. Water quality samples collected at Bells Run RM 1.97 (X02K32)

Parameter	# of samples	Begin date	End date	Min[a]	Max[a]	Average[a]	Exceed target[b]
Ammonia	5	7/27/2006	9/28/2006	0.172	19	7.9	60%
E. coli	5	8/14/2006	8/18/2006	40	3,000	335[c]	40%
Fecal coliform	5	8/14/2006	8/18/2006	340	3,700	923[c]	20%
Nitrate + nitrite	5	7/27/2006	9/28/2006	0.1	1.3	0.6	40%
Phosphorus, total	5	7/27/2006	9/28/2006	0.304	2.96	1.7	100%
TSS	5	7/27/2006	9/28/2006	5	174	45.4	40%

[a]The units for ammonia, nitrate + nitrite, total phosphorus, and TSS are mg/L; the units for *E. coli* and fecal coliform are cfu/100 mL.
[b]For a discussion of targets, see Section 3.1. For *E. coli* and fecal coliform, the displayed value is the percentage of individual samples that exceeded the instantaneous standards.
[c]The geometric mean, not the arithmetic mean, is displayed.

A spatial analysis of the data for Bells Run is not possible because only one station was sampled. Ohio EPA reports that cattle have unrestricted access to the stream near Bells Run RM 1.97 (X02K32); this likely explains the elevated bacteria, nutrient, and TSS concentrations.

3.2.2.2 East Fork White Oak Creek

East Fork is a tributary to White Oak Creek and is designated as PCR. East Fork was not part of a listed HUC in the *Integrated Report* (Ohio EPA 2008a). Water quality samples collected in 2006 exceeded the instantaneous and geometric mean standards for *E. coli* and fecal coliform. Table 13 and Table 14 summarize the pertinent water quality data at three of the five stations in East Fork: East Fork RM 10.48 (X02K35), East Fork RM 16.50 (X02K41), East Fork RM 18.69 (X02K42), East Fork RM 5.81 (X02W10), and East Fork RM 3.30 (X02W11) (see Figure 3 and Figure 4).

Table 13. *E. coli* samples collected in East Fork White Oak Creek

Station ID	Drainage area[a]	# of samples	Begin date	End date	Min[b]	Max[b]	Geometric mean[b]	Exceed target[c]
X02K41	39.0	5	8/14/2006	8/18/2006	4,700	14,000	8,400	100%
X02K35	12.7	5	8/14/2006	8/18/2006	100	300	160	60%
X02W11	70.0	5	8/14/2006	8/18/2006	60	900	266	80%

[a]Drainage areas were reported by Ohio EPA and are in square miles.
[b]The units for *E. coli* are cfu/100 mL.
[c]The displayed value is the percentage of individual samples that exceeded the instantaneous standards. For a discussion of targets, see Section 3.1.

Table 14. Fecal coliform samples collected in East Fork White Oak Creek

Station ID	Drainage area[a]	# of samples	Begin date	End date	Min[b]	Max[b]	Geometric mean[b]	Exceed target[c]
X02K41	12.7	5	8/14/2006	8/18/2006	5,400	22,000	13,500	100%
X02K35	39.0	5	8/14/2006	8/18/2006	120	370	239	0%
X02W11	70.0	5	8/14/2006	8/18/2006	260	1,100	446	0%

[a]Drainage areas were reported by Ohio EPA and are in square miles.
[b]The units for fecal coliform are cfu/100 mL.
[c]The displayed value is the percentage of individual samples that exceeded the instantaneous standards. For a discussion of targets, see Section 3.1.

East Fork RM 10.48 (X02K35) and East Fork RM 3.30 (X02W11) are in compliance with bacteria standards (see Section 3.1). At both stations, the fecal coliform data collected in 2006 do not exceed the 2,000 cfu/100 mL instantaneous standard or 1,000 cfu/100 mL geometric mean standard (Table 15 and Table 16, respectively). Thus, the stations are in compliance even though the *E. coli* data exceed the instantaneous standard and geometric mean standards.

Table 15. Bacteria samples collected at East Fork RM 10.48 (X02K35)

Sample date	Fecal coliform (cfu/100 mL)	*E. coli* (cfu/100 mL)
8/14/2006	120	100
8/15/2006	360	220
8/16/2006	350	300[a]
8/17/2006	140	160
8/18/2006	370	100
Geometric Mean	*239*	*160*[b]

[a]Exceeds *E. coli* instantaneous standard (298 cfu/100 mL).
[b]Exceeds *E. coli* geometric mean standard (126 cfu/100 mL).

Table 16. Bacteria samples collected at East Fork RM 3.30 (X02W11)

Sample date	Fecal coliform (cfu/100 mL)	*E. coli* (cfu/100 mL)
8/14/2006	260	60
8/15/2006	1,100	900[a]
8/16/2006	510	400[a]
8/17/2006	320	280
8/18/2006	380	220
Geometric Mean	*446*	*266*[b]

[a]Exceeds *E. coli* instantaneous standard (298 cfu/100 mL).
[b]Exceeds *E. coli* geometric mean standard (126 cfu/100 mL).

Decreasing trends are apparent with median bacteria concentrations from upstream to downstream along East Fork (Figure 5 and Figure 6). Samples collected from upstream East Fork RM 16.50 (X02K41) are a full order of magnitude larger than the two instantaneous standards. East Fork RM 16.50 (X02K41) is just downstream of a confluence with a small tributary that runs parallel to a road with numerous residences that are likely unsewered. Additionally, Ohio EPA reports that cattle have unrestricted access to East Fork upstream of this sample station. This could result in the observed elevated bacteria concentrations.

East Fork RM 3.30 (X02W11) is downstream of the confluence of Slabcamp Run and displays elevated concentrations of bacteria compared to the upstream station East Fork RM 10.48 (X02K35). Sardinia

WWTP discharges to Slabcamp Run, but it is not likely the source of any elevated fecal coliform concentrations in East Fork (see the Sardinia WWTP discussion in Section 3.2.2.3).

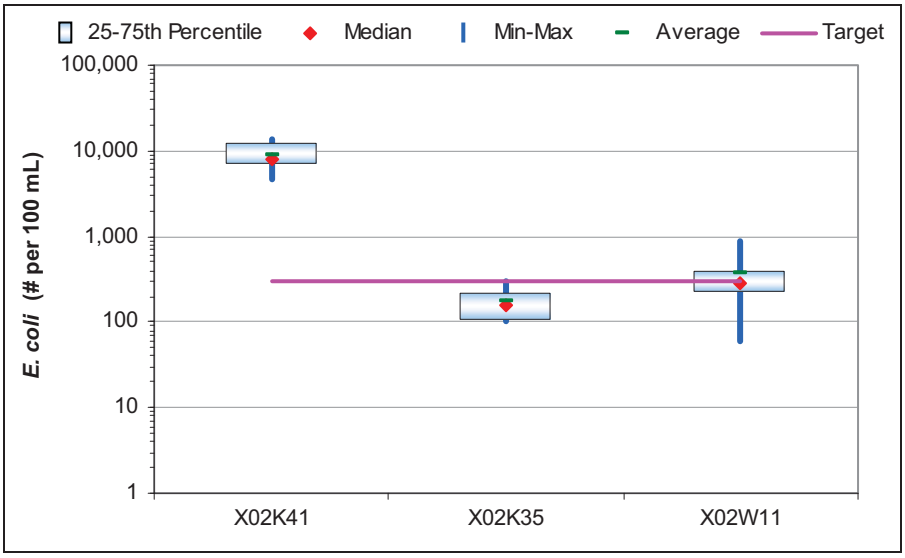

Figure 5. *E. coli* concentrations along East Fork White Oak Creek.

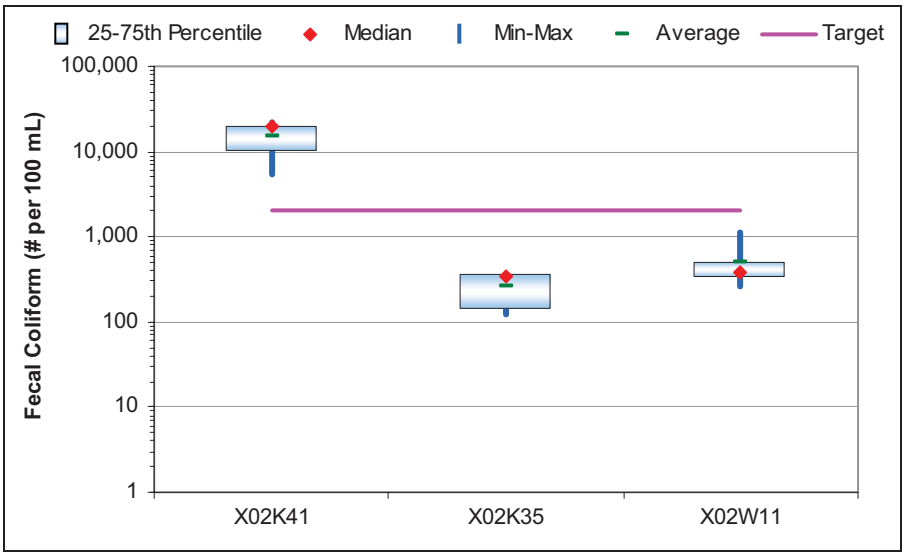

Figure 6. Fecal coliform concentrations along East Fork White Oak Creek.

3.2.2.3 Slabcamp Run

Slabcamp Run is a tributary to North Fork and is designated as WWH and PCR. Ohio EPA identified Slabcamp Run as requiring a TMDL for habitat (siltation and low flow alterations). Water quality samples also exceeded the instantaneous standard for fecal coliform. Samples were collected biannually, and the geometric mean standard does not apply. Table 17 and Table 18 summarize the pertinent water quality data at the four stations on Slabcamp Run (see Figure 4). DMR data from the Sardinia WWTP was used because Ohio EPA did not sample bacteria from Slabcamp Run.

Table 17. Fecal coliform samples collected in Slabcamp Run

Station ID	Drainage area	# of samples	Begin date	End date	Min[a]	Max[a]	Geometric mean[b]	Exceed target[c]
S-801	7.4[d]	7	6/10/2003	8/9/2006	50	267	123	0%
S-901	8.9[d]	8	6/10/2003	8/9/2006	20	5,150	401	12.5%

[a]The units for fecal coliform are cfu/100 mL.

[b]The geometric mean was calculated using all available data; samples were collected biannually.

[c]The displayed value is the percentage of individual samples that exceeded the instantaneous standards. For a discussion of targets, see Section 3.1. The target is not applicable to station S-1 and X02K30 because effluent samples were collected at these stations.

[d]Drainage areas were determined in USGS StreamStats using coordinates provided by Ohio EPA.

Table 18. TSS samples collected in Slabcamp Run

Station ID	Drainage area[a]	# of samples	Begin date	End date	Min (mg/L)	Max (mg/L)	Average (mg/L)	Exceed target[b]
X02K31	3.3	5	7/27/2006	9/28/2006	5	112	28.6	20%
X02W12	7.8	5	7/27/2006	9/28/2006	5	134	31.0	20%

[a]Drainage areas were reported by Ohio EPA and are in square miles.

[b]For a discussion of targets, see Section 3.1. The target is not applicable to station S-1 and X02K30 because effluent samples were collected at these stations.

There is an increasing trend in fecal coliform concentrations (median, average, and range) along Slabcamp Run (Figure 7). Between 5/5/2003 and 10/31/2006, 137 fecal coliform samples were collected from the effluent pipe at the Sardinia WWTP, and the samples ranged from 10 to 57,100 cfu/100 mL with an average of 1,527 cfu/100 mL. The only in-stream sample collected by Sardinia WWTP personnel that exceeded water quality standards occurred on 8/5/2005 at station S-901 (5,150 cfu/100 mL). The samples collected on 8/5/2005 at the outfall (S-1, 600 cfu/100 mL) and upstream (S-801, 50 cfu/100 mL) did not exceed water quality standards. Because sample times are not provided in the DMR data, it is not possible to determine if the WWTP is the source of the downstream exceedance on 8/5/2005. In addition, there are no known combined sewer overflows or sanitary sewer overflows in the area that might be contributing bacteria. During 2006 field sampling, Ohio EPA personnel observed sewage sludge in the stream, which could be, in part, responsible for elevated fecal coliform concentrations. There is a slight decreasing trend with median TSS concentrations, a slight increasing trend with average TSS concentrations, and a decreasing trend with 25th to 75th percentile range of TSS concentrations. However, there is no apparent increasing or decreasing trend with the range (minimum to maximum) of TSS concentrations (Figure 8).

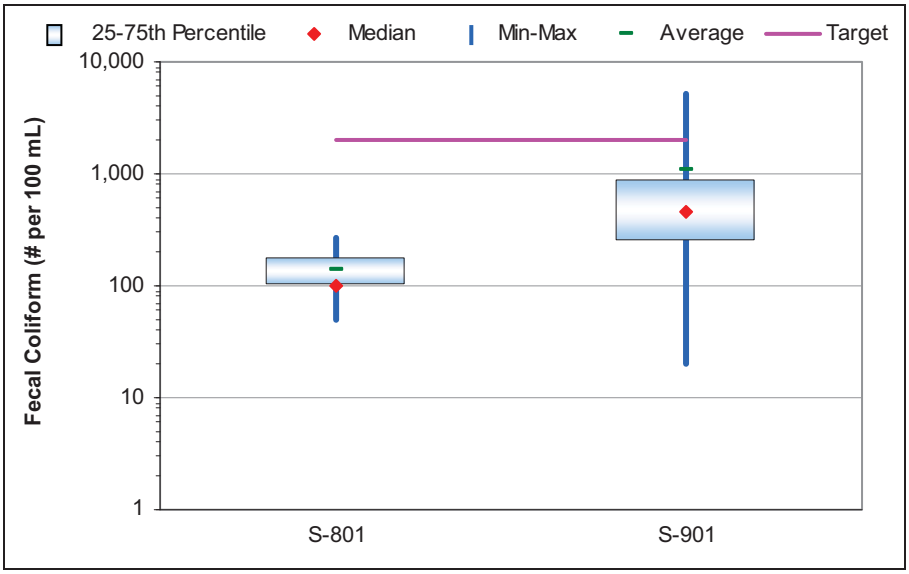

Figure 7. Fecal coliform concentrations along Slabcamp Run.

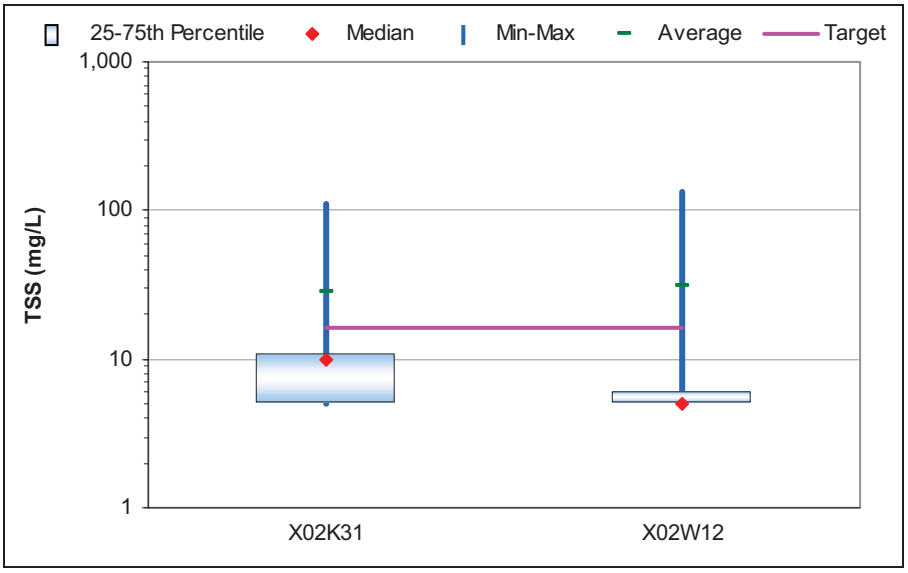

Figure 8. TSS concentrations along Slabcamp Run.

3.2.3 HUC 05090201 09 03

This HUC 12 is listed in the *Integrated Report* (Ohio EPA 2008a), and two segments require TMDLs: Little North Fork White Oak Creek and North Fork. There are six Ohio EPA sample stations in this subwatershed (Figure 9).

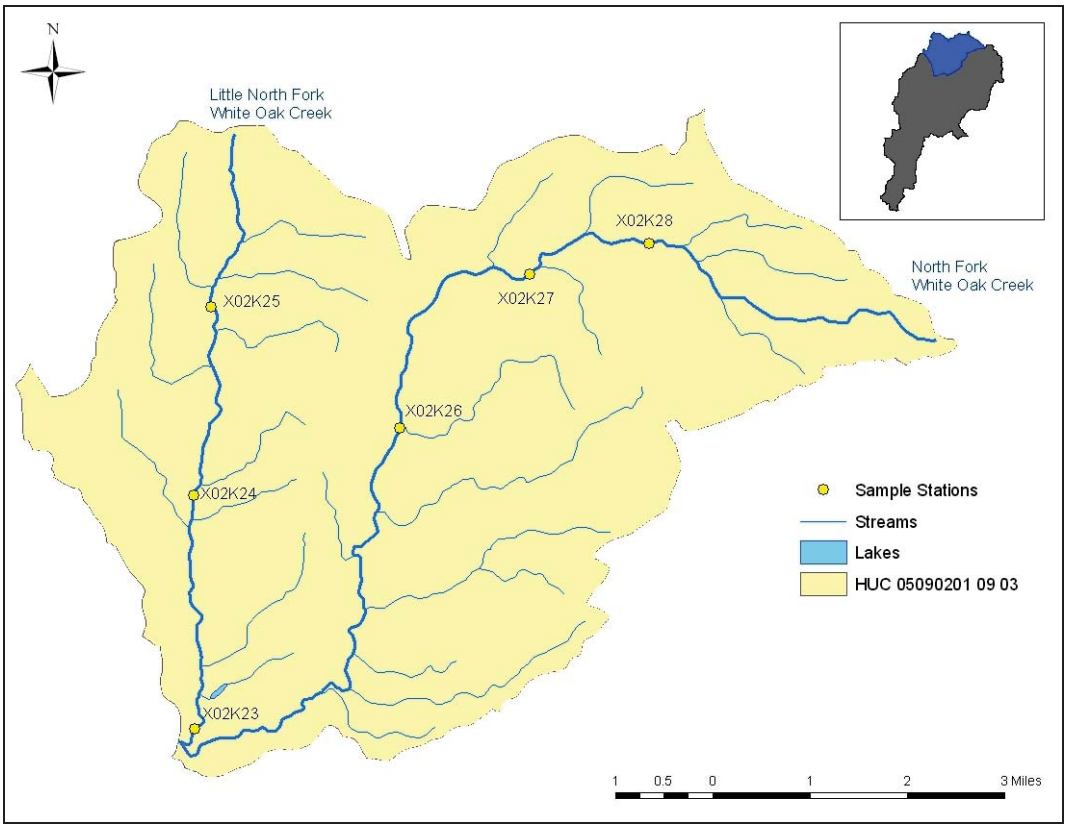

Figure 9. Sample stations in HUC 05090201 09 03.

3.2.3.1 Little North Fork White Oak Creek

Little North Fork is a tributary to North Fork and is designated as WWH and PCR. The stream was previously designated EWH, but was re-classified in the rule revisions adopted on July 9, 2009. Ohio EPA identified the stream as being impaired due to habitat (siltation, low flow alterations, and direct habitat alterations) and total phosphorus. A nitrate plus nitrite analysis is also discussed in this section because some samples exceed the TMDL targets. Table 19 through Table 21 summarize the pertinent water quality data at the three stations on Little North Fork: Little North Fork RM 0.28 (X02K23), Little North Fork RM 2.94 (X02K24), and Little North Fork RM 5.06 (X02K25) (see Figure 9).

Table 19. Nitrate plus nitrite samples collected in Little North Fork White Oak Creek

Station ID	Drainage area[a]	# of samples	Begin date	End date	Min (mg/L)	Max (mg/L)	Average (mg/L)	Exceed target[b]
X02K25	3.6	5	7/27/2006	9/28/2006	0.10	6.08	2.16	40%
X02K24	7.3	5	7/27/2006	9/28/2006	0.10	0.55	0.24	0%
X02K23	13.8	5	7/27/2006	9/28/2006	0.10	1.30	0.44	20%

[a]Drainage areas were reported by Ohio EPA and are in square miles.
[b]For a discussion of targets, see Section 3.1.

Table 20. Total phosphorus samples collected in Little North Fork White Oak Creek

Station ID	Drainage area[a]	# of samples	Begin date	End date	Min (mg/L)	Max (mg/L)	Average (mg/L)	Exceed target[b]
X02K25	3.6	5	7/27/2006	9/28/2006	0.13	0.62	0.28	100%
X02K24	7.3	5	7/27/2006	9/28/2006	0.03	0.32	0.19	80%
X02K23	13.8	5	7/27/2006	9/28/2006	0.24	0.33	0.28	100%

[a]Drainage areas were reported by Ohio EPA and are in square miles.
[b]For a discussion of targets, see Section 3.1.

Table 21. TSS samples collected in Little North Fork White Oak Creek

Station ID	Drainage area[a]	# of samples	Begin date	End date	Min (mg/L)	Max (mg/L)	Average (mg/L)	Exceed target[b]
X02K25	3.6	5	7/27/2006	9/28/2006	5	16	9.4	0%
X02K24	7.3	5	7/27/2006	9/28/2006	5	17	9.2	20%
X02K23	13.8	5	7/27/2006	9/28/2006	5	16	7.8	0%

[a]Drainage areas were reported by Ohio EPA and are in square miles.
[b]For a discussion of targets, see Section 3.1.

Nitrate plus nitrite concentrations are higher upstream in Little North Fork, total phosphorus displays no apparent trend, and median TSS concentrations decrease (see Figure 10, Figure 11, and Figure 12, respectively). Concentrations of nitrate plus nitrite exceeded the statewide targets of 1.0 mg/L for WWH headwaters streams at all three stations (Ohio EPA 1999, Table 1, p. 4). The significant variability in nitrate plus nitrite concentrations between Little North Fork RM 5.06 (X02K25) and Little North Fork RM 2.94 (X02K24) could be due to direct agricultural runoff and lack of riparian cover on Little North Fork upstream of Little North Fork RM 5.06 (X02K25). The riparian corridor is forested between Little North Fork RM 5.06 (X02K25) and Little North Fork RM 2.94 (X02K24); however, the fields come right up to the river upstream of Little North Fork RM 5.06 (X02K25). Concentrations of total phosphorus exceeded the statewide targets of 0.08 mg/L for WWH headwaters streams at all three stations (Ohio EPA 1999, Table 2, p. 5). The increased levels of total phosphorus at Little North Fork RM 5.06 (X02K25) can also be explained by the previously mentioned discussion of riparian cover. One sample of TSS collected at station Little North Fork RM 2.94 (X02K24) exceeded the 75th percentile statewide target of 16 mg/L for headwaters streams (Ohio EPA 1999, Appendix 1, p. 24). There does not appear to be a strong relationship between TSS and total phosphorus in Little North Fork as shown in Figure 13, suggesting that erosion of soil particles with attached phosphorus might not be the cause of the high concentrations.

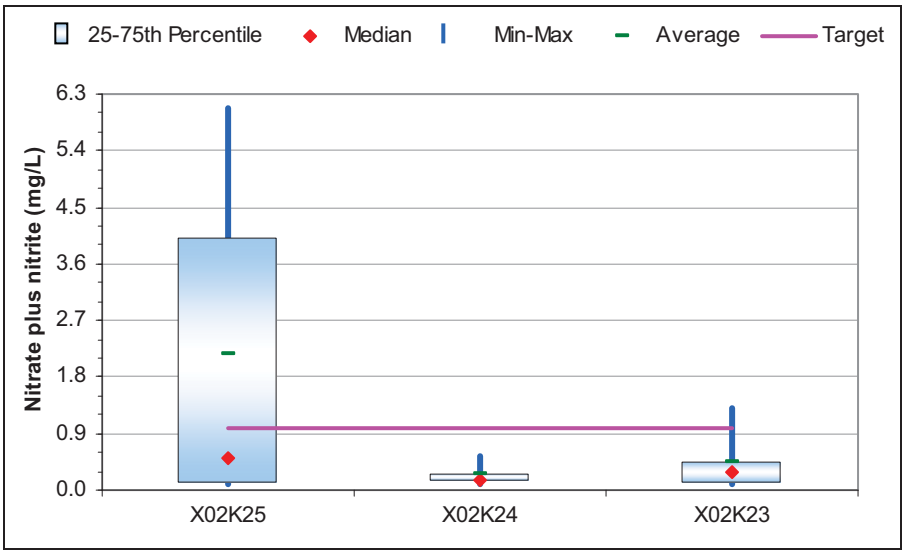

Figure 10. Nitrate plus nitrite concentrations along Little North Fork White Oak Creek.

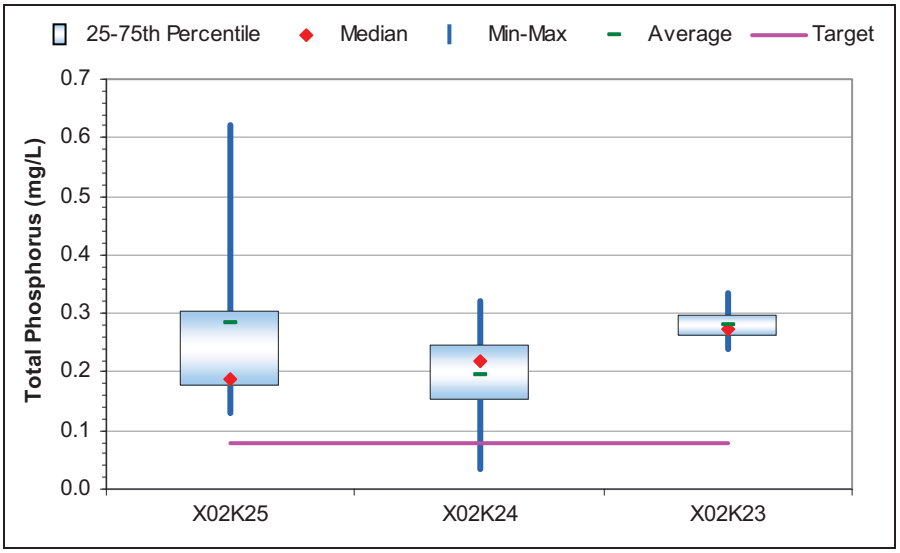

Figure 11. Total phosphorus concentrations along Little North Fork White Oak Creek.

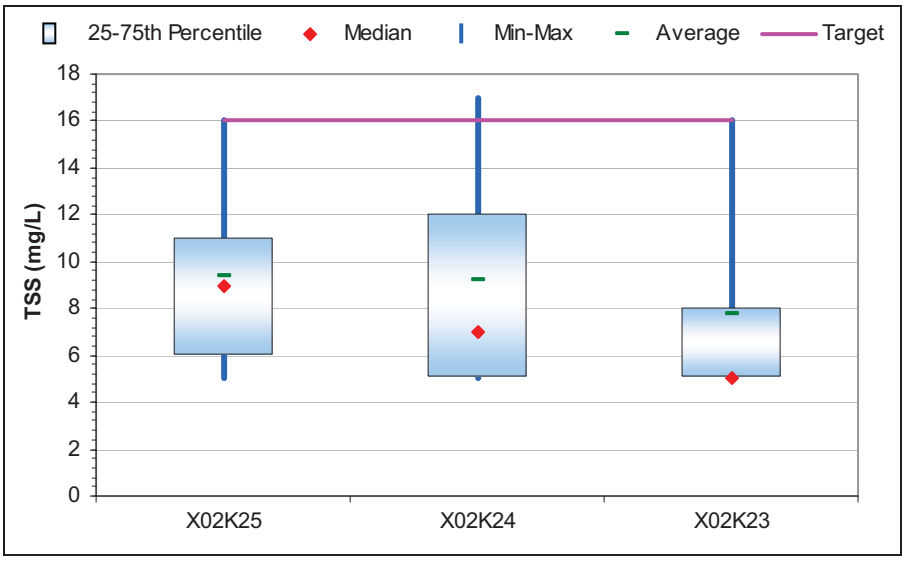

Figure 12. TSS concentrations along Little North Fork White Oak Creek.

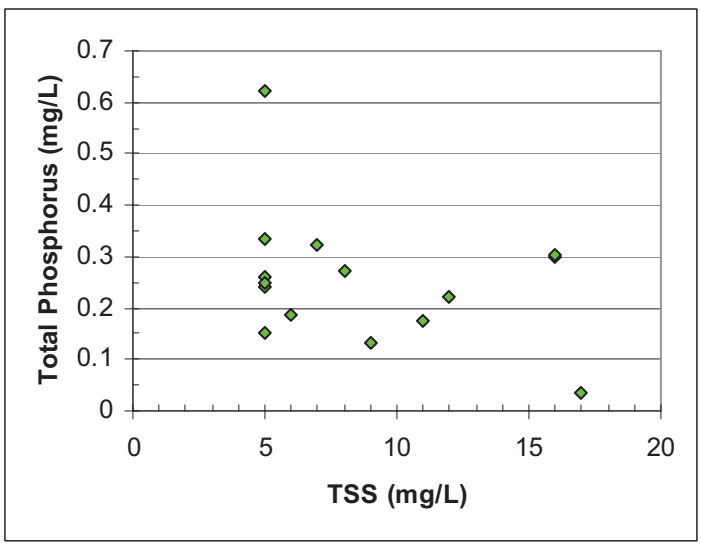

Figure 13. TSS and total phosphorus concentrations in Little North Fork White Oak Creek.

3.2.3.2 North Fork White Oak Creek

North Fork is a tributary to White Oak Creek and is designated as WWH and PCR. Ohio EPA identified this stream as impaired for habitat (siltation, low flow alteration, and direct habitat alterations) and nitrate, and the HUC 12 is listed in the *Integrated Report* (Ohio EPA 2008a). Water quality samples collected in 2006 exceeded the instantaneous standards for *E. coli* and fecal coliform. Table 22 through Table 24 summarize the pertinent water quality data at the three stations on North Fork: North Fork RM 15.36 (X02K26), North Fork RM 18.10 (X02K27), and North Fork RM 19.67 (X02K28) (see Figure 9).

Table 22. Bacteria samples collected at North Fork RM 15.36 (X02K26)

Station ID	Drainage area[a]	# of samples	Begin date	End date	Min[b]	Max[b]	Geometric mean[b]	Exceed target[c]
E. coli	12.0	5	8/14/2008	8/18/2008	210	10,000	940	80%
Fecal coliform	12.0	5	8/14/2008	8/18/2008	290	27,000	1,670	20%

[a]Drainage areas were reported by Ohio EPA and are in square miles.
[b]The units for *E. coli* and fecal coliform are cfu/100 mL.
[c]The displayed value is the percentage of individual samples that exceeded the instantaneous standards. For a discussion of targets, see Section 3.1.

Table 23. Nitrate plus nitrite samples collected in North Fork White Oak Creek

Station ID	Drainage area[a]	# of samples	Begin date	End date	Min (mg/L)	Max (mg/L)	Average (mg/L)	Exceed target[b]
X02K28	4.0	5	7/27/2006	9/28/2006	0.1	0.89	0.28	0%
X02K27	7.2	5	7/27/2006	9/28/2006	0.1	0.99	0.29	0%
X02K26	12.0	5	7/27/2006	9/28/2006	0.1	3.68	1.25	40%

[a]Drainage areas were reported by Ohio EPA and are in square miles.
[b]For a discussion of targets, see Section 3.1.

Table 24. TSS samples collected in North Fork White Oak Creek

Station ID	Drainage area[a]	# of samples	Begin date	End date	Min (mg/L)	Max (mg/L)	Average (mg/L)	Exceed target[b]
X02K28	4.0	5	7/27/2006	9/28/2006	11	42	24.8	60%
X02K27	7.2	5	7/27/2006	9/28/2006	5	33	14.0	40%
X02K26	12.0	5	7/27/2006	9/28/2006	5	87	22.2	20%

[a]Drainage areas were reported by Ohio EPA and are in square miles.
[b]For a discussion of targets, see Section 3.1.

A spatial analysis of *E. coli* and fecal coliform in North Fork is not possible because only one station was sampled for each parameter; however, the elevated bacteria concentrations at North Fork RM 15.36 (X02K26) could be the result of the nearby unsewered, unincorporated community of Pricetown. There is a slightly increasing trend for median nitrate plus nitrite concentrations and a decreasing trend for median TSS concentrations on North Fork (Figure 14 and Figure 15, respectively). In both cases, an unknown factor (potentially the nearby community) is affecting water quality at North Fork RM 15.36 (X02K26). Finally, Ohio EPA reports that the stream near North Fork RM 19.67 (X02K28) is channelized and that the riparian cover has been removed; this likely explains increased siltation and elevated TSS concentrations.

