Total Maximum Daily Loads for Duck Creek

Final Report

prepared by

Ohio Environmental Protection Agency
Division of Surface Water

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The TMDL in Brief

Basin:
Duck Creek is a direct tributary to the Ohio River

Study Area:
The entire Duck Creek basin was assessed and TMDLs were completed where impairments were identified

Goal:
Attainment of the appropriate Aquatic Life Use

Major Causes:
Acid mine drainage metals, total suspended solids, habitat alteration, nutrient enrichment, low dissolved oxygen

Major Sources:
Past mining, agricultural runoff, failing septic systems

Measure:
Metals, total suspended solids, D.O. and biological and habitat indices

Restoration Options:
Remining, mining remediation, agricultural runoff controls, habitat protection and revegetation

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ACKNOWLEDGMENTS

A key aspect of the project involved public participation and coordination at the local level. Kaabe Shaw, the watershed coordinator for Duck Creek under the sponsorship of the Washington County Soil and Water Conservation District, was invaluable in communicating the goals of the TMDL project to local stakeholders.

The following individuals provided technical services for this project:

Biology and Chemical Water Quality	-	Ed Moore and Brian Alsdorf (Ohio EPA)
Water Quality Modeling	-	Ana Maria Garcia and Kevin Kratt (Tetra Tech), Keith Orr (Ohio EPA)
Project Leader	-	Keith Orr (Ohio EPA)

Many full- and part-time staff participated in field monitoring; chemistry analyses were provided by the Ohio EPA Division of Environmental Services.

Acknowledgment is also given to the property owners that allowed Ohio EPA personnel access to the Duck Creek and its tributaries.

INTRODUCTION

The 1972 Clean Water Act (CWA) Section 303(d) requires States, Territories, and authorized Tribes to list and prioritize waters for which technology-based treatment limits alone do not ensure attainment of water quality standards. The 303(d) list of impaired waters is made available to the public and submitted to the U.S. Environmental Protection Agency (USEPA) in every even-numbered year (40 CFR 130.7(d) did not require a 303(d) list submittal in the year 2000). The Ohio Environmental Protection Agency (Ohio EPA) identified the Duck Creek watershed as a priority impaired water on the 1998 and 2002 303(d) lists.

The Clean Water Act and USEPA regulations require that Total Maximum Daily Loads (TMDLs) be developed for all waters on the section 303(d) lists. A TMDL is a calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards, and an allocation of that amount to the pollutant's sources. Ultimately, the goal of Ohio's TMDL process is full attainment of biological and chemical Water Quality Standards (WQS) and, subsequently, delisting of water bodies from the 303(d) list.

This report serves to document the Duck Creek TMDL process and provide for tangible actions to restore and maintain this water body. The main objectives of the report are to: describe the water quality and habitat condition of Duck Creek and to quantitatively assess the factors affecting non or partial attainment of WQS.

The Duck Creek watershed is in southeast Ohio and occupies portions of Noble, Washington, Monroe, and Guernsey counties (Attachment 2, Figure 1). The principal drainage in the watershed is Duck Creek and its tributaries, the West, Middle and East Forks. The watershed is mostly rural with several small towns and a portion of the city of Marietta. Duck Creek drains into the Ohio River at the eastern boundary of Marietta. The watershed has a drainage area of approximately 288 square miles.

This report on the Duck Creek watershed serves a number of purposes. First, it documents TMDL work completed by a consultant under contract to U.S. EPA. Second, it contains discussion of other impairments not addressed by the consultant and options to move toward remediation of the causes of the impairments. Finally, this document, along with a biological and water quality study report on the findings of the Duck Creek watershed assessment conducted in 2000, serve as supporting documentation for a watershed plan to be developed by the Duck Creek watershed coordinator in 2004.

The key events in the development of this report are as follows:

1. Duck Creek is included on the 1998 303(d) list as an impaired watershed based on data collected in 1987. Duck Creek consists of two subwatersheds (as defined by the 11-digit Hydrologic Unit Code (HUC) drainage): Duck Creek including West Fork, and East Fork Duck Creek. Only the Duck Creek and West Fork subwatershed

were included on the 1998 list[1]. Duck Creek was subsequently scheduled for a watershed assessment in 2000, with a TMDL to be submitted to U.S. EPA in 2002.

2. In keeping with its watershed focus for TMDL work, Ohio EPA conducted a full watershed assessment (biological, chemical, physical (habitat)) of Duck Creek in 2000. Approximately 61 sites were distributed throughout the watershed using a geometric study design. Preliminary assessment information was available in late 2001. The study's finding are summarized in Attachment 1.

3. Using the preliminary assessment information, TetraTech, under contract to U.S. EPA, completed TMDL calculations. Because of the TMDL schedule and contracting timelines within U.S. EPA, TMDL work had to proceed with preliminary assessment information. The TMDL work contained in this report addresses the mining related impairments (metals and siltation) in both subwatersheds, as identified during the assessment. TetraTech's work is included here as Attachment 2.

4. While the TMDL work was proceeding, the final assessment information was developed. A number of additional localized impairments were identified. These localized impairments included five organic enrichment/dissolved oxygen (OE/DO) and five siltation impairments. Three of the five OE/DO impairments were modeled and two are discussed. To address the additional TSS impairments, an addendum to Attachment 2's Table 15, Total Suspended Solids TMDL Allocations, was included in Attachment 3.

5. Ohio's 2002 Section 303(d) listing information (included in the *Ohio 2002 Integrated Water Quality Monitoring and Assessment Report*) reflects the final assessment information for Duck Creek. Both subwatersheds are listed as impaired.

6. The Washington County Soil and Water Conservation District was awarded a watershed coordinator grant for the Duck Creek watershed under a program sponsored by Ohio EPA and the Ohio Department of Natural Resources using Section 319 funds. The watershed coordinator is constructing a watershed action plan, due to be completed in March 2004.

Table 1 describes the report layout. Table 2 indicates where the various impairment causes are addressed in this report.

[1] Some changes in Ohio's HUC numbering system were made in the late 1990s. The drainage of Duck Creek and West Fork is now 05030201 120 (was 05030201 240). The East Fork Duck Creek drainage is 05030201 110 (was 05030201 230).

Table 1. Report Layout

Section	Title	Source	Purpose	No. of Pages
Introduction	Total Maximum Daily Loads for Duck Creek	OEPA	To summarize the report and attachments	10
Attachment 1	Final Results of Biological and Water Quality Sampling	OEPA	To summarize the Aquatic Life Use status	17
Attachment 2	TMDL Development for the Duck Creek Watershed, Ohio	Tetra Tech	Modeling and writeup for metals and TSS (AMD)	40, plus Appendix A Appendix B Appendix C
Attachment 3	Organic Enrichment/DO Impairment Modeling	OEPA	To address the dissolved oxygen/organic enrichment impairments	9
Attachment 4	Implementation	OEPA	To discuss potential control options	9
Attachment 5	Public Involvement and Reasonable Assurance	OEPA	To discuss reasonable assurance and public participation	7

Table 2. Impaired streams in the Duck Creek watershed

Stream	Impairment Cause	TMDL in This Report?	Report Location
Duck Creek	DDT Flow Alterations Siltation OE/DO	other remedy no √ other remedy	Attachment 3, sect. 1.3.4 Attachment 4, sect. 2.8 Attachment 3, sect. 2.0 Attachment 3, sect. 1.3.4
East Fork Duck Creek	Aluminum Iron Manganese Siltation Ammonia	√ √ √ √ other remedy	Attachment 2 Attachment 2 Attachment 2 Attachment 2 Attachment 3, sect. 1.3.4
Middle Fork Duck Creek	Aluminum Iron Manganese Siltation	√ √ √ √	Attachment 2 Attachment 2 Attachment 2 Attachment 3, sect. 2.0
Pawpaw Creek	*tempory construction related impairment*	not needed	Attachment 4, sect. 2.5
Whipple Run	Siltation Bacteria OE/DO	√ no √	Attachment 2 Attachment 4, sect. 2.3 Attachment 3, sect. 1.3.3
Dog Run	Siltation	√	Attachment 2
Wolf Run	Hydrologic Modification Ammonia Bacteria OE/DO	no other remedy other remedy other remedy	Attachment 4, sect. 2.6 Attachment 3, sect. 1.3.5 Attachment 3, sect. 1.3.5 Attachment 3, sect. 1.3.5
Buffalo Run	Aluminum	√	Attachment 2
Warren Run	Aluminum	√	Attachment 2
West Fork Duck Creek Tributary (RM[d] 3.05)	Aluminum Manganese Iron	√ √ √	Attachment 2 Attachment 2 Attachment 2
West Fork Duck Creek Tributary (RM 2.30)	Aluminum	√	Attachment 2
Otterslide Run	Aluminum Iron Manganese	√ √ √	Attachment 2 Attachment 2 Attachment 2
Mare Run	Aluminum Nutrients Siltation OE/DO	√ √ √ √	Attachment 2 Attachment 3, sect. 1.3.2 Attachment 2 Attachment 3, sect. 1.3.2
West Fork East Fork Duck Creek	Aluminum Manganese Iron Siltation	√ √ √ √	Attachment 2 Attachment 2 Attachment 2 Attachment 3, sect. 2.0

Stream	Impairment Cause	TMDL in This Report?	Report Location
East Fork Duck Creek Tributary (RM 5.73)	Aluminum Iron Manganese Siltation	√ √ √ √	Attachment 2 Attachment 2 Attachment 2 Attachment 2
East Fork Duck Creek Tributary (RM 4.15)	Siltation Aluminum	√ √	Attachment 2 Attachment 2
Schwab Run	Siltation	√	Attachment 2
Greasy Run	Siltation	√	Attachment 2
Elk Fork	Aluminum Manganese Nutrients Siltation OE/DO	√ √ √ √ √	Attachment 2 Attachment 2 Attachment 3, sect. 1.3.1 Attachment 3, sect. 2.0 Attachment 3, sect. 1.3.1
Flag Run	Aluminum Iron Siltation	√ √ √	Attachment 2 Attachment 2 Attachment 3, sect. 2.0
Road Fork	Siltation Aluminum Iron Manganese	√ √ √ √	Attachment 2 Attachment 2 Attachment 2 Attachment 2
Barnes Run	Aluminum	√	Attachment 2

RM=river mile
OE/DO = oganic enrichment/dissolved oxygen

ATTACHMENT 1

FINAL RESULTS OF
BIOLOGICAL AND WATER QUALITY SAMPLING

(Completed after Attachment 2 work was done by TetraTech; updates information in Attachment 2, Appendix A)

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1.0 STUDY DESCRIPTION

As part of the five-year basin approach for monitoring, assessment, and the issuance of National Pollution Discharge Elimination System (NPDES) permits, ambient biological, water column chemical, sediment, and bioassay sampling was conducted in the Duck Creek basin from June to October 2000. This study area included Duck Creek mainstem; the East, West, and Middle Forks of Duck Creek; Pawpaw Creek; and other tributaries greater than approximately two square miles. Specific objectives of this evaluation were to:

1) Monitor and assess the chemical (water and sediment) integrity, physical habitat, and biological integrity (biomonitoring of macroinvertebrates and fish along with fish tissue) of the streams within the Duck Creek watershed study area;

2) Evaluate the smaller headwater streams in subwatersheds to assess general watershed quality and to assign aquatic life use designation or primary headwater habitat classification as determined;

3) Determine the attainment status of the currently designated Warmwater Habitat (WWH) or Limited Resource Water (LRW) aquatic life use and other non-aquatic use designations and recommend changes in use where appropriate; and

4) Conduct water resource trend assessments where historical data exists.