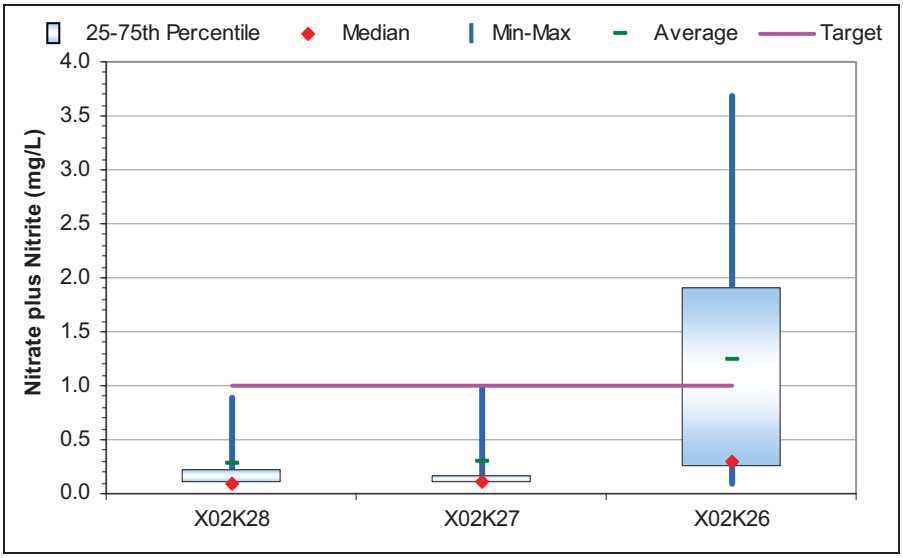

Figure 14. Nitrate plus nitrite concentrations along North Fork White Oak Creek.

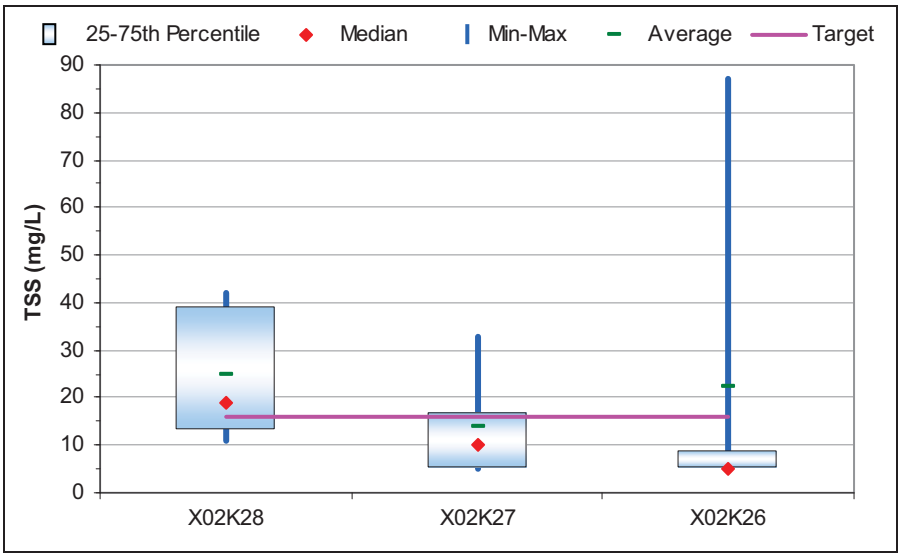

Figure 15. TSS concentrations along North Fork White Oak Creek.

3.2.4 HUC 05090201 09 04

This HUC 12 is listed in the *Integrated Report* (Ohio EPA 2008a). Ohio EPA identified one stream that requires a TMDL: Flat Run. There are five Ohio EPA sample stations in this subwatershed (Figure 16).

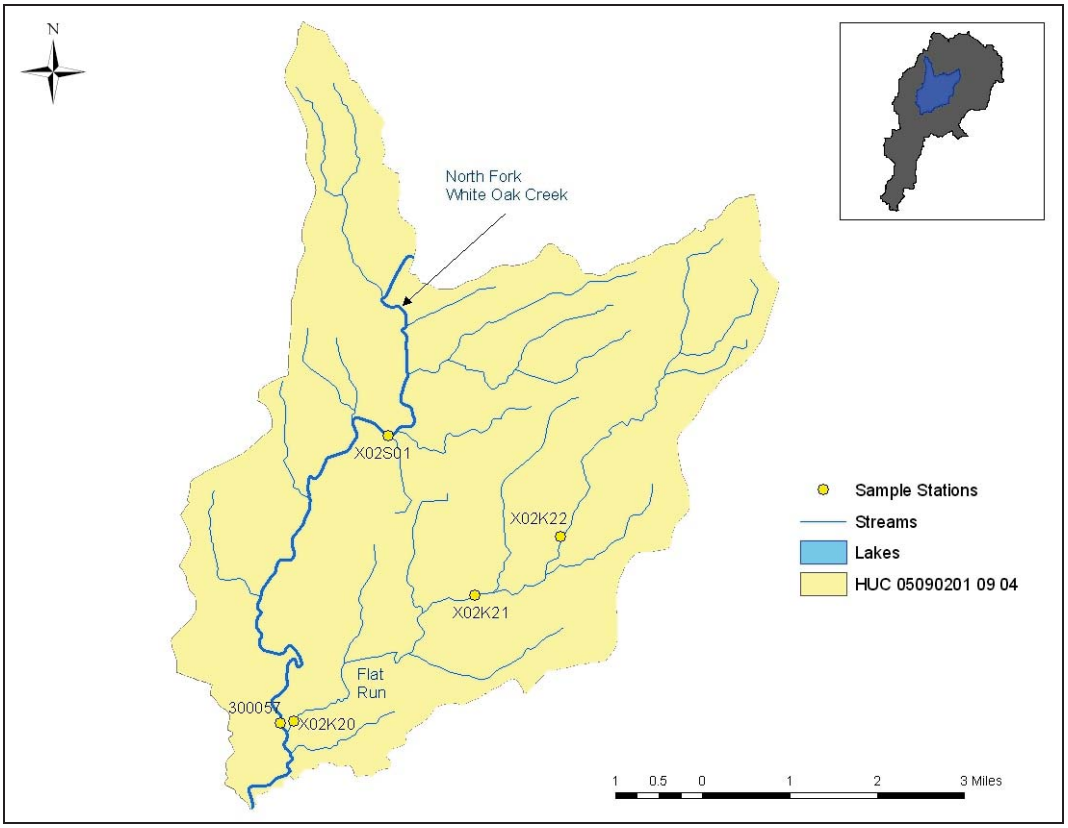

Figure 16. Sample stations in HUC 05090201 09 04.

Flat Run is a tributary to North Fork and is designated as WWH and PCR. Flat Run was listed for habitat (siltation and direct habitat alterations) in the *Integrated Report* (Ohio EPA 2008a). Table 25 summarizes the pertinent water quality data at the three stations on Flat Run: Flat Run RM 0.15 (X02K20), Flat Run RM 3.39 (X02K21), and Flat Run RM 4.80 (X02K22) (see Figure 16).

Table 25. TSS samples collected in Flat Run

Station ID	Drainage area[a]	# of samples	Begin date	End date	Min (mg/L)	Max (mg/L)	Average (mg/L)	Exceed target[b]
X02K22	3.9	6	7/27/2006	9/28/2006	5	56.5	14.4	17%
X02K21	7.4	5	7/27/2006	9/28/2006	5	68	19.4	20%
X02K20	12.3	5	7/27/2006	9/28/2006	5	78	20.8	20%

[a]Drainage areas were reported by Ohio EPA and are in square miles.
[b]For a discussion of targets, see Section 3.1.

One TSS sample from each of the stations on Flat Run was above the 75th percentile statewide criterion of 16 mg/L for headwaters streams (Ohio EPA 1999, Appendix 1, p. 24). There does not appear to be a strong increasing or decreasing spatial trend with median TSS concentrations (Figure 17).

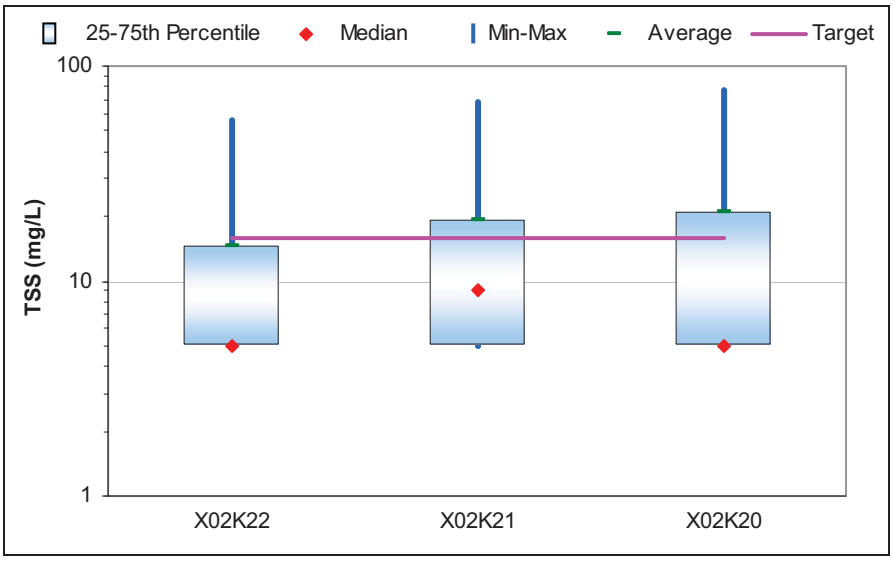

Figure 17. TSS concentrations along Flat Run.

3.2.5 HUC 05090201 10 01

Ohio EPA identified two segments requiring TMDLs in this HUC 12, which is listed in the *Integrated Report* (Ohio EPA 2008a): Sterling Run (multiple contiguous segments) and Sterling Run (RM 6.68) Tributary RM 0.68 and 2.4. Tetra Tech determined that bacteria samples from one additional segment exceeded standards: Snapping Turtle Run. There are 14 Ohio EPA sample stations in this subwatershed (Figure 18).

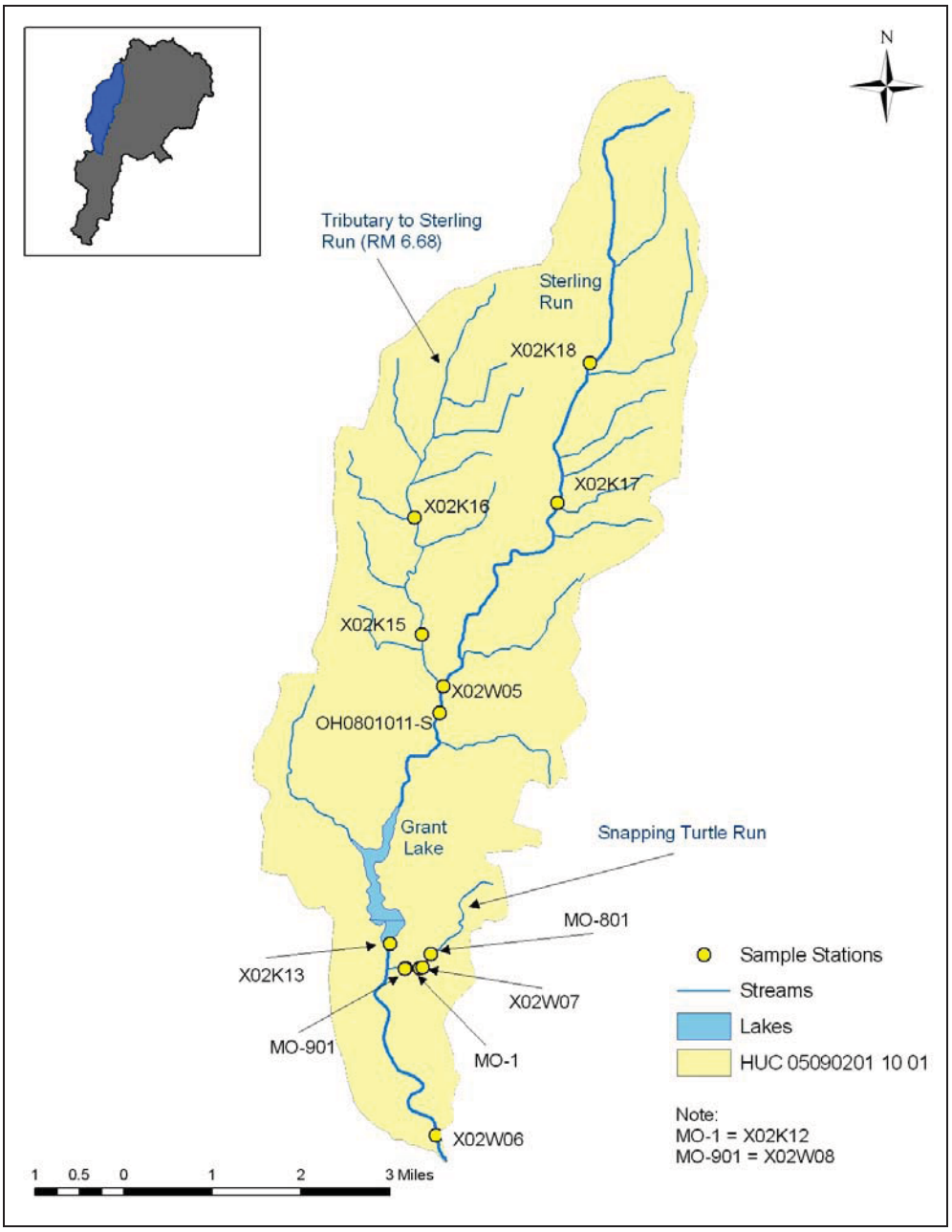

Figure 18. Sample stations in HUC 05090201 10 01.

3.2.5.1 Snapping Turtle Run

Snapping Turtle Run is a tributary to Sterling Run and is designated as PCR. This stream was not identified as exceeding a chemical pollutant water quality standard. However, water quality samples exceeded the instantaneous standard for fecal coliform. Table 26 summarizes the pertinent DMR water quality data at two of the six stations on Snapping Turtle Run; bacteria data were available at only four stations. WWTP effluent was collected under two sample station numbers: MO-1 (by Mount Orab WWTP) and X02K12 (by Ohio EPA). Surface water samples were collected from four stations: two by Mount Orab WWTP staff (MO-801 and MO-901) and two by Ohio EPA at Snapping Turtle Run RM 0.50 (X02W07) and Snapping Turtle Run RM 0.20 (X02W08) (see Figure 18). DMR data from Mount Orab WWTP were used because Ohio EPA did not sample bacteria from Snapping Turtle Run.

Table 26. Fecal coliform samples collected in Snapping Turtle Run

Station ID	Drainage area[a]	# of samples	Begin date	End date	Min[b]	Max[b]	Geometric mean[b]	Exceed target[c]
MO-801	1.0	6	6/3/2003	6/12/2006	100	2,320	393	50%
MO-901	1.25	7	6/3/2003	8/15/2006	60	5,260	971	42.9%

[a]Drainage area was determined in USGS StreamStats using coordinates estimated in a geographic information system.
[b]The units for fecal coliform are cfu/100 mL.
[c]The displayed value is the percentage of individual samples that exceeded the instantaneous standards. For a discussion of targets, see Section 3.1.

A spatial analysis of *E. coli* collected from Snapping Turtle Run is not possible because only effluent was sampled. However, there is an increasing trend in fecal coliform concentrations (median, average, and range) along Snapping Turtle Run (Figure 19). Between 5/5/2003 and 10/31/2006, 197 fecal coliform samples were collected from the effluent pipe at the Mount Orab WWTP, and the samples ranged from 3 to 16,350 cfu/100 mL with an average of 408 cfu/100 mL.

Exceedances of the in-stream water quality standard occurred at the downstream station (MO-901) on 6/3/2003 (5,260 cfu/100 mL) and 6/7/2005 (4,250 cfu/100 mL). No exceedances occurred at the upstream station (MO-801) on those dates (200 cfu/100 mL and 150 cfu/100 mL, respectively), and the samples collected at the outfall pipe were well below the in-stream standard (720 cfu/100 mL and 150 cfu/100 mL, respectively). Because sample times are not provided in the DMR data, it is not possible to determine if the WWTP is the source of the downstream exceedances on 6/3/2005 and 6/7/2005. However, Ohio EPA has found elevated levels of ammonia in stream sediment samples and observed black sewage sludge in the creek downstream of the WWTP that are likely from the WWTP (Ohio EPA 2008b). Additionally, on 8/2/2005, the instantaneous standard was exceeded at the upstream station (2,320 cfu/100mL) but not at the downstream station (60 cfu/100 mL); sample times were not provided. Thus, the Mount Orab WWTP is not likely the source of the exceedance that occurred on 8/2/2005.

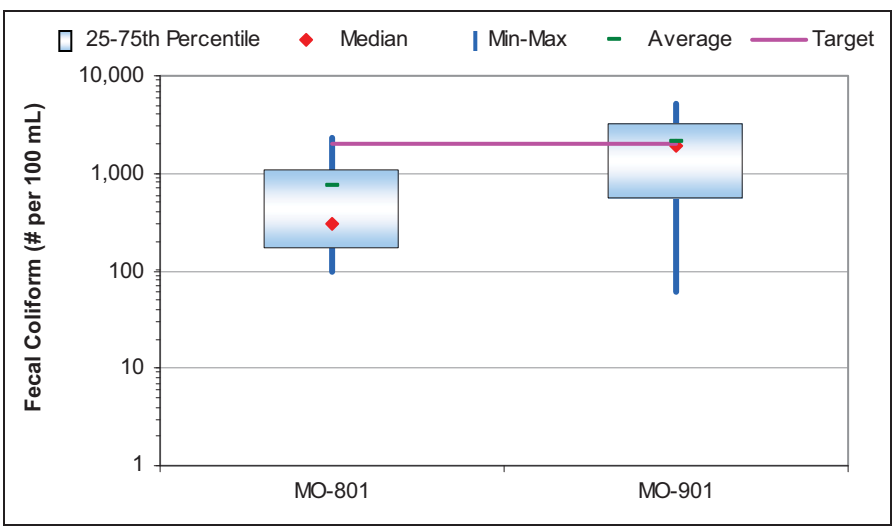

Figure 19. Fecal coliform concentrations along Snapping Turtle Run.

3.2.5.2 Sterling Run

Sterling Run is a tributary to White Oak Creek and is designated as WWH, PCR, and PWS. Sterling Run is impaired for atrazine, habitat (siltation and low flow alterations), and total phosphorus and this HUC is listed in the *Integrated Report* (Ohio EPA 2008a). Bacteria concentrations in samples collected during the summer of 2006 exceeded instantaneous standards. Geometric mean standards are not applicable because

only four samples were collected in a thirty day period. Table 27 through Table 31 summarize the pertinent water quality data at the seven stations on Sterling Run: OH08101011, Sterling Run RM 3.08 (X02K13), Sterling Run RM 6.47 (X02K14), Sterling Run RM 9.65 (X02K17), Sterling Run RM 11.35 (X02K18), Sterling Run RM 6.74 (X02W05), and Sterling Run RM 0.59 (X02W06) (see Figure 18). The in-stream samples from OH08101011 are designated as OH08101011-S.

Table 27. Atrazine samples collected in Sterling Run

Station ID	Drainage area[a]	# of samples	Begin date	End date	Min (µg/L)	Max (µg/L)	Average (µg/L)	Exceed target[b]
X02K17	6.1	3	8/30/2006	6/5/2008	1.36	44.6	16.2	33%
X02W05	11.8	4	8/30/2006	6/5/2008	0.29	47.4	12.8	25%
X02K14[c]	19.1[d]	3	6/29/2006	6/5/2008	0.33	2.37	1.03	0%
OH0801011-S[c]	19.1[d]	87	6/22/2004	9/22/2008	0.03	227	6.37	3%
X02W06	29.7	3	4/10/2006	8/30/2006	0.35	0.90	0.58	0%

[a]Drainage areas were reported by Ohio EPA and are in square miles.

[b]For a discussion of targets, see Section 3.1.

[c]These two sample stations are at the same site. Station X02K14 was sampled and analyzed by Ohio EPA; station OH0801011 was sampled by Mount Orab WTP personnel and analyzed by a laboratory retained by Syngenta.

[d]Drainage area was determined in USGS StreamStats using coordinates provided by Ohio EPA.

Table 28. *E. coli* samples collected in Sterling Run

Station ID	Drainage area[a]	# of samples	Begin date	End date	Min[b]	Max[b]	Geometric mean[b]	Exceed target[c]
X02W05	11.8	4	8/15/2006	8/18/2006	230	20,000	951	50%
X02K14	19.1[d]	4	8/14/2006	8/18/2006	30	320	99	25%
X02W06	29.7	4	8/15/2006	8/18/2006	10	370	97	25%

[a]Drainage areas were reported by Ohio EPA and are in square miles.

[b]The units for *E. coli* are cfu/100 mL.

[c]The displayed value is the percentage of individual samples that exceeded the instantaneous standards. For a discussion of targets, see Section 3.1.

[d]Drainage area was determined in USGS StreamStats using coordinates provided by Ohio EPA.

Table 29. Fecal coliform samples collected in Sterling Run

Station ID	Drainage area[a]	# of samples	Begin date	End date	Min[b]	Max[b]	Geometric mean[b]	Exceed target[c]
X02W05	11.8	4	8/15/2006	8/18/2006	390	32,000	1,770	25%
X02K14	19.1[d]	4	8/14/2006	8/18/2006	20	590	116	0%
X02W06	29.7	4	8/15/2006	8/18/2006	150	740	274	0%

[a]Drainage areas were reported by Ohio EPA and are in square miles.

[b]The units for fecal coliform are cfu/100 mL.

[c]The displayed value is the percentage of individual samples that exceeded the instantaneous standards. For a discussion of targets, see Section 3.1.

[d]Drainage area was determined in USGS StreamStats using coordinates provided by Ohio EPA.

Table 30. Total phosphorus samples collected in Sterling Run

Station ID	Drainage area[a]	# of samples	Begin date	End date	Min (mg/L)	Max (mg/L)	Average (mg/L)	Exceed target[b]
X02K18	3.4	4	7/26/2006	9/27/2006	0.47	0.60	0.52	100%
X02K17	6.1	5	7/26/2006	9/27/2006	0.46	0.91	0.66	100%
X02W05	11.8	5	7/26/2006	9/27/2006	0.15	0.32	0.24	100%
X02K14	19.1[c]	5	7/26/2006	9/27/2006	0.17	0.34	0.26	100%
X02K13	26.3	5	7/26/2006	9/27/2006	0.05	0.31	0.19	80%
X02W06	29.7	9	2/9/2006	12/14/2006	0.12	0.52	0.26	100%

[a]Drainage areas were reported by Ohio EPA and are in square miles.
[b]For a discussion of targets, see Section 3.1.
[c]Drainage area was determined in USGS StreamStats using coordinates provided by Ohio EPA.

Table 31. TSS samples collected in Sterling Run

Station ID	Drainage area[a]	# of samples	Begin date	End date	Min (mg/L)	Max (mg/L)	Average (mg/L)	Exceed target[b]
X02K18	3.4	4	7/26/2006	9/27/2006	8	30	18.8	75%
X02K17	6.1	5	7/26/2006	9/27/2006	5	54	30.8	80%
X02W05	11.8	5	7/26/2006	9/27/2006	5	9	6.4	0%
X02K14	19.1 [a]	5	7/26/2006	9/27/2006	5	24	15	60%
X02K13	26.3	5	7/26/2006	9/27/2006	5	9	7	0%
X02W06	29.7	9	2/9/2006	12/14/2006	5	16	7.8	0%

[a]Drainage areas were reported by Ohio EPA and are in square miles.
[b]For a discussion of targets, see Section 3.1.
[a]Drainage area was determined in USGS StreamStats using coordinates provided by Ohio EPA.

A decreasing trend is apparent along Sterling Run for atrazine concentrations. The largest range of data is at the PWS intake (Sterling Run RM 6.47 (X02K14) and OH08101011-S). Samples at Sterling Run RM 9.65 (X02K17), Sterling Run RM 6.74 (X02W05), and the PWS intake exceed the TMDL target. For a discussion of atrazine at the PWS intake, see Section 3.4. A decreasing trend is apparent with median bacteria concentrations in Sterling Run (Figure 21 and Figure 22). There is a large decrease in bacteria concentrations from Sterling Run RM 6.74 (X02W05) to Sterling Run RM 6.47 (X02K14); this could be the result of dilution from a small tributary whose confluence with Sterling Run is between the previously mentioned stations. Also, Ohio EPA reports that it discovered a sanitary sewer overflow (SSO) in July 2006. Though it was capped, the sludge that was discharged was not removed, and this could explain the elevated bacteria concentrations. Total phosphorus concentrations significantly decrease between Sterling Run RM 9.65 (X02K17) and Sterling Run RM 6.74 (X02W05) (Figure 23); Sterling Run RM 6.74 (X02W05) is downstream of the confluence with Tributary to Sterling Run at RM 6.68, and the lower concentrations below this confluence might be the result of dilution. A similar trend is apparent with TSS (Figure 24). Sterling Run RM 9.65 (X02K17) and Sterling Run RM 11.35 (X02K18) are in areas of the subwatershed that are dominated by agriculture, whereas Sterling Run RM 6.74 (X02W05) is near Mount Orab. Higher concentrations of total phosphorus and TSS in the upper reaches of Sterling Run might dilute or settle out by the time they reach Sterling Run RM 6.74 (X02W05).

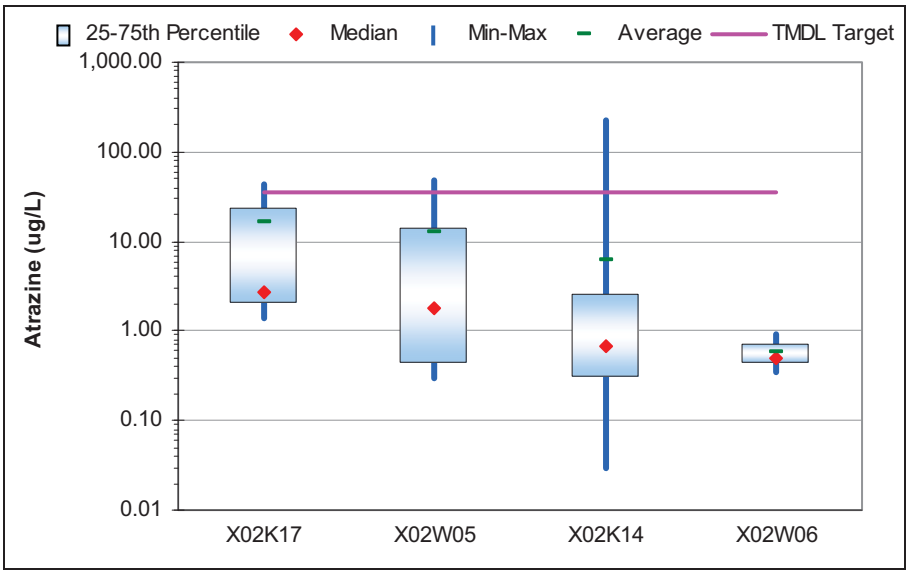

Figure 20. Atrazine concentrations along Sterling Run.

In Figure 20, the atrazine TMDL target is displayed for all four sample stations on Sterling Run. However, compliance with the standard (Ohio EPA 2008e, 3745-1-34(C)(2)(A) and Table 34-1) would only apply to sample stations within 500 yards of the PWS.

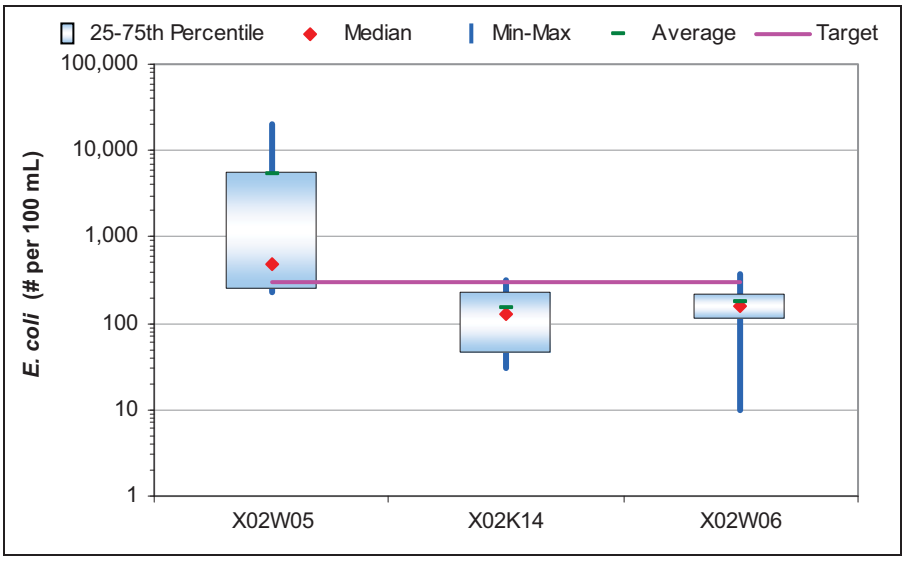

Figure 21. *E. coli* concentrations along Sterling Run.

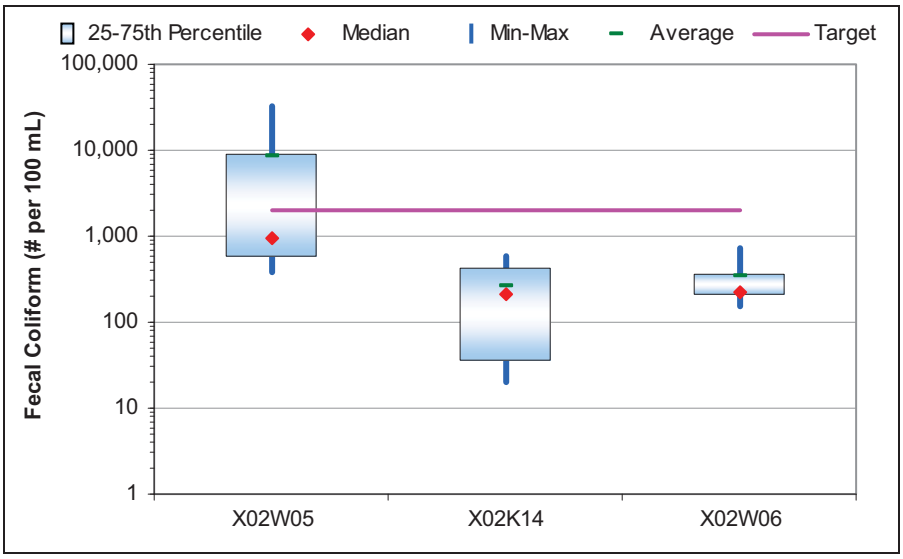

Figure 22. Fecal coliform concentrations along Sterling Run.

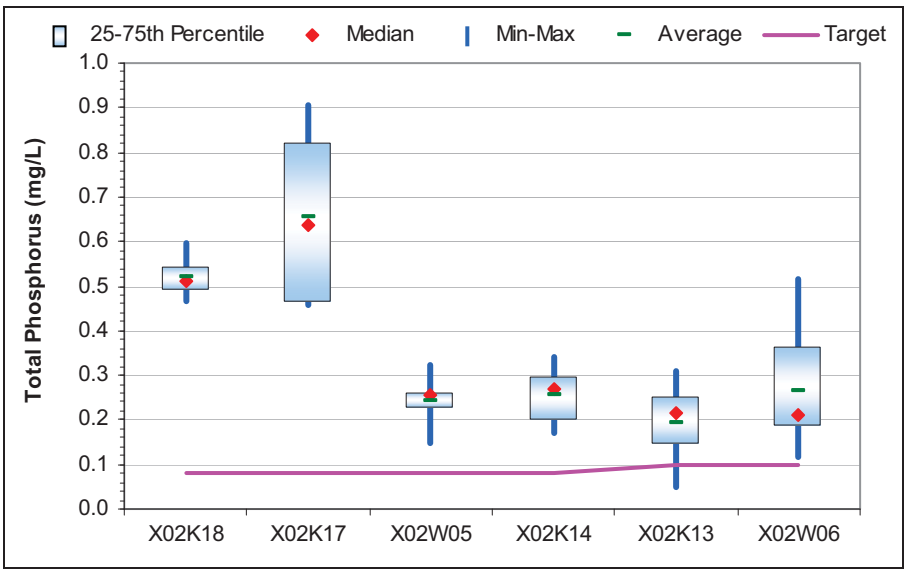

Figure 23. Total phosphorus concentrations along Sterling Run.

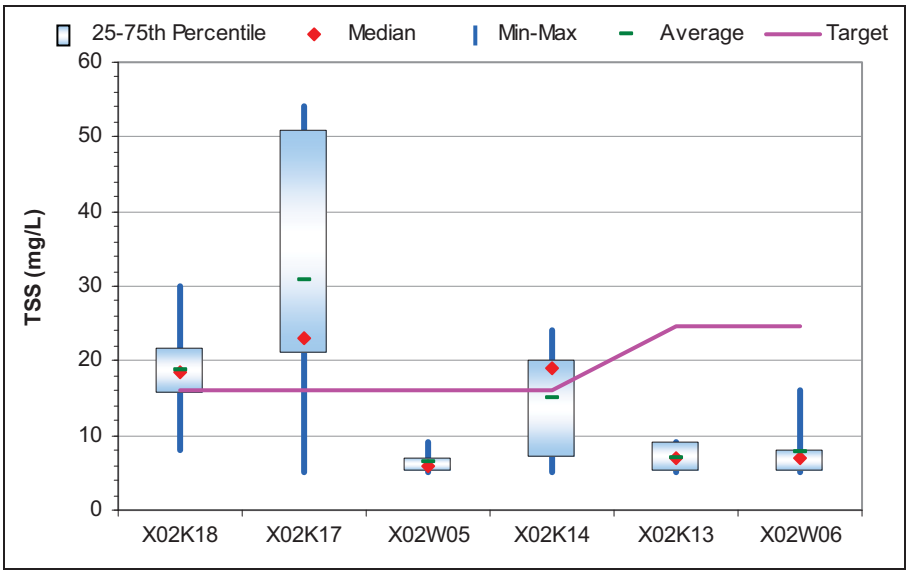

Figure 24. TSS concentrations along Sterling Run.