The findings of this evaluation factor into regulatory actions taken by the Ohio EPA (*e.g.*, NPDES permits, Director's Orders, the Ohio Water Quality Standards [OAC 3745-1], Water Quality Permit Support Documents [WQPSDs]) and are incorporated into Total Maximum Daily Load studies, State Water Quality Management Plans, the Ohio Nonpoint Source Assessment, and the biennial Water Resource Inventory (305[b]) report.

2.0 SUMMARY OF FINDINGS

In the basin survey, there was an attempt to sample all streams $\geq$ 2 $mi.^2$. There were 180.3 miles of stream assessed in Duck Creek basin. Overall, 85 percent of stream miles in all sampled streams in Duck Creek basin fully attained the designated or recommended aquatic life uses. Nine percent partially attained, and only six percent of stream miles sampled did not attain the designated or recommended aquatic life use.

2.1 Duck Creek Mainstem

The 2000 Duck Creek mainstem study area included the whole mainstem reach (RM 24.3) to the mouth. Good to exceptional conditions persisted that attained WWH biocriteria extending downstream to Marietta (except for a short zone at RM 5.5 almost recovered from a manure spill/fish kill). There was some NON attainment in the mouth area (lower 2.5 miles) due to contaminated sediments, hazardous waste site discharges (now eliminated) and other NPS effects. All effects were magnified by the pooling of Duck Creek at the mouth by Ohio River impoundments. There were 20.8 of 24.3 miles of mainstem Duck Creek in attainment of its WWH criteria (85.6 %).

2.2 East, West, and Middle Forks of Duck Creek

West Fork Duck Creek fully attained its WWH use designation for its full length of 36.4 miles (100%) (good to exceptional performance) despite some unsewered areas contributing improperly treated waste and cattle NPS inputs (higher fecal coliform bacteria concentrations and sedimentation). Downstream from Caldwell there was a short reach where excess nutrient concentrations combined with open canopy conditions to threaten biological attainment (use marginally met but high primary production from nutrient enrichment present with possible low nighttime dissolved oxygen concentrations from decomposition/oxygen demand).

East Fork Duck Creek (proposed to be WWH) met WWH use designation biocriteria in 28.8 miles of 30.5 miles of stream (94%). Good to exceptional performance was recorded except one short segment where accumulated NPS sedimentation (siltation and mining runoff) had clogged the stream channel resulting in limited fish biomass. Also, infrequent lower pH concentrations (6.43 was < 5thpercentile of all pHs in Western Allegheny Plateau (WAP) ecoregion streams that attained WWH biocriteria) that are input via nearby old mining tributaries upstream likely contributes to lower fish community biomass score.

Approximately 50 percent of Middle Fork Duck Creek attained WWH biocriteria through its length (6.8 of 13.8 miles with <1 mile unassessed). Middle Fork Duck Creek had 5.5 miles in partial attainment and 0.7 miles in NON attainment of WWH biological standards. Mining (residual and/or current NPS runoff in form of sedimentation, low pH, and elevated metals concentrations) was the main source with some agricultural (cattle grazing) and road construction inputs. Most impacts were in the lower six miles.

2.3 Pawpaw Creek

Pawpaw Creek achieved the EWH biocriteria standards in 10.8 miles of 11.0 miles assessed (93%) with 0.6 miles unassessed. There was temporary sedimentation in a short reach above one sampled site due to private road construction after bank stabilization would have occurred (also, IBI of 44 at impaired site was only two points below EWH absolute minimum score). Pawpaw Creek appears to be one of the least mined basins in the Duck Creek watershed and has recovered where some mining had occurred, though there was some NPS sediment accumulation near the Pawpaw Creek mouth at the confluence with East Fork Duck Creek.

2.4 Smaller Tributaries

Tributaries greater than two square miles in the Duck Creek basin were sampled (and also some 1 $mi.^2$) where some water column chemical, physical and bacteriological data were recorded (see attainment table). Twenty-two of thirty sampled streams (73%) had some portion or all of the sampled stream reach that fully attained its designated stream use, and the linear total comprised 85 percent of stream miles evaluated. Most sampled tributaries surveyed throughout the basin improved dramatically from past or perceived impaired water quality from historical legacy mining and other uses. Time, mine land restoration, and, in some areas, remining, contributed to improvements. Most water quality use designations were upgraded based on biological sampling. Where NON attainment (6% of stream miles) or partial attainment (9% of stream miles) of the assigned aquatic life use designations were documented, various causes and sources of impairment were found: mining (residual and/or current NPS runoff in form of habitat or flow alterations, siltation/sedimentation, low pH, and elevated metals concentrations); agriculture (cattle grazing/pastoral use with siltation and loss of riparian buffer with nutrient/bacterial inputs); and organic inputs with low dissolved oxygen measurements (from poor or failing septic treatment (nutrient or bacterial inputs) and agriculture or cattle waste inputs). Now, WWH aquatic life use designation or better is the norm within Duck Creek basin with few streams still listed as lower quality designations of Limited Resource Water (AMD) or Modified Warmwater Habitat.

Individual streams with impairment causes are included in the summary TMDL table in this report's introduction.

Table 1. Aquatic life use attainment status of sites sampled in the Duck Creek basin from June-October, 2000. The Index of Biotic Integrity (IBI), Modified Index of well being (MIwb), and the Invertebrate Community Index (ICI) are scores based on the performance of the biotic community. The Qualitative Habitat Evaluation Index (QHEI) measures the ability of the physical habitat to support a biotic community. Aquatic life uses for the Duck Creek basin were based on biological sampling conducted during June - October 2000.

RIVER MILE Fish/Invert.	IBI	MIwb	ICI[a]	QHEI	Attainment Status[b]	Site Location
Duck Creek (06-300) 2000 Western Allegheny Plateau (WAP) - WWH (existing)						
21.2 w	50	9	48	51.5	FULL	
16.1 b / 16.4	53	8.8	50	58	FULL	
11.2 b / 11.3	51	9.3	48	72.5	FULL	
5.5w	43[ns]	6.7*	44	59.5	PARTIAL	**manure spill**
3.2 b	43	8.5[ns]	--	60	(FULL)	**influenced by Ohio R dam & barge traffic**
-- / 2.5	--	--	F*		**(NON)**	ust. Cytec "impounded"
1.8 b	38[ns]	6.3*	P*	59.5	**NON**	dst. Cytec "impounded"
0.5 b / --	42	7.6*	--	57.5	(PARTIAL)	near mouth / recovery
Duck Creek (1997) (WAP) - WWH (existing)						
-- / 3.7	--	--	40		(FULL)	ust. landfills
3.5 b / 3.5	30*	7.1*	44	65.5	PARTIAL	ust. landfills (& last riffle area)
-- / 3.3	--	--	38		(FULL)	dst. Vandale Landfill Trib.
3.2 b	31*	7.2*	32[ns]	67	PARTIAL	dst. possible second landfill Trib.
Duck Creek 1984 (WAP) - WWH (existing)						
21.1	40[ns]	7.5*	40		PARTIAL	
West Fork Duck Creek (06-340) 2000 (WAP) - WWH (existing)						
34.2	54	--	VG	51	FULL	
33.3	48	--	VG	58.5	FULL	
31.4	47	8.7	40	74.5	FULL	
28	46	8.9	46	61.5	FULL	
23.1	50	8.7	VG[d]	63.5	FULL	
22.99/23.00	46	9.5	P		--	Acute Mix zone effluent was not acutely toxic
22.9/22.6	44	8.8	G[d]		FULL	dst. Caldwell WWTP
-- / 22.3	--	--	MG[ns]	--	FULL	dst. Caldwell
20.7	46	9.2	44	60	FULL	dst. Dana / recovery
16	51	9.9	32[ns]	74	FULL	adjacent SR 821 nr. I-77 crossover
11.2 / 12.8	48	9.6	48	65.5	FULL	ust. Dexter
9.1	49	9	42	59	FULL	dst. Macksburg
4.6	45	8.9	48	75	FULL	
0.1	49	8.6	E	59	FULL	nr. mouth
East Fork Duck Creek (06-320) 2000 (WAP) - LWH (existing); WWH (proposed)						
29.9 / 30.3	44	--	E	66.5	FULL	adj. CR 6
28.4	42[ns]	--	G	56	FULL	adj. CR 6
26.3	44	--	40	46.5	FULL	from SR 78

RIVER MILE Fish/Invert.	IBI	MIwb	ICI[a]	QHEI	Attainment Status[b]	Site Location
20.7	55	9.7	40	80	FULL	dst. TR 263
14.3 / 14.1	46	7.9[ns]	VG	68.5	FULL	dst. CR 48
9.6	53	9	E	72	FULL	CR 47 (Harrietsville)
4.2	40[ns]	6.6*	46	42.5	PARTIAL	ust. TR 313
0.1 / 0.9	46	8.4	G	51	FULL	ust. SR 821 & dst. Pawpaw Cr. confl
Middle Fork Duck Creek (06-322) 2000 (WAP) - WWH (existing)						
12.7	42[ns]	–	–	52.5	(FULL)	CR 50 (1.1 mi.[2])
11.8	44	--	G	37.5	FULL	adj. SR 564
10.8	48	--	E	44	FULL	SR 564 and CR 15
– / 10.4	--	--	P*		(**NON**)	adj. SR 564 (new road construction)
9.8	40[ns]	--	VG	60.5	FULL	SR 564
5.4	26*	--	48	50	PARTIAL	ust. SR 564 (Middleburg)
0.2 / 0.1	32*	3.9*	P*	54	**NON**	SR 564 & SR 145 (AMD trib. ust. & NPS)
Middle Fork Duck Creek (06-322) 1998 (WAP) - WWH (existing)						
1.1	44	7.6*	--	65.0	(PARTIAL)	
Pawpaw Creek (06-321) 2000 WAP - EWH (existing)						
11	50	--	E	59.5	FULL	adj. SR 564
9.6	56	--	E	66.5	FULL	CR 30 and CR 15
8.2	52	--	E	71.5	FULL	from CR 15
3.8	44*	--	E	72	PARTIAL	TR 324 or 460 (active “401" during sample)
Pawpaw Creek (06-321) (1998) - EWH (existing)						
0.3	52	10.1	E	70.5	FULL	near mouth
Whipple Run (06-306) 2000 (WAP) - WWH (existing)						
4.6	48	--	E	65.5	FULL	
4	52	--	VG	65.5	FULL	
0.2 / 0.1	48	--	F*	63.5	PARTIAL	town of Whipple septic? NPS silt, RR?
Nelots Creek (06-360) 2000 (WAP) - WWH (proposed)						
1.6 / 1.1	48	--	VG	61.5	FULL	
0.2 / 0.1	42[ns]	--	G	60.5	FULL	
Coal Run (06-366) 2000 (WAP) - WWH (proposed)						
3.6	54	--	MG[ns]	47	FULL	cattle, NPS sedimentation/nutrients
2.9	50	--	MG[ns]	51	FULL	cattle, NPS sedimentation/nutrients
0.8 / 1.0	54	--	G	55	FULL	siltation
Dog Run (06-346) 2000 (WAP) - WWH (existing)						
2.6	28*	--	MG[ns]	59	PARTIAL	ust. Lk Caldwell/interstitial pool/NPS
1	32*	--	F*	35.5	**NON**	dst Lk Caldwell/NPS silt, more lentic
Wolf Run (06-347) 2000 (WAP) - WWH (existing)						
2.7 / 2.5	40[ns]	--	MG[ns]	59	FULL	ust. Lake Caldwell
-- / 0.5	--	--	F*		**(NON)**	dst Wolf Run Res releases/ town NPS
0.4 / --	50	--	--	46.5	(FULL)	dst. Wolf Run Reservoir

RIVER MILE Fish/Invert.	IBI	MIwb	ICI[a]	QHEI	Attainment Status[b]	Site Location
Johnny Woods River (06-348) 2000 (WAP) - LWH (existing); WWH (proposed)						
1.6 / 1.4	50	--	G	54	FULL	
0.4 / 0.3	48	--	G	70	FULL	
Horse Run (06-363) 2000 (WAP) - WWH (proposed)						
2.5 / 2.2	48	--	G	56	FULL	
1.1	48	--	G	57	FULL	
Trib. to Horse Run (confl. @ RM 2.15) (So. Br. Horse Run) (06-347) 2000 (WAP) - WWH (proposed)						
0.2 / 0.1	44	--	MG^{ns}	50.5	FULL	
Patty Creek (06-368) 2000 (WAP) - WWH (proposed)						
1.7	44	--	--	49.0	(FULL)	
			(WAP) - EWH (proposed)			
0.1	58	--	E	75.0	FULL	
Salt Run (06-362) 2000 (WAP) - WWH (existing)						
2.1 / 2.2	42^{ns}	--	MG^{ns}	55	FULL	
0.8 / 0.9	42^{ns}	--	MG^{ns}	46.5	FULL	
– / 0.2	--	--	MG^{ns}	66	(FULL)	
Elk Run (06-344) 2000 (WAP) - WWH (proposed)						
0.4 / --	48	--	--	47.0	(FULL)	
Trib to West Fork Duck Creek (confl.@ RM 9.35)(Macksburg Run)(06-361)2000 (WAP)						
0.3	42^{ns}	--	E	49.5	FULL	WWH (proposed)
Buffalo Run (06-342) 2000 (WAP) - LRW (existing); WWH (proposed)						
1.6	28*	--	26*	53	**NON**	likely AMD/gray slag/coagulent present on rocks
0.2 / 0.1	44	--	G	42	FULL	
Warren Run (06-343) 2000 (WAP) - LWH (existing); WWH (proposed)						
0.3 /0.1	38*	--	F*	52	**NON**	irregular pulse AMD/bugs recovering
Trib. to West Fork Duck Cr. (confluence @ RM 3.05) (06-359) 2000 (WAP) - MWH (proposed)						
0.2	12*	--	F*	49.5	**NON**	AMD impacts
Trib. to West Fork Duck Cr. (confluence @ RM 2.30) (06-358) 2000 (WAP) - MWH (proposed)						
0.2/ --	28	--	E	42	(FULL)	MH ust.-Wetland/pool-mining repair? WWH (proposed)
-- / 0.1	--	--	E	--	(FULL)	
Sugar Creek (06-304) 2000 (WAP) - WWH (existing)						
0.2 / 0.1	48	--	E	61	FULL	

RIVER MILE Fish/Invert.	IBI	MIwb	ICI[a]	QHEI	Attainment Status[b]	Site Location
Killwell Run (06-301) 2000 (WAP) - WWH (existing)						
0.2 / 0.1	44	--	VG	47.5	FULL	
Otterslide Run (06-323) 2000 (WAP) - LWH (existing); WWH (proposed)						
0.2 / 0.1	34*	--	G	65	PARTIAL	mined/had mining recovery, roadwork
Mare Run (06-324) 2000 (WAP) - LWH (existing); WWH (proposed)						
0.7	48	--	F*	42.5	PARTIAL	NPS nutrients enriched,silt/cows open
– / 0.1	--	--	G		(FULL)	
West Fork East Fork Duck Cr. (06-335) 2000 (WAP) - LWH (existing); MWH (proposed)						
1.4	30	--	MG	40.5	FULL	
						WWH (proposed)
0.1	48	--	G	61.5	FULL	
Trib. to East Fork Duck Cr. (confluence @ RM 5.73) (06-353) 2000 (WAP) - LRW-AMD (proposed)						
0.2 / 0.1	12*	--	VP*	40	**NON**	AMD & NPS siltation & w'coal fines
Trib. to East Fork Duck Cr. (confluence @ RM 4.15) (06-352) 2000 (WAP) - WWH (proposed)						
0.2 / 0.1	38*	--	G	57	PARTIAL	NPS siltation, there is coal mining nr.
Barnes Run (06-334) 2000 (WAP) - LWH (existing); WWH (proposed)						
1.5	48	--	VG	65	FULL	
0.1	52	--	G	47.1	FULL	
Schwab Run (06-330) 2000 (WAP) - LWH (existing); WWH (proposed)						
2.8 / 3.0	28*	--	E	56	PARTIAL	NPS ag. siltation/ open cow pasture
Greasy Run (06-332) 2000 (WAP) - LWH (existing); WWH (proposed)						
2.1 / 1.2	38*	--	MG[ns]	62.5	PARTIAL	
0.7	56	--	F*	35	PARTIAL	NPS agri., open canopy/open pasture
Elk Fork (06-331) 2000 (WAP) - LWH (existing); WWH (proposed)						
2.5 / --	50	--	--	61	(FULL)	Ust. McBride Run (~1 mi.^{2})
– / 2.2	--	--	F*	--	**(NON)**	pulsed AMD from 1 mi.^{2} trib ust.(dst. McBride Run)
1.8	48	--	MG[ns]	55	FULL	
0.2 / 0.1	50	--	P*	59	**NON**	NPS nutrients & poss. AMD(coal dust)
Creighton Run (06-327) 2000 (WAP) - LWH (existing); EWH (proposed)						
0.9 / 0.8	50	--	E	62	FULL	
Flag Run (06-329) 2000 (WAP) - LWH (existing); WWH (proposed)						
2.5 / --	30*	--	--	54.5	**(NON)**	
1.0 / 0.8	36*	--	VG	54.5	PARTIAL	gas line const. ust./ old mining area
– / 0.4	--	--	E	54	(FULL)	
0.1	40[ns]	--	E	58.5	FULL	
Road Fork (06-328) 2000 (WAP) - LWH (Existing); CWH (proposed)						
2.0	42[ns]	--	E	60.5	FULL	

RIVER MILE Fish/Invert.	IBI	MIwb	ICI[a]	QHEI	Attainment Status[b]	Site Location
					WWH (proposed)	
1.5 / 1.4	34*	--	G	63	PARTIAL	past mining/coal fines,silt/gravel load
0.7	48	--	E	61.5	FULL	

Biological Criteria for Western Allegheny Plateau (WAP)

Site Type INDEX	IBI Headwaters	IBI Wading	IBI Boat	MIwb Wading	MIwb Boat	ICI (all sites)
EWH Habitat	50	50	48	9.4	9.6	46
WWH Habitat	44	44	40	8.4	8.6	36
MWH	24	24	24	6.2	5.8	22
LRW	18	18	18	4.0	4.0	8

* Significant departure from ecoregion biocriterion; poor and very poor results are underlined.
ns Nonsignificant departure from biocriterion (<4 IBI or ICI units; <0.5 MIwb units).
a Narrative evaluation used in lieu of ICI (E=Exceptional; VG=Very Good; G=Good; MG=Marginally Good; F=Fair; P=Poor).
b Use attainment status based on one organism group is parenthetically expressed.
c Sampled or evaluated in 2000.
d sampled in July 2002 (follow-up sample) to match sites.
NA Not Applicable. The MIwb (Modified Index of Well-being) is not applicable to headwater sites.

Table 2. Water quality data for aluminum.