3.2.5.3 Sterling Run (RM 6.68) Tributary

The Sterling Run (RM 6.68) tributary was previously undesignated, but was designated WWH and PCR when the rule revisions were adopted on July 9, 2009. Ohio EPA identified this stream as impaired for habitat (siltation, low flow alterations, and direct habitat alterations) and total phosphorus. Table 32 and Table 33 summarize the pertinent water quality data at the two stations on the Sterling Run (RM 6.68) Tributary: Sterling Run (RM 6.68) Tributary RM 0.68 (X02K15) and Sterling Run (RM 6.68) Tributary RM 2.41 (X02K16) (see Figure 18).

Table 32. Total phosphorus samples collected in Sterling Run (RM 6.68) Tributary

Station ID	Drainage area[a]	# of samples	Begin date	End date	Min (mg/L)	Max (mg/L)	Average (mg/L)	Exceed target[b]
X02K16	3.7	4	7/26/2006	9/27/2006	0.33	0.63	0.43	100%
X02K15	6.9	5	7/26/2006	9/27/2006	0.29	0.42	0.35	100%

[a]Drainage areas were reported by Ohio EPA and are in square miles.
[b]For a discussion of targets, see Section 3.1.

Table 33. TSS samples collected in Sterling Run (RM 6.68) Tributary

Station ID	Drainage area[a]	# of samples	Begin date	End date	Min (mg/L)	Max (mg/L)	Average (mg/L)	Exceed target[b]
X02K16	3.7	4	7/26/2006	9/27/2006	6	45	18.0	25%
X02K15	6.9	5	7/26/2006	9/27/2006	5	53	17.6	20%

[a]Drainage areas were reported by Ohio EPA and are in square miles.
[b]For a discussion of targets, see Section 3.1.

There is a decreasing trend in total phosphorus concentrations (median, average, and range) along Tributary to Sterling Run (RM 6.68) (Figure 25). A slight decreasing trend is present in median TSS concentrations (Figure 26); however, the range of TSS concentrations at Sterling Run (RM 6.68) Tributary RM 0.68 (X02K15) is larger than the range at Sterling Run (RM 6.68) Tributary RM 2.41 (X02K16). There appears to be a slight positive relationship between total phosphorus and TSS (Figure 27), suggesting that the high phosphorus might be due to the erosion of soil particles containing attached phosphorus.

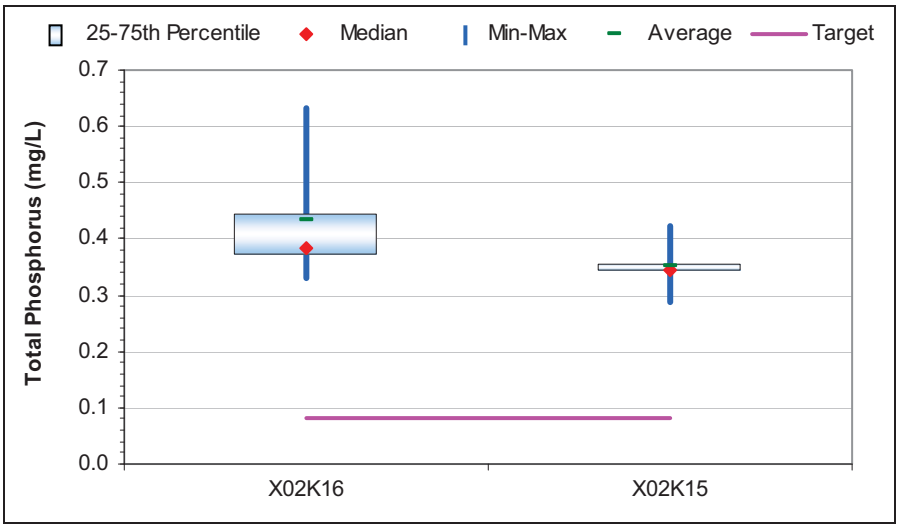

Figure 25. Total phosphorus concentrations along Sterling Run (RM 6.68) Tributary.

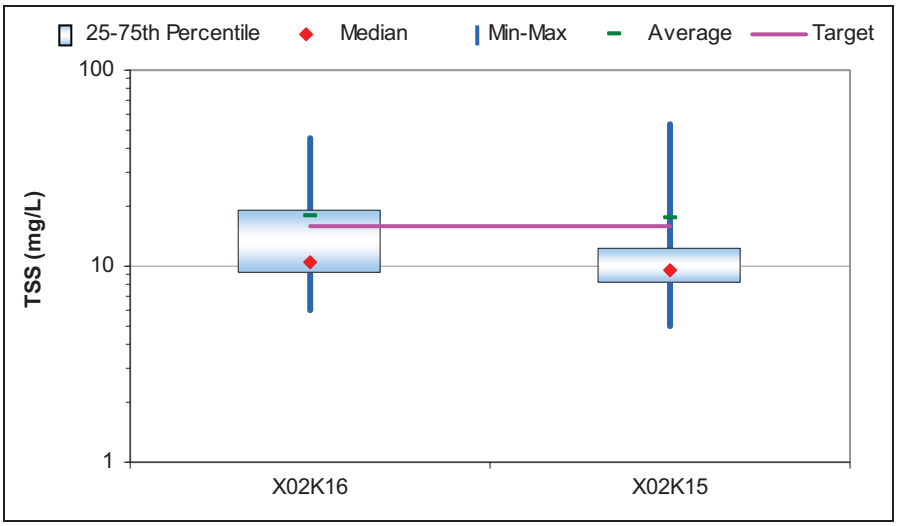

Figure 26. TSS concentrations along Sterling Run (RM 6.68) Tributary.

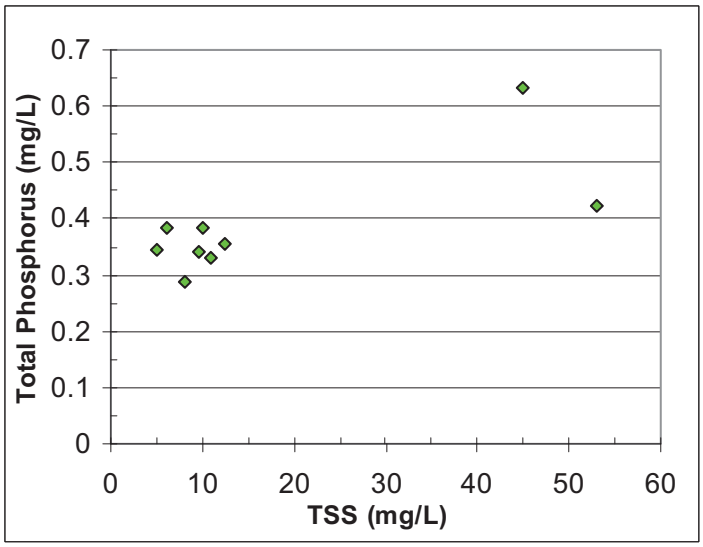

Figure 27. TSS and total phosphorus concentrations in Sterling Run (RM 6.68) Tributary.

3.2.6 HUC 05090201 10 02

One segment in this HUC 12 is impaired, and the HUC is listed in the *Integrated Report* (Ohio EPA 2008a). There are eight Ohio EPA sample stations in this subwatershed (Figure 28). Note that station X02K07 in Figure 28 does not appear on a stream. This is not a plotting error. Station X02K07 is on a small stream that is not represented in the National Hydrography Dataset stream layer displayed in Figure 28.

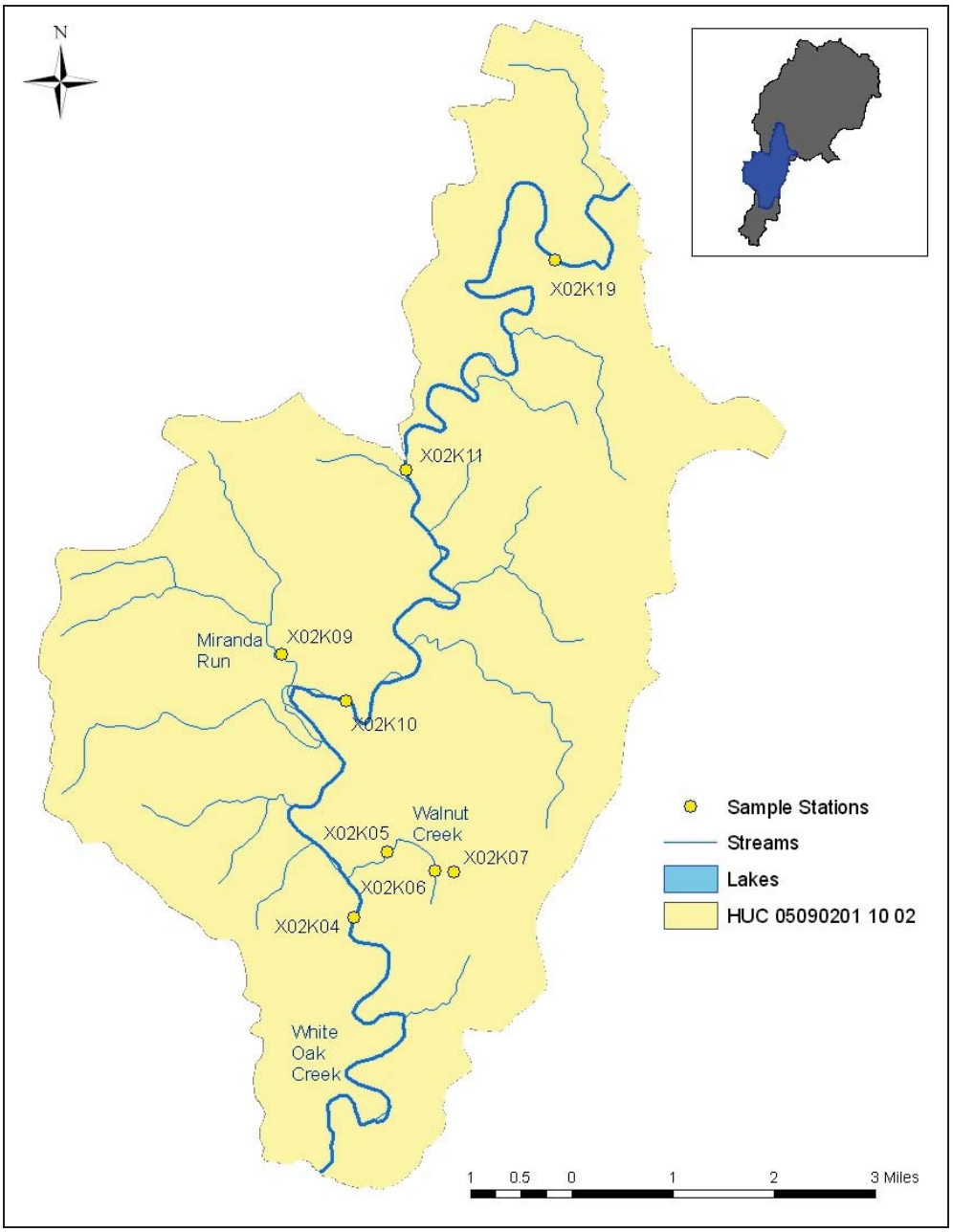

Figure 28. Sample stations in HUC 05090201 10 02.

White Oak Creek is designated as EWH, and it is impaired for habitat (siltation) and nitrate. Table 34 and Table 35 summarize the pertinent water quality data at the four stations on White Oak Creek: White Oak Creek RM 12.40 (X02K04), White Oak Creek RM 16.60 (X02K10), White Oak Creek RM 20.65 (X02K11), and White Oak Creek RM 27.50 (X02K19) (see Figure 28). Stations above White Oak Creek RM 12.40 (X02K04) are considered wading (20 to 200 square mile drainage area) and stations below X02K04, including X02K04, are considered small rivers (200 to 1,000 square mile drainage area).

Table 34. Nitrate plus nitrite samples collected in White Oak Creek

Station ID	Drainage area[a]	# of samples	Begin date	End date	Min (mg/L)	Max (mg/L)	Average (mg/L)	Exceed target[b]
X02K19	150.0	5	7/26/2006	9/27/2006	0.1	0.72	0.36	20%
X02K11	188	5	7/26/2006	9/27/2006	0.34	2.22	1.16	60%
X02K10	190.0	5	7/26/2006	9/27/2006	0.1	0.79	0.42	40%
X02K04	213	5	7/26/2006	9/27/2006	0.1	0.63	0.27	0%

[a]Drainage areas were reported by Ohio EPA and are in square miles.
[b]For a discussion of targets, see Section 3.1.

Table 35. TSS samples collected in White Oak Creek

Station ID	Drainage area[a]	# of samples	Begin date	End date	Min (mg/L)	Max (mg/L)	Average (mg/L)	Exceed target[b]
X02K19	150.0	5	7/26/2006	9/27/2006	5	16	10.0	0%
X02K11	188	5	7/26/2006	9/27/2006	5	11	6.2	0%
X02K10	190.0	5	7/26/2006	9/27/2006	5	21	10.2	0%
X02K04	213	5	7/26/2006	9/27/2006	5	12	6.6	0%

[a]Drainage areas were reported by Ohio EPA and are in square miles.
[b]For a discussion of targets, see Section 3.1.

There is no apparent increasing or decreasing trend in either nitrate plus nitrite concentrations or TSS concentrations on White Oak Creek (Figure 29 and Figure 30, respectively). White Oak Creek RM 7.54 (609110) and White Oak Creek RM 2.20 (X02K02) are displayed for comparison purposes; these stations are on segments of White Oak Creek that are in full attainment (although one nitrate plus nitrite value at White Oak Creek RM 7.54 (609110) slightly exceeds the TMDL target). The elevated nitrate plus nitrite concentrations at White Oak Creek RM 20.65 (X02K11) could be a result of the confluence with Sterling Run just upstream of White Oak Creek RM 20.65 (X02K11). Similarly, Town Run discharges to White Oak Creek just upstream of White Oak Creek RM 7.54 (609110), and this could explain the elevated concentration of nitrate plus nitrite and TSS at station White Oak Creek RM 7.54 (609110).

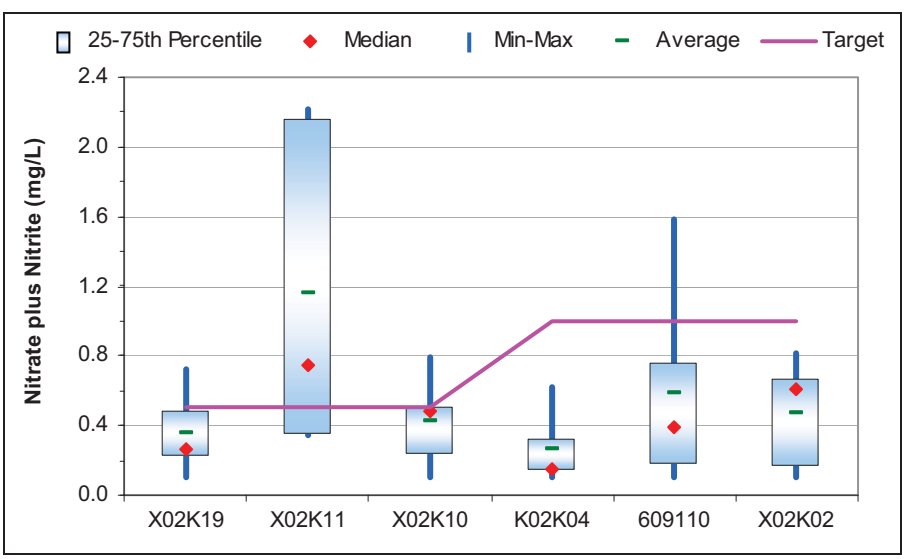

Figure 29. Nitrate plus nitrite concentrations along White Oak Creek.

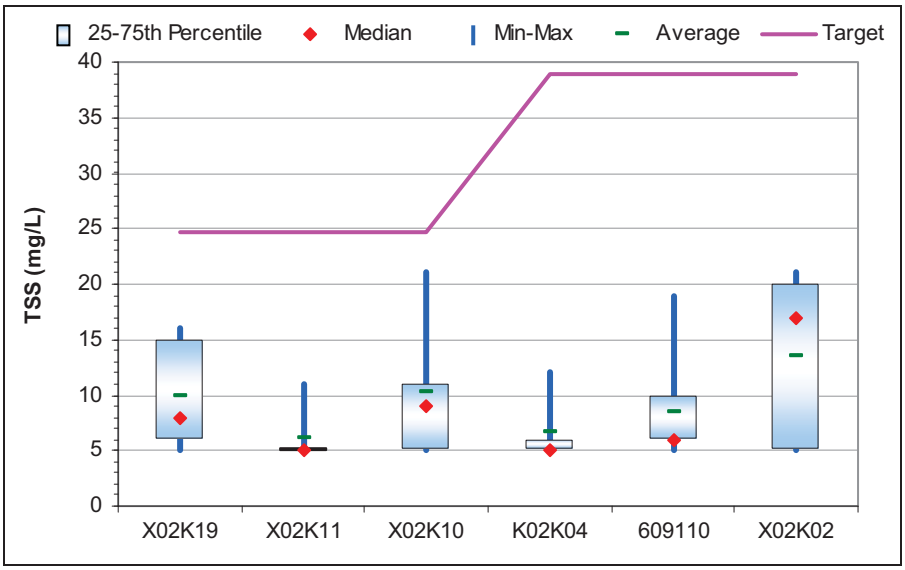

Figure 30. TSS concentrations along White Oak Creek.

3.2.7 HUC 05090201 10 03

Town Run is the only impaired segment identified in this subwatershed. It is a tributary to White Oak Creek and is now designated as CWH and PCR. There are six Ohio EPA sample stations in this subwatershed (Figure 31).

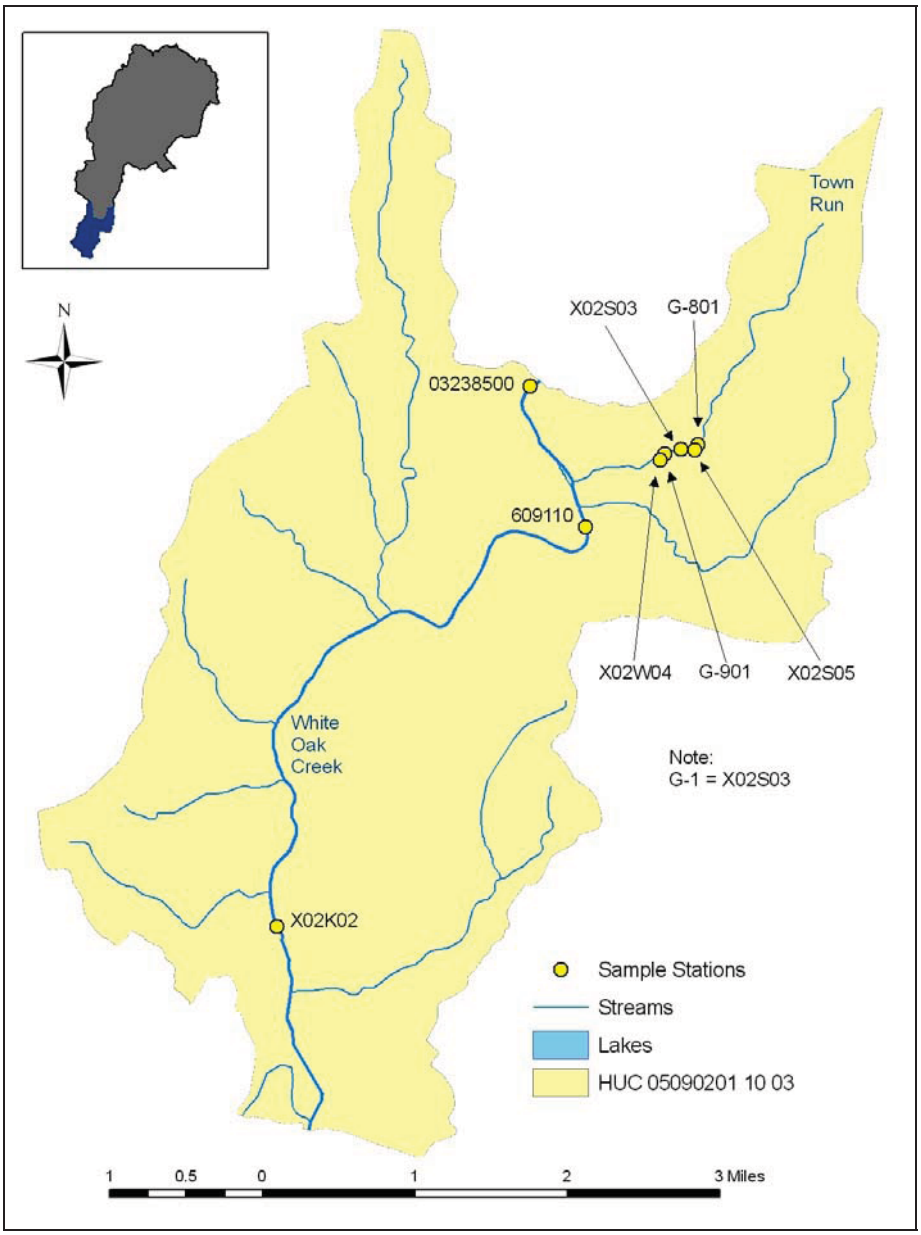

Figure 31. Sample stations in HUC 05090201 10 03.

Table 37 summarizes the pertinent water quality data at the two stations on Town Run: Town Run RM 0.90 (X02S05) and Town Run RM 0.63 (X02W04) (see Figure 33). Samples are collected by Georgetown WWTP personnel at locations upstream (G-801, which is located near station X02S05) and downstream (G-901, which is located near station X02W04) of the primary WWTP outfall, but they do not analyze samples for nitrate plus nitrite or total phosphorus.

Table 36. Nitrate plus nitrite samples collected in Town Run

Station ID	Drainage area[a]	# of records	Begin date	End date	Min (mg/L)	Max (mg/L)	Average (mg/L)	Exceed target[b]
X02S05	1.3	5	7/26/2006	9/27/2006	0.11	0.68	0.31	20%
X02W04	1.4	5	7/26/2006	9/27/2006	4.07	10.90	6.62	100%

[a]Drainage areas were reported by Ohio EPA and are in square miles.
[b]For a discussion of targets, see Section 3.1.

Table 37. Total phosphorus samples collected in Town Run

Station ID	Drainage area[a]	# of records	Begin date	End date	Min (mg/L)	Max (mg/L)	Average (mg/L)	Exceed target[b]
X02S05	1.3	5	7/26/2006	9/27/2006	0.08	0.11	0.10	80%
X02W04	1.4	5	7/26/2006	9/27/2006	2.52	5.84	3.66	100%

[a]Drainage areas were reported by Ohio EPA and are in square miles.
[b]For a discussion of targets, see Section 3.1 and Section 6.2.3.

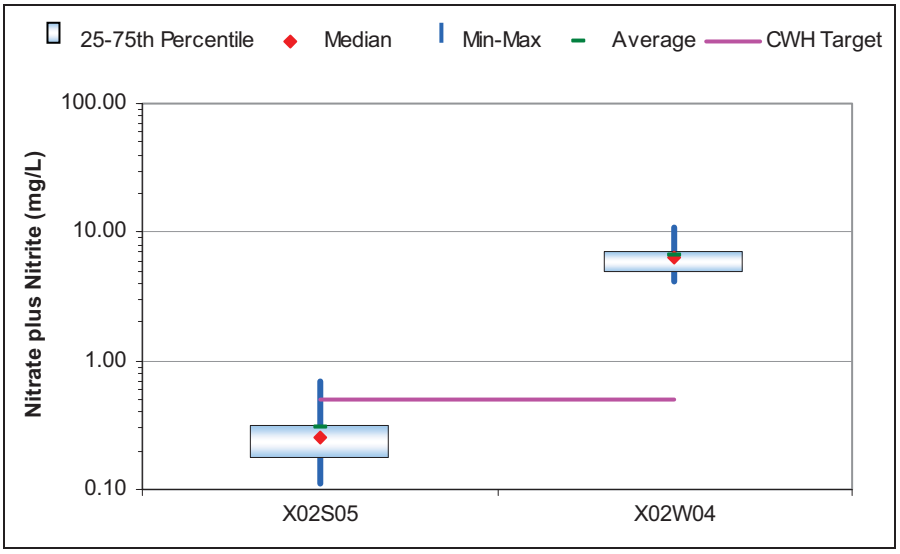

Figure 32. Nitrate plus nitrite concentrations along Town Run.

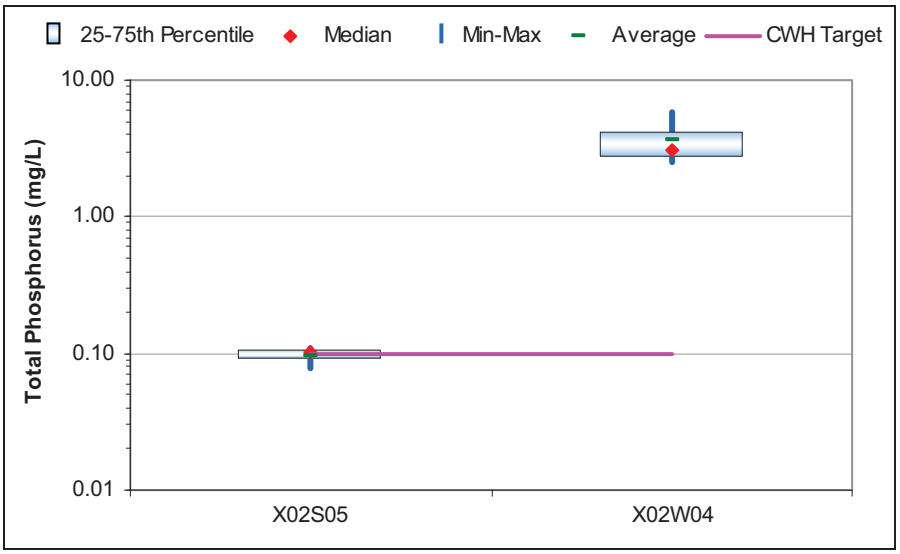

Figure 33. Total phosphorus concentrations along Town Run.

There are apparent increasing trends in nitrate plus nitrite and total phosphorus concentrations in Town Run (Figure 33). For total phosphorus, the increase occurs over a full order of magnitude. The elevated concentrations at Town Run RM 0.63 (X02W04) could be a result of the discharge from the Georgetown WWTP. Total phosphorus samples were collected by both Ohio EPA and Georgetown WWTP personnel; the sampling entity is identified with the statistics for these data, as presented below.

The median nitrate plus nitrite concentration at Town Run RM 0.63 (X02W04) is 6.4 mg/L. The median nitrate plus nitrite concentration at Georgetown WWTP's outfall (i.e., G-1 and X02S03) as measured by Georgetown WWTP personnel and Ohio EPA personnel are 9.5 and 6.5 mg/L, respectively. The median total phosphorus concentration at Town Run RM 0.63 (X02W04) is 3.0 mg/L, and the median total phosphorus concentration at Georgetown WWTP's outfall (i.e., G-1 and X02S03) as measured by Georgetown WWTP personnel and Ohio EPA personnel are 5.8 and 3.3 mg/L, respectively.

Ohio EPA upstream and downstream samples were collected within an hour of each other; therefore, it is likely that the Georgetown WWTP is the dominant contributor to total phosphorus and nitrate plus nitrite exceedances in Town Run. However, because 80 percent of the total phosphorus samples exceeded targets at the upstream station, there is likely another source of total phosphorus; whether it is anthropogenic is not known. Ohio EPA found elevated concentrations of phosphorus in stream sediments in White Oak Creek downstream of the confluence with Town Run (Ohio EPA 2008b). These elevated stream sediment concentrations of phosphorus might be derived from elevated concentrations of total phosphorus in the surface water in Town Run. An analysis of total phosphorus and TSS is not presented because all but one TSS samples yielded a result below detection limit.

3.3 Evaluation of Patterns throughout the Watershed

Bacteria data for eight streams exceed Ohio's bacteria standards; five of these streams are also listed for other parameters. Elevated concentrations of *E. coli* and fecal coliform were in the headwaters region of East Fork White Oak Creek and near Mount Orab in the Sterling Run subwatershed, and these and other less elevated concentrations could be the result of failing septic systems from unsewered residences and communities (Figure 34 and Figure 35).

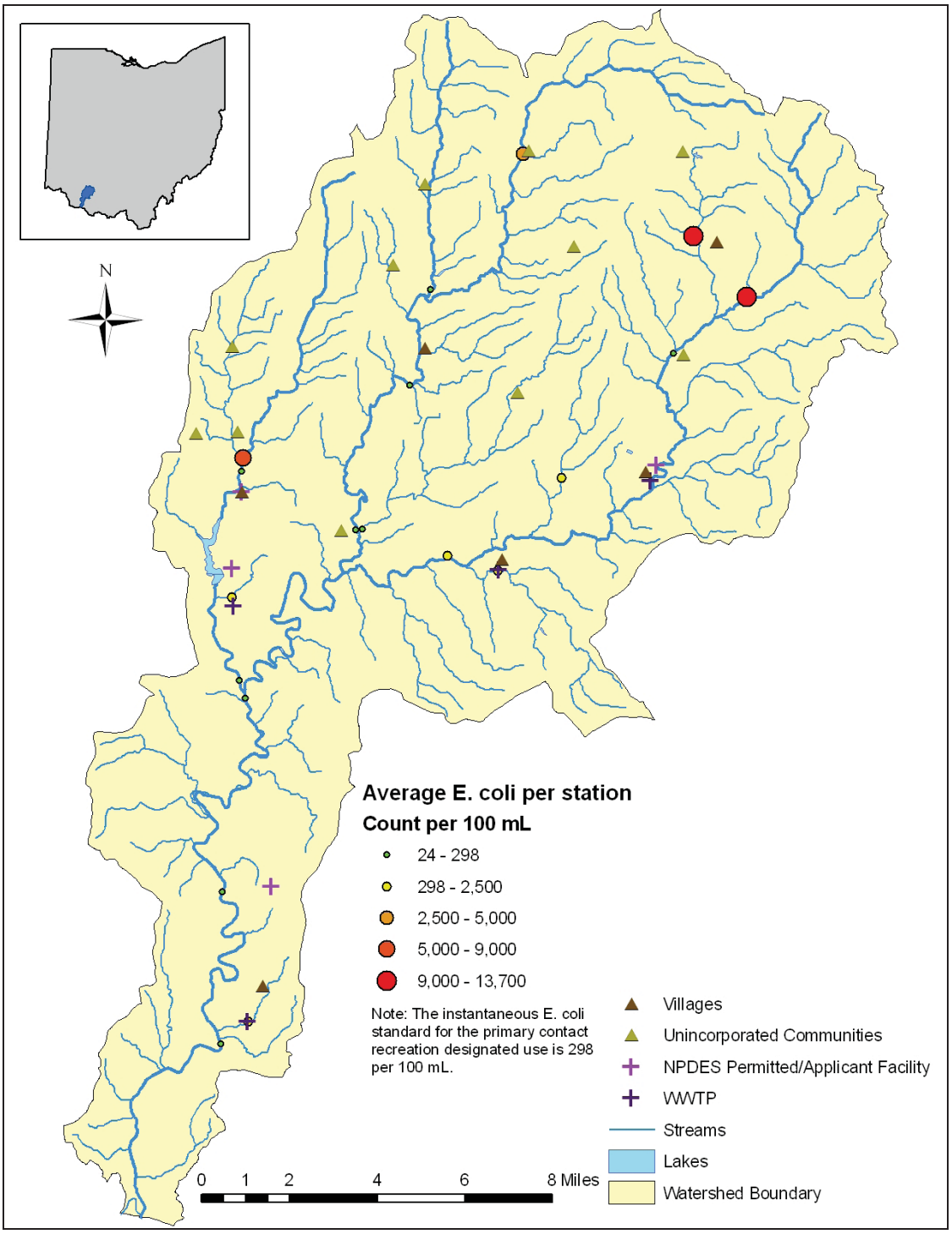

Figure 34. Average *E. coli* concentrations throughout the watershed.