Station	Avg (µg/l)	Min (µg/l)	Max (µg/l)	Count	Start Date	End Date
C01G01	987	544	1770	7	7/11/2000	9/18/2000
C01G02	1695	530	4760	5	7/11/2000	9/18/2000
C01G03	309	200	464	3	8/16/2000	9/18/2000
C01G04	686	249	1300	6	7/11/2000	9/18/2000
C01G05	835	216	2560	9	7/11/2000	9/18/2000
C01G06	355	201	487	6	7/11/2000	9/18/2000
C01G07	337	200	732	9	7/11/2000	9/18/2000
C01G08	809	365	1840	6	7/11/2000	9/18/2000
C01G09	1094	544	2050	6	7/11/2000	9/18/2000
C01G10	859	620	1140	10	7/11/2000	9/18/2000
C01G11	548	200	1020	6	7/11/2000	9/18/2000
C01G12	511	323	827	10	7/11/2000	9/18/2000
C01G13	259	200	390	9	7/11/2000	9/18/2000
C01G14	221	200	324	11	7/11/2000	9/18/2000
C01G15	305	201	369	7	7/11/2000	9/18/2000
C01G16	731	358	1130	6	7/11/2000	9/18/2000
C01G17	274	200	791	8	7/11/2000	9/18/2000
C01G18	1694	200	4510	8	7/11/2000	9/18/2000
C01G19	200	200	200	7	7/11/2000	9/18/2000
C01G20	200	200	200	5	7/11/2000	9/18/2000
C01G21	200	200	200	6	7/11/2000	9/18/2000
C01G22	615	366	1400	7	7/11/2000	9/18/2000
C01G23	599	200	2370	7	7/11/2000	9/18/2000
C01G24	414	200	1430	11	7/11/2000	9/18/2000
C01G25	224	200	303	6	7/11/2000	9/18/2000
C01G26	221	200	282	9	7/11/2000	9/18/2000
C01G27	200	200	200	6	7/11/2000	9/18/2000
C01G28	448	209	954	9	7/11/2000	9/18/2000
C01G29	231	200	433	9	7/11/2000	9/18/2000
C01G30	320	200	426	7	7/11/2000	9/18/2000
C01G31	209	200	246	7	7/11/2000	9/18/2000
C01G32	200	200	200	7	7/11/2000	9/18/2000

Station	Avg (µg/l)	Min (µg/l)	Max (µg/l)	Count	Start Date	End Date
C01G33	18745	200	108000	6	7/11/2000	9/18/2000
C01G34	200	200	200	7	7/11/2000	9/18/2000
C01G35	200	200	200	4	7/11/2000	8/1/2000
C01G36	204	200	231	7	7/11/2000	9/18/2000
C01G37	200	200	200	6	7/11/2000	9/18/2000
C01G38	200	200	200	7	7/11/2000	9/18/2000
C01G39	200	200	200	11	7/11/2000	9/18/2000
C01G40	239	200	326	8	7/11/2000	9/18/2000
C01G41	288	200	726	6	7/11/2000	9/18/2000
C01G42	214	200	350	11	7/11/2000	9/18/2000
C01G43	326	200	1080	7	7/11/2000	9/18/2000
C01G44	218	200	307	6	7/11/2000	9/18/2000
C01G45	495	200	1620	6	7/11/2000	9/18/2000
C01G46	200	200	200	6	7/11/2000	9/18/2000
C01G49	91300	88000	94600	2	8/30/2000	9/18/2000
C01S06	1393	812	2080	6	7/11/2000	9/18/2000
C01S08	719	547	972	6	7/11/2000	9/18/2000
C01S09	213	200	266	8	7/11/2000	9/18/2000
C01S15	365	200	1160	6	7/11/2000	9/19/2000

Table 3. Water quality data for iron.

Station	Avg (µg/l)	Min (µg/l)	Max (µg/l)	Count	Start Date	End Date
C01G01	1140	537	1980	7	7/11/2000	9/18/2000
C01G02	2129	596	6360	5	7/11/2000	9/18/2000
C01G03	350	205	500	3	8/16/2000	9/18/2000
C01G04	774	428	1410	6	7/11/2000	9/18/2000
C01G05	963	357	2880	9	7/11/2000	9/18/2000
C01G06	464	353	543	6	7/11/2000	9/18/2000
C01G07	350	122	830	9	7/11/2000	9/18/2000
C01G08	865	383	2020	6	7/11/2000	9/18/2000
C01G09	1183	511	2490	6	7/11/2000	9/18/2000
C01G10	874	545	1270	10	7/11/2000	9/18/2000
C01G11	507	76	913	6	7/11/2000	9/18/2000
C01G12	809	508	1230	10	7/11/2000	9/18/2000
C01G13	334	187	650	9	7/11/2000	9/18/2000
C01G14	294	80	476	11	7/11/2000	9/18/2000
C01G15	429	331	523	7	7/11/2000	9/18/2000
C01G16	962	391	1750	6	7/11/2000	9/18/2000
C01G17	263	97	1040	8	7/11/2000	9/18/2000
C01G18	2216	182	6080	8	7/11/2000	9/18/2000
C01G19	196	76	256	7	7/11/2000	9/18/2000
C01G20	206	50	340	5	7/11/2000	9/18/2000
C01G21	82	50	121	6	7/11/2000	9/18/2000
C01G22	120	50	177	7	7/11/2000	9/18/2000
C01G23	515	50	2430	7	7/11/2000	9/18/2000
C01G24	346	129	728	11	7/11/2000	9/18/2000
C01G25	159	101	257	6	7/11/2000	9/18/2000
C01G26	241	105	339	9	7/11/2000	9/18/2000
C01G27	145	56	195	6	7/11/2000	9/18/2000
C01G28	678	310	1490	9	7/11/2000	9/18/2000
C01G29	397	135	811	9	7/11/2000	9/18/2000
C01G30	446	342	566	7	7/11/2000	9/18/2000
C01G31	305	160	465	7	7/11/2000	9/18/2000
C01G32	115	70	182	7	7/11/2000	9/18/2000

Station	Avg (µg/l)	Min (µg/l)	Max (µg/l)	Count	Start Date	End Date
C01G33	36549	197	213000	6	7/11/2000	9/18/2000
C01G34	90	50	165	7	7/11/2000	9/18/2000
C01G35	109	50	183	4	7/11/2000	8/1/2000
C01G36	205	55	426	7	7/11/2000	9/18/2000
C01G37	149	50	272	6	7/11/2000	9/18/2000
C01G38	70	50	91	7	7/11/2000	9/18/2000
C01G39	106	50	306	11	7/11/2000	9/18/2000
C01G40	267	85	486	8	7/11/2000	9/18/2000
C01G41	270	50	989	6	7/11/2000	9/18/2000
C01G42	178	86	494	11	7/11/2000	9/18/2000
C01G43	431	161	1730	7	7/11/2000	9/18/2000
C01G44	476	341	676	6	7/11/2000	9/18/2000
C01G45	1091	549	2790	6	7/11/2000	9/18/2000
C01G46	153	82	241	6	7/11/2000	9/18/2000
C01G49	6915	5440	8390	2	8/30/2000	9/18/2000
C01S06	1246	946	1530	6	7/11/2000	9/18/2000
C01S08	652	394	972	6	7/11/2000	9/18/2000
C01S09	103	50	173	8	7/11/2000	9/18/2000
C01S15	489	200	1590	6	7/11/2000	9/19/2000

Table 4. Water quality data for manganese.

Station	Avg (µg/l)	Min (µg/l)	Max (µg/l)	Count	Start Date	End Date
C01G01	382	148	708	7	7/11/2000	9/18/2000
C01G02	395	264	498	5	7/11/2000	9/18/2000
C01G03	108	94	127	3	8/16/2000	9/18/2000
C01G04	179	149	233	6	7/11/2000	9/18/2000
C01G05	109	81	158	9	7/11/2000	9/18/2000
C01G06	105	83	141	6	7/11/2000	9/18/2000
C01G07	146	89	197	9	7/11/2000	9/18/2000
C01G08	169	127	238	6	7/11/2000	9/18/2000
C01G09	211	155	275	6	7/11/2000	9/18/2000
C01G10	176	132	217	10	7/11/2000	9/18/2000
C01G11	181	110	276	6	7/11/2000	9/18/2000
C01G12	240	98	321	10	7/11/2000	9/18/2000
C01G13	149	91	329	9	7/11/2000	9/18/2000
C01G14	152	95	280	11	7/11/2000	9/18/2000
C01G15	296	232	392	7	7/11/2000	9/18/2000
C01G16	681	409	1070	6	7/11/2000	9/18/2000
C01G17	196	63	543	8	7/11/2000	9/18/2000
C01G18	644	168	1080	8	7/11/2000	9/18/2000
C01G19	400	197	650	7	7/11/2000	9/18/2000
C01G20	1301	608	2080	5	7/11/2000	9/18/2000
C01G21	75	20	128	6	7/11/2000	9/18/2000
C01G22	532	356	1020	7	7/11/2000	9/18/2000
C01G23	225	87	398	7	7/11/2000	9/18/2000
C01G24	238	105	1020	11	7/11/2000	9/18/2000
C01G25	493	326	711	6	7/11/2000	9/18/2000
C01G26	127	102	143	9	7/11/2000	9/18/2000
C01G27	64	55	74	6	7/11/2000	9/18/2000
C01G28	291	139	483	9	7/11/2000	9/18/2000
C01G29	229	93	486	9	7/11/2000	9/18/2000
C01G30	393	245	688	7	7/11/2000	9/18/2000
C01G31	594	301	761	7	7/11/2000	9/18/2000
C01G32	61	41	78	7	7/11/2000	9/18/2000

Station	Avg (µg/l)	Min (µg/l)	Max (µg/l)	Count	Start Date	End Date
C01G33	2768	467	12600	6	7/11/2000	9/18/2000
C01G34	13	10	20	7	7/11/2000	9/18/2000
C01G35	20	10	26	4	7/11/2000	8/1/2000
C01G36	94	10	137	7	7/11/2000	9/18/2000
C01G37	73	10	184	6	7/11/2000	9/18/2000
C01G38	21	10	29	7	7/11/2000	9/18/2000
C01G39	122	60	185	11	7/11/2000	9/18/2000
C01G40	141	67	209	8	7/11/2000	9/18/2000
C01G41	257	111	537	6	7/11/2000	9/18/2000
C01G42	29	16	41	11	7/11/2000	9/18/2000
C01G43	217	154	414	7	7/11/2000	9/18/2000
C01G44	521	361	648	6	7/11/2000	9/18/2000
C01G45	625	300	1040	6	7/11/2000	9/18/2000
C01G46	22	10	40	6	7/11/2000	9/18/2000
C01G49	46150	44400	47900	2	8/30/2000	9/18/2000
C01S06	135	96	158	6	7/11/2000	9/18/2000
C01S08	133	92	154	6	7/11/2000	9/18/2000
C01S09	82	11	253	8	7/11/2000	9/18/2000
C01S15	87	65	114	6	7/11/2000	9/19/2000

Table 5. Water quality data for total suspended solids.

Station	Avg (mg/L)	Min (mg/L)	Max (mg/L)	Count	Start Date	End Date
C01G01	27	13	45	7	7/11/2000	9/18/2000
C01G02	102	11	387	5	7/11/2000	9/18/2000
C01G03	6	5	8	3	8/16/2000	9/18/2000
C01G04	20	6	46	6	7/11/2000	9/18/2000
C01G05	25	5	66	9	7/11/2000	9/18/2000
C01G06	11	5	16	6	7/11/2000	9/18/2000
C01G07	9	5	23	9	7/11/2000	9/18/2000
C01G08	24	8	63	6	7/11/2000	9/18/2000
C01G09	37	8	116	6	7/11/2000	9/18/2000
C01G10	19	13	30	10	7/11/2000	9/18/2000
C01G11	12	5	20	6	7/11/2000	9/18/2000
C01G12	16	13	22	10	7/11/2000	9/18/2000
C01G13	9	5	32	9	7/11/2000	9/18/2000
C01G14	6	5	9	11	7/11/2000	9/18/2000
C01G15	11	5	14	7	7/11/2000	9/18/2000
C01G16	21	14	26	6	7/11/2000	9/18/2000
C01G17	7	5	17	8	7/11/2000	9/18/2000
C01G18	37	5	89	8	7/11/2000	9/18/2000
C01G19	5	5	5	7	7/11/2000	9/18/2000
C01G20	5	5	5	5	7/11/2000	9/18/2000
C01G21	5	5	5	6	7/11/2000	9/18/2000
C01G22	6	5	7	7	7/11/2000	9/18/2000
C01G23	19	5	64	8	7/11/2000	9/18/2000
C01G24	9	5	18	11	7/11/2000	9/18/2000
C01G25	5	5	5	6	7/11/2000	9/18/2000
C01G26	6	5	10	9	7/11/2000	9/18/2000
C01G27	5	5	5	6	7/11/2000	9/18/2000
C01G28	16	5	33	9	7/11/2000	9/18/2000
C01G29	7	5	12	9	7/11/2000	9/18/2000
C01G30	10	6	17	7	7/11/2000	9/18/2000
C01G31	7	5	12	7	7/11/2000	9/18/2000
C01G32	5	5	5	7	7/11/2000	9/18/2000

Station	Avg (mg/L)	Min (mg/L)	Max (mg/L)	Count	Start Date	End Date
C01G33	1,002	5	5880	6	7/11/2000	9/18/2000
C01G34	5	5	5	7	7/11/2000	9/18/2000
C01G35	5	5	5	4	7/11/2000	8/1/2000
C01G36	5	5	5	7	7/11/2000	9/18/2000
C01G37	5	5	5	6	7/11/2000	9/18/2000
C01G38	5	5	5	7	7/11/2000	9/18/2000
C01G39	5	5	5	11	7/11/2000	9/18/2000
C01G40	7	5	12	8	7/11/2000	9/18/2000
C01G41	11	5	32	6	7/11/2000	9/18/2000
C01G42	5	5	9	11	7/11/2000	9/18/2000
C01G43	12	5	51	7	7/11/2000	9/18/2000
C01G44	8	5	16	6	7/11/2000	9/18/2000
C01G45	21	7	70	6	7/11/2000	9/18/2000
C01G46	5	5	5	6	7/11/2000	9/18/2000
C01G49	7	5	8	2	8/30/2000	9/18/2000
C01S06	28	22	35	6	7/11/2000	9/18/2000
C01S08	14	6	20	6	7/11/2000	9/18/2000
C01S09	5	5	7	8	7/11/2000	9/18/2000
C01S15	14	5	55	6	7/11/2000	9/19/2000

ATTACHMENT 2

TMDL Development for the Duck Creek Watershed, Ohio

by TetraTech

TMDL Development for the Duck Creek Watershed, Ohio

Submitted to:
U.S. Environmental Protection Agency
77 W. Jackson Boulevard
Chicago, IL 60604

and

Ohio Environmental Protection Agency
122 South Front Street
Columbus, OH 43216

Submitted by:
Tetra Tech, Inc.
1468 W. 9th Street
Suite 620
Cleveland, OH 44113

September 13, 2002

CONTENTS

TABLES

FIGURES

EXECUTIVE SUMMARY

The Duck Creek watershed is in southeast Ohio and occupies portions of Noble, Washington, Monroe, and Guernsey Counties (Figure 1). The principal drainage in the watershed is Duck Creek and its tributaries, the West, Middle and East Forks. The watershed is mostly rural with several small towns and a portion of the city of Marietta.

Several streams within the Duck Creek watershed are considered impaired by the Ohio Environmental Protection Agency (OEPA). These waters and their cause of impairment will appear on Ohio's next section 303(d) list (Table 1). Impairments are primarily for metals and siltation but also include nutrients and bacteria. The impairments result from acid mine drainage (AMD), pasture land, stormwater runoff, habitat alterations, reservoir release, and failing septic systems. Impaired designated uses include warmwater habitat and limited warmwater habitat.

The Clean Water Act and U.S. Environmental Protection Agency's (USEPA) regulations require that Total Maximum Daily Loads (TMDLs) be developed for waters on a state's section 303(d) list. This report identifies TMDLs for each of the waters in the Duck Creek watershed impaired due to metals (aluminum, iron, and manganese) or siltation. The existing and allowable loads were determined through the use of the Mining Data Analysis System (MDAS). The MDAS is a comprehensive data management and modeling system that is capable of representing loading from nonpoint and point sources in the Duck Creek watershed and simulating in-stream processes. It has been extensively used to develop TMDLs in watersheds where mining has occurred. Allowable loads are presented by subbasin and by land use category and include a margin of safety and seasonal variations, as required by the Clean Water Act.

1.0 INTRODUCTION AND DESCRIPTION OF THE WATERSHED

The Duck Creek watershed is in southeast Ohio and occupies portions of Noble, Washington, Monroe, and Guernsey Counties (Figure 1). The principal drainage in the watershed is Duck Creek and its tributaries, the West, Middle and East Forks. The watershed is mostly rural with several small towns and a portion of the city of Marietta. Duck Creek drains into the Ohio River at the eastern boundary of Marietta. The watershed is approximately 288 square miles.

Several streams within the Duck Creek watershed are considered impaired by the Ohio Environmental Protection Agency (OEPA). These waters and their cause of impairment will appear on Ohio’s next section 303(d) list (Table 1). The 1998 section 303(d) listings are also included in the table for reference. Impairments include DDT, flow alterations, metals, siltation, nutrients, bacteria, and organic enrichment/low dissolved oxygen (DO). The impairments result from acid mine drainage (AMD), pasture land, stormwater runoff, habitat alterations, reservoir release, and failing septic systems. Impaired designated uses include warmwater habitat and limited warmwater habitat. The locations of the impaired streams are shown in Figure 2.

The Clean Water Act and U.S. Environmental Protection Agency's (USEPA's) regulations require that Total Maximum Daily Loads (TMDLs) be developed for waters impaired by pollutants. A TMDL is the sum of the allowable amount of a single pollutant that a waterbody can receive from all contributing point and nonpoint sources and still meet water quality standards. This draft report presents the TMDLs for the segments in the Duck Creek watershed impaired by metals and siltation. It is expected that the report will be modified later to include TMDLs for the other impairments.

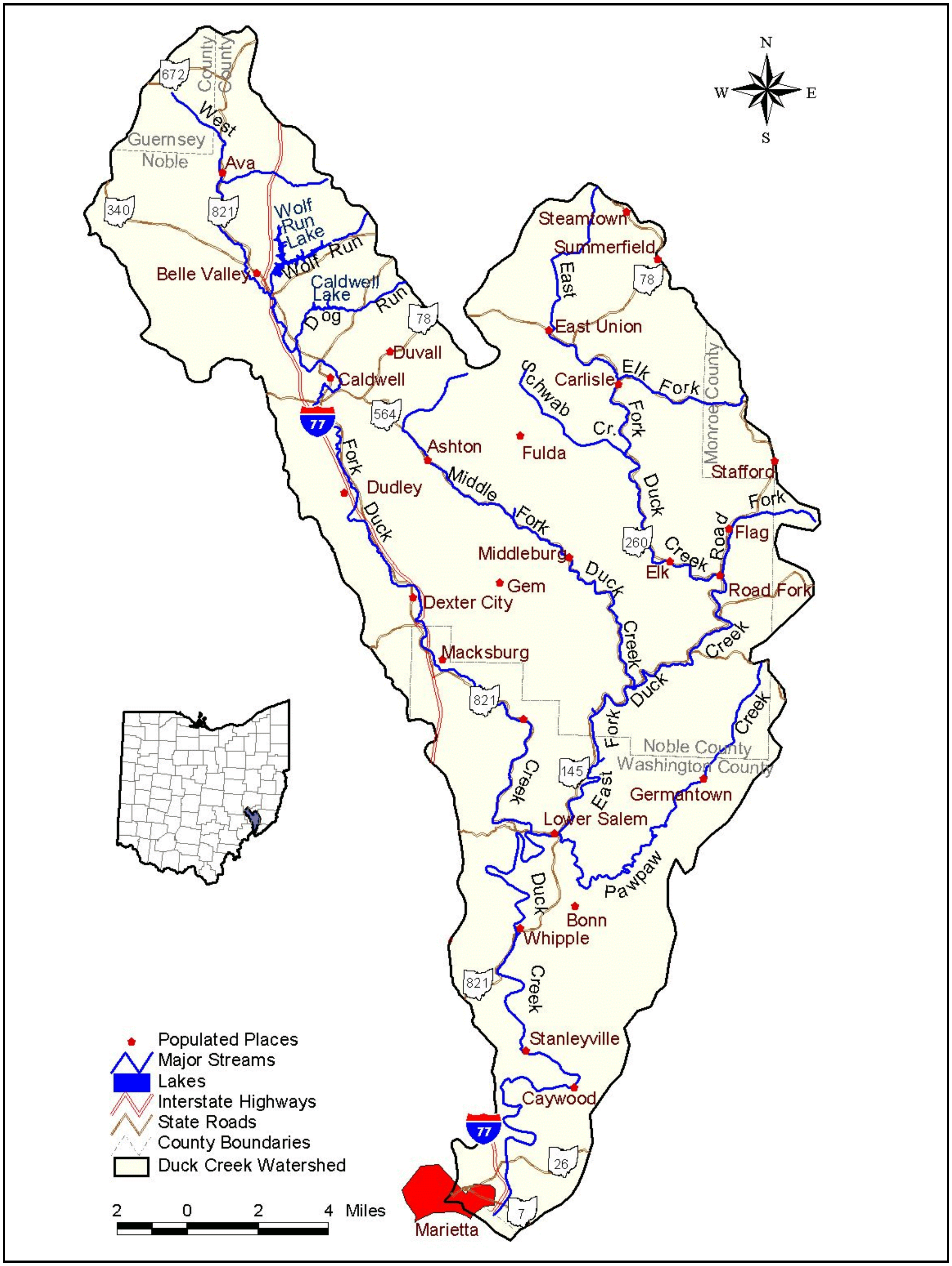

Figure 1. Location of Duck Creek watershed.