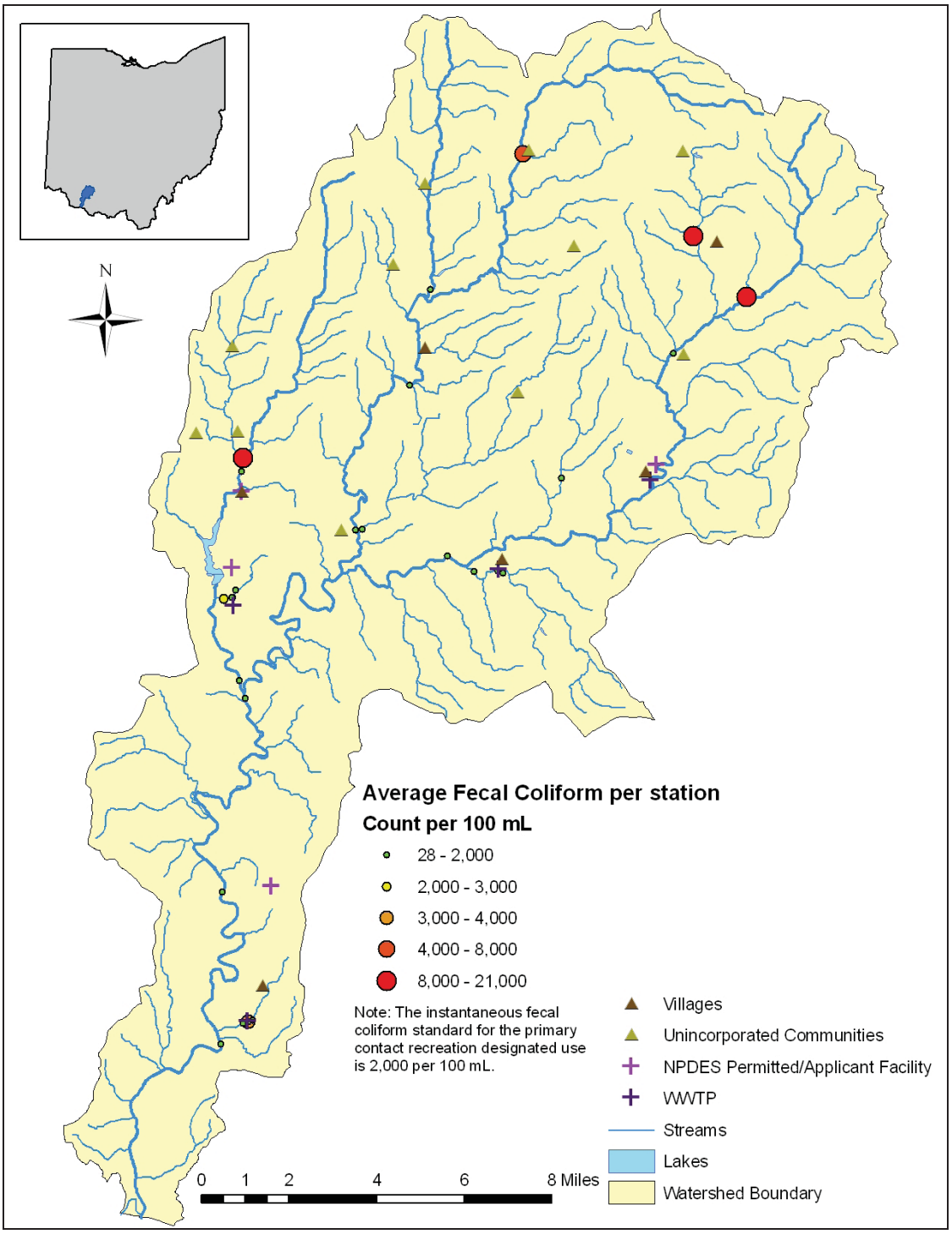

Figure 35. Average fecal coliform concentrations throughout the watershed.

Habitat issues affect eight of the streams on the 303(d) list. Ohio EPA found that all eight habitat-listed streams are impaired by siltation, which can be evaluated with TSS data. Elevated concentrations of TSS tended to occur in the East Fork subwatershed (Figure 36). In some areas, the elevated concentrations might be reflective of agricultural activities. Little North Fork has the lowest levels of in-stream, average TSS concentrations and has the highest relative percentage of crop cultivation. These low average TSS

concentrations are likely reflective of the dry weather conditions during the summer of 2006 when the streams were sampled. Normally, it is expected that higher levels of TSS would occur in agricultural areas and areas with high soil erodibility but concentrations may have been low in summer 2006 because no runoff events occurred during or immediately preceding the sampling.

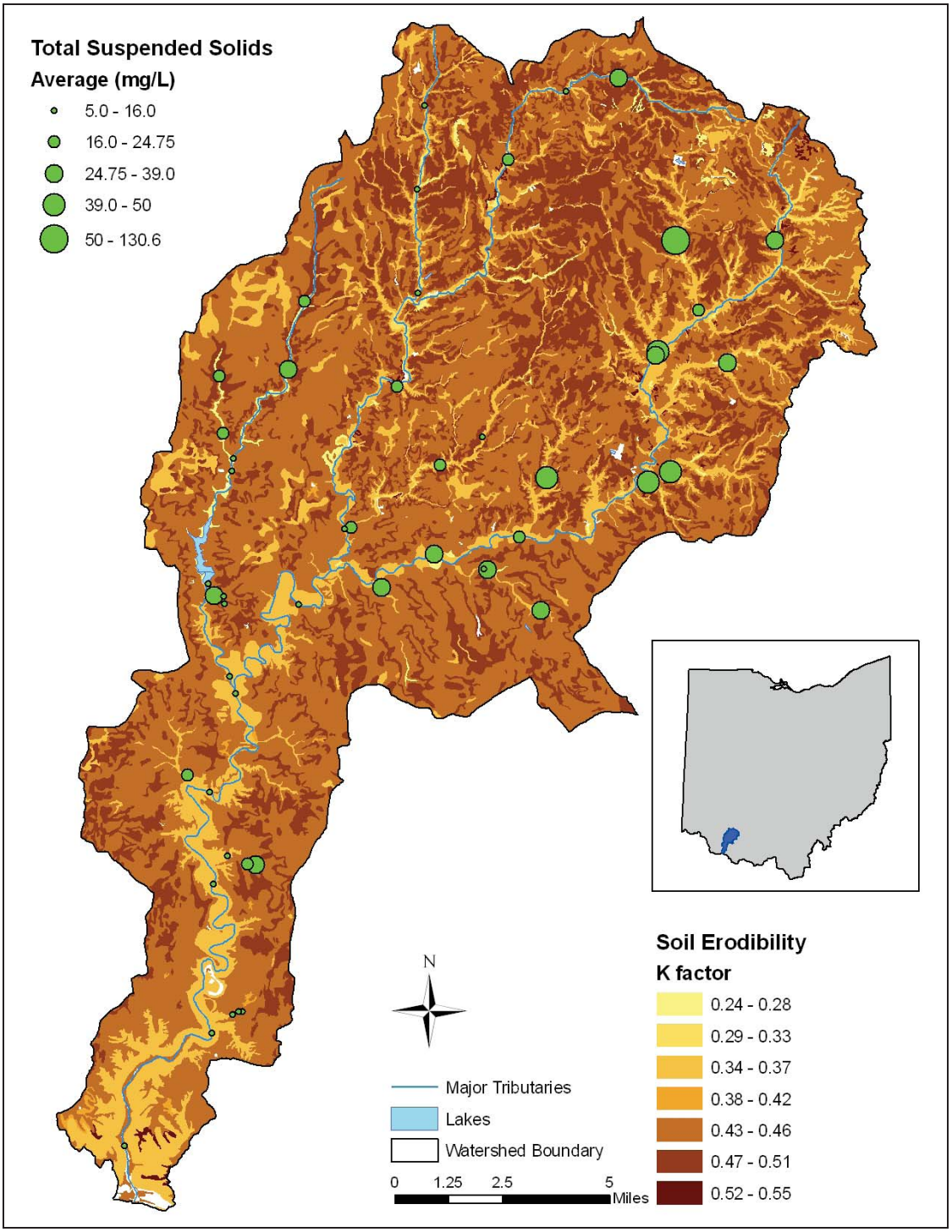

Figure 36. Average TSS concentrations throughout the watershed.

Ohio EPA primarily focused its atrazine-sampling events on the PWS intake in Sterling Run. However, Ohio EPA performed synoptic sampling over two 2-day periods during the summer of 2006. All the samples displayed concentrations below the 3.0 µg/L drinking water maximum contaminant level (Figure 37). Atrazine is further discussed in Section 3.4; however, it can be noted here that atrazine concentrations tend to be highest in the late spring and early summer. Synoptic sampling in May or June would likely show higher atrazine concentrations. A brief discussion of Ohio EPA's 2008 summer atrazine sampling is presented in Appendix F.

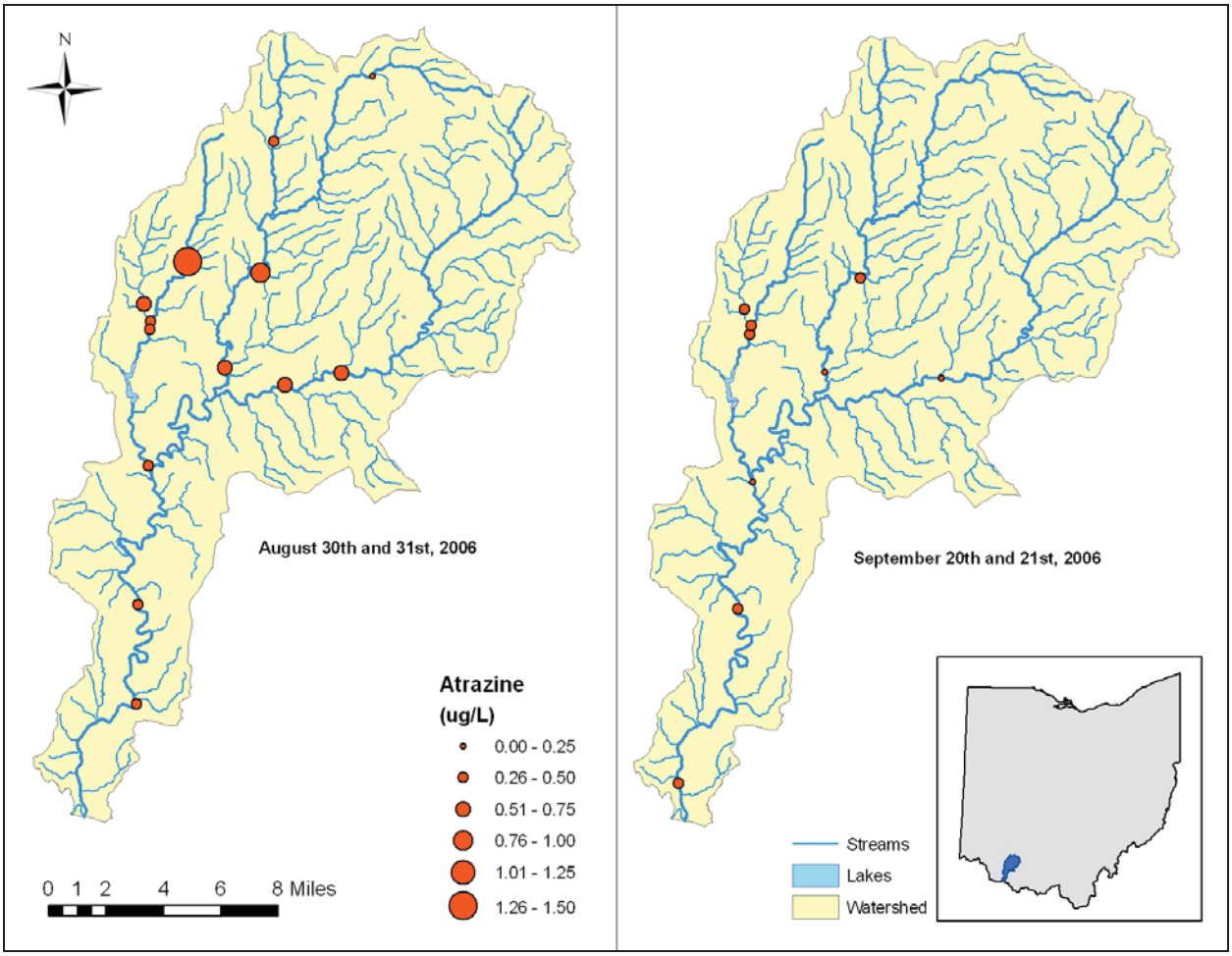

Figure 37. Atrazine concentrations throughout the watershed.

3.4 Atrazine at the Mount Orab PWS Intake

This section discusses atrazine regulations and water quality results at the Mount Orab WTP.

3.4.1 Background

Atrazine (CAS # 1912-24-9) is the most widely used herbicide in conservation tillage systems and was designed for treating broadleaf and grassy weeds (U.S. EPA 2003c). It is used in 80 countries throughout the world, and an estimated 77 million pounds were applied in the United States in 2003. The chemical formula is $C_8H_{14}ClN_5$ and is known as 2-chloro-4-(ethylamine)-6-(isopropylamine)-s-triazine. Atrazine has a half-life of approximately 13–261 days (U.S. EPA 2003c).

The U.S. Geological Survey (USGS) conducted a pesticide study in the East Fork Little Miami River (Funk et al. 2003), which is the watershed immediately northwest of the White Oak Creek watershed. USGS found numerous herbicides, fungicides, and pesticide degradates in water quality samples collected at a treatment plant intake, the plant's finished water, and an upstream location. The pertinent findings are that (1) pesticides detected in finished water were below U.S. EPA drinking water standards, (2) degradates were detected at higher concentrations in the finished water than at the treatment plant intake and the upstream location, and (3) the granular activated carbon method significantly reduced pesticides concentrations (Funk et al. 2003).

As discussed in Section 3.1.2.3, the maximum contaminant level for atrazine is 3 µg/L (U.S. EPA 2003a), and the Ohio EPA standard for atrazine concentrations within 500 yards of a PWS intake is 3.0 µg/L (Ohio EPA 2008e, 3745-1-34(C)(2)(A) and Table 34-1). The TMDL target for atrazine in Sterling Run is 35 µg/L (i.e., a maximum daily limit to maintain a 90-day average of 3.0 µg/L) and the community action level is 3.0 µg/L.

3.4.2 Memorandum of Agreement

During the re-registration process of atrazine, U.S. EPA entered into an MOA with the atrazine registrants when U.S. EPA published its Interim Re-registration Eligibility Decision (IRED) for atrazine on January 31, 2003 (U.S. EPA 2003b). The MOA includes provisions for sampling and reporting protocol for watersheds where atrazine is applied and is/was detected at a community water supply (CWS). If MOA criteria are not met, U.S. EPA has the authority to ban atrazine application in a watershed; at the time of publication, atrazine application has not been banned in any watershed (AWIC 2008). Since the publication of the IRED, U.S. EPA has published a Revised IRED on October 21, 2003. On April 6, 2006 U.S. EPA published a decision document that included the finalization of the IRED and completion of the tolerance reassessment and re-registration eligibility process (U.S. EPA 2006a).

The Mount Orab WTP and Sardinia WTP (no longer existent) were two of the CWSs studied for the re-registration process for atrazine. Mount Orab WTP was included in the Revised IRED as one of the 34 CWSs in which *intermediate-term (seasonal) drinking water risk estimates* exceeded the U.S. EPA *level of concern* on the basis of the chronic population adjusted dose (U.S. EPA 2003c, p.2).

3.4.3 Mount Orab WTP

The PWS intake at the Mount Orab WTP is at RM 6.74 on Sterling Run. The intake pump operates at approximately 1,000 gallons per minute and automatically shuts down when the water level in the stream is too low[2]. Currently, when atrazine levels in Sterling Run exceed the community action level (3.0 µg/L), the WTP hesitates to pump raw water to their upground reservoirs because of increased cost and risk to

[2] John Van Harlingen, operator, Mount Orab WTP, telephone conversation and email correspondence, August 2008.

human health. During the springs of 2006 through 2008, water was not withdrawn from the stream because of high atrazine concentrations derived from runoff from the spring rains.[3] This has led to water quantity issues for Mount Orab and caused the community to bear additional costs due to increased water purchases from Brown County Rural Water Association. In 2008, the WTP had to purchase one-half of its water because the reservoirs were too low after a dry fall and the lack of water withdrawal during the spring[4]. Additionally, inadequate water levels in the reservoirs can lead to water quality issues because of decreased retention times in the reservoirs. Using water with atrazine levels above the community action level requires running 100 percent of the water through the Granular Activated Carbon filters (a multi-million dollar system installed in 2005), leading to shortened filter run times and increased cost. Maintaining atrazine levels below the community action level would be directly in line with the Safe Drinking Water Act's multi-barrier approach by shifting some of the burden and cost of contaminant removal from the WTP to the sources of the contaminant, out in the watershed.

3.4.4 Analysis of Water Quality Samples Collected at or near the Mount Orab PWS Intake

Atrazine samples are collected from the PWS intake on Sterling Run, the reservoirs, and finished drinking water at Mount Orab WTP by plant personnel and analyzed by a laboratory contracted by Syngenta Crop Production, Inc. (an atrazine registrant for the MOA). From April through July, samples are collected weekly; for the remaining months, samples are collected biweekly. Sample statistics are summarized in Section 3.2.5.2 and the monthly results are presented in Figure 38. Samples were also collected by Ohio EPA at Sterling Run RM 6.74 (X02W05), which is 555 yards upstream of the PWS intake (Figure 39). Ohio EPA has defined the TMDL daily target as 35 µg/L and the community action level daily target as 3.0 µg/L; the target lines in the following figures represents these values.

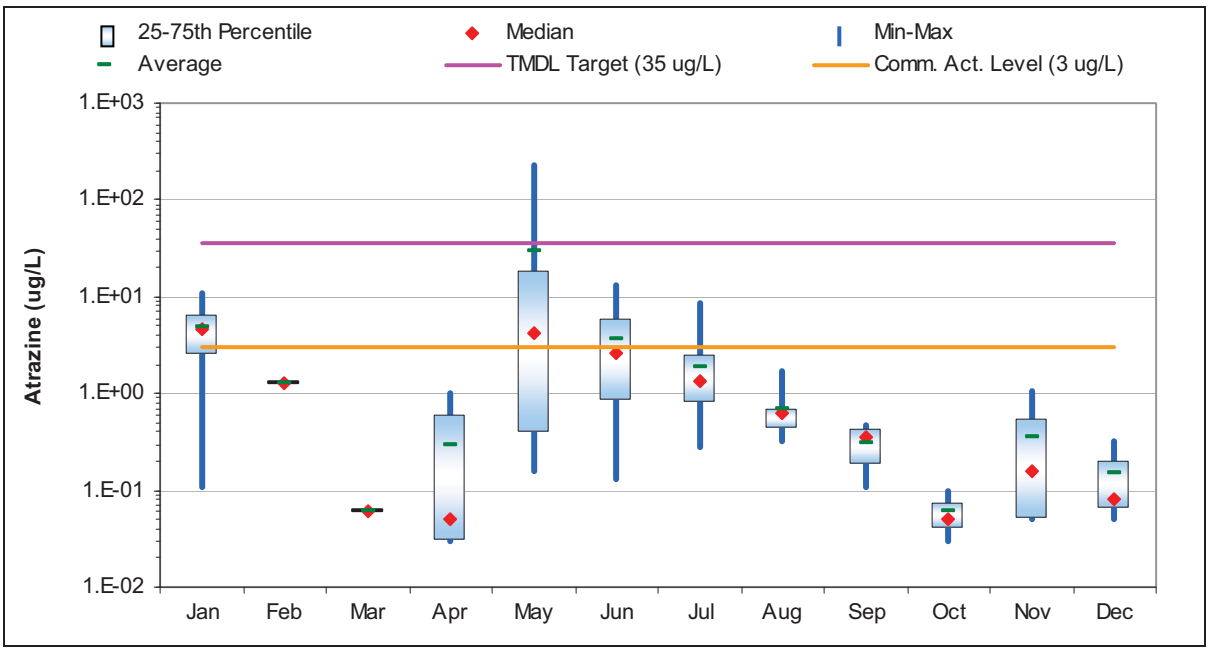

Figure 38. Summary statistics of atrazine concentrations at the Mount Orab PWS intake.

[3] John Van Harlingen, operator, Mount Orab WTP, telephone conversation and email correspondence, August 2008.
[4] John Van Harlingen, operator, Mount Orab WTP, telephone conversation and email correspondence, August 2008.

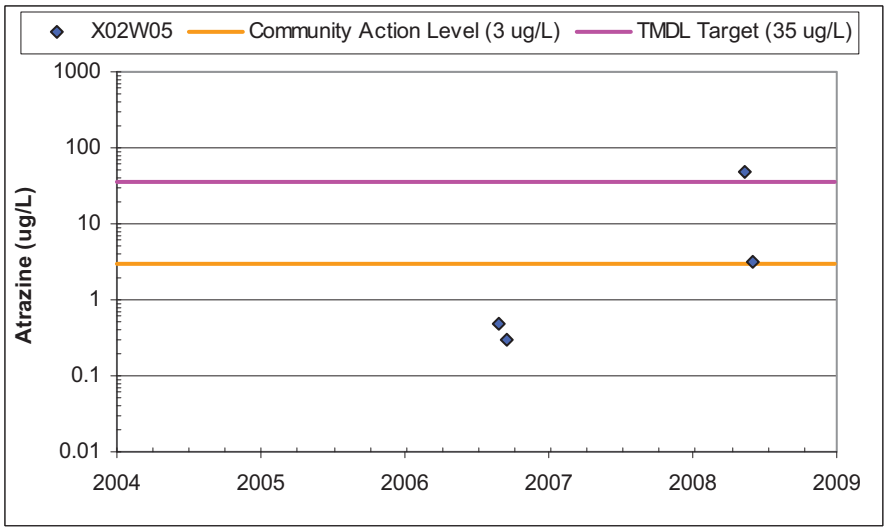

Figure 39. Atrazine concentrations at station X02W05.

Figure 38 shows that the highest concentrations of atrazine occur in January and between May and July, which likely represent runoff from spring rains after atrazine application (for a discussion of atrazine application and runoff, see Appendix F). Median and average concentrations of atrazine per season are always below the 35 µg/L target. However, data from January through May include only seven samples (five from 2006 and two from 2008), and data from October through December includes only 12 samples (five from 2006 and seven from 2007).

The 2006, 2007, and 2008 data show spikes in concentration during late May or early June and during early July (Figure 40). There is also a spike in January 2006 that could be the result of a fall application of atrazine in 2005[5]. Figure 41 displays the 90-day rolling averages of atrazine concentration at the PWS intake. Note that data from five of the seven biweekly samples from January through March 2008 were not provided, and one weekly sample from April 2008 was not provided. These missing samples would likely decrease the spike of 90-day rolling averages beginning in May 2008. Figure 41 presents calculations performed by Tetra Tech and not the 90-day rolling averages calculated by Syngenta as mandated by the MOA.

[5] John Van Harlingen, operator, Mount Orab WTP, telephone conversation and email correspondence, August 2008.

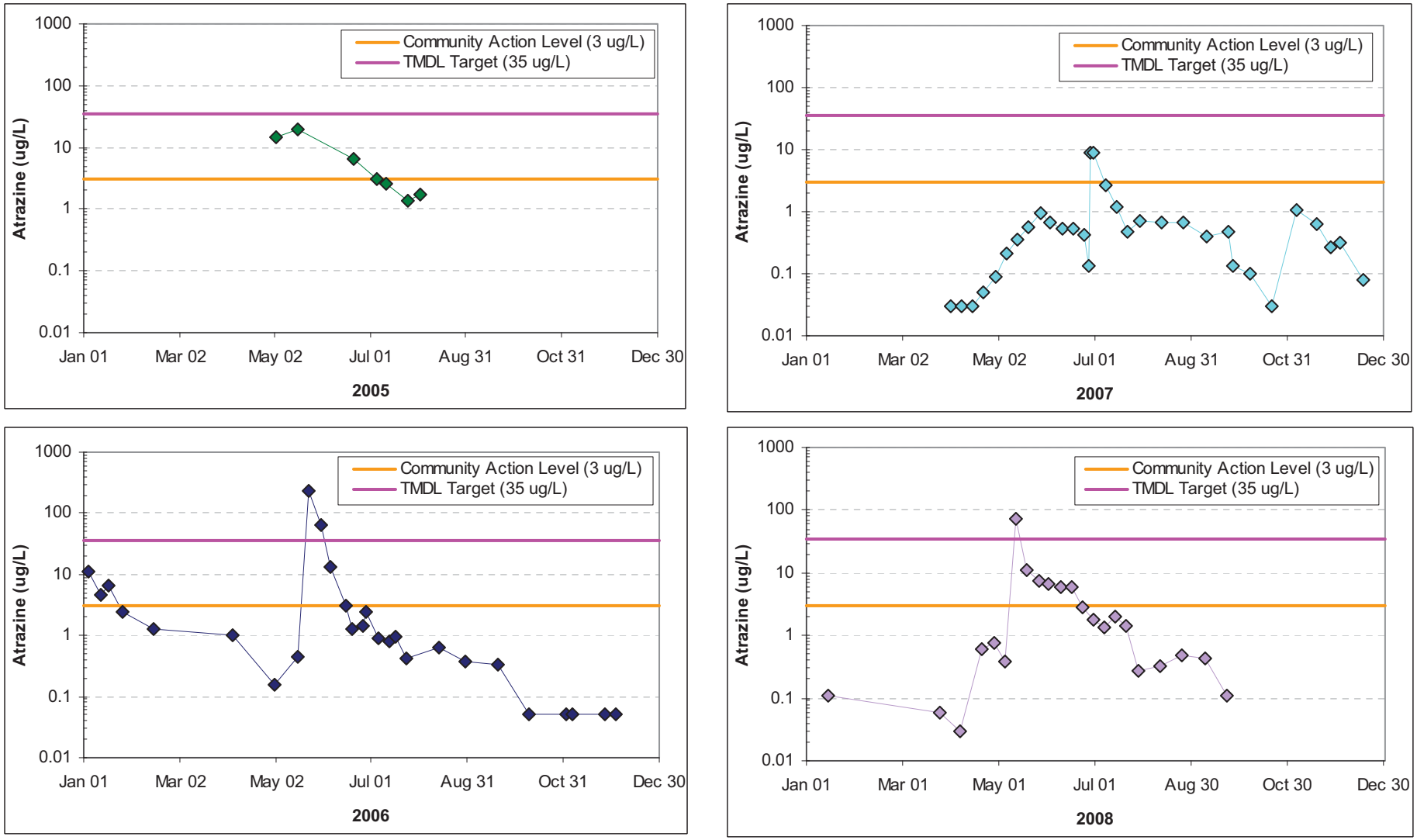

Figure 40. Atrazine concentrations at the Mount Orab PWS intake from 2005 to 2008.

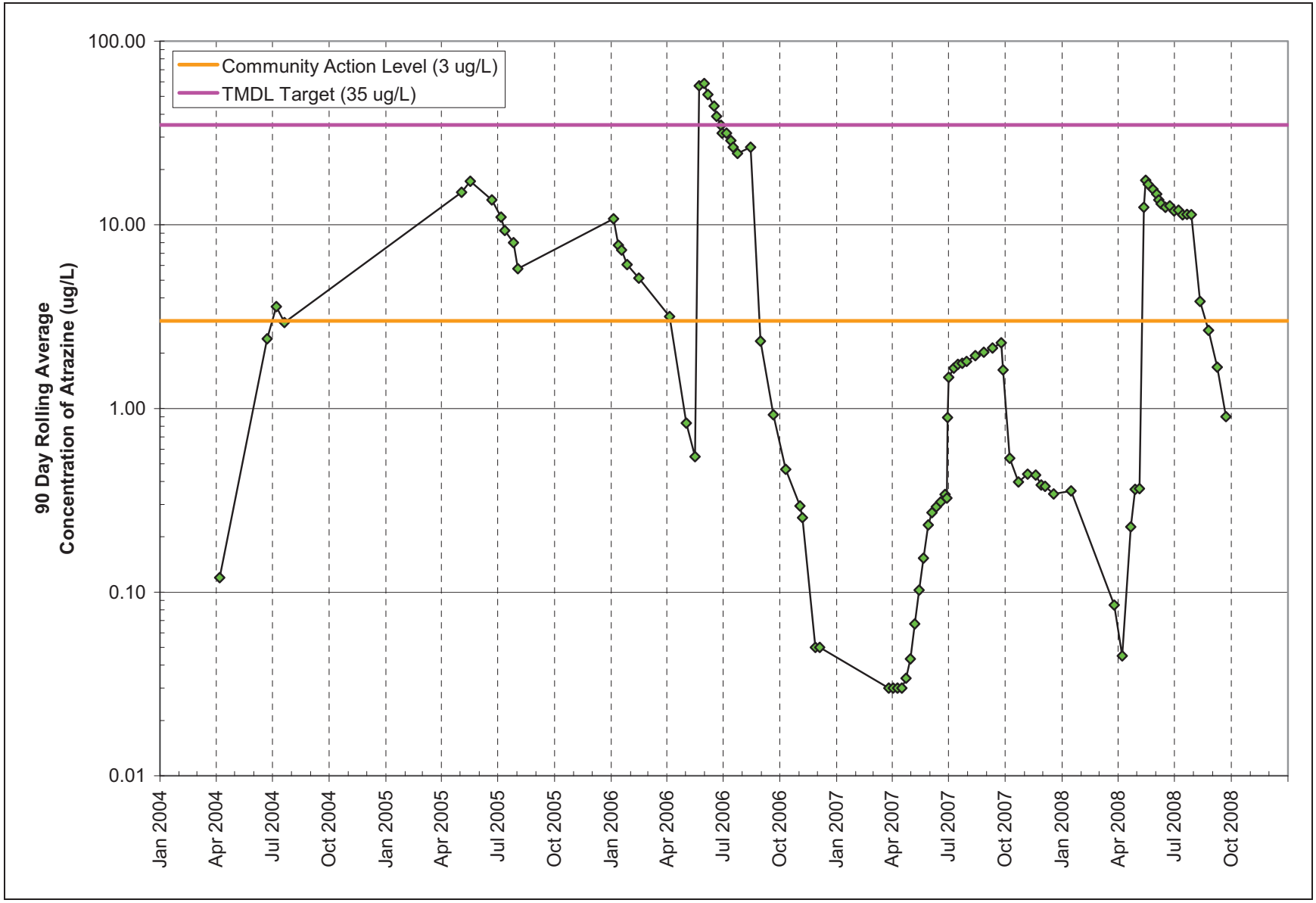

Figure 41. Ninety-day rolling average concentrations of atrazine at the Mount Orab PWS intake.

4 SOURCE ASSESSMENT

This section provides an inventory of the potential point and nonpoint sources of bacteria, nutrients (nitrate plus nitrite, ammonia and total phosphorus), sediment, and atrazine in the White Oak Creek watershed. The significance of each of these potential point and nonpoint sources is more fully explored in the *linkage analysis* presented in Section 5.

All loads presented in this section are preliminary loads calculated by the White Oak Creek watershed coordinator using the Spreadsheet Tool for Estimating Pollutant Loads (STEPL). The load reductions that result from implementing various best management practices (BMPs) were estimated using U.S. EPA Load Reduction Program, a component of the STEPL model. The details of these load calculations are in the *White Oak Creek Watershed Action Plan and Inventory* (Dragoo 2004).

4.1 Point Sources

This section presents information on the potential pollutant sources in the White Oak Creek watershed that are regulated through the National Pollutant Discharge Elimination System (NPDES) program. There are no combined sewer overflows, municipal separate storm sewer systems, animal feeding operations, or confined animal feeding operations within the White Oak Creek watershed. Although SSOs are a point source in some communities, they do not receive a wasteload allocation (WLA) because they are illegal.

4.1.1 Wastewater Treatment Plants and Industrial Dischargers

There are five active WWTPs and industrial discharge facilities that are permitted to discharge within the White Oak Creek watershed (Figure 42 and Table 39). All five facilities are minor dischargers—facilities with a design flow of less than 1 million gallons per day (MGD). Four of these facilities are permitted to discharge wastewater containing bacteria and nutrients to tributaries of White Oak Creek. These facilities include four municipal WWTPs (Georgetown, Mount Orab, Sardinia, and Highland County Southwest WWTPs). The Rumpke Sanitary Landfill NPDES permit is for a series of seven sediment ponds; leachate is trucked to the Georgetown WWTP.

The permit limits of each facility are summarized in Table 39. The WLAs presented in the TMDL tables (Section 6) will be based on these permit limits. For TMDL parameters not specifically addressed in the facility permits, literature values or the in-stream water quality standards will be used to calculate the WLAs.

On April 1, 2008, Ohio EPA performed an inspection of the Mount Orab WWTP. The NPDES Compliance Inspection (Ohio EPA 2008c) found that seven SSOs had occurred between September 2006 and April 2008 (Table 38). Additionally, the WWTP was rated *unsatisfactory* for final effluent discharge because of 73 violations between January 2007 and February 2008. Of these violations, 32 were for TSS (7- and 30-day quantity and concentration), 13 for carbonaceous biochemical oxygen demand (7- and 30-day quantity), and 28 for nitrogen-ammonia (7- and 30-day quantity and concentration). However, Mount Orab WWTP discharges to Snapping Turtle Run, which had no listed impairments in the *Integrated Report* (Ohio EPA 2008a).

Table 38. SSOs at Mount Orab WWTP

Dates	Release (gallons)
9/12/2006–9/13/2006	235,750
10/17/2006	122,000
1/14/2007–1/15/2007	128,300[a]
2/20/2007–2/21/2007	79,000
12/9/2007–12/10/2007	17,500
2/5/2008–2/6/2008	98,000
3/18/2008–3/20/2008	224,000

[a]There is a typographical error in the report (Ohio EPA 2008c); the value listed here is correct.

The Highland County Southwest WWTP will also be allowed to apply final effluent to an adjacent farm field (outfall 002) during May through October (recreation season). The only parameter regulated in the permit is fecal coliform (1,000 cfu/100 mL). This facility was designed to a 2010 capacity of 862 residents: 462 from the village of Mowrystown and 400 from surrounding areas (Ohio EPA 2008b).