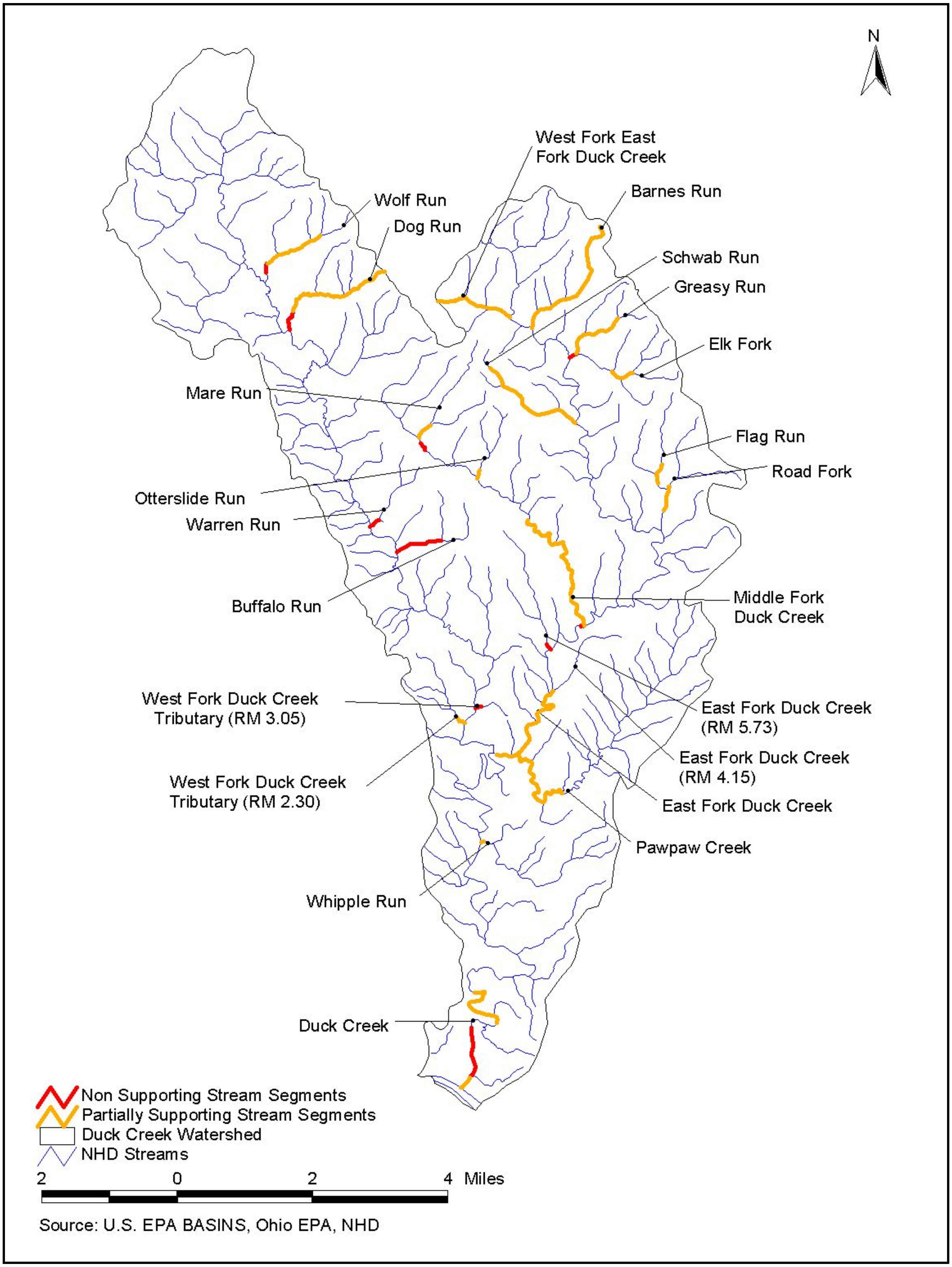

Figure 2. Impaired streams in the Duck Creek watershed.

Table 1. Impaired streams in the Duck Creek watershed as identified by OEPA .

Stream Segment	Support Status	Designated Use[a]	Cause	Source	TMDL Included in This Report
1998 Listings					
Duck Creek	Partially Supporting	LWH	Siltation	AMD[b]	
West Fork Duck Creek (Salt Run to East Fork Duck Creek)	Partially Supporting	LWH	Siltation	AMD	
West Fork Duck Creek (Headwaters to Salt Run)	Partially Supporting	WWH	Metals Siltation Organic Enrichment/Low DO	AMD AMD Point Sources	
Draft 2002 Listings[c]					
Duck Creek	Partially Supporting	WWH	DDT Flow Alterations		
East Fork Duck Creek	Partially Supporting	WWH	Aluminum Iron Manganese Siltation Ammonia	AMD AMD AMD AMD	√ √ √ √
Middle Fork Duck Creek	Nonsupporting	WWH	Aluminum Iron Manganese	AMD AMD AMD	√ √ √
Pawpaw Creek	Partially Supporting	EWH			
Whipple Run	Partially Supporting	WWH	Siltation Bacteria	Stormwater	√
Dog Run	Nonsupporting	WWH	Siltation	Pasture land	√
Wolf Run	Nonsupporting	WWH	Hydrologic Modification Low DO Ammonia Bacteria		
Buffalo Run	Nonsupporting	WWH	Aluminum	AMD	√
Warren Run	Nonsupporting	WWH	Aluminum	AMD	√
West Fork Duck Creek Tributary (RM[d] 3.05)	Nonsupporting	WWH	Aluminum Manganese Iron	AMD AMD AMD	√ √ √
West Fork Duck Creek Tributary (RM 2.30)	Partially Supporting	WWH	Aluminum	AMD	√
Otterslide Run	Partially Supporting	WWH	Aluminum Iron Manganese	AMD AMD AMD	√ √ √
Mare Run	Partially Supporting	WWH	Aluminum Nutrients Siltation	AMD Pasture land	√ √

Stream Segment	Support Status	Designated Use[a]	Cause	Source	TMDL Included in This Report
West Fork East Fork Duck Creek	Partially Supporting	WWH	Aluminum Manganese Iron	AMD AMD AMD	√ √ √
East Fork Duck Creek Tributary (RM 5.73)	Nonsupporting	WWH	Aluminum Iron Manganese Siltation	AMD AMD AMD AMD	√ √ √ √
East Fork Duck Creek Tributary (RM 4.15)	Partially Supporting	WWH	Siltation Aluminum	AMD AMD	√ √
Schwab Run	Partially Supporting	WWH	Siltation	Pasture land	√
Greasy Run	Partially Supporting	WWH	Siltation	Pasture land	√
Elk Fork	Nonsupporting	WWH	Aluminum Manganese Nutrients	AMD AMD	√ √
Flag Run	Partially Supporting	WWH	Aluminum Iron	AMD AMD	√ √
Road Fork	Partially Supporting	WWH	Siltation Aluminum Iron Manganese	Pasture land AMD AMD AMD	√ √ √ √
Barnes Run	Partially Supporting	WWH	Aluminum	AMD	√

[a] EPA Use Designations: WWH=Warmwater habitat; EWH=Exceptional warmwater; LWH=Limited warmwater habitat.
[b] AMD=acid mine drainage.
[C] Draft 2002 Section 303(d) listings for the watershed are pending approval by USEPA.
[d] RM=river mile.

1.1 Population

Approximately 20,000 people live in the Duck Creek watershed; 82 percent live in rural areas and 18 percent in urban areas. Urban areas within the watershed include Belle Valley, Caldwell, Dexter, Macksburg, Lower Salem, Summerfield, and Stafford. The largest urban population near the watershed is Marietta, Washington County, with a population of 14,515 (U.S. Census Bureau, 2000). Population growth in the area has been relatively slow in the past 10 years (Table 2) (U.S. Census Bureau, 2000).

Table 2. 1990 and 2000 population estimates and percent population change for counties and cities within the Duck Creek watershed.

City or County	1990	2000	Percent Change
Counties			
Guernsey	39,024	40,792	4.5
Noble	11,336	14,058	24.0
Monroe	15,497	15,180	−2.0
Washington	62,254	63,251	1.6
Cities			
Belle Valley	267	263	−1.5
Caldwell	1,786	1,956	9.5
Dexter	161	166	3.1
Macksburg	218	202	−7.3
Lower Salem	103	109	5.8
Summerfield	295	296	0.3
Stafford	89	86	−3.3
Marietta	15,026	14,515	−3.4

Source: U.S. Census Bureau, 2000.

1.2 Topography and Land Use

The Duck Creek watershed is in the Allegheny Plateau, and the terrain is composed of hills, ridges, and plateaus. The highest point in the watershed, 1,210 feet above sea level, is at the headwaters of the West Fork of Duck Creek. The lowest point is at the mouth of Duck Creek, 600 feet above sea level (Figure 3).