The Sardinia WWTP was recently upgraded as well. It serves 943 residents and now has a 2030 design capacity for 1,354 residents (Ohio EPA 2008b). During an Ohio EPA water quality survey, significant amounts of sewage sludge were found in Slabcamp Run downstream of the WWTP. Ohio EPA ordered the removal of the WWTP operator for improper operation and falsification of reports; a new operator then took over operation of the Sardinia WWTP. One hundred thirty-seven NPDES violations occurred at the Sardinia WWTP between 2002 and 2006 (Ohio EPA 2008b).

The city of Georgetown WWTP discharges to Town Run RM 0.80. The treatment plant was constructed in 1972 with major modifications in 1991. Plant improvements were undertaken in 2007. The collection system is 100% sanitary sewer with no bypasses or overflows. The population served is approximately 3,691 persons. There are two industrial users, Stanley Mac Tool and leachate from Rumpke landfill.

Biological sampling in Town Run upstream of the Georgetown WWTP found a marginally good community of macroinvertebrates and a reproducing population of the cold water indicator two-lined salamander. Downstream from the WWTP discharge (RM 0.7 in 2008), the macroinvertebrate community was very poor and there was no observed reproduction of the two-lined salamander. High concentrations of ammonia-N (median of 3.24 mg/L), phosphorus-T (median of 3.04 mg/L), and nitrate-nitrite-N (median of 6.39 mg/L) were recorded downstream from the WWTP discharge in 2006 (Ohio EPA 2008b).

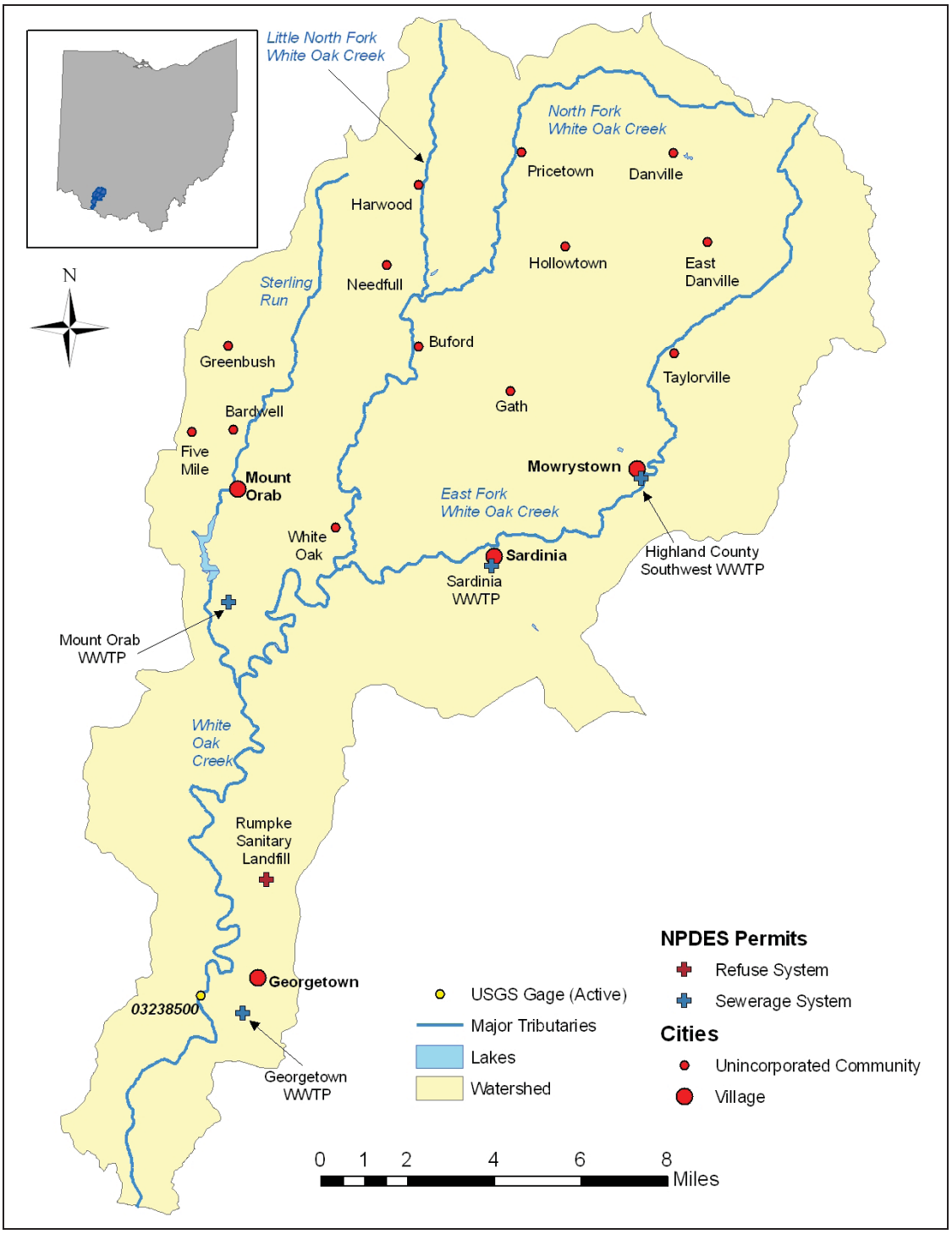

Figure 42. NPDES facilities in the White Oak Creek watershed.

Table 39. NPDES permitted dischargers within the White Oak Creek watershed

NPDES facility	NPDES permit #	Design flow (MGD)	Average flow (MGD)[a]	TSS limit (mg/L)	Fecal coliform (cfu/100ml)	Ammonia summer/winter limits (mg/L)
Georgetown WWTP	OH0021300	0.80	0.61	18[d]	2,000[d]	7.0[d]/8.0[d]
Mount Orab WWTP	OH0026646	0.70	0.50 / 0.45[e]	18[d]	2,000[d]	1.5[d]/3.0[d]
Sardinia WWTP	OH0020729	0.30	0.10	18[d]	2,000[d]	1.3[d]/2.8[d]
Highland County Southwest WWTP	OH0137499	n/a[b]	n/a[c]	18[d]	--	--/4.5[d]
Rumpke Sanitary Landfill	OH0109193	n/a[b]	n/a[c]	65	---	---

[a]Average flow was calculated from the DMR data; it is the mean over the entire available period of record (June 2003–October 2006). Values are rounded to the nearest one-hundredth of an MGD.
[b]Data were not reported in the permit for this facility.
[c]DMR data were not available for this facility.
[d]Limit presented is a weekly discharge limitation. No daily limits are presented in the permit.
[e]The value of 0.45 MGD was reported in the NPDES Compliance Inspection Report for Mount Orab WWTP (Ohio EPA 2008c).

4.2 Nonpoint Sources

This section presents information on all potential pollutant sources in the White Oak Creek watershed that are not regulated through the NPDES program.

4.2.1 On-site Wastewater Systems

Human waste is a potential source of bacteria and nutrient impairment in the White Oak Creek watershed. Unsewered areas, with failing or poorly maintained home sewage treatment systems (HSTS), are of concern because untreated sanitary wastewater, from rural residential areas or small businesses, is discharged directly or indirectly into streams. These unsewered areas rely on septic tanks, leaching fields, or subsurface sand filters for sewage treatment.

If these HSTS are not properly designed, installed, and maintained, they have the potential to significantly affect local water quality. Such effects include excessive nutrient and bacteria loads causing algal blooms, strong odors, and aquatic life impairments. Furthermore, HSTS malfunctions pose a danger to human health when they contaminate drinking water supplies, wells, and fishing and swimming areas.

Other natural features in the White Oak Creek watershed further compound the installation, maintenance, and effluent treatability issues for HSTS. These geologic and hydrologic features include (Dragoo 2004) the following:

- A seasonally high water table
- Restricted soil permeability
- Poor drainage
- Flooding
- Limited depth to bedrock
- High clay content of local soils

There are several rural areas in the White Oak Creek watershed that do not have a centralized wastewater collection and treatment facility (Dragoo 2004; Ohio EPA 2004). If not properly installed or maintained, the HSTS in these areas can pose a serious threat to water quality, and the communities within the White Oak Creek watershed recognize this threat. Results of a community survey, mailed by the White Oak Creek watershed coordinator, show that the second highest issue of concern of residents in the watershed was failing HSTS (Dragoo 2004).

Approximately 60 percent of Highland County is not served by a public sewage system, and those residents rely on HSTS (Dragoo 2004). In 2004 there were no sewered areas in the portions of Highland County that lie within the White Oak Creek watershed (Dragoo 2004). The watershed plan (Dragoo 2004) for White Oak Creek suggests that HSTS in the northern two-thirds of the watershed (mostly covered by Highland County) are most likely to be failing because of the low permeability and high clay content of the local soils.

The Highland County General Health District estimates that nearly 23,000 Highland County residents (or about 8,850 households) are not in sewered areas and use HSTS (HCGHD 2004). The General Health District found that HSTS at 14 of 93 residences in Buford and 2 of 44 residences in Pricetown were failing. Table 40 presents a summary of the estimated populations in each Highland County governmental unit and the proportion of those populations using HSTS (HCGHD 2004). However, these data are from 2004 and do not reflect the recent construction of the Highland County Southwest WWTP, which now serves the village of Mowrystown.

Table 40. Highland County General Health District sewered and unsewered population estimates

Governmental unit	Total population	Estimate of population using HSTS	Proportion of population using HSTS (%)
Brushcreek Township (total)	1,308	442	34%
Village of Sinking Springs (part of)	**158**	**61**	**39%**
Remainder of Brushcreek Township	1,150	442	38%
Clay Township	1,219	469	38%
Concord Township	1,167	449	38%
Dodson Township (total)	2,514	463	18%
Village of Lynchburg (part of)*	**1,310**	**0**	**0%**
Remainder of Dodson Township	1,204	463	38%
Fairfield Township (total)	3,219	668	21%
Village of Leesburg (part of)*	**1,200**	**0**	**0%**
Village of Highland (part of)*	**283**	**109**	**39%**
Remainder of Fairfield Township	1,736	668	38%
Hamer Township	699	269	38%
Jackson Township	1,099	423	38%
Liberty Township (total)	9,798	1,319	13%
City of Hillsboro (part of)*	**6,368**	**0**	**0%**
Remainder of Liberty Township	3,430	1,319	38%
Madison Township (total)	6,922	682	10%
City of Greenfield (part of)*	**5,150**	**0**	**0%**
Remainder of Madison Township	1,772	682	38%
Marshall Township	1,008	388	38%
New Market Township	1,941	747	38%
Paint Township (total)	4,112	82	2%
Rocky Fork Lake, N. Shore (part of)*	**3,900**	**0**	**0%**
Remainder of Paint Township	212	82	39%
Penn Township	1,055	406	38%
Salem Township	682	262	38%
Union Township	1,710	658	38%
Washington Township	1,048	403	38%
White Oak Township (total)*	1,374	528	38%
Village of Mowrystown (part of)*	**373**	**143**	**38%**
Remainder of White Oak Township	1,001	385	38%
Totals	**40,875**	**8,825**	**22%**

* Sewered Areas (17,928 people/6,895 households).

The HSTS estimates were derived by subtracting the populations served by centralized sewer systems from the 2000 county population.

The data in this table are from HCGHD (2004) and predate the construction of the Highland County Southwest WWTP, which serves the village of Mowrystown.

On the basis of 2000 U.S. Census data, Brown County has a population of approximately 42,285, and it is estimated that about 67 percent of that population (21,120) uses HSTS (BCGHD 2004). Of the total unsewered population in Brown County, an estimated 3,590 HSTS are within the White Oak Creek watershed (BCGHD 2004). The Brown County Health Department surveyed 200 systems over 3 months and found that 55 percent of the systems surveyed were failing (Dragoo 2004). In Sterling Run, the Brown County Health Department and White Oak Creek Watershed Partners estimate that one-quarter of HSTS are failing (Ohio EPA 2008b). Both Highland and Brown counties have completed sewage plans that address the problems, solutions, rules, and regulations for HSTS in the White Oak Creek watershed (HCGHD 2004; BCGHD 2004; BCGHD 2007).

Table 41 presents estimates of HSTS in White Oak Creek by subwatershed, as well as estimates for the nitrogen and phosphorus loading rates to each subwatershed on the basis of STEPL and Load Reduction models. Very conservative failure rates were used to calculate the number of failing systems (Dragoo 2004).

Table 41. Estimates of failing HSTS and nutrient loading from HSTS in the White Oak watershed

Subwatershed	Total no. of HSTS	No. of people served per system	HSTS failure rate	No. of failing HSTS	Estimates loading rate (lbs/year)		
					TN	TP	BOD
Sterling Run	1,747	2.69	25%	437	15,031	5,887	61,375
Upper Main	1,536	2.69	15%	230	7,929	3,105	32,377
Lower Main	1,017	2.69	10%	101	3,500	1,371	14,292
East Fork	720	2.6	25%	180	5,987	2,345	24,448
North Fork	230	2.6	25%	58	1,913	749	7,810
Little North Fork	305	2.6	25%	76	2,536	993	10,357
Total	**5,555**	--	--	**1,082**	**36,896**	**14,450**	**150,659**

Adapted from Dragoo (2004). The data in this table predate the construction of the Highland County Southwest WWTP, which serves the village of Mowrystown.

BOD = biochemical oxygen demand; TN = total nitrogen; TP = total phosphorus

Target areas for failing HSTS include the community of Buford, the State Route 134 corridor, the community of Danville, the community of East Danville, and other small patches of rural, unsewered areas in the White Oak Creek watershed drainage area (Dragoo 2004; HCGHD 2004).

Two other specific communities in the Sterling Run subwatershed are noted by the *Mount Orab Drinking Water Source Assessment Report* as areas with HSTS issues: Mount Orab and Green Township (Ohio EPA 2004). The report also estimates that 437, or 25 percent, of the 1,747 HSTS in the Sterling Run watershed are failing. Brown County has banned land application of septage within the county to help address previous issues with septic haulers disposing of waste (Ohio EPA 2004).

The White Oak Creek watershed coordinator along with the Brown Soil and Water Conservation District (SWCD) and Highland SWCD had previously maintained cost-share programs to help mitigate these impacts. Eighteen HSTS in Highland County and fifteen HSTS in Brown County were improved via this cost-share program by early 2004. These upgraded systems treat 11,760 gallons per day (Dragoo 2004).

4.2.2 Livestock

Although there are no permitted animal feeding operations or concentrated animal feeding operations in the White Oak Creek watershed, pasture-based livestock populations exist throughout the watershed and are potential sources of bacteria and nutrients. Unrestricted livestock access is a listed cause of impairment in White Oak Creek (Ohio EPA 2008a). When cattle have direct access to streams, riparian vegetation is trampled and severe erosion could result, causing elevated sedimentation. Permanent pasture exists in portions of Sterling Run, North Fork, Little North Fork, and East Fork subwatersheds (Dragoo 2004).

Properly managed pasture land can have minimal impacts on adjacent waterbodies; however, poorly managed or unmanaged pasture land can have significant environmental consequences such as increased runoff rates, soil erosion, manure runoff (or direct inputs to streams where livestock have access), and minimized nutrient removal capabilities.

Table 42 outlines the total number of livestock operations, number of operations needing improvement, and livestock access details as provided by the *White Oak Creek Watershed Action Plan and Inventory* (Dragoo 2004).

Table 42. Livestock operations in the White Oak Creek watershed

Subwatershed	Total # of livestock operations	# of livestock operations needing improvement	Direct livestock access present?
Lower Main	20	17	YES- along 8 miles of streambank
Upper Main	54	39	YES- along 5 miles of streambank
Sterling Run	14	11	YES- along 3 miles of streambank
North Fork	13	11	YES- along 3 miles of streambank
Little North Fork	20	6	YES- along 2 miles of streambank
East Fork	85	48	YES- along 10 miles of streambank

Watershed-specific data are not available for livestock populations in White Oak Creek. However, countywide statistics are available from the National Agricultural Statistic Service (NASS 2008). Table 43 details the county statistics for all available cattle and hogs/pigs data from 2005 to 2008, and Table 44 displays the proportion of each county that the White Oak Creek watershed covers.

Table 43. Livestock data for Brown and Highland counties

County	Commodity (values in head)						
	All cattle (2005)	All cattle (2006)	All cattle (2007)	All cattle (2008)	Hogs & pigs (2005)	Hogs & pigs (2006)	Hogs & pigs (2007)
Brown	17,900	18,300	17,800	18,800	2,000	1,800	2,100
Highland	21,000	21,200	20,600	21,100	8,700	9,600	10,900

Table 44. White Oak Creek County coverage

County	Total county area (acres)	Area of White Oak Creek within county (acres)	Percentage of:	
			County Covered by Watershed	Watershed Area Within County
Brown	314,180	76,648	24%	51%
Highland	350,806	73,972	21%	49%

The White Oak Creek watershed coordinator along with the Brown SWCD and Highland SWCD has instituted cost-share programs to help mitigate these impacts, such as the following: livestock exclusion fencing and winter livestock storage structures (Dragoo 2004). At publication, the only active cost-sharing program is livestock exclusion fencing.

4.2.3 Wildlife

Wildlife (e.g., deer, geese, ducks) can also be sources of bacteria and nutrients. Deer population data are sometimes used as surrogates for estimating wildlife populations; however, no specific Ohio county deer population data are available. The Ohio Department of Natural Resources' white-tail deer status report indicates that the 2006 statewide population was expected to be around 600,000 deer (Ohio Department of Natural Resources [ODNR] 2007). The 2008 pre-hunting season population estimate is at about 675,000 deer, and the Division of Wildlife anticipates that between 115,000 to 120,000 deer will be killed during the

9-day 2008 season (ODNR 2007). White-tail deer are found in all 88 Ohio counties and population abundance is noted as high for both Brown and Highland counties (ODNR 2007).

4.2.4 Agricultural Runoff

Brown and Highland counties both contain over 200,000 acres in farmland and of that area, over 70 percent is dedicated to cropland in both counties (Ohio Department of Agriculture [DOA] 2004). The 2001 NLCD data show that 83,122 acres of the White Oak Creek watershed are cropland. While there is some residential development encroaching on farmland, the number of farms and land in farms has remained relatively consistent from 2003 to 2004, as indicated by Table 45.

Table 45. Agricultural statistics for Brown and Highland counties

	Number of farms		Land in farms (acres)	
County	**2003**	**2004**	**2003**	**2004**
Brown	1,400	1,390	215,000	215,000
Highland	1,380	1,370	261,000	261,000

Source: Ohio DOA 2004

When proper BMPs are not in place, agricultural practices can be a significant source of sediment, nutrients, pathogens, and pesticides. Surface runoff can wash cropland applications of fertilizer, manure, and herbicide into adjacent waterbodies. The *White Oak Creek Watershed Action Plan and Inventory* notes that intensive agricultural practices and a loss of protective streamside filter strips are the leading cause of sediment runoff that impairs streams in the White Oak Creek watershed (Dragoo 2004). A lack of crop rotation, improper fertilizer and herbicide application, and missing riparian filter strips are some of the agricultural issues thought to be causing nutrient and atrazine exceedances (Dragoo 2004). Row crop agriculture with drainage ditches in the fields is a major factor that could be the cause of increased sediment and nutrient loads in the streams (Ohio EPA 2008b).

Atrazine is a commonly used herbicide in corn, hay, sorghum, rangeland, grass crops, and grassland crops to control broadleaf and grassy weeds. In 1987/89, it was estimated that atrazine was the most heavily used herbicide on corn and soybean crops in Ohio and several other states (U.S. EPA 2006b). During wet-weather events (rain and snowmelt), atrazine can be washed from croplands into adjacent streams where it remains fairly mobile. This is because atrazine is not highly soluble in water and typically does not adsorb very strongly to sediments, with the exception of muck and sediments with high clay content (U.S. EPA 2006b). Atrazine most readily degrades through microbial synthesis in soils, giving it a half-life in topsoil of about 60 days (Christensen and Ziegler 1998). It also degrades in water through the process of hydrolysis, though its half life in water is much longer than that on land.

As noted in Section 2.2, the White Oak Creek watershed is dominated by agricultural land use. The individual 12-digit HUC land cover statistics also indicate that all subwatersheds (with the exception of 05090201 10 02 and 05090201 10 03) contain 50 percent or more row crop land cover. All subwatersheds contain 38 percent or greater row crop land cover (Table 5).

Another issue in the White Oak Creek watershed that exacerbates agricultural runoff is the loss of forested and grassed filter strips, or riparian buffers. These vegetated areas lie on the stream banks and terrestrial areas adjacent to streams and act as a *living filter* that can trap sediment, nutrients, and herbicides before they reach the stream as runoff. While there are several areas of healthy riparian vegetation throughout the White Oak Creek watershed, there are many areas that have minimal or no riparian buffers (Table 46). To maximize farmable land and water drainage, many of the riparian buffer areas have been removed or minimized and the streams have been channelized. This is particularly true for the central and northern reaches of the watershed (Dragoo 2004).

Table 46. Riparian buffer health in the White Oak Creek watershed

Subwatershed[a]	Riparian buffer present (miles)	Riparian buffer needed (miles)	Channelized stream length (miles)
Lower Main	22.08	3.19	4.75
Upper Main	36.28	14.56	9.08
Sterling Run	19.07	27.92	33.98
North Fork	30.13	17.29	14.66
Little North Fork	26.95	27.33	26.63
East Fork	75.57	57.32	38.34

Table adapted from Dragoo (2004).

[a]Subwatersheds reported in Dragoo (2004) were derived from the 14-digit HUCs. Data reported elsewhere in this report and other Tetra Tech documents are from the 12-digit HUCs. Corresponding 14-digit and 12-digit HUCs do not perfectly align and one HUC-14 was split into two HUC-12s. See Appendix D for further details.

As previously mentioned, the STEPL model was used to estimate nitrogen, phosphorus, BOD5, and sediment loads for each 14-digit HUC in the White Oak Creek watershed. The results from the *White Oak Creek Watershed Action Plan and Inventory* (Dragoo 2004) are presented in Table 47 and Table 49 below. These preliminary loading values are presented to illustrate the estimated magnitude of loads from various land uses and subwatersheds. Table 48 displays the loads (from Table 47) per square mile; the Little North Fork subwatershed contributes the highest rate of loading per square mile for all four parameters.

Table 47. Modeled pollutant loads by subwatershed

	Estimates loading rates			
Subwatershed[a]	Nitrogen (lbs/yr)	Phosphorus (lbs/yr)	BOD (lbs/yr)	Sediment (tons/yr)
Sterling Run	79,793	22,039	213,340	8,685
Upper Main	72,957	17,868	197,981	7,658
Lower Main	46,342	12,871	107,204	6,171
East Fork	205,294	56,038	451,981	29,262
North Fork	106,058	30,333	220,812	16,359
Little North Fork	131,708	37,572	274,570	20,207
Total	**642,151**	**176,721**	**1,465,888**	**88,341**

Table adapted from Dragoo (2004).

[a]Subwatersheds reported in Dragoo (2004) were derived from the 14-digit HUCs. Data reported elsewhere in this report and other Tetra Tech documents are from the 12-digit HUCs. Corresponding 14-digit and 12-digit HUCs do not perfectly align and one HUC-14 was split into two HUC-12s.

Table 48. Loading rates per unit area for the modeled pollutant loads by subwatershed

Subwatershed[a]	Loading rates per area[b]			
	Nitrogen (lbs/yr per mi^2)	Phosphorus (lbs/yr per mi^2)	BOD (lbs/yr per mi^2)	Sediment (tons/yr per mi^2)
Sterling Run	2,660	735	7,111	290
Upper Main	1,806	442	4,902	190
Lower Main	2,642	734	6,112	352
East Fork	2,563	700	5,644	365
North Fork	2,853	816	5,941	440
Little North Fork	4,367	1,246	9,104	670

Table adapted from Dragoo (2004).

[a]Subwatersheds reported in Dragoo (2004) were derived from the 14-digit HUCs. Data reported elsewhere in this report and other Tetra Tech documents are from the 12-digit HUCs. Corresponding 14-digit and 12-digit HUCs do not perfectly align and one HUC-14 was split into two HUC-12s.

[b]Loading rates per area were calculated using the area of the 14-digit HUCs. Values are rounded to the nearest pound per year per square mile or ton per year per square mile.

Table 49. Modeled pollutant loads by source

Sources[a]	Estimates loading rates			
	Nitrogen (lbs/yr)	Phosphorus (lbs/yr)	BOD (lbs/yr)	Sediment (tons/yr)
Urban and Septic	82,914	18,666	321,541	1,536
Cropland	481,960	140,944	962,228	79,368
Pastureland	63,776	13,405	157,910	6,582
Forest	7,226	2,551	15,495	856
Feedlots	6,275	1,154	8,714	0
Total	**642,151**	**176,721**	**1,465,888**	**88,341**

Table adapted from Dragoo (2004).

[a] Land use reported in Dragoo (2004) was derived from the 1992 NLCD and 14-digit HUCs. Data reported elsewhere in this report and other Tetra Tech documents are from the 2001 NLCD and the 12-digit HUCs.

The White Oak Creek watershed coordinator previously ran a cost-share program with the Brown SWCD and Highland SWCD that reduced nitrogen, phosphorus, and sediment loading. These BMPs were estimated to reduce the nitrogen load by 6,709 pounds per year (~1 percent of the annual load), the phosphorus load by 3,362 pounds per year (~2 percent of the annual load) and the sediment load by 2,265 tons per year (~2.6 percent of the annual load).

5 TECHNICAL APPROACH AND LINKAGE ANALYSIS

This section presents the technical approach used to estimate current and allowable loading to White Oak Creek and its tributary streams. The section also evaluates the most likely connection between the observed water quality (Section 3) and the sources of concern (Section 4)—a step in the TMDL process that is often referred to as the *linkage analysis*.

5.1 Linkage Analysis

This subsection provides an evaluation of impacts to specific sample stations that can be attributed to point and nonpoint sources.

5.1.1 Wastewater Treatment Plants

WWTPs are in four villages within the watershed: Georgetown, Mount Orab, Mowrystown, and Sardinia. The Highland County Southwest Water Treatment Facility in Mowrystown was recently constructed, and no data are available for it.

Ohio EPA is creating a Category 4B decision document for the aquatic life use designation for Town Run, and Tetra Tech performed analyses for total phosphorus and nitrate plus nitrite. There are elevated concentrations of total phosphorus and nitrate plus nitrite downstream of the Georgetown WWTP, which is known to discharge wastewater that contains both constituents. The upstream sample station also exceeded standards; however, the increase from upstream to downstream stations was a full order of magnitude. Georgetown WWTP contributes to the total phosphorus and nitrate plus nitrite exceedances in Town Run. Ohio EPA found a marginally good macroinvertebrate community and a reproducing population of cold water indicator, two-lined salamanders, upstream of Georgetown WWTP; Ohio EPA found only a very poor macroinvertebrate community and no salamanders downstream of the WWTP.

Exceedances of fecal coliform standards did occur in samples collected upstream and downstream of the WWTPs in Sardinia and Mount Orab. However, there is no evidence that directly links the elevated concentrations of fecal coliform to either WWTP (see Sections 3.2.2.3 and 3.2.5.1).

Ohio EPA also reported that an SSO was discovered in July 2006 upstream of Sterling Run RM 6.47 (X02K14); a sewer line had ruptured. It was capped, but the discharged sludge was not removed. Ohio EPA hypothesized that the SSO might explain the elevated bacteria concentrations in samples collected at Sterling Run RM 6.47 (X02K14). The available aerial imagery is not of a sufficient resolution to analyze this station, and an SSO and its impacts are not likely visible from aerial imagery. Additional SSOs are discussed in Section 4.1.1. However, these SSOs all occurred after the 2006 sampling season; therefore, they cannot be attributed to any exceedances of bacteria standards from the 2006 samples. Unless additional data from the other WWTPs or more historic data from the Mount Orab WWTP are provided, the SSOs, with the exception of the previously mentioned SSO near Sterling Run RM 6.47 (X02K14), cannot be attributed to any of the fecal coliform exceedances.

5.1.2 Private Sewerage Systems

More than a dozen unincorporated communities are in the watershed without public wastewater treatment systems. Additionally, isolated residences are located throughout the watershed. Many of the homes in the communities and residences might have failing HSTS. North Fork RM 15.36 (X02K26) is near the unincorporated community of Pricetown. Failing HSTS could explain the elevated concentrations of fecal

coliform at this station. Additional stations with samples that exceed bacteria standards could be affected by failing HSTS, but insufficient data are available to directly attribute such exceedances to failing HSTS.

5.1.3 Livestock

There are numerous farms and pastures along White Oak Creek and its tributaries. According to the 2001 NLCD, there are about 9,400 acres of pasture/hay land in HUC 05090201 09 and about 1,750 acres in HUC 05090201 10. There are numerous areas of unrestricted cattle access to the streams (see Table 42) that potentially contribute to fecal coliform exceedances.

During the 2006 sampling season, Ohio EPA personnel observed cattle with unrestricted access to three stream segments when they sampled Bells Run RM 1.97 (X02K32), East Fork (15.52) Tributary RM 2.10 (X02K40) and East Fork RM 16.50 (X02K41). An analysis of aerial imagery showed that East Fork (15.52) Tributary RM 2.10 (X02K40) is immediately downstream of a farm. Two dark brown areas visible on aerial imagery (northeast of the buildings and west of the stream above a meander) might be exposed soil resulting from cattle impacts. Unrestricted cattle access to East Fork near East Fork RM 16.50 (X02K41) is not readily apparent in any aerial imagery. Another potential factor affecting the fecal coliform exceedances is that a small tributary discharges to East Fork just upstream of East Fork RM 16.50 (X02K41), and there are residences along this tributary that might be unsewered and might have failing HSTS. Bells Run RM 1.97 (X02K32) is immediately downstream of a farm, which could be the source of the cattle observed by Ohio EPA personnel during their sampling. This subwatershed is similar to surrounding streams in that there are crop field and pastures along the stream, and the stream has some riparian cover along certain segments.

Exceedances at the three previously mentioned sample stations can be attributed (in part) to cattle access to waterways, though failing HSTS may affect East Fork RM 16.50 (X02K41) and Bells Run RM 1.97 (X02K32) . Additional sample stations could be affected by unrestricted cattle access to streams, but sufficient evidence is not available to support such a connection.

5.1.4 Agricultural Runoff

The dominant land use in the White Oak Creek watershed is agriculture, and this is likely a source for many of the water quality impairments. *Headwaters White Oak Creek* (05090201 09) is 63 percent cropland and 10 percent pasture/hay, and *Sterling Run-White Oak Creek* (05090201 10) is 43 percent cropland and 13 percent pasture.

The White Oak Creek watershed coordinator performed a STEPL analysis to determine what land uses and subwatersheds nitrogen, phosphorus, and sediment were derived from (Dragoo 2004). The results show that HUC 05090201 09 contributed 70 percent of the nitrogen load to the entire watershed's nitrogen load. This HUC contains 71 percent of the cropland in the entire watershed. Cropland was also determined to be the dominant source of the sediment load. Cropland is therefore considered a significant potential source of nitrogen, phosphorus, and sediment loadings. This is consistent with Ohio EPA's finding that "residual farm soils in the stream sediments of the watershed appear to be releasing phosphorus to clear flowing streams" (Ohio EPA 2008b, p. 30).

Water quality samples collected at six stations on three listed streams exceeded EWH or WWH targets for nitrate plus nitrite; samples collected at 12 stations on four listed streams exceeded targets for total phosphorus (for the listed streams, see Table 10 and Ohio 2008a). An analysis of aerial imagery showed that each of these listed streams drains crop fields and pastures. Additionally, with the exception of the stations in Mount Orab, aerial imagery showed that all the stations are immediately adjacent to agricultural lands. Thus, a potential source for elevated concentrations of nutrients at all the stations that are on listed streams is runoff from the agricultural fields.

5.1.5 Physical Habitat Conditions

Eight stream segments in the White Oak Creek watershed are listed for habitat impairments (see Table 10). At the eight segments, a total of seventeen sample locations were not in full attainment. The locations of the QHEI samples and their scores are shown in Figure 43.

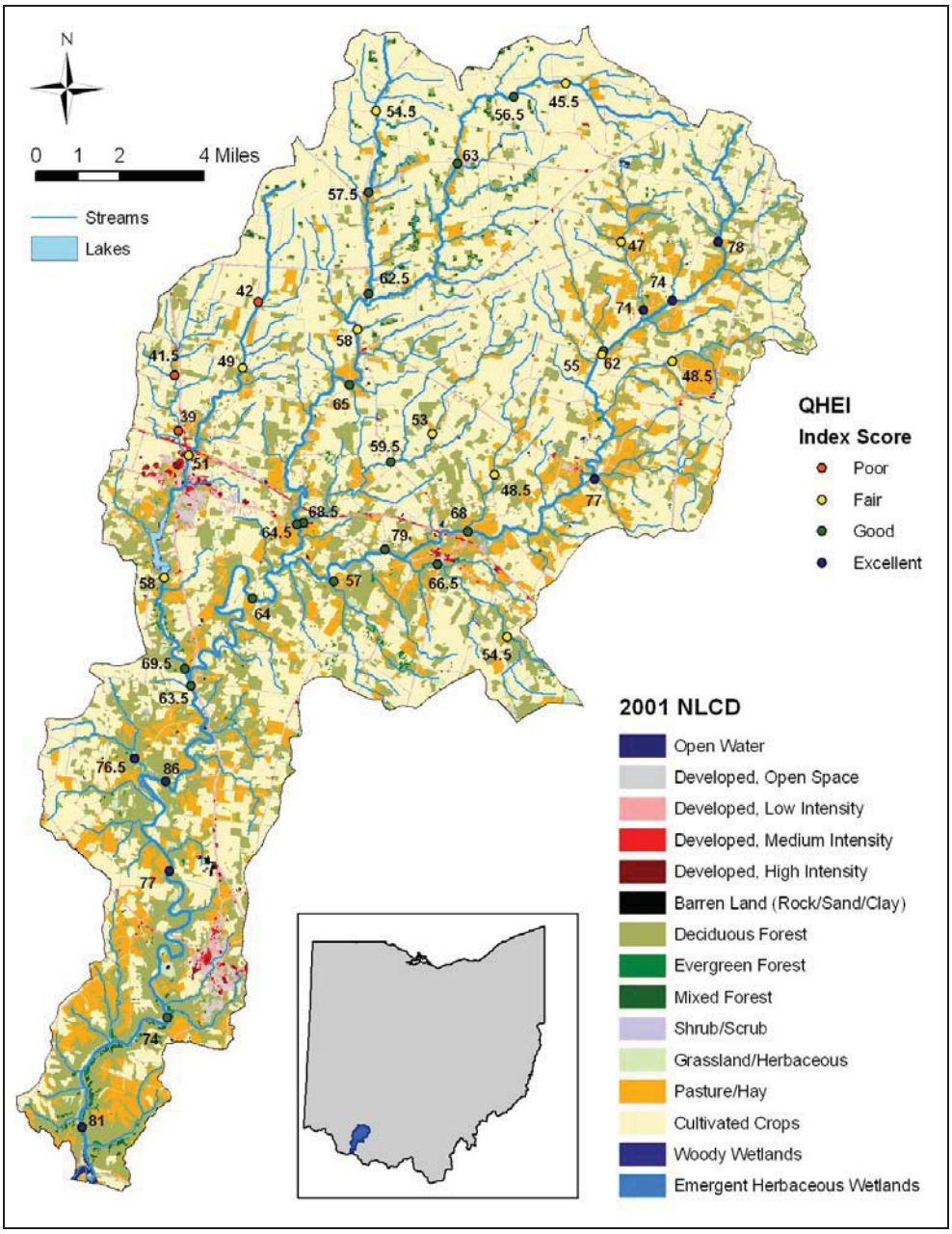

Figure 43. 2006 QHEI scores in the White Oak Creek watershed.

White Oak Creek and its tributaries are classified as WWH, EWH or CWH, and the goals for these aquatic life use designations are displayed in Table 50. The narrative scores and score ranges for the QHEI, IBI, and ICI are displayed in Table 51and Table 52.

Table 50. Target goals for the biologic indices in the White Oak Creek watershed

	IBI		ICI	
	EWH	WWH	EWH	WWH
Headwaters	50	40	46	30
Wading	50	40	46	30

Table 51. Narrative scores and numeric ranges for the IBI and ICI

Narrative score		ICI range[a]	IBI range[b]
E	Excellent	46–60	50–60
VG	Very Good	42–44	46–49
G	Good	30–40	40–45
MG	Marginally Good	32–34	36–39
F	Fair	14–30	28–35
P	Poor	8–12	18–27
VP	Very Poor	0–6	12–17

[a]The narrative score *low fair* was previously used in the ICI between *fair* and *poor*. *Low fair* scores are identified as "LF" in Table 53.
[b]The headwaters/wading streams numeric score ranges are displayed.

Table 52. Narrative scores and numeric ranges for the QHEI

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

Table 53 displays the habitat-impaired streams (including segments in full attainment on the same stream) along with the QHEI, IBI, and ICI scores. Additionally, the percentages of samples that contained TSS that exceeded the targets are also listed. Figure 44 displays the QHEI scores delineated by principal metrics for the 17 sample locations on eight habitat-listed stream segments that were not in full attainment; a table of these data delineated by both principal metric and individual attributes is presented in Appendix E.

TSS is commonly used as a surrogate for the siltation habitat impairment and was used as a surrogate in this study. However, as shown in Table 53, TSS samples did not exceed targets for six habitat-impaired sample stations on the following streams four waterbodies: Little North Fork, Sterling Run, tributary to Sterling Run at RM 6.68, and White Oak Creek. Therefore, further analysis of these segments is necessary to address the habitat impairment.

Table 53. Streams with segments listed for habitat-impairments

Waterbody[a]	Designated use[b]	RM[c]	Att.[d]	Habitat impairment[e]	IBI[f]	ICI[g]	QHEI[h]	TSS target exceedance[i]
Bells Run	WWH	2.0/1.9[H]	**NON**	S	**24**	**P**	48.5	40%
Slabcamp Run	WWH	2.9/3.0[H]	**NON**	S, LFA	**38**	**P**	54.5	20%
		1.1[H]	**Partial**		50	**F**	66.5	20%
North Fork White Oak Creek	WWH	19.7/19.6[H]	**Partial**	S, LFA, DHA	36	**LF**	45.5	60%
		18.1[H]	**Partial**		46	**F**	56.5	40%
		15.3/15.1[H]	Full		44	MG	63.0	20%
		9.7[W]	Full		53	G	58.0	NS
		7.0[W]	Full		49	44	64.0	40%
		1.5/1.4[W]	Full		49	44	64.5	11%
Little North Fork White Oak Creek	WWH	5.1[H]	**NON**	S, LFA, DHA	48	**P**	51.5	0%
		2.9/3.0[H]	**Partial**		50	**F**	57.5	20%
		0.3[H]	Full		52	MG	62.5	0%
Flat Run	WWH	4.8[H]	**Partial**	S, LFA	40	**F**	53.0	20%
		3.4[H]	**Partial**		54	**LF**	59.5	20%
		0.2/0.1[H]	Full		48	G	68.5	20%
Sterling Run	WWH	11.4[H]	**NON**	S, LFA	**20**	**P**	42.0	75%
		9.7[H]	**NON**		**30**	**P**	49.0	80%
		6.8[H]	**NON**		**30**	**F**	51.0	0%[j]
		3.0[W]	**NON**		44	**P**	58.0	0%
		0.6/0.4[W]	Full		48	G	69.5	0%
Tributary to Sterling Run at RM 6.68	WWH	2.4[H]	**NON**	S, LFA, DHA	**22**	**P**	41.5	20%
		0.7/0.8[H]	**NON**		**22**	**P**	39.0	0%
White Oak Creek	EWH	27.5/27.6[W]	Full	S	51	E	64.0	0%
		20.7/20.6[W]	**Partial**		**42**	E	63.5	0%
		16.5[W]	Full		50	E	86.0	0%
		12.8/12.4[W]	**Partial**		**44**	46	77.0	0%
		7.5/7.6[W]	Full		52	E	74.0	0%
		2.6/2.7[W]	Full		48	50	81.0	0%

[a]Only waterbodies with a listed habitat impairment are displayed.
[b]Aquatic life use designations are displayed.
[c]River mile. If two river miles are listed, the first is for the IBI and the second is for the ICI. H = headwaters; W = wading.
[d]Attainment statuses. Bolded values are not in full attainment.
[e]Habitat impairment listings: S = siltation, LFA = low flow alterations, DHA = direct habitat alterations.
[f]Index of biotic integrity (IBI). Bolded values represent significant departure from biocriteria target (> 4 units).
[g]Invertebrate community index (ICI). VP = very poor, P = poor, LF = low fair, F = fair, MG = marginally good, G = good, VG = very good, E = exceptional. Bolded values represent significant departure from biocriteria target (> 4 units).
[h]QHEI.
[i]Percent of samples that exceeded TSS target: 16.0 mg/L for headwaters and 24.75 mg/L for wading. NS = TSS was not sampled.
[j]60% of TSS samples exceeded the target (16.0 mg/L) at RM 6.47, which is downstream of the tributary at RM 6.68.

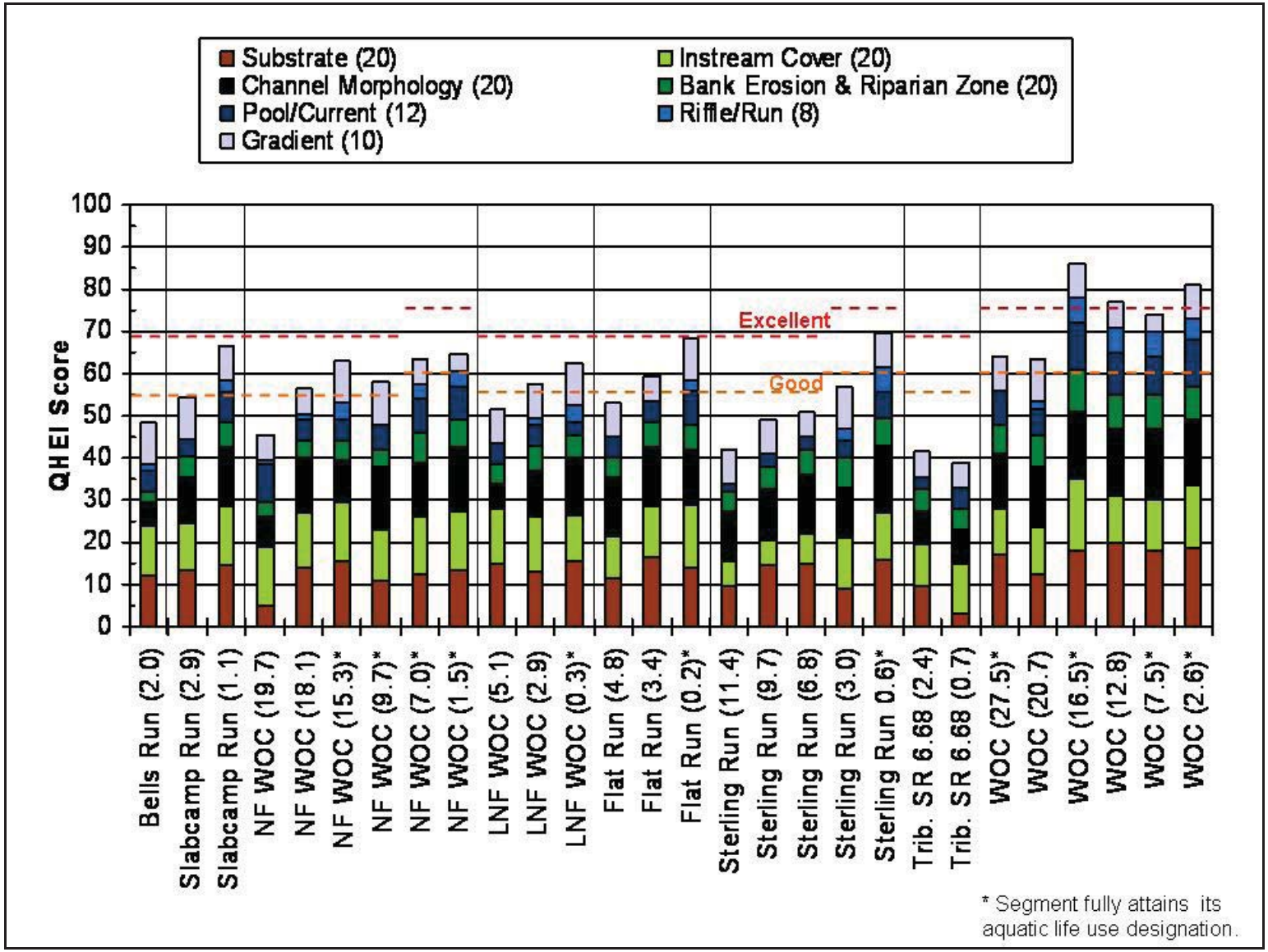

Figure 44. Principal metric scores for habitat-listed segments.

The following analysis of habitat impairments is based, in part, on the underlying premises of the sediment TMDL presented in the Euclid Creek TMDL (Ohio EPA 2005) and the Draft Nimishillen Creek TMDL (Ohio EPA 2008f). A sediment TMDL was created using three of the six principal metrics; the three metrics used for the sediment TMDL were: Substrate, Channel Morphology, and Bank Erosion & Riparian Zone. A discussion of these metrics with respect to White Oak Creek is presented below, and the data are in Appendix E.

5.1.5.1 Substrate

Five impaired segments scored less than half of the available points for the *Substrate* principal metric. Of these five, three had a QHEI narrative score of Poor; the other two segments had a score of Fair, likely due to higher scores for other principal metrics (Appendix E).

All the poor *Substrate* scores were driven by poor *Type* scores. There are eleven types ranging from boulder/slabs to sand to artificial. In this watershed, the two poorest Type scores were due to silt substrate. The most common substrate in the White Oak watershed was gravel (12 of 17 impaired segments)

Poor *Quality* score also drove down the Substrate scores (Appendix E). These attribute scores were driven down by extensive and moderate embeddedness. Of the 17 listed segments, only 1 segment had no embeddedness, and 3 segments had low embeddedness.

5.1.5.2 Channel Morphology

The White Oak Creek watershed coordinator found that between 17 and 70 percent of the total stream length in the 14-digit HUCs was channelized (Dragoo 2004). These results were evident in the QHEI scores: 5 of the 17 samples stations that were not in full attainment scored less than half of the maximum potential score for this metric; all 5 of these segments were affected by some level of channelization (Appendix E). Two additional segments were also affected by some degree of channelization.

Also driving the *Channel Morphology* score were the *Sinuosity* and *Development* attributes. Except for one listed segment, all had moderate or low sinuosity (i.e., poor). The Development attribute scored the worst of the Channel Morphology metrics (Appendix E). Thirteen segments scored less than 75 percent of the maximum potential score. Not a single segment had excellent development, and seven of the segments had poor development.

5.1.5.3 Bank Erosion & Riparian Zone

For the most part, the *Erosion* score was not the main factor in reducing the *Bank Erosion & Riparian Zone* score. Ten habitat-impaired sample stations had no to little erosion (3 points) and in only two cases (Sterling Run at RM 6.8 and Tributary to Sterling Run (RM 6.68) at RM 2.4) was the Erosion subscore less than 75 percent of the maximum potential subscore (Appendix E).

Conversely, the *Riparian Width & Floodplain Quality* scores drove down the Bank Erosion & Riparian Zone scores. Only three of the 17 habitat-impaired sample stations scored 75 percent or more of the *Riparian Width* score; nine stations scored less than 50 percent of the maximum potential subscore (Appendix E). In 2004, using the 14-digit HUCs, the White Oak Creek watershed coordinator found that only between 39 and 81 percent of the total stream length per HUC had riparian cover (Dragoo 2004). QHEI scores showed that two stations (Bells Run at RM 2.0 and North Fork White Oak Creek at RM 19.7) had no riparian cover on both banks, and one station (North Fork at RM 18.1) had riparian cover (less than 5 meters wide) on only one bank. White Oak Creek was the only stream that had at least 10 to 50 meters of riparian cover on both banks. White Oak Creek at the end of Miller Ring Road (RM 12.8) scored a 3.5 (Appendix E), which equates to 50 meters or more of riparian cover on one bank and 10 to

50 meters of riparian cover on the other bank (Figure 45). Figure 46 presents an example of a segment needing restoration of the riparian zone. It shows the tributary to Sterling Run at RM 6.68 (RM 0.7), which scored a 1.0 (no riparian cover on one bank and less than 5 meters on the other bank). Note that these photographs were taken by the Ohio EPA macroinvertebrate-sampling team and not by the team(s) that calculated QHEI.

Figure 45. Riparian cover near White Oak Creek at the end of Miller Ring Road (RM 12.8).

Figure 46. Riparian cover on the tributary to Sterling Run at RM 6.68 at Bardwell West Road (RM 0.7).

For the *Floodplain Quality* score, 13 of the 17 habitat-impaired sample stations scored less than half of the maximum potential points; only one segment (Sterling Run at RM 6.8) scored the full three points. Twelve stations had a floodplain consisting of residences, parks, and new fields. The portion of the

floodplain shown in Figure 46 that was scored for QHEI had a score of 1.0, which equates to residences, parks, and field on both banks. Nine stations (stations could have two listed categories) were in floodplains dominated by open pastures or row crops. North Fork White Oak Creek at Dawson Road (RM 18.1) scored 0.5 points equating to open pasture and row crops on one bank and residences/parks, and fields on the other bank (station is at or near the segment displayed in Figure 47, open pasture and row crops are in the background in the upper-right corner of the photograph).

Figure 47. Floodplain quality at North Fork White Oak Creek at Dawson Road (RM 18.1).

Figure 48 also shows poor floodplain quality. Fenced pasture along the banks earns a poor score because such habitat has limited ecological diversity (scores one point out of three). Additionally, in some places cattle have free access to the stream. The cattle degrade bank habitat by removing (i.e., eating and trampling) riparian vegetation and destabilizing the banks, which increases sedimentation/siltation.

Figure 48. Floodplain quality at Bells Run near Township Road 142A (RM 1.97).

5.2 Load Duration Curves

Allowable pollutant loads in the White Oak Creek watershed have been determined through the use of load duration curves. Discussions of load duration curves are presented in *An Approach for Using Load Duration Curves in the Development of TMDLs* (U.S. EPA 2007a) and *Protocol for Developing Pathogen TMDLs* (U.S. EPA 2001). 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.

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 cfu/100 mL), then multiplying by conversion factors to yield results in the proper unit (i.e., kilograms per day or billions of cfu/day). The resulting points are plotted to create a load duration curve.

3. Each water quality sample is converted to a load by multiplying the water quality sample concentration by the average daily flow on the day the sample was collected. Then, the individual loads are plotted as points on the TMDL graph and can be compared to the water quality standard/target, or load duration curve.

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 locations contribute loads above or below the water quality standard/target.

5. The area beneath the TMDL curve is interpreted as the loading capacity of the stream. The difference between this area and the area representing the current loading conditions 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 may be derived from sources such as HSTS and illicit sewer connections. Exceedances on the left side of the graph occur during higher flow events, and may be derived from sources such as runoff. An example is shown in Figure 49, which shows that the exceedances occur in the moist condition and dry condition zones. 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. If loads are considerable during wet-weather events (including snowmelt), implementation efforts can target those BMPs that will most effectively reduce storm water runoff.

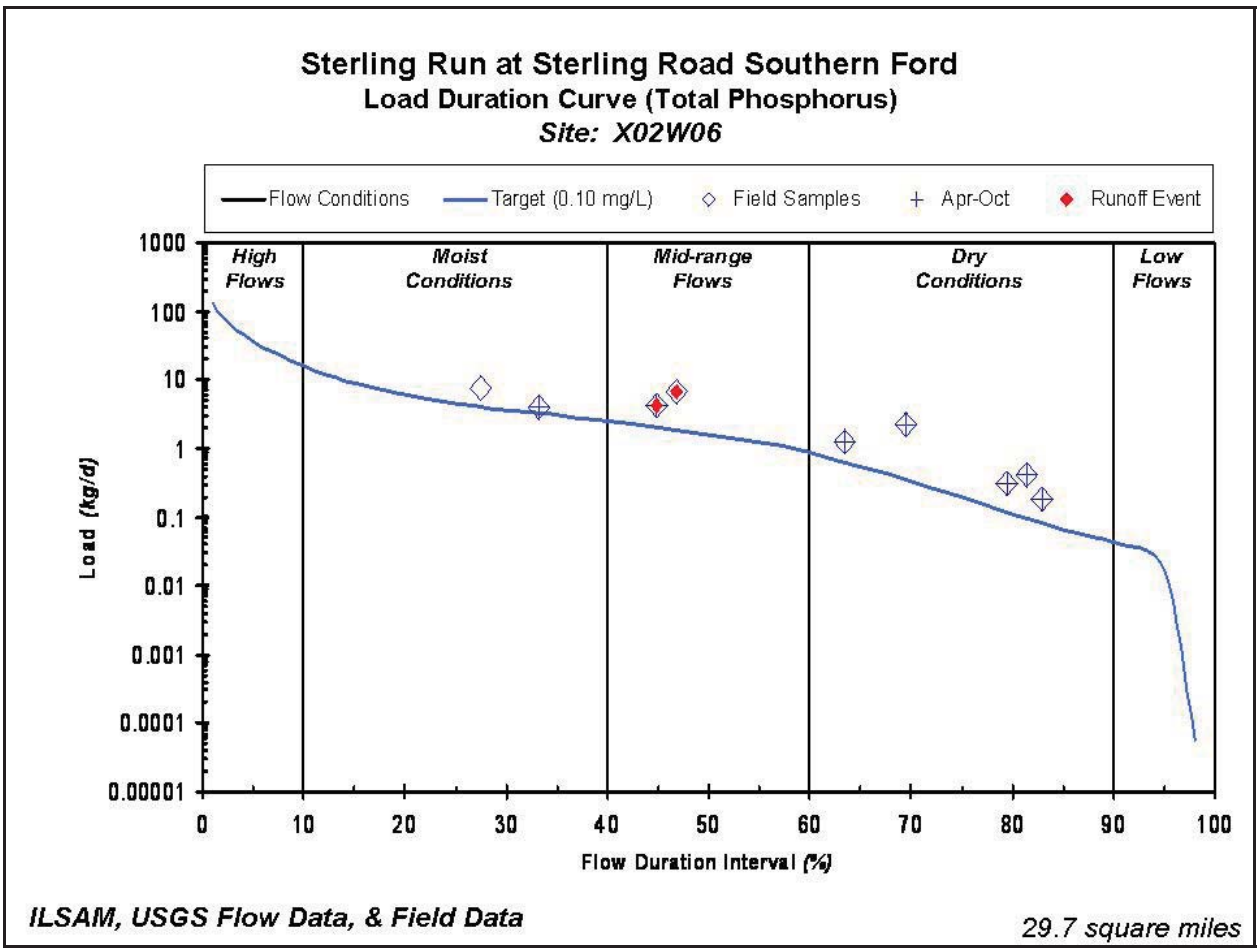

Figure 49. Example of a load duration curve at station X02K23.

The stream flows displayed on a load duration curve can be grouped into various flow regimes to aid with interpretation of 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; Cleland 2007):

- High-flow zone: streamflows 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 helps to identify the issues surrounding the impairment and to roughly differentiate between sources. Table 54 summarizes the relationship between the five hydrologic zones and potentially contributing source areas (Cleland 2005; Cleland 2007).

The load reduction approach also considers critical conditions and seasonal variation in the TMDL development as required by the Clean Water Act 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 may vary depending on watershed or pollutant characteristics.

Table 54. Relationship between load duration curve zones and contributing sources

	Duration curve zone				
Contributing source area	**High**	**Moist**	**Mid-range**	**Dry**	**Low**
Point source				M	H
Livestock direct access to streams				M	H
On-site wastewater systems	M	M-H	H	H	H
Riparian areas		H	H	M	
Storm water: Impervious		H	H	H	
Combined sewer overflow	H	H	H		
Storm water: Upland	H	H	M		
Field drainage: Natural condition	H	M			
Field drainage: Tile system	H	H	M-H	L-M	
Bank erosion	H	M			

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

5.3 Stream Flow Estimates

There is one current/active USGS stream gage within the White Oak Creek watershed, but it is on the mainstem. Therefore flow data are not available for the impaired waterbody segments. Flow estimates are needed as part of the data assessment process using a duration curve framework.

The Illinois Streamflow Assessment Model (ILSAM) was used to estimate streamflow at the ungaged Ohio EPA water quality sample stations. This streamflow estimation technique was found to be the most accurate method of other techniques tried. The drainage area weighting technique and linear regression method were also considered. However, suitability testing found that the estimation error for these two methods was higher than that for ILSAM. A full discussion of the testing of streamflow estimation techniques is presented in Appendix A.

6 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 WLAs for point sources and load allocations (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:

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

A summary of the allowable loads for all parameters in the White Oak Creek watershed is presented in this section. The allocations by each of the various sources and parameters are shown in the tables throughout this section.

Load duration analyses were conducted for selected sites with a sufficient number of samples (in most cases five samples). The Ohio EPA Southwest District Office provided water quality data from intensive survey sampling that took place in 2006. Additional sampling in the White Oak Creek watershed has been completed by three WWTPs (Georgetown, Mount Orab, and Sardinia) and by Syngenta and the Mount Orab WTP. These data are Level 3-qualified data (as outlined in Ohio Administrative Code, Chapter 3745-4), and therefore are included in TMDL development.

The following is a brief description of how the data are presented in the tables in this section. When no data were available for a flow zone, the observed load was recorded as *No Data*, the TMDL was calculated at the flow duration interval that was the midpoint of the flow zone, and the percent reduction was not calculated. If data were available and more than one load was above the load duration curve, the observed load displayed in the table is the load with the largest differential above the load duration curve. If data were available and no loads were above the load duration curve, the observed load displayed in the table is the load with the smallest differential below the load duration curve. In either case, the TMDL displayed in the table was calculated at the flow duration interval corresponding to the observed load. The percent reduction was recorded as *0%* when no loads were above the load duration curve.

The following section provides the TMDL results for each 12-digit subwatershed and is organized by 10-digit Assessment Units: *Headwaters White Oak Creek* (HUC 05090201 09), and *Sterling Run-White Oak Creek* (HUC 05090201 10). A map of locations at which load duration analyses were performed is provided as Figure 50. Appendix B contains figures of the detailed load duration results per station. Appendix C presents a discussion of the linear extrapolation of selected flow duration curves and linear interpolation of load duration curves.

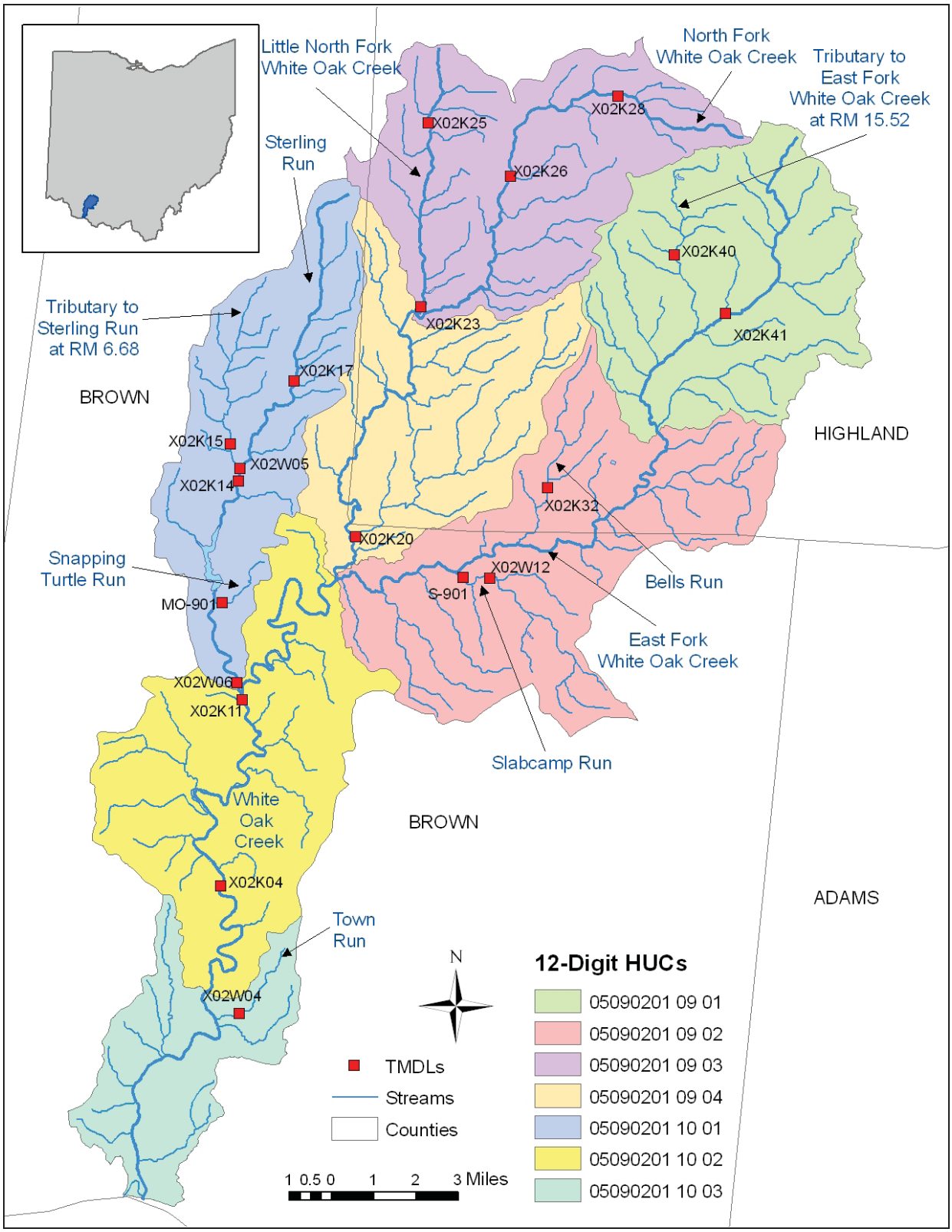

Figure 50. Stations where TMDLs were generated.

6.1 Assessment Unit 05090201 09: Headwaters White Oak Creek

The load duration approach was applied to 10 sampling stations within this assessment unit. For each load duration site, all appropriate and available water quality and flow data were used. Because of the limitations of ILSAM, the load duration analyses for fecal coliform were based on flows collected throughout the year; there is no apparent way to use ILSAM to calculate flow durations for only the recreation season (May 1 to October 15). Figures displaying water quality samples and load duration curves are presented in Appendix B.

This assessment unit is divided into four 12-digit subwatersheds that are further discussed in the following subsections.

6.1.1 HUC 05090201 09 01

Headwaters East Fork White Oak Creek subwatershed drains 43.56 square miles. A discussion of water quality samples collected in this subwatershed is provided in Section 3.2.1. Figure 3 and Figure 50 display the sample stations in this subwatershed and all the TMDL stations in the watershed, respectively.

6.1.1.1 East Fork White Oak Creek RM 16.50 (X02K41)

Table 55 presents the TMDL summary for station East Fork RM 16.50 (X02K41) (figure in Appendix B). All the fecal coliform observations were found to exceed the loading limit, resulting in observed loads well above allowable loads (for details, see Appendix B). During dry conditions and low flows, fecal coliform data display needed reductions of 90 percent or greater.

Table 55. Loading statistics for East Fork White Oak Creek RM 16.50 (X02K41)

X02K41		High flows	Moist conditions	Mid-range flows	Dry conditions	Low flows
Pollutant	**TMDL component**	**0–10**	**10–40**	**40–60**	**60–90**	**90–100**
Fecal coliform (billion cfu/day)	Observed Load	No Data	No Data	No Data	47.7	20.9
	TMDL = LA + WLA + MOS	**3,183**	**393**	**129**	**4.77**	**1.90**
	LA	2,865	353	117	4.30	1.71
	Future Growth Reserve (0%)	0	0	0	0	0
	WLA: Facilities	0	0	0	0	0
	MOS (10%)	318	39.3	12.9	0.47	0.190
	TMDL Reduction (%)	No Data	No Data	No Data	**90%**	**91%**

For a discussion of the percentiles used to calculate the TMDLs for each flow zone, see Appendix C.

6.1.1.2 East Fork (RM 15.52) Tributary RM 2.10 (X02K40)

Table 56 presents the TMDL summary for East Fork (RM 15.52) Tributary RM 2.10 (X02K40) (figure in Appendix B). All the fecal coliform observations were found to exceed the loading limit, resulting in observed loads well above allowable loads (see Appendix B for details). During dry conditions and low flows, fecal coliform data display needed reductions of 89 percent or greater.

Table 56. Loading statistics for East Fork (RM 15.52) Tributary RM 2.10 (X02K40)

X02K40		High flows	Moist conditions	Mid-range flows	Dry conditions[a]	Low flows[a]
Pollutant	**TMDL component**	**0–10**	**10–40**	**40–60**	**60–90**	**90–100**
Fecal coliform (billion cfu/day)	Observed Load	No Data	No Data	No Data	11.0	29.3
	TMDL = LA + WLA + MOS	**1,149**	**140**	**45.2**	**1.22**	**0.837**
	LA	1,034	126	40.7	1.10	0.753
	Future Growth Reserve (0%)	0	0	0	0	0
	WLA: Facilities	0	0	0	0	0
	MOS (10%)	115	14	4.5	0.12	0.084
	TMDL Reduction (%)	No Data	No Data	No Data	**89%**	**97%**

For a discussion of the percentiles used to calculate the TMDLs for each flow zone, for a discussion of the linear extrapolation of the flow and load duration curves, and for a discussion of the linear interpolation of the load duration curve, see Appendix C.
[a]Loads were calculated on the basis of a linear extrapolation of the ILSAM-generated flow duration curve.

6.1.2 HUC 05090201 09 02

Slabcamp Run-East Fork White Oak Creek subwatershed drains 36.33 square miles. A discussion of water quality samples collected in this subwatershed is provided in Section 3.2.2. Figure 4 and Figure 50 display the sample stations in this subwatershed and all the TMDL stations in the watershed, respectively.

6.1.2.1 Bells Run RM 1.97 (X02K32)

Table 57 presents the TMDL summary for Bells Run RM 1.97 (X02K32) (figures in Appendix B). Three of five ammonia, all five total phosphorus, two of five TSS and two of five fecal coliform samples were above their respective target loads. Ammonia data display needed reductions of 92 percent or higher; total phosphorus 91 percent or higher; TSS 43 percent or higher; and fecal coliform 46 percent during low flow conditions.