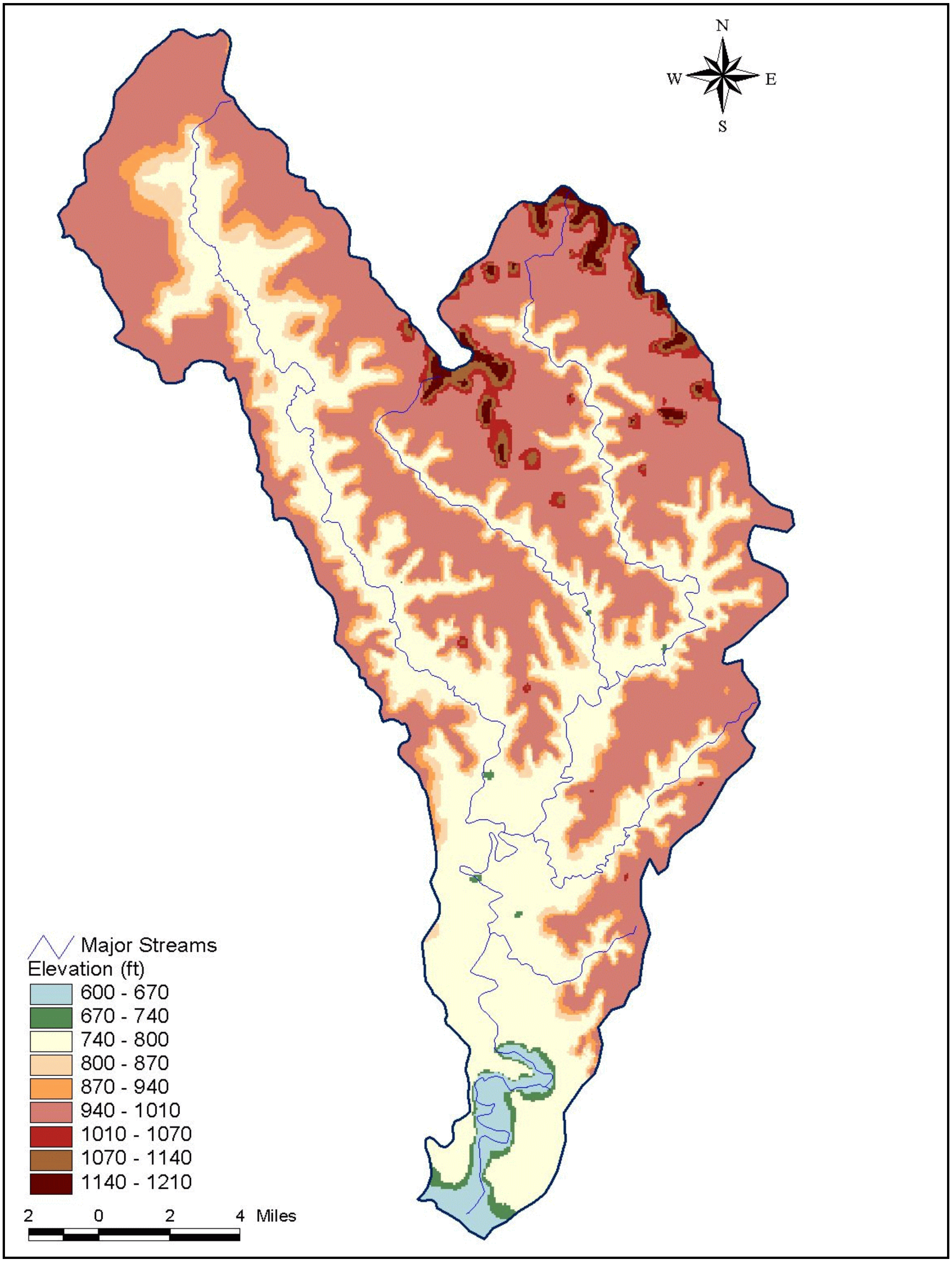

Figure 3. Topography in the Duck Creek watershed.

Land use in the Duck Creek watershed includes a mix of deciduous forest, pasture/hay, evergreen forest, and agriculture. Land use data for the area are available from the Multi-Resolution Land Characterization (MRLC) database for Ohio and are shown in Table 3 and Figure 4 (MRLC, 2000). Deciduous forest and pasture/hay collectively account for approximately 87 percent of the total land cover. The classification "deciduous forest" is defined as areas dominated by trees where 75 percent or more of the tree species shed foliage simultaneously in response to seasonal change. The classification "pasture/hay" is defined as areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops.

Table 3. Land use distribution by Major land use category.

Land Use	Area (acres)	Percentage
Deciduous Forest	108,163	58.68
Pasture/Hay	52,753	28.61
Evergreen Forest	7,377	4.01
Row Crops	7,076	3.83
Mixed Forest	2,679	1.46
Low-Intensity Residential	1,659	0.9
Open Water	1,361	0.83
Transitional	1,330	0.72
High-Intensity Commercial	823	0.45
Quarries/Strip Mines/ Gravel Pits	429	0.23
Other Grasses	316	0.17
High-Intensity Residential	182	0.1
Woody Wetlands	139	0.1
Emergent Herbaceous Wetlands	67	0.035
Total	184,354	100.0

Source: MRLC, 2000.

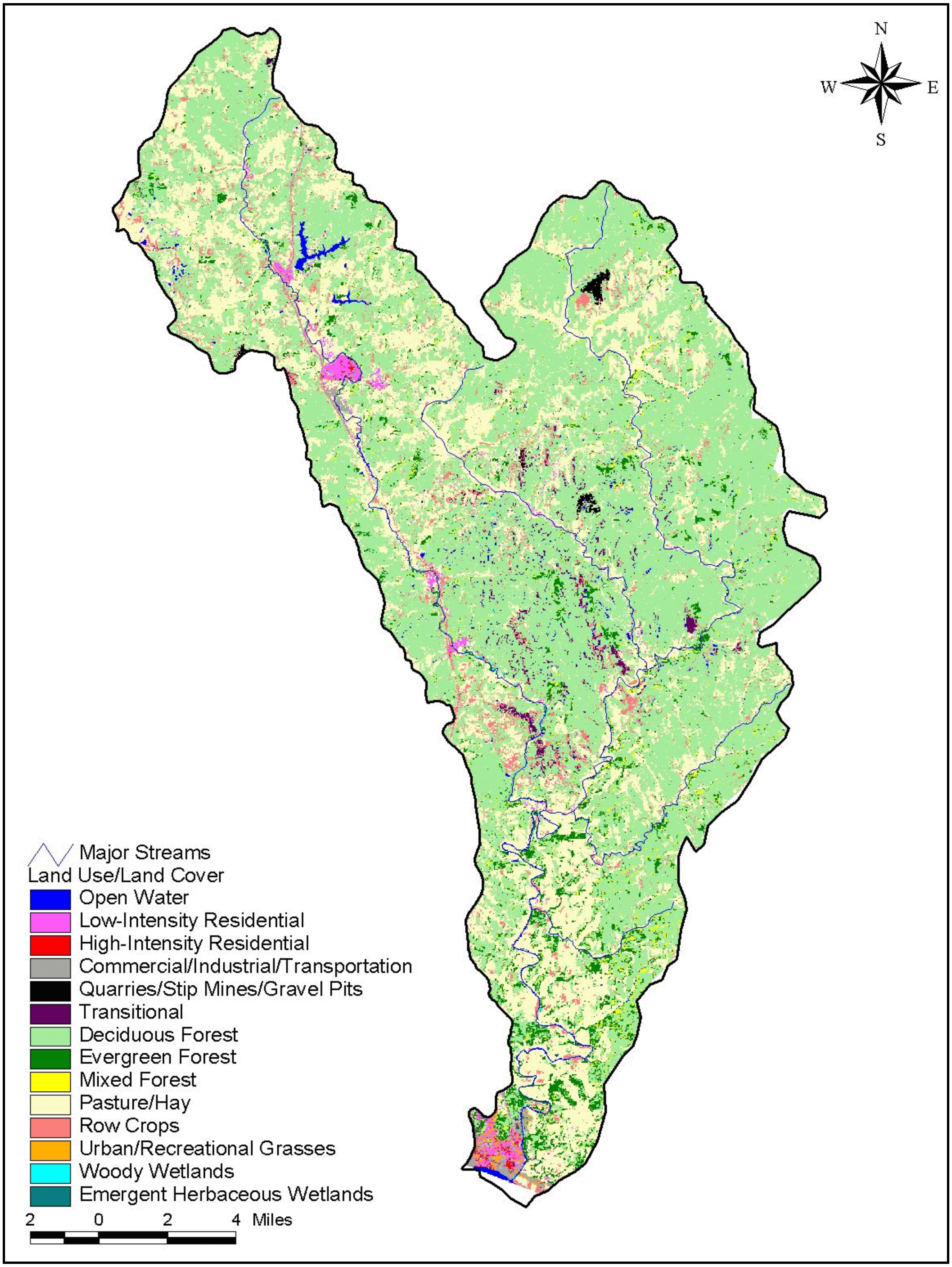

Figure 4. Duck Creek watershed land use.

1.3 Climate

The climate of the Duck Creek watershed is considered humid continental. Humid continental climates are characterized by large seasonal temperature changes, with January temperatures averaging below 32 °F and average July temperatures exceeding 75 °F. Precipitation events occur year-round, with annual averages ranging between 30 and 40 inches. Precipitation is slightly higher during the summer, while the autumns are relatively dry (NCDC, 2001). Average annual precipitation for the watershed for 1980 through 2000 is shown in Figure 5.

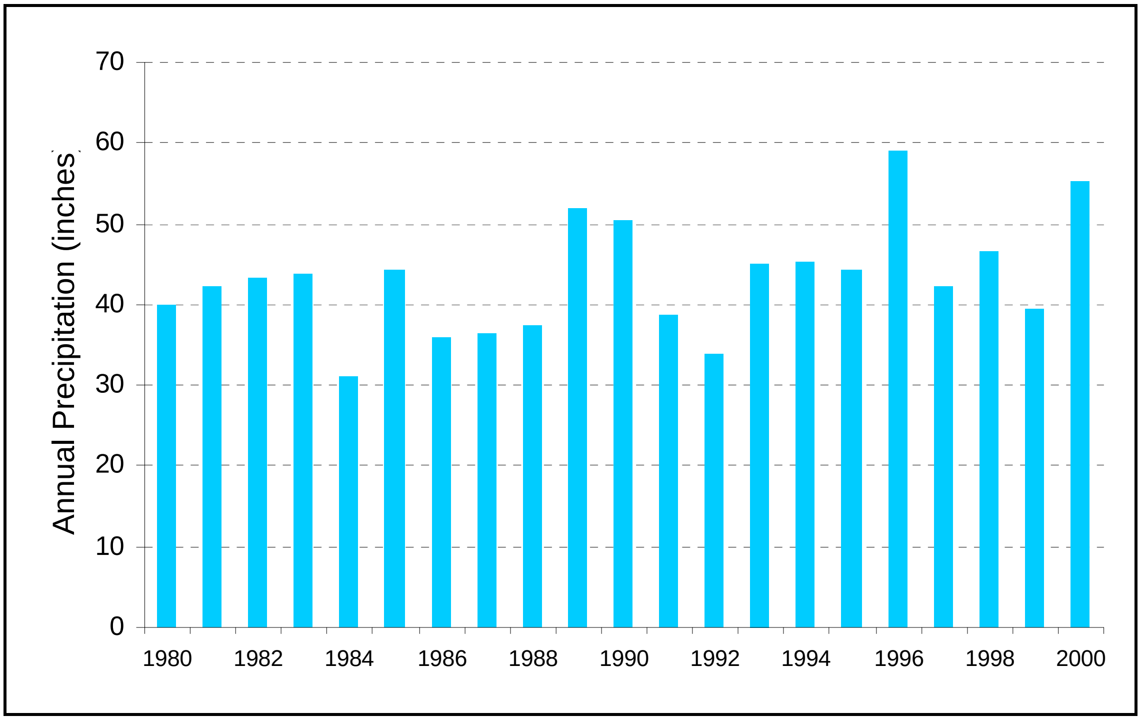

Figure 5. Average annual precipitation at the McConnesville Lock 7 precipitation station for the period 1980 to 2000.

1.4 Watershed and Stream Hydrology

Duck Creek has three primary tributaries: the West Fork Duck Creek, the Middle Fork Duck Creek, and the East Fork Duck Creek. There are no active U.S. Geological Survey (USGS) gaging stations in the watershed. Flow data for Raccoon Creek (USGS gaging station 03202000) at Adamsville, Ohio, were therefore used to make assumptions about flow characteristics in the Duck Creek watershed (Figure 6). This gage is approximately 62 miles from the Duck Creek confluence with the Ohio River and drains a watershed with similar land uses, soils, topography, and climate.