Table 57. Loading statistics for Bells Run RM 1.97 (X02K32)

X02K32		High flows	Moist conditions	Mid-range flows	Dry conditions[a]	Low flows[b]
Pollutant	**TMDL component**	**0–10**	**10–40**	**40–60**	**60–90**	**90–100**
Ammonia (kg/day)	Observed Load	No Data	203	No Data	2.64	No Data
	TMDL = LA + WLA + MOS	**49.9**	**10.7**	**1.95**	**0.200**	**9.79 E-3**
	LA	44.9	9.60	1.75	0.180	8.81 E-3
	Future Growth Reserve (0%)	0	0	0	0	0
	WLA: Facilities	0	0	0	0	0
	MOS (10%)	4.99	1.07	0.195	2.00 E-2	9.79 E-4
	TMDL Reduction (%)	No Data	**95%**	No Data	**92%**	No Data
Total Phosphorus (kg/day)	Observed Load	No Data	9.52	No Data	0.424	No Data
	TMDL = LA + WLA + MOS	**3.99**	**0.854**	**0.156**	**1.15 E-2**	**7.83 E-4**
	LA	3.59	0.768	0.140	1.03 E-2	7.05 E-4
	Future Growth Reserve (0%)	0	0	0	0	0
	WLA: Facilities	0	0	0	0	0
	MOS (10%)	0.399	8.54 E-2	1.56 E-2	1.15 E-3	7.83 E-5
	TMDL Reduction (%)	No Data	**91%**	No Data	**97%**	No Data
TSS (kg/day)	Observed Load	No Data	1,860	No Data	5.60	No Data
	TMDL = LA + WLA + MOS	**799**	**171**	**31.2**	**3.20**	**0.157**
	LA	719	154	28.1	2.89	0.141
	Future Growth Reserve (0%)	0	0	0	0	0
	WLA: Facilities	0	0	0	0	0
	MOS (10%)	7.99	17.1	3.12	0.320	1.57 E-2
	TMDL Reduction (%)	No Data	**91%**	No Data	**43%**	No Data
Fecal coliform (billion cfu/day)	Observed Load	No Data	No Data	No Data	1.77	0.703
	TMDL = LA + WLA + MOS	**999**	**121**	**39.0**	**0.958**	**0.740**
	LA	899	109	35.1	0.863	0.666
	Future Growth Reserve (0%)	0	0	0	0	0
	WLA: Facilities	0	0	0	0	0
	MOS (10%)	99.9	12.1	3.90	9.58 E-2	7.40 E-2
	TMDL Reduction (%)	No Data	No Data	No Data	**46%**	**0%**

For a discussion of the percentiles used to calculate the TMDLs for each flow zone, for a discussion of the linear extrapolation of the flow and load duration curves, and for a discussion of the linear interpolation of the load duration curve, see Appendix C.
[a]Fecal coliform loads were calculated on the basis of a linear extrapolation of the ILSAM-generated flow duration curve.
[b]Loads were calculated on the basis of a linear extrapolation of the ILSAM-generated flow duration curve.

6.1.2.2 Slabcamp Run RM 1.13 (X02W12)

Table 58 presents the TMDL summary for Slabcamp Run RM 1.13 (X02W12) (figure in Appendix B). Four of five TSS samples were below the target load. The single exceedance in the moist conditions zone displays a needed reduction of 88 percent. The Sardinia WWTP is on this stream, and its discharge was added to the ILSAM-estimated discharge. The NPDES permit for the Sardinia WWTP establishes an 18 mg/L limit for TSS; the design flow is 0.3 MGD. The calculated WLA is 20.4 kg/day.

Table 58. Loading statistics for Slabcamp Run RM 1.13 (X02W12)

X02W12		High flows	Moist conditions	Mid-range flows	Dry conditions	Low flows
Pollutant	**TMDL component**	**0–10**	**10–40**	**40–60**	**60–90**	**90–100**
TSS (kg/day)	Observed Load	No Data	2,965	No Data	8.22	No Data
	TMDL = LA + WLA + MOS	**1,579**	**354**	**80.9**	**26.3**	**18.2**
	LA	1,401	298	52.4	3.27	0[a]
	Future Growth Reserve (0%)	0	0	0	0	0
	WLA: Facilities	20.4	20.4	20.4	20.4	18.2[b]
	MOS (10%)	158	35.4	8.09	2.63	0[a]
	TMDL Reduction (%)	No Data	**88%**	No Data	**0%**	No Data

For a discussion of the percentiles used to calculate the TMDLs for each flow zone, see Appendix C.
[a]A load of zero was allocated to the LA and MOS because the entire TMDL was allocated to the WLA. The allocation of zero to the LA is permissible because there is no natural streamflow (ILSAM-estimated) above the 90th percentile; the flow is derived from WWTP discharge.
[b]Only 18.2 kg/day of the total permit limit (20.4 kg/day) is allocated to the WLA because 18.2 kg/day is the TMDL.

6.1.2.3 Slabcamp Run at Homer Road Bridge (S-901)

Table 59 presents the TMDL summary for this site. Seven of the eight fecal coliform samples were below the target load. The single exceedance in the low flow zone displays a needed reduction of 61 percent. The observed loads data were calculated using DMR data because Ohio EPA did not collect fecal coliform samples from Slabcamp Run. The NPDES permit for the Sardinia WWTP establishes a 2,000 cfu/100 mL limit for fecal coliform; the design flow is 0.3 MGD. The calculated WLA is 22.7 billion cfu/day.

Table 59. Loading statistics for Slabcamp Run at Homer Road Bridge (S-901)

S-901		High flows	Moist conditions	Mid-range flows	Dry conditions	Low flows
Pollutant	**TMDL component**	**0–10**	**10–40**	**40–60**	**60–90**	**90–100**
Fecal coliform (billion cfu/day)	Observed Load	No Data	229	23.9	7.74	59.8
	TMDL = LA + WLA + MOS	**2,255**	**261**	**116**	**51.6**	**23.2**
	LA	2,007	212	82.1	23.7	0[a]
	Future Growth Reserve (0%)	0	0	0	0	0
	WLA: Facilities	22.7	22.7	22.7	22.7	22.7
	MOS (10%)	226	26.1	11.6	5.16	0.507[b]
	TMDL Reduction (%)	No Data	**0%**	**0%**	**0%**	**61%**

For a discussion of the percentiles used to calculate the TMDLs for each flow zone, see Appendix C.
[a]A load of zero was allocated to the LA because the entire load was assigned to the MOS and WLA. This is permissible because there is no natural streamflow (ILSAM-estimated) above the 90th percentile; the flow is derived from WWTP discharge.
[b]Only 0.507 billion cfu/day of the TMDL is available for allocation after 22.7 billion cfu/day was assigned to the WLA.

6.1.3 HUC 05090201 09 03

Little North Fork-North Fork White Oak Creek subwatershed drains 36.89 square miles. A discussion of water quality samples collected in this subwatershed is provided in Section 3.2.3. Figure 9 and Figure 50 display the sample stations in this subwatershed and all the TMDL stations in the watershed, respectively.

6.1.3.1 North Fork White Oak Creek RM 19.67 (X02K28)

Table 60 presents the TMDL summary for North Fork RM 19.67 (X02K28) (figure in Appendix B). Four of the five TSS samples exceeded the target load, which displays a needed reduction of 59 percent or more.

Table 60. Loading statistics for North Fork White Oak Creek RM 19.67 (X02K28)

X02K28		High flows	Moist conditions	Mid-range flows	Dry conditions	Low flows[a]
Pollutant	**TMDL component**	**0–10**	**10–40**	**40–60**	**60–90**	**90–100**
TSS (kg/day)	Observed Load	No Data	494	No Data	9.06	No Data
	TMDL = LA + WLA + MOS	**879**	**188**	**34.5**	**3.72**	**0.117**
	LA	791	169	31.0	3.34	0.105
	Future Growth Reserve (0%)	0	0	0	0	0
	WLA: Facilities	0	0	0	0	0
	MOS (10%)	8.79	18.8	3.45	3.72	1.17 E-2
	TMDL Reduction (%)	No Data	**62%**	No Data	**59%**	No Data

For a discussion of the percentiles used to calculate the TMDLs for each flow zone, for a discussion of the linear extrapolation of the flow and load duration curves, and for a discussion of the linear interpolation of the load duration curve, see Appendix C.

[a]Loads were calculated on the basis of a linear extrapolation of the ILSAM-generated flow duration curve.

6.1.3.2 North Fork White Oak Creek RM 15.36 (X02K26)

Table 61 presents the TMDL summary for North Fork RM 15.36 (X02K26) (figure in Appendix B). Two of the five nitrate plus nitrite samples exceeded the target load, which displays a needed reduction of 48 percent or more. One of the five fecal coliform samples exceeded the target load, yielding a needed reduction of 93 percent.

Table 61. Loading statistics for North Fork White Oak Creek RM 15.36 (X02K26)

X02K26		High flows	Moist conditions	Mid-range flows	Dry conditions	Low flows[a]
Pollutant	**TMDL component**	**0–10**	**10–40**	**40–60**	**60–90**	**90–100**
Nitrate plus Nitrite (kg/day)	Observed Load	No Data	120	No Data	0.718	No Data
	TMDL = LA + WLA + MOS	**150**	**32.5**	**6.11**	**0.376**	**3.67 E-2**
	LA	135	29.2	5.50	0.338	3.30 E-2
	Future Growth Reserve (0%)	0	0	0	0	0
	WLA: Facilities	0	0	0	0	0
	MOS (10%)	15.0	3.25	0.611	3.76 E-2	3.67 E-3
	TMDL Reduction (%)	No Data	**73%**	No Data	**48%**	No Data
Fecal coliform (billion cfu/day)	Observed Load	No Data	No Data	No Data	2.00	19.4
	TMDL = LA + WLA + MOS	**3,007**	**371**	**122**	**2.00**	**1.43**
	LA	2,706	334	110	1.80	1.29
	Future Growth Reserve (0%)	0	0	0	0	0
	WLA: Facilities	0	0	0	0	0
	MOS (10%)	301	37.1	12.2	0.200	0.143
	TMDL Reduction (%)	No Data	No Data	No Data	**0%**	**93%**

For a discussion of the percentiles used to calculate the TMDLs for each flow zone, for a discussion of the linear extrapolation of the flow and load duration curves, and for a discussion of the linear interpolation of the load duration curve, see Appendix C.

[a]Loads were calculated on the basis of a linear extrapolation of the ILSAM-generated flow duration curve.

6.1.3.3 Little North Fork White Oak Creek RM 5.06 (X02K25)

Table 62 presents the TMDL summary for Little North Fork RM 5.06 (X02K25) (figure in Appendix B). Two of the five nitrate plus nitrite samples exceeded the target load, which displays a needed reduction of 75 percent or more.

Table 62. Loading statistics for Little North Fork White Oak Creek RM 5.06 (X02K25)

X02K25		High flows	Moist conditions	Mid-range flows	Dry conditions	Low flows[a]
Pollutant	**TMDL component**	**0–10**	**10–40**	**40–60**	**60–90**	**90–100**
TSS (kg/day)	Observed Load	No Data	38.5	No Data	0.710	No Data
	TMDL = LA + WLA + MOS	**44.9**	**9.59**	**5.43**	**0.117**	**4.89 E-3**
	LA	40.4	8.63	4.89	0.105	4.40 E-3
	Future Growth Reserve (0%)	0	0	0	0	0
	WLA: Facilities	0	0	0	0	0
	MOS (10%)	4.49	0.959	0.543	1.17 E-2	4.89 E-4
	TMDL Reduction (%)	No Data	**75%**	No Data	**84%**	No Data

For a discussion of the percentiles used to calculate the TMDLs for each flow zone, for a discussion of the linear extrapolation of the flow and load duration curves, and for a discussion of the linear interpolation of the load duration curve, see Appendix C.

[a]Loads were calculated on the basis of a linear extrapolation of the ILSAM-generated flow duration curve.

6.1.3.4 Little North Fork White Oak Creek RM 0.28 (X02K23)

Table 63 presents the TMDL summary for Little North Fork RM 0.28 (X02K23) (figures in Appendix B). All the total phosphorus, one of the five nitrate plus nitrite, and two of the five TSS samples exceeded the target loads. The total phosphorus data displays a need for a 79 percent or more reduction. The single nitrate plus nitrite exceedances yields a needed reduction of 23 percent. The TSS data displays a needed reduction of 43 percent or more.

Table 63. Loading statistics for Little North Fork White Oak Creek RM 0.28 (X02K23)

X02K32		High flows	Moist conditions	Mid-range flows	Dry conditions	Low flows
Pollutant	**TMDL component**	**0–10**	**10–40**	**40–60**	**60–90**	**90–100**
Nitrate plus Nitrite (kg/day)	Observed Load	No Data	48.7	No Data	0.348	No Data
	TMDL = LA + WLA + MOS	**173**	**37.4**	**7.05**	**0.792**	**1.11 E-2**
	LA	156	33.7	6.35	0.713	1.00 E-2
	Future Growth Reserve (0%)	0	0	0	0	0
	WLA: Facilities	0	0	0	0	0
	MOS (10%)	17.3	3.74	0.705	7.92 E-2	1.11 E-3
	TMDL Reduction (%)	No Data	**23%**	No Data	**0%**	No Data
Total Phosphorus (kg/day)	Observed Load	No Data	11.2	No Data	0.240	No Data
	TMDL = LA + WLA + MOS	**13.8**	**1.87**	**0.564**	**5.01 E-2**	**8.85 E-4**
	LA	12.4	1.68	0.508	4.51 E-2	7.97 E-4
	Future Growth Reserve (0%)	0	0	0	0	0
	WLA: Facilities	0	0	0	0	0
	MOS (10%)	1.38	0.187	5.64 E-3	5.01 E-3	8.85 E-5
	TMDL Reduction (%)	No Data	**83%**	No Data	**79%**	No Data
TSS (kg/day)	Observed Load	No Data	6,514	No Data	28.0	No Data
	TMDL = LA + WLA + MOS	**2,768**	**599**	**113**	**16.0**	**0.177**
	LA	2,491	539	102	14.4	0.159
	Future Growth Reserve (0%)	0	0	0	0	0
	WLA: Facilities	0	0	0	0	0
	MOS (10%)	277	59.9	11.3	1.60	1.77 E-2
	TMDL Reduction (%)	No Data	**91%**	No Data	**43%**	No Data

For a discussion of the percentiles used to calculate the TMDLs for each flow zone, see Appendix C.

6.1.4 HUC 05090201 09 04

Flat Run-North Fork White Oak Creek subwatershed drains 30.39 square miles. A discussion of water quality samples collected in this subwatershed is provided in Section 3.2.4. Figure 16 and Figure 50 display the sample stations in this subwatershed and all the TMDL stations in the watershed, respectively.

Table 64 presents the TMDL summary for Flat Run RM 0.15 (X02K20) (figure in Appendix B). One of the five TSS samples exceeded the target load, which displays a needed reduction of 79 percent.

Table 64. Loading statistics for Flat Run RM 0.15 (X02K20)

X02K20		High flows	Moist conditions	Mid-range flows	Dry conditions	Low flows[a]
Pollutant	**TMDL component**	**0–10**	**10–40**	**40–60**	**60–90**	**90–100**
TSS (kg/day)	Observed Load	No Data	2,601	No Data	9.66	No Data
	TMDL = LA + WLA + MOS	**2,466**	**534**	**100**	**14.0**	**0.587**
	LA	2,219	480	90	12.6	0.528
	Future Growth Reserve (0%)	0	0	0	0	0
	WLA: Facilities	0	0	0	0	0
	MOS (10%)	247	53.4	10.0	1.40	5.87 E-2
	TMDL Reduction (%)	No Data	**79%**	No Data	**0%**	No Data

For a discussion of the percentiles used to calculate the TMDLs for each flow zone, for a discussion of the linear extrapolation of the flow and load duration curves, and for a discussion of the linear interpolation of the load duration curve, see Appendix C.

[a]Loads were calculated on the basis of a linear extrapolation of the ILSAM-generated flow duration curve.

6.2 Assessment Unit 05090201: Sterling Run-White Oak Creek

The load duration approach was applied to nine sampling stations in the lower White Oak Creek assessment unit. For each load duration site, all appropriate and available water quality and flow data were used. Because of the limitations of ILSAM, the load duration analyses for fecal coliform were based on flows collected throughout the year; there is no apparent way to use ILSAM to calculate flow durations for only the recreation season (May 1 to October 15). This assessment unit is divided into three 12-digit subwatersheds that will be further discussed in the following subsections. Figures displaying water quality samples and load duration curves are presented in Appendix B.

6.2.1 HUC 05090201 10 01

Sterling Run subwatershed drains 29.56 square miles. A discussion of water quality samples collected in this subwatershed is provided in Section 3.2.5. Figure 18 and Figure 50 display the sample stations in this subwatershed and all the TMDL stations in the watershed, respectively.

6.2.1.1 Sterling Run RM 9.65 (X02K17)

Table 65 presents the TMDL summary for Sterling Run RM 9.65 (X02K17) (figures in Appendix B). Four of the five TSS samples and all the total phosphorus samples exceeded the target loads. In the mid-range flows and dry-conditions zones, total phosphorus displays a needed reduction of 82 percent or more and TSS of 69 percent or more.

Table 65. Loading statistics for Sterling Run RM 9.65 (X02K17)

X02K17		High flows	Moist conditions	Mid-range flows	Dry conditions	Low flows[a]
Pollutant	**TMDL component**	**0–10**	**10–40**	**40–60**	**60–90**	**90–100**
Total Phosphorus (kg/day)	Observed Load	No Data	No Data	1.06	0.252	No Data
	TMDL = LA + WLA + MOS	**6.10**	**0.741**	**0.186**	**2.22 E-2**	**9.79 E-5**
	LA	5.49	0.670	0.167	2.00 E-2	8.81 E-5
	Future Growth Reserve (0%)	0	0	0	0	0
	WLA: Facilities	0	0	0	0	0
	MOS (10%)	0.610	7.41 E-2	1.86 E-2	2.22 E-3	9.79 E-6
	TMDL Reduction (%)	No Data	No Data	**82%**	**91%**	No Data
TSS (kg/day)	Observed Load	No Data	No Data	118	1.60	No Data
	TMDL = LA + WLA + MOS	**1,220**	**148**	**37.1**	**0.475**	**1.96 E-2**
	LA	1,098	133	33.7	0.427	1.76 E-2
	Future Growth Reserve (0%)	0	0	0	0	0
	WLA: Facilities	0	0	0	0	0
	MOS (10%)	122	14.8	3.71	4.75 E-2	1.96 E-3
	TMDL Reduction (%)	No Data	No Data	**69%**	**70%**	No Data

For a discussion of the percentiles used to calculate the TMDLs for each flow zone, for a discussion of the linear extrapolation of the flow and load duration curves, and for a discussion of the linear interpolation of the load duration curve, see Appendix C.

[a]Loads were calculated on the basis of a linear extrapolation of the ILSAM-generated flow duration curve.

6.2.1.2 Sterling Run RM 6.74 (X02W05)

Table 66 presents the TMDL summary for Sterling Run RM 6.74 (X02W05) (figure in Appendix B). One of the four fecal coliform samples exceeded the target load. In the low flows zone, fecal coliform displays a needed reduction of 94 percent.

Table 66. Loading statistics for Sterling Run RM 6.74 (X02W05)

X02W05		High flows	Moist conditions	Mid-range Flows	Dry conditions	Low flows[a]
Pollutant	**TMDL component**	**0–10**	**10–40**	**40–60**	**60–90**	**90–100**
Fecal coliform (billion cfu/day)	Observed Load	No Data	No Data	No Data	0.828	22.2
	TMDL = LA + WLA + MOS	**2,957**	**364**	**120**	**4.25**	**1.39**
	LA	2,661	328	108	3.83	1.25
	Future Growth Reserve (0%)	0	0	0	0	0
	WLA: Facilities	0	0	0	0	0
	MOS (10%)	296	36.4	12.0	0.425	0.139
	TMDL Reduction (%)	No Data	No Data	No Data	**0%**	**94%**

[a]Loads were calculated on the basis of a linear extrapolation of the ILSAM-generated flow duration curve.

For a discussion of the percentiles used to calculate the TMDLs for each flow zone, for a discussion of the linear extrapolation of the flow and load duration curves, and for a discussion of the linear interpolation of the load duration curve, see Appendix C.

6.2.1.3 Sterling Run RM 6.47 (X02K14 and OH0801011)

Table 67 presents the TMDL summary for Sterling Run RM 6.47 (X02K14) and OH0801011 (figures in Appendix B). All the total phosphorus samples exceeded the target load. In the mid-range flows and dry-conditions zones, total phosphorus displays a needed reduction of 70 percent or more. Three atrazine samples exceeded the target load, displaying a needed reduction of 47 percent or more.

Table 67. Loading statistics for Sterling Run RM 6.47 (X02K14 and OH0801011)

X02K14 & OH0801011		High flows	Moist conditions	Mid-range flows	Dry conditions	Low flows
Pollutant	**TMDL component**	**0–10**	**10–40**	**40–60**	**60–90**	**90–100**
Total Phosphorus (kg/day)	Observed Load	No Data	No Data	2.02	0.391	No Data
	TMDL = LA + WLA + MOS	**19.2**	**2.34**	**0.606**	**9.21 E-2**	**5.14 E-3**
	LA	17.3	2.11	0.545	8.29 E-2	4.63 E-3
	Future Growth Reserve (0%)	0	0	0	0	0
	WLA: Facilities	0	0	0	0	0
	MOS (10%)	1.92	0.234	6.06 E-2	9.21 E-3	5.14 E-4
	TMDL Reduction (%)	No Data	No Data	**70%**	**76%**	No Data
Atrazine[a] (kg/day)	Observed Load	13.3	0.311	1.60	0.272	3.57 E-4
	TMDL = LA + WLA + MOS	**6.38**	**3.17**	**0.247**	**0.145**	**7.31 E-3**
	LA	5.74	2.85	0.222	0.130	6.58 E-3
	Future Growth Reserve (0%)	0	0	0	0	0
	WLA: Facilities	0	0	0	0	0
	MOS (10%)	0.638	0.317	2.47 E-2	1.45 E-2	7.31 E-4
	TMDL Reduction (%)	**52%**	**0%**	**85%**	**47%**	**0%**

[a]The Atrazine TMDL was based on the standard of 35 µg/L. See Section 3.1.2.3.

For a discussion of the percentiles used to calculate the TMDLs for each flow zone, see Appendix C.

6.2.1.4 Sterling Run RM 0.59 (X02W06)

Table 68 presents the TMDL summary for Sterling Run RM 0.59 (X02W06) (figures in Appendix B). All nine total phosphorus samples and none of the TSS samples exceeded the target loads. The TMDLs were calculated by including the design flow of the Mount Orab WWTP: 0.7 MGD (i.e., approximately 1.083 cfs) because this facility discharges upstream of RM 0.59. The WLA for total phosphorus was calculated as 0.1 mg/L at 0.7 MGD, yielding 0.265 kg/d; the WLA for TSS is the weekly average permitted limit of 47.7 kg/d. In the moist conditions, mid-range flows, and dry-conditions zones, total phosphorus displays a needed reduction of 38, 69, and 69 percent, respectively.

Table 68. Loading statistics for Sterling Run RM 0.59 (X02W06)

X02W06		High flows	Moist conditions	Mid-range flows	Dry conditions	Low flows
Pollutant	**TMDL component**	**0–10**	**10–40**	**40–60**	**60–90**	**90–100**
Total Phosphorus (kg/day)	Observed Load	No Data	7.70	6.75	2.27	No Data
	TMDL = LA + WLA + MOS	**37.7**	**4.76**	**2.12**	**0.706**	**0.282**
	LA	33.665	4.019	1.643	0.365	0[a]
	Future Growth Reserve (0%)	0	0	0	0	0
	WLA: Facilities	0.265	0.265	0.265	0.265	0.265
	MOS (10%)	3.77	0.476	0.212	7.06 E-2	1.70 E-2[b]
	TMDL Reduction (%)	No Data	**38%**	**69%**	**69%**	No Data
TSS (kg/day)	Observed Load	No Data	552	145	35.5	No Data
	TMDL = LA + WLA + MOS	**9,323**	**919**	**577**	**241**	**69.9**
	LA	8,343	779.4	471.6	169.2	15.21
	Future Growth Reserve (0%)	0	0	0	0	0
	WLA: Facilities	47.7	47.7	47.7	47.7	47.7
	MOS (10%)	932	91.9	57.7	24.1	6.99
	TMDL Reduction (%)	No Data	**0%**	**0%**	**0%**	No Data

For a discussion of the percentiles used to calculate the TMDLs for each flow zone, see Appendix C.
[a]A load of zero was allocated to the LA because the entire TMDL was allocated to the WLA and MOS.
[b]A load of only 0.017 kg/d was allocated to the MOS because the remainder of TMDL was allocated to the WLA.

The average concentration of total phosphorus from the Mount Orab WWTP is (2003 through 2006) is 0.86 mg/L. Although the loading analysis recommends that a very low effluent phosphorus concentration (0.1 mg/L) is necessary to meet the TMDL target, an effluent concentration of 1.0 mg/L of total phosphorus is recommended to be added for the next permit cycle.

The Mount Orab WWTP discharges to Snapping Turtle Run, about two miles upstream of this site on Sterling Run. Ohio EPA did not document biological impairment from phosphorus in Snapping Turtle Run, in part because of insufficient sampling. Any reduction in phosphorus effluent limits should be evaluated after the biological condition of the stream has been more fully assessed.

Ohio EPA is in the process of developing nutrient criteria, including a criterion for total phosphorus, that are planned to be incorporated into the OAC in the future. As currently envisioned (subject to change during rule development and promulgation), when the total phosphorus criterion is adopted, dischargers associated with biological impairment caused by total phosphorus would need to reduce effluent concentrations sufficiently to allow the in-stream concentrations to meet the criterion. However, if biological performance is documented as being in full attainment, then the proposed total phosphorus criteria would not trigger further reduction requirements at the WWTP.

6.2.1.5 Sterling Run (RM 6.68) Tributary RM 0.68 (X02K15)

Table 69 presents the TMDL summary for Sterling Run (RM 6.68) Tributary RM 0.68 (X02K15) (figure in Appendix B). Only one of the five TSS samples exceeded the target load. In the dry-conditions zone, TSS displays a needed reduction of 70 percent.

Table 69. Loading statistics for Sterling Run (RM 6.68) Tributary RM 0.68 (X02K15)

X02K15		High flows	Moist conditions	Mid-range flows	Dry conditions	Low flows[a]
Pollutant	**TMDL component**	**0–10**	**10–40**	**40–60**	**60–90**	**90–100**
TSS (kg/day)	Observed Load	No Data	No Data	33.0	2.61	No Data
	TMDL = LA + WLA + MOS	**1,380**	**168**	**42.3**	**0.789**	**5.87 E-2**
	LA	1,242	151	38.0	0.710	5.28 E-2
	Future Growth Reserve (0%)	0	0	0	0	0
	WLA: Facilities	0	0	0	0	0
	MOS (10%)	138	16.8	4.23	7.89 E-2	5.87 E-3
	TMDL Reduction (%)	No Data	No Data	**0%**	**70%**	No Data

[a]Loads were calculated on the basis of a linear extrapolation of the ILSAM-generated flow duration curve.

For a discussion of the percentiles used to calculate the TMDLs for each flow zone, for a discussion of the linear extrapolation of the flow and load duration curves, and for a discussion of the linear interpolation of the load duration curve, see Appendix C.

6.2.1.6 Snapping Turtle Run at 50 feet downstream of plant outfall (MO-901)

Table 70 presents the TMDL summary for stations MO-901 (figure in Appendix B). Three of the seven fecal coliform samples exceeded the target load. In the high flow, mid-range flows and dry-conditions zones, fecal coliform displays a needed reduction of 62, 9, and 53 percent, respectively. The observed loads data were calculated using DMR data because Ohio EPA did not collect fecal coliform samples from Snapping Turtle Run. The NPDES permit for the Mount Orab WWTP establishes a 2,000 cfu/100 mL limit for fecal coliform, and the design flow is 0.7 MGD. The calculated WLA is 53.0 billion cfu/100 mL.

Table 70. Loading statistics for Snapping Turtle Run at 50 feet downstream of the plant outfall (MO-901)

MO-901		High flows	Moist conditions	Mid-range flows	Dry conditions	Low flows
Pollutant	**TMDL component**	**0–10**	**10–40**	**40–60**	**60–90**	**90–100**
Fecal coliform (billion cfu/day)	Observed Load	908	115	67.3	118	25.0
	TMDL = LA + WLA + MOS	**345**	**118**	**61.2**	**55.3**	**53.0**
	LA	258	53.0	2.00[a]	0[b]	0[c]
	Future Growth Reserve (0%)	0	0	0	0	0
	WLA: Facilities	53.0	53.0	53.0	53.0	53.0
	MOS (10%)	34.5	11.8	6.12	2.32[b]	0[c]
	TMDL Reduction (%)	**62%**	**0%**	**9%**	**53%**	**0%**

For a discussion of the percentiles used to calculate the TMDLs for each flow zone, see Appendix C.

[a]A load of 2.00 billion cfu/day was allocated to the LA because the remainder of the TMDL as allocated to the WLA and MOS.

[b]A load of zero was allocated to the LA, and a load of 2.32 billion cfu/day allocated to the MOS because the remainder of the TMDL was allocated to the WLA. The allocation of zero to the LA is permissible because there is no natural streamflow (ILSAM-estimated) above the 60th percentile; the flow is derived from WWTP discharge.

[c]A load of zero was allocated to the LA and MOS because the entire TMDL was allocated to the WLA. The allocation of zero to the LA is permissible because there is no natural streamflow (ILSAM-estimated) above the 60th percentile; the flow is derived from WWTP discharge.

6.2.2 HUC 05090201 10 02

Miranda Run-White Oak Creek subwatershed drains 39.76 square miles. A discussion of water quality samples collected in this subwatershed is provided in Section 3.2.6. Figure 28 and Figure 50 display the sample stations in this subwatershed and all the TMDL stations in the watershed, respectively.

6.2.2.1 White Oak Creek RM 20.65 (X02K11)

Table 71 presents the TMDL summary for White Oak Creek RM 20.65 (X02K11) (figure in Appendix B). The TMDLs were calculated by including the design flow of the WWTPs that discharge upstream: Highland County Southwest WWTP (0.095 MGD), Mount Orab WWTP (0.7 MGD), and Sardinia WWTP (0.3 MGD). Since the Highland County Southwest WWTP is not permitted to discharge when streamflow is below 1.0 cfs, its design flow was not included in the calculations of the TMDLs for the dry-conditions and low-flows zones. Two of the five nitrate plus nitrite samples exceeded the target load. In the mid-range flows and dry-conditions zones, nitrate plus nitrite displays a needed reduction of 77 percent.

Table 71. Loading statistics for White Oak Creek RM 20.65 (X02K11)

X02K11		High flows	Moist conditions	Mid-range flows	Dry conditions	Low flows
Pollutant	**TMDL component**	**0–10**	**10–40**	**40–60**	**60–90**	**90–100**
Nitrate plus Nitrite (kg/day)	Observed Load	No Data	No Data	184	42.0	No Data
	TMDL = LA + WLA + MOS	**1,236**	**172**	**42.6**	**9.46**	**3.07**
	LA	1,071	113.3	36.27	6.62	0.873
	Future Growth Reserve (0%)	0	0	0	0	0
	WLA: Facilities	41.5[a]	41.5[a]	2.07[b]	1.89[c]	1.89[c]
	MOS (10%)	124	17.2	4.26	0.946	0.307
	TMDL Reduction (%)	No Data	No Data	**77%**	**77%**	No Data

For a discussion of the percentiles used to calculate the TMDLs for each flow zone, see Appendix C.

[a]A WLA of 41.5 kg/d was calculated using a nitrate plus nitrite target of 10 mg/L and including the design flows from the following WWTPs: Highland County Southwest, Mount Orab, and Sardinia.

[b]A WLA of 2.07 kg/d was calculated using a nitrate plus nitrite target of 0.5 mg/L and including the design flows from the following WWTPs: Highland County Southwest, Mount Orab, and Sardinia.

[c]A WLA of 1.89 kg/d was calculated using a nitrate plus nitrite target of 0.5 mg/L and including the design flows from the following WWTPs: Mount Orab and Sardinia.

6.2.2.2 White Oak Creek RM 12.40 (X02K04)

Table 72 presents the TMDL summary for White Oak Creek RM 12.40 (X02K04) (figure in Appendix B). The TMDLs were calculated by including the design flow of the WWTPs that discharge upstream: Highland County Southwest WWTP (0.095 MGD), Mount Orab WWTP (0.7 MGD), and Sardinia WWTP (0.3 MGD). Since the Highland County Southwest WWTP is not permitted to discharge when streamflow is below 1.0 cfs, its design flow was not included in the calculations of the TMDLs for the dry-conditions and low-flows zones. None of the TSS samples exceeded the target load.

Table 72. Loading statistics for White Oak Creek RM 12.40 (X02K04)

X02K04		High flows	Moist conditions	Mid-range flows	Dry conditions	Low flows
Pollutant	**TMDL component**	**0–10**	**10–40**	**40–60**	**60–90**	**90–100**
TSS (kg/day)	Observed Load	No Data	No Data	484	65.8	No Data
	TMDL = LA + WLA + MOS	**109,934**	**15,433**	**3,772**	**428**	**256**
	LA	98,929	13,819	3,324	320.4	165.6
	Future Growth Reserve (0%)	0	0	0	0	0
	WLA: Facilities	71.3 [a]	71.3 [a]	71.3 [a]	64.8 [b]	64.8 [b]
	MOS (10%)	10,934	1,543	377	42.8	25.6
	TMDL Reduction (%)	No Data	No Data	**0%**	**0%**	No Data

For a discussion of the percentiles used to calculate the TMDLs for each flow zone, see Appendix C.

[a]A WLA of 71.3 kg/d was calculated as the summation the permitted weekly average TSS loads from the Mount Orab WWTP (47.7 kg/d), the Sardinia WWTP (17.1 kg/d) with the calculation of a TSS load for the Highland County Southwest WWTP (6.47 kg/d) using the weekly average permit limit of 18 mg/L.

[b]A WLA of 64.8 kg/d was calculated as the summation of the permitted weekly average TSS loads from the Mount Orab WWTP (47.7 kg/d) and the Sardinia WWTP (17.1 kg/d).

6.2.3 HUC 05090201 10 03

Only Town Run is listed as impaired in the *Big Run-White Oak Creek* subwatershed. The Town Run subwatershed drains 1.4 square miles. A discussion of water quality samples collected in this subwatershed is provided in Section 3.2.7. Figure 31 and Figure 50 display the sample stations in this subwatershed and all the TMDL stations in the watershed, respectively.

Table 73 presents the TMDL summary for Town Run RM 0.63 (X02W04) (figures in Appendix B). All the nitrate plus nitrite samples and all the total phosphorus samples exceeded the target loads. In the mid-range flows and dry-conditions zones, nitrate plus nitrite displays a needed reduction of 88 and 95 percent (respectively), and total phosphorus displayed a needed reduction of 96 and 98 percent (respectively). The NPDES permit for the Georgetown WWTP does not currently have total phosphorus or nitrate plus nitrite limits.

Table 73. Loading statistics for Town Run RM 0.63 (X02W04)

X02W04		High flows	Moist conditions	Mid-range flows	Dry conditions	Low flows
Pollutant	**TMDL Component**	**0–10**	**10–40**	**40–60**	**60–90**	**90–100**
Nitrate plus Nitrite (kg/day)	Observed Load	None	None	14.1	33.0	None
	TMDL = LA + WLA + MOS	**10.2**	**2.53**	**1.73**	**1.51**	**1.51**
	LA	7.67[a]	0.77[b]	0.05[c]	0[d]	0[d]
	Future Growth Reserve (0%)	0	0	0	0	0
	WLA: Facilities	1.51[e]	1.51[e]	1.51[e]	1.51[e]	1.51[e]
	MOS (10%)	1.02	0.25	0.17	0[d]	0[d]
	TMDL Reduction (%)	None	None	**88%**	**95%**	None
Total Phosphorus (kg/day)	Observed Load	None	None	8.73	17.7	None
	TMDL = LA + WLA + MOS	**2.04**	**0.506**	**0.347**	**0.303**	**0.303**
	LA	1.54[f]	0.152[g]	0.009[h]	0[d]	0[d]
	Future Growth Reserve (0%)	0	0	0	0	0
	WLA: Facilities	0.303[i]	0.303[i]	0.303[i]	0.303[i]	0.303[i]
	MOS (10%)	0.20	0.051	0.035	0[d]	0[d]
	TMDL Reduction (%)	None	None	**96%**	**98%**	None

[a]A load of 7.67 kg/day was allocated to the LA because the remainder of the TMDL is allocated to the WLA and MOS.

[b]A load of 0.77 kg/day was allocated to the LA because the remainder of the TMDL is allocated to the WLA and MOS.

[c]A load of 0.05 kg/day was allocated to the LA because the remainder of the TMDL is allocated to the WLA and MOS.

[d]A load of zero was allocated to the LA and MOS because the entire TMDL was allocated to the WLA. The allocation of zero to the LA is reasonable because there is no natural streamflow (ILSAM-estimated) above the 60th percentile; the flow is derived from WWTP discharge.

[e]The WLA was calculated as the multiplication of Georgetown WWTP's design flow (0.8 MGD) by a target of 0.5 mg/L (EWH target for nitrate plus nitrite [Ohio EPA 1999]) and converted to a daily load. The NPDES permit for Georgetown WWTP does not establish effluent limits for nitrate plus nitrite.

[f]A load of 1.54 kg/day was allocated to the LA because the remainder of the TMDL is allocated to the WLA and MOS.

[g]A load of 0.77 kg/day was allocated to the LA because the remainder of the TMDL is allocated to the WLA and MOS.

[h]A load of 0.009 kg/day was allocated to the LA because the remainder of the TMDL is allocated to the WLA and MOS.

[i]The WLA was calculated as the multiplication of Georgetown WWTP's design flow (0.8 MGD) by a target of 0.1 mg/L (Ohio EPA recommendation). The NPDES permit for Georgetown WWTP does not establish effluent limits for total phosphorus.

For a discussion of the percentiles used to calculate the TMDLs for each flow zone, see Appendix C.

The effluent from the Georgetown WWTP is nutrient-rich; the average concentrations of total phosphorus (6/16/2005 to 11/2/2006) and nitrate plus nitrite (1/2/2003 to 11/2/2006) are 7.33 and 10.94 mg/L, respectively. Although the loading analysis recommends that a very low effluent nutrient concentration is necessary to meet the TMDL target, an effluent concentration of 1.0 mg/L of total phosphorus is recommended for the next permit cycle. While the loading analysis indicates that this limit will not meet total phosphorus in-stream target concentration, it does represent a considerable reduction in nutrient loads (86% for total phosphorus) from the Georgetown WWTP. It is expected that improvements made at the WWTP during the next permit cycle in order to meet the total phosphorus limit will result in reductions in nitrate plus nitrite as well.

This limit, combined with reductions in other pollution loads (e.g., ammonia) should provide enough in-stream nutrient reduction to improve aquatic life in Town Run while imposing achievable NPDES limits. Any further reduction in nutrient effluent limits should be evaluated after these reductions are attained and after the biological condition of the stream has been evaluated.

As discussed above in Section 6.2.1.4, Ohio EPA is in the process of developing nutrient criteria, including a criterion for total phosphorus, that are planned to be incorporated into the OAC in the future. As currently envisioned (subject to change during rule development and promulgation), when the total

phosphorus criterion is adopted, dischargers associated with biological impairment caused by total phosphorus would need to reduce effluent concentrations sufficiently to allow the in-stream concentrations to meet the criterion. However, if the Georgetown WWTP reduces its effluent to 1.0 mg/L and biological performance improves from non-attainment to full attainment, then the proposed total phosphorus criteria would not trigger further reduction requirements at the WWTP.

6.3 Margin of Safety

The Clean Water Act requires that a TMDL include an MOS to account for any lack of knowledge concerning 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).

An implicit MOS has been included in selecting targets for some parameters. For example, in Bells Run, the ammonia target of 1.0 mg/L represents the 30-day average but is used as a daily target. Additionally, the value of 1.0 mg/L was selected because it is the most restrictive of the three potential values derived from the water quality standard (1.0, 1.3, and 2.1 mg/L).

An explicit MOS has been applied as part of most of the White Oak Creek TMDLs by reserving 10 percent of the allowable load (see the allocation tables in Sections 6.1 and 6.2). Ten percent was considered an appropriate MOS given the uncertainty associated with the flow estimates that (along with the targets) are the basis of the TMDL calculations (refer to Appendix A for more details).

Insignificant growth is expected over the next several years for Brown and Highland counties. Therefore, the future growth reserve was set to 0%.

6.4 Critical Conditions and Seasonality

The Clean Water Act 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 Clean Water Act 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 15) for fecal coliform. The load duration approach also accounts for seasonality by evaluating allowable loads on a daily basis over the entire range of observed flows and by presenting daily allowable loads that vary by flow.

7 PUBLIC INVOLVEMENT

Public involvement is fundamental to the success of water restoration projects, including TMDL efforts. From the beginning, Ohio EPA has invited participation in all aspects of the TMDL program. The Ohio EPA convened an external advisory group in 1998 to assist the Agency with the development of the TMDL program in Ohio. The advisory group issued a report in July 2000 to the Director of Ohio EPA on their findings and recommendations. The White Oak Creek watershed TMDL project has been completed using the process endorsed by the advisory group.

Ohio EPA met with the White Oak Creek Watershed Advisory Board in June 2007 to discuss preliminary results from the 2006 watershed survey and to explain the TMDL process. That meeting included visiting several sites at which agricultural best management practices to protect water quality had been installed in the watershed.

Consistent with Ohio's current Continuous Planning Process (CPP), the draft TMDL report will be available for public comment from October 15 through November 17, 2009. A copy of the draft report will be posted on Ohio EPA's web page (**http://www.epa.ohio.gov/dsw/tmdl/index.aspx**).

Continued public involvement is critical to the success of any TMDL project. Ohio EPA will continue to support the implementation process and will facilitate, to the fullest extent possible, restoration actions that are acceptable to the communities and stakeholders in the study area and to Ohio EPA. Ohio EPA is reluctant to rely solely on regulatory actions and strongly upholds the need for voluntary actions facilitated by the local stakeholders, watershed organization, and agency partners to restore the White Oak Creek watershed.

8 WATER QUALITY IMPROVEMENT STRATEGY

Biological, physical habitat, and surface water chemistry information was collected from 46 stations (43 stations with an assigned attainment status) in 18 streams in the White Oak Creek watershed. Of these, 25 were fully attaining (58%) their existing or recommended aquatic life use, eight were partially attaining (19%), and 10 were not attaining (23%). Three stations were sampled only with qualitative macroinvertebrate methods and did not receive a use attainment status. The state listed (threatened) fish bigeye shiner (*Notropis boops*) was found at 23 stations during this study. Nutrients, low flow alterations, low dissolved oxygen and siltation were the most common causes of aquatic life use impairment in the watershed.

Bacteriological samples were collected from 16 stations in the White Oak Creek watershed to evaluate attainment of their existing or recommended recreational use designations. Of these, 11 were attaining the PCR use and five were not. In several cases, unrestricted cattle access to the stream was the source of bacteria. In other cases, failing home sewage treatment systems (HSTS) and a sanitary sewer overflow (SSO; at Sterling Run RM 6.74) were sources of bacteria. The SSO was sealed less than a month after its discovery by Ohio EPA field personnel in 2006, but sludges were still present during the August 2006 sampling at that site.

Table 74 shows an overview of all of the 12-digit HUCs that contained sites with partial and non-attainment of aquatic life and recreation uses. Causes (e.g., nutrients or habitat) are shown within parentheses following each source that might contribute to that cause of impairment. Tables 75 and 76 each represent a separate 10-digit HUC (see Figure 1 for a map). For each 12-digit HUC, specific actions are recommended. Recommendations were developed after consultation with local technical stakeholders and agency staff. In each case, 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 G.

Table 74. Recommendations for improving water quality in the White Oak Creek watershed.

10-Digit HUC (Location Description) 12-Digit HUC (Location Description) 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
Headwaters White Oak Creek (05090201 09)												
Headwaters East Fork White Oak Creek (09 01)												
Unrestricted cattle access (bacteria)	x								x	x		
Slabcamp Run - East Fork White Oak Creek (09 02)												
Manure runoff (low DO, ammonia-N, total phosphorus, siltation)	x								x	x		
Unrestricted cattle access (low DO, ammonia-N, total phosphorus, siltation, bacteria)	x								x	x		
Crop production (low flow alterations, siltation)	x	x		x					x	x		
Urban runoff (low flow alterations, siltation)	x	x							x		x	?
Little North Fork - North Fork White Oak Creek (09 03)												
Channelization (direct habitat alterations, siltation)	x	x							x	x		
Loss of riparian vegetation (siltation, direct habitat alterations)	x			x					x	x		
Crop production (low flow alterations, siltation)	x								x	x		
Unrestricted cattle access (total phosphorus, siltation)	x								x	x		
On-site treatment systems (nutrients/eutrophication)								x	x			
Unsewered community (bacteria)									x			x

Table 74 (cont). Recommendations for improving water quality in the White Oak Creek watershed.

10-Digit HUC (Location Description) 12-Digit HUC (Location Description) 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
Sterling Run - White Oak Creek (05090201 10)												
Sterling Run (10 01)												
Crop production (low flow alterations, siltation, low DO, total phosphorus)	x								x	x		
Lake Grant (low flow alterations, low DO)			x	x	x				x			
Channelization (direct habitat alterations, siltation)	x	x		x					x	x		
Sanitary sewer overflow (low DO, bacteria)*									x			x*
Crop production (atrazine - PDWS)	x								x	x		
Miranda Run - White Oak Creek (10 02)												
Upstream source, esp. Mt. Orab (nutrients/eutrophication, siltation)	x								x	x		x
Big Run - White Oak Creek (10 03)												
Georgetown WWTP (ammonia-N, total phosphorus, nitrate-nitrite-N, bacteria)	x	x		x								x

* The SSO was removed via a lift station upgrade in 2008.

Table 75. Specific actions recommended for the Headwaters White Oak Creek watershed.

Restoration Categories		Specific Restoration Actions	Headwaters White Oak Creek (05090201 09)		
			Headwaters East Fork White Oak Creek (09 01)	Slabcamp Run - East Fork White Oak Creek (09 02)	Little North Fork - North Fork White Oak Creek (09 03)
Bank & Riparian Restoration	constructed	Restore streambank using bio-engineering		x	
		Restore streambank by recontouring or regrading		x	x
	planted	Plant grasses in riparian areas		x	x
		Plant prairie grasses in riparian areas		x	x
		Remove/treat invasive species			
		Plant trees or shrubs in riparian areas		x	x
Stream Restoration		Restore flood plain		x	x
		Restore stream channel		x	x
		Install in-stream habitat structures		x	x
		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	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			
		Construct acid mine drainage wetland			

Table 75 (cont.). Specific actions recommended for the Headwaters White Oak Creek watershed.

Restoration Categories		Specific Restoration Actions	Headwaters White Oak Creek (05090201 09)		
			Headwaters East Fork White Oak Creek (09 01)	Slabcamp Run - East Fork White Oak Creek (09 02)	Little North Fork - North Fork White Oak Creek (09 03)
Abandoned Mine Land Reclamation (cont.)	flow diversion	Repair subsidence sites			
		Reclaim pit impoundments			
		Reclaim abandoned mine land			
		Eliminate stream captures			
		Restore positive drainage			
		Cover toxic mine spoils			
Home Sewage Planning and Improvement		Develop HSTS plan			x*
		Inspect HSTS			x
		Repair or replace traditional HSTS			x
		Repair or replace alternative HSTS			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		x	x
		Implement conservation tillage practices		x	x
		Implement grass/legume rotations		x	x
		Convert to permanent hayland		x	x
		Install grassed waterways		x	x
		Install vegetated buffer areas/strips		x	x
		Install location-specific conservation buffer		x	x
		Install / restore wetlands			
	nutrients / agro-chemicals	Conduct soil testing		x	x
		Install nitrogen reduction practices		x	x
		Develop nutrient management plans		x	x
	Drainage	Install sinkhole stabilization structures			
		Install controlled drainage system			
		Implement drainage water management		x	x
		Construct overwide ditch			
		Construct 2-stage channel			
	Livestock	Implement prescribed & conservation grazing practices		x	
		Install livestock exclusion fencing		x	x
		Install livestock crossings			
		Install alternative water supplies		x	x
		Install livestock access lanes			

* Development of a HSTS plan was recommended in the WAP and has been completed in both counties.

Table 75 (cont.). Specific actions recommended for the Headwaters White Oak Creek watershed.

Restoration Categories		Specific Restoration Actions	Headwaters White Oak Creek (05090201 09)		
			Headwaters East Fork White Oak Creek (09 01)	Slabcamp Run - East Fork White Oak Creek (09 02)	Little North Fork - North Fork White Oak Creek (09 03)
Agricultural Best Management Practices (cont.)	manure	Implement manure management practices		x	x
		Construct animal waste storage structures		x	
		Implement manure transfer practices		x	
		Install grass manure spreading strips		x	
	misc. infrastructure and mgt	Install chemical mixing pads			
		Install heavy use feeding pads		x	x
		Install erosion & sediment control structures		x	x
		Install roof water management practices			
		Install milkhouse waste treatment practices		x	
		Develop whole farm management plans		x	x
Storm Water Best Management Practices	planning	Develop/implement local ordinances/resolutions		x	
		Develop local comprehensive land use plans		x	
	construction practices	Implement erosion controls		x	
		Implement sediment controls		x	
		Implement non-sediment controls		x	
	post construction practices	Reduce pollutant(s) through treatment			
		Reduce pollutant(s) through flow/volume management		x	
	post development/ storm water retrofit	Implement erosion controls		x	
		Implement sediment controls		x	
		Implement non-sediment controls			
		Reduce pollutant(s) through treatment			
		Reduce pollutant(s) through flow/volume management		x	

Table 75 (cont.). Specific actions recommended for the Headwaters White Oak Creek watershed.

Restoration Categories		Specific Restoration Actions	Headwaters White Oak Creek (05090201 09)		
			Headwaters East Fork White Oak Creek (09 01)	Slabcamp Run - East Fork White Oak Creek (09 02)	Little North Fork - North Fork White Oak Creek (09 03)
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			x
		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			
		Increase effluent monitoring			
	alternatives	Establish water quality trading			
	construction practices	Issue permit(s) and/or modify permit limit(s)			
		Implement erosion controls			
		Implement sediment controls			
		Implement non-sediment controls			
	post construction practices	Issue permit(s) and/or modify permit limit(s)			
		Reduce pollutant(s) through treatment			
		Reduce pollutant(s) through flow/volume management			
	post development/ storm water retrofit	Issue permit(s) and/or modify permit limit(s)			
		Implement erosion controls			
		Implement sediment controls			
		Implement non-sediment controls			
		Reduce pollutant(s) through treatment			
		Reduce pollutant(s) through flow/volume management			
		Reduce volume to CSOs			

Table 76. Specific actions recommended for the Sterling Run – White Oak Creek watershed.

Restoration Categories		Specific Restoration Actions	Sterling Run - White Oak Creek (05090201 10)		
			Sterling Run (10 01)	Miranda Run - White Oak Creek (10 02)	Big Run - White Oak Creek (10 03)
Bank & Riparian Restoration	constructed	Restore streambank using bio-engineering			
		Restore streambank by recontouring or regrading	x		
	planted	Plant grasses in riparian areas	x	x	
		Plant prairie grasses in riparian areas	x	x	
		Remove/treat invasive species			
		Plant trees or shrubs in riparian areas	x	x	x
Stream Restoration		Restore flood plain	x		x
		Restore stream channel	x		
		Install in-stream habitat structures	x		
		Install grade structures			
		Construct 2-stage channel			
		Restore natural flow	x		
Wetland Restoration		Reconnect wetland to stream			
		Reconstruct & restore wetlands	x		
		Plant wetland species	x		
Conservation Easements		Acquire conservation easements	x		x
Dam Modification or Removal		Remove dams	x		
		Modify dams			
		Remove associated dam support structures			
		Install fish passage and/or habitat structures			
		Restore natural flow	x		
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			
		Construct acid mine drainage wetland			

Table 76 (cont.). Specific actions recommended for the Sterling Run – White Oak Creek watershed.

Restoration Categories		Specific Restoration Actions	Sterling Run - White Oak Creek (05090201 10)		
			Sterling Run (10 01)	Miranda Run - White Oak Creek (10 02)	Big Run - White Oak Creek (10 03)
Abandoned Mine Land Reclamation (cont.)	flow diversion	Repair subsidence sites			
		Reclaim pit impoundments			
		Reclaim abandoned mine land			
		Eliminate stream captures			
		Restore positive drainage			
		Cover toxic mine spoils			
Home Sewage Planning and Improvement		Develop HSTS plan			
		Inspect HSTS			
		Repair or replace traditional HSTS			
		Repair or replace alternative HSTS			
Education and Outreach		Host meetings, workshops, and/or other events	x	x	
		Distribute educational materials	x	x	
Agricultural Best Management Practices	farmland	Plant cover/manure crops	x	x	
		Implement conservation tillage practices	x	x	
		Implement grass/legume rotations	x	x	
		Convert to permanent hayland	x	x	
		Install grassed waterways	x	x	
		Install vegetated buffer areas/strips	x	x	
		Install location-specific conservation buffer	x	x	
		Install / restore wetlands			
	nutrients / agro-chemicals	Conduct soil testing	x		
		Install nitrogen reduction practices	x		
		Develop nutrient management plans	x	x	
	drainage	Install sinkhole stabilization structures			
		Install controlled drainage system			
		Implement drainage water management	x		
		Construct overwide ditch			
		Construct 2-stage channel			
	livestock	Implement prescribed & conservation grazing practices			
		Install livestock exclusion fencing		x	
		Install livestock crossings			
		Install alternative water supplies		x	
		Install livestock access lanes			

Table 76 (cont.). Specific actions recommended for the Sterling Run – White Oak Creek watershed.

Restoration Categories		Specific Restoration Actions	Sterling Run - White Oak Creek (05090201 10)		
			Sterling Run (10 01)	Miranda Run - White Oak Creek (10 02)	Big Run - White Oak Creek (10 03)
Agricultural Best Management Practices (cont.)	manure	Implement manure management practices			
		Construct animal waste storage structures			
		Implement manure transfer practices			
		Install grass manure spreading strips			
	misc. infrastructure and mgt	Install chemical mixing pads	x		
		Install heavy use feeding pads		x	
		Install erosion & sediment control structures		x	
		Install roof water management practices			
		Install milkhouse waste treatment practices			
		Develop whole farm management plans	x	x	
Storm Water Best Management Practices	planning	Develop/implement local ordinances/resolutions			
		Develop local comprehensive land use plans			
	construction practices	Implement erosion controls			
		Implement sediment controls			
		Implement non-sediment controls			
	post construction practices	Reduce pollutant(s) through treatment			
		Reduce pollutant(s) through flow/volume management			
	post development/ storm water retrofit	Implement erosion controls			
		Implement sediment controls			
		Implement non-sediment controls			
		Reduce pollutant(s) through treatment			
		Reduce pollutant(s) through flow/volume management			

Table 76 (cont.). Specific actions recommended for the Sterling Run – White Oak Creek watershed.

Restoration Categories		Specific Restoration Actions	Sterling Run - White Oak Creek (05090201 10)		
			Sterling Run (10 01)	Miranda Run - White Oak Creek (10 02)	Big Run - White Oak Creek (10 03)
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	x*		
	enhanced treatment	Issue permit(s) and/or modify permit limit(s)		x	x
		Improve quality of effluent		x	x
	monitoring	Establish ambient monitoring program			
		Increase effluent monitoring		x	x
	alternatives	Establish water quality trading			
	construction practices	Issue permit(s) and/or modify permit limit(s)			
		Implement erosion controls			
		Implement sediment controls			
		Implement non-sediment controls			
	post construction practices	Issue permit(s) and/or modify permit limit(s)			
		Reduce pollutant(s) through treatment			
		Reduce pollutant(s) through flow/volume management			
	post development/ storm water retrofit	Issue permit(s) and/or modify permit limit(s)			
		Implement erosion controls			
		Implement sediment controls			
		Implement non-sediment controls			
		Reduce pollutant(s) through treatment			
		Reduce pollutant(s) through flow/volume management			
		Reduce volume to CSOs			

* The SSO was removed via a lift station upgrade in 2008.

The *Biological and Water Quality Study of White Oak Creek Watershed, 2006* (Ohio EPA 2008b) suggests that impairment associated with agricultural practices may be addressed by improving riparian buffers, proper fertilizer and pesticide application and ceasing of traditional "cleaning" of streams (which disturbs habitat significantly). In particular, the above document suggests that it would be beneficial to fence the cattle out of the headwaters of East Fork White Oak Creek (RM 16.50), tributary to East Fork White Oak Creek at RM 15.52 (RM 2.1), Plum Run (RM 0.9) and Bells Run (RM 2.0). Urbanization impairments could be addressed through a combination of regulatory, educational and funding actions including improvements at each WWTP, management of failing septic systems, advances in storm water management, controlled development and alternatives to traditional stream channelization and riparian removal. One method to reduce polluted urban runoff would be to incorporate bioretention areas into existing and new infrastructure (Ohio EPA 2008b).

In addition, the Watershed Action Plan (Dragoo 2004) makes several recommendations for water quality improvement for sources that were not identified as causing impairment in the *Biological and Water Quality Study of the White Oak Creek Watershed, 2006* (Ohio EPA 2008b), as follows:

05090201 09 04 (no aquatic life use impairment was identified in Ohio EPA's 2006 study)

- Install livestock exclusion fencing
- Install alternative water supplies
- Implement prescribed grazing practices
- Plant grasses in riparian areas
- Restore stream channel
- Acquire conservation easements

05090201 10 01

- Install livestock exclusion fencing
- Install alternative water supplies
- Implement prescribed grazing practices
- Install heavy use feeding pads

05090201 10 03

- Install livestock exclusion fencing
- Install alternative water supplies
- Complete a dam removal/modification feasibility study (Georgetown Dam)

8.1 NPDES Program Recommendations

Recommendations related to NPDES permits are listed by discharger and 12-digit watershed in Table 77. Any suggestions in permit limits reflect calculated TMDLs. For the Mount Or0ab WWTP, the relationship of the total phosphorus recommendation to the TMDL allocation is discussed in Section 6.2.1.4. For the Georgetown WWTP, the relationship of the total phosphorus recommendation to the TMDL allocation is discussed in Section 6.2.3. The ammonia recommendation is based on the 4B analysis contained in Appendix H.

Table 77. Implementation actions through the NPDES program.

Note: any specific permit condition under a parameter indicates a change from current permit conditions. "No change" means no change is recommended.

HUC12	Entity	Ohio EPA Permit #	Receiving Stream	Total Phosphorus *[00665]*	Ammonia *[00610]*	Dissolved Oxygen *[00300]*
05090201 09 02	Sardinia WWTP	1PB00108	Slabcamp Run	No change	No change	No change
05090201 09 02	Highland County Southwest WWTP	1PA00029	East Fork White Oak Cr.	No change	No change	No change
05090201 10 01	Mt. Orab WWTP	1PB00044	Snapping Turtle Run	*Average 7-day limit:* 1.5 mg/l *Average 30-day limit:* 1.0 mg/l	No change	No change
05090201 10 02	Rumpke Sanitary Landfill	1IN00142	Walnut Run; unnamed trib. to White Oak Creek	No change	No change	No change
05090201 10 03	Georgetown WWTP	1PB00101	Town Run	*Average 7-day limit:* 1.5 mg/l *Average 30-day limit:* 1.0 mg/l	*Summer average limits:* 7-day: 0.9 mg/l 30-day: 0.6 mg/l *Winter average limits:* 7-day: 2.9 mg/l 30-day: 1.93 mg/l	*Minimum daily limit:* 7.0 mg/l

8.2 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 there be a committed effort by state and local agencies, governments, and private groups to carry out and/or facilitate such actions. The availability of adequate resources is also imperative for successful implementation.

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 wasteload allocations contained in the TMDL will be achieved. This is because 40 C.F.R. 122.44(d)(1)(vii)(B) requires that effluent limits in permits be consistent with the assumptions and requirements of any available wasteload allocation 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 this end, Appendix G discusses organizations and programs that have an important role or can provide assistance for meeting the goals and recommendations of this TMDL. The appendix establishes in greater detail why it is reasonable to be assured of successful implementation.

8.2.1 Local Zoning and Regional Planning

The Brown County Department of Economic Development (**http://www.county.brown.oh.us/**) exists to assist in preparing the county for growth through planning, infrastructure and program development, and participation in organizations that have been formed to prepare and promote Ohio and its individual counties. Such an organization can often help to promote conservation-minded development.

8.2.2 Local Watershed Groups

The White Oak Creek Watershed Partners group was formed in September 2000 and is led by a watershed coordinator out of the Brown County SWCD (**http://www.brownswcd.org/watershed.htm**). In 2004, the State of Ohio fully endorsed the Watershed Action Plan, available at the Web link above. The group has been extremely active in the watershed, implementing many best management practices (BMPs) and disseminating information about water quality to residents throughout the watershed.

Watershed programs have included installing storm drain markers; annual stream clean-ups; a high school water monitoring program; a junior high school macroinvertebrate monitoring program; conservation field days; various educational school days; and teachers' workshops. In addition, the watershed group has helped to coordinate agricultural cost-share programs to improve water quality, including HSTS replacements, livestock exclusion fencing and grassed waterway installation.

Multiple 319 grants have been given to the Watershed Partners (see Section 8.2.3). In 2008, progress continued to be made in the watershed, as shown by the following actions reported to Ohio EPA 319 staff for grant purposes:

Actions Reported	Quantity	Units
Install Livestock Exclusion Fencing	10,000	Linear ft
Install Alternative Water Supplies	4	Supplies
Implement Prescribed Grazing Practices	50	Acres
Repair/Replace failing HSTS	3	HSTS
Plant Grasses in Riparian Areas	12	Acres
Pesticide Application Education	3	Workshops
Install Heavy Use Feeding Pads	5	Pads
Implement Conservation Tillage Practice	100	Acres
Install Grassed Waterways	4	Acres
Develop Nutrient Management Plans	2	Acres
Develop Whole Farm Management Plans	30	Acres
Construct Animal Waste Storage Structures	1	Structure
Implement Grass/Legume Rotations	10	Acres
Implement Roof Water Management Practices	1	Practice
Implement Manure Management Practices	80	Acres

8.2.3 Other Sources of Funding and Special Projects

There have been two 319 grants awarded for the watershed. The first one in 1999 was for $263,500 with $183,500 in local match and $1,500 from ODNR ($445,500 total). This grant paid for WAP development, the school water quality monitoring program, septic system repairs/upgrades, riparian buffers, filter strips and grassed waterways.

The second grant was for $228,265 with $174,150 in local match ($402,415 total). This grant addressed livestock issues with winter feeding pads, structures, and lanes. It also paid for septic system repairs (causing development of county-wide HSTS plans) and continued the education program. In addition to the 319 grants the watershed also received two watershed coordinator grants.

Other activities included the livestock fencing program which was funded by ODNR, Division of Wildlife. The watershed also was the recipient of a 94 acre conservation easement resulting from a supplemental environmental project with Rumpke Waste Management.

8.2.4 Past and Ongoing Water Resource Evaluation

Ohio EPA monitored the watershed previously in 1987 and 1997. *The Biological and Water Quality Study of the White Oak Creek Watershed, 2006* (Ohio EPA 2008b) analyzed trends between 1997 and 2006 sampling. Future monitoring is tentatively scheduled for 2022 based on Ohio's rotating basin schedule (Ohio EPA 2008a).

Several past and ongoing projects have occurred in the watershed.

- In 2004, a University of Southern Mississippi student collected bigeye shiners at eight of nine sample locations for a graduate school project. The project was sponsored by the White Oak Creek Watershed Group using 319 funds and verified a relatively large bigeye shiner population in the North Fork.
- High school water monitoring program: A water monitoring program was set up with 8 local school districts in Brown and Highland County. Each school was equipped with $5,000 worth of state-of-the-art equipment. The school water monitoring teams monitor for ten different physical, chemical, and biological parameters. These monitoring data have been used for baseline data by the watershed group.
- Junior high macroinvertebrate monitoring program: Students and teachers participate in the macroinvertebrate monitoring program. Activities include collecting, identifying and documenting the invertebrate life forms that inhabit the watershed.
- In 2005, the Brown SWCD office performed research about the Clermont soil series, a predominant soil type in the watershed. The project determined that the characteristic most affected by disturbance in Clermont soils was infiltration, the rate at which soil is able to absorb rainfall or irrigation. The collaborators concluded that a logical next step regarding this water quality issue must include additional focus on implementation of agricultural BMPs to improve soil infiltration and providing outreach to watershed land owners and managers for more widespread adoption of appropriate BMPs.

  This opportunity came to fruition when Brown County SWCD was awarded a U.S. Department of Agriculture grant in 2009 for a project titled "The Affects of Land Management Practices on a Clermont Soil Type: Ultimately Improving Overall Soil and Water Quality." This project will be done in collaboration with ODNR and Highland County SWCD. The primary purpose of the project is to demonstrate improvements of the overall soil quality in the Clermont Soil Series. By improving certain soil quality features, it is possible that water quality improvement will be gained. This is a three year project. The information gathered will be compiled into a final report and will expand upon the existing initiative (which began in 2005) to understand the effect of

cover crops on Clermont soil. Data from prior efforts, from this grant and from future endeavors will be merged to produce a comprehensive resource for landowners and personnel.

8.2.5 Potential and Future Evaluation

Another 319 grant was signed recently in 2009. The focus of the grant is to reduce atrazine levels in Sterling Run in order to protect the Mt. Orab water supply and improve aquatic life.

8.2.6 Revision to the Implementation Approach

An adaptive management approach will be taken in the watershed. Adaptive management is recognized as a viable strategy for managing natural resources (Baydack et al., 1999) and this approach is applied on federally-owned lands. An adaptive management approach allows for changes in the management strategy if environmental indicators suggest that the current strategy is inadequate or ineffective. The recommendations put forth for the watershed are discussed in the last chapter of the main report. If chemical water quality does not show improvement and/or water bodies are still not attaining water quality standards after the implementation plan has been carried out, then a TMDL revision would be initiated. The Ohio EPA would initiate the revision if no other parties wish to do so.

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