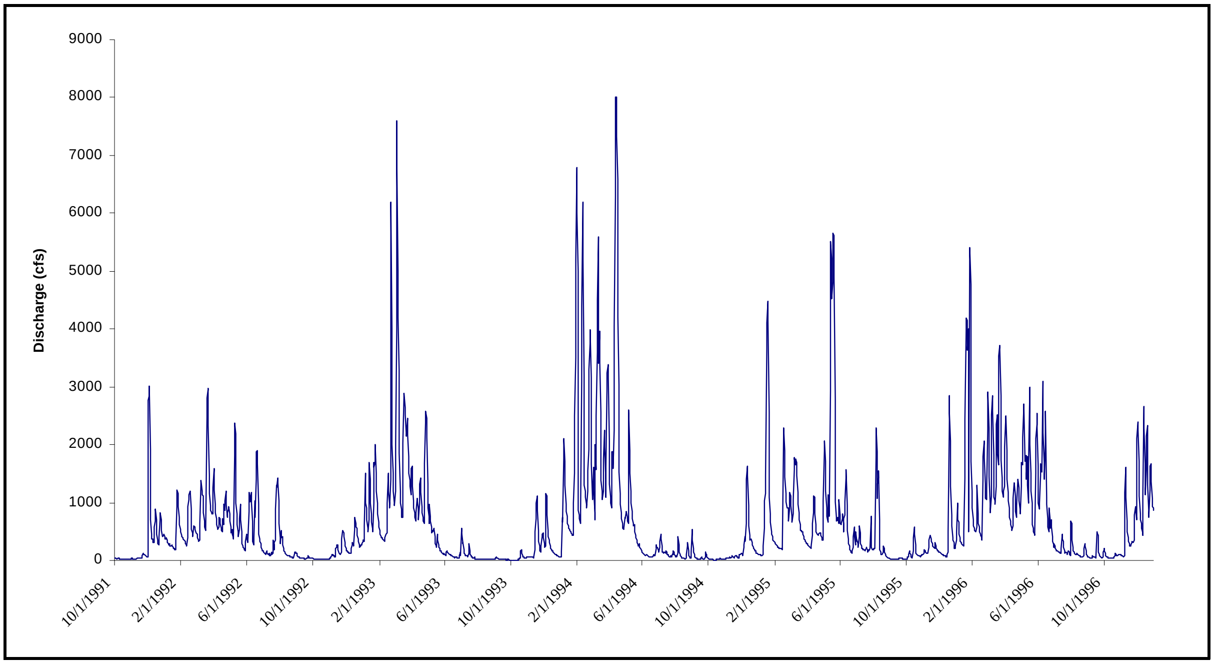

Figure 6. Hydrologic conditions for Raccoon Creek, USGS Gaging Station 03202000 at Adamsville, Ohio.

2.0 WATER QUALITY STANDARDS AND NUMERIC WATER QUALITY TARGETS

2.1 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. Table 4 describes the components of Ohio's water quality standards.

Table 4. 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).
Numeric Criteria	Chemical criteria represent the concentration of a pollutant that can be in the water and still protect the designated use of the waterbody. Biological criteria indicate the health of the in-stream biological community by using one of three indices: • Index of Biotic Integrity (IBI) (measures fish health). • Modified Index of well being (MIwb) (measures fish health). • Invertebrate Community Index (ICI) (measures bug or 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 the director may allow new or increased discharges of pollutants, and requires those seeking to discharge additional pollutants to demonstrate an important social or economic need. Refer to <http://www.epa.state.oh.us/dsw/wqs/wqs.html> for more information.

Paragraph (C)(1) of rule 3745-1-05 requires that existing instream waters uses be maintained and protected and that there may be no degradation of water quality that results in a violation of the applicable water quality criteria for the designated uses. Paragraph (A) (6) of rule 3745-1-07 identifies the biological criteria in Table 7-14 of rule 3745-01-07 as direct measures of attainment of the warmwater habitat, exceptional warmwater habitat and modified warmwater habitat aquatic life uses. Therefore, degradation of water quality that will result in nonattainment of the biological criteria must not be permitted.

High metal concentrations that exceed thresholds, such as the Tier I Criteria and Teir II Values contained in and developed pursuant to Chapter 3745-1 of the Ohio Administrative Code or TMDL developed targets, have been found to be toxic to fish and macroinvertabrates and thus can cause a violation of the use designation.

Most streams in the watershed are designated for WWH aquatic life use support, although Pawpaw Creek is an Exceptional EWH stream. Waters designated as WWH are capable of supporting and maintaining a balanced integrated community of warmwater aquatic organisms. Waters designated as EWH are capable of supporting "exceptional or unusual" assemblages of aquatic organisms that are characterized by a wide diversity of species, particularly those which are highly pollutant intolerant and/or are rare, threatened, or endangered.

Attainment of aquatic life uses in Ohio is measured in two ways. First, water chemistry is compared to the available numeric criteria. For example, DO in streams designated as WWH must average at least 5 mg/L. Second, the measured biological scores are compared to those seen in the least impacted areas of the same ecological region and aquatic life use. Attainment benchmarks from these least impacted areas are established in the form of "biocriteria," which are then compared to the measurements obtained from the study area. If the measurements of a stream do not achieve the biocriteria, the stream is considered in "nonattainment." If the stream measurements achieve some of the biological criteria but not others, the stream is said to be in "partial-attainment."

2.2 Numeric Water Quality Targets

A TMDL target is the quantitative value used to measure whether or not the applicable water quality standard is attained. TMDL targets must be the same as the numeric criteria expressed in water quality standards where such criteria exist, but site-specific targets should be identified in cases where only narrative criteria are available. The numeric targets that will be used for the Duck Creek watershed are shown in Table 5 and explained below.

Table 5. TMDL targets for the Duck Creek TMDLs.

Constituent	TMDL Target	Reference	Averaging Period
Total Aluminum	712.5 μg/L	USEPA, 1999	4-day average
Total Iron	950μg/L	USEPA, 1999	Monthly average
Total Manganese)	950 μg/L	West Virginia TMDLs	Monthly average
Total Suspended Solids	8.0 mg/L	Reference reach approach	Monthly average

2.2.1 Aluminum

Ohio does not have numeric criteria for aluminum. Therefore, the national aquatic life standard of 750 μg/L was used as a basis for the Duck Creek aluminum TMDLs (USEPA, 1999). A 5 percent margin of safety (MOS) was introduced into the TMDL by basing the allocations on meeting a target of 712.5 μg/L (750 μg/L minus 5 percent). A margin of safety is one of the required components of a TMDL (see section 5.2.3 below).

2.2.2. Iron

Ohio does not have numeric criteria for iron. Therefore, the national aquatic life standard of 1,000 μg/L was used as the basis for the Duck Creek iron TMDLs (USEPA, 1999). A 5 percent MOS was introduced into the TMDL by basing the allocations on meeting a target of 950 μg/L (1,000 μg/L minus 5 percent).

2.2.3 Manganese

Neither Ohio nor USEPA has established aquatic life criteria for manganese. A target of 1,000 µg/L was chosen based on best professional judgment. This value is the same as that used to develop numerous manganese TMDLs in mining affected watersheds in West Virginia and is believed to be protective of aquatic life. Several considerations were made in choosing this value:

- The Duck Creek watershed is very similar to the watersheds in West Virginia where the 1,000 µg/L was applied, both in terms of topography, land cover, and historic and current land use.
- Manganese has been reported to kill fish in 8 to 18 hours at concentrations of 2,200 to 4,100 µg/L (River Assessment Monitoring Project, 2003). Other studies recommend manganese targets ranging from 790 µg/L to 1,040 µg/L (Government of British Columbia, 2001). The 1,000 µg/L is therefore believed to be protective of aquatic life.

A 5 percent MOS was introduced into the TMDL by basing the allocations on meeting a target of 950 µg/L (1,000 µg/L minus 5 percent).

2.2.4 Total Suspended Solids

Sedimentation was identified as a cause of impairment in the Duck Creek basin. OAC Rule 3745-1-04 (A) states that all waters of the state shall be free from suspended solids and other substances that enter the waters as a result of human activity and that will settle to form objectionable sludge deposits, or that will adversely affect aquatic life. However, no statewide numeric criteria have been developed specifically for sediment or Total Suspended Solids (TSS). In part, the reason that there are not numeric criteria for TSS or sediment is that it is difficult to directly associate these pollutants with toxicity to aquatic life. Rather, the effect on aquatic life is that sediment smothers bottom dwelling (benthic) organisms, or chokes the habitat such that there is no place for aquatic organisms to live. In addition, it is difficult to associate water quality measurements of TSS on any given day with the amount of sediment that can get deposited over a given period of time (e.g., a year).

Because no numeric criteria are available average TSS concentrations in the upstream portions of Pawpaw Creek watershed were therefore used as a basis for the TMDL target because habitat conditions in these segments are among the best in the watershed. It should be noted that the primary concern in the impaired segments is stream bottom siltation for which TSS is an imperfect surrogate. Future monitoring should focus on collecting data such as cobble embeddedness or percent fine sediments as better indicators of the impairment. The average concentration of TSS in the upstream Pawpaw Creek segments was found to be 8 mg/L.

2.2.5 Biocriteria

The ultimate determination of whether streams in the Duck Creek watershed are supporting their aquatic life use will be made by comparing observed biological data to Ohio’s biocriteria. The criteria for metals and sediment described above serve as the link between the desired biological conditions and the necessary water chemistry. The biocriteria that apply to the Duck Creek watershed are shown in Table 6, and the results of the most recent biological sampling are provided in Appendix A.

Table 6. Biological Criteria for Western Allegheny Plateau.

Site Type INDEX[a]	IBI[b] Headwaters	IBI Wading	IBI Boat	MIwb[b] Wading	MIwb Boat	ICI[b] (all sites)
EWH Habitat	50	50	48	9.4	9.6	46
WWH Habitat	44	44	40	8.4	8.6	36
MWH	24	24	24	6.2	5.8	22
LRW	18	18	18	4	4	8

[a] OEPA use designations: EWH=exceptional warmwater habitat; WWH=warmwater habitat: MWH=marginal warmwater habitat; LRW=limited resource water.
[b] IBI=Index of Biotic Integrity; MIwb=Modified Index of well being; ICI=Invertebrate Community Index.
Source: OEPA, 2001.

3.0 USE ATTAINMENT AND SOURCE ASSESSMENT

3.1 Aquatic Life Use Attainment Status

Approximately 50 percent of Middle Fork Duck Creek attained WWH biocriteria through its length (6.8 of 13.8 miles with less than one mile unassessed). Middle Fork Duck Creek had 5.5 miles in partial attainment and 0.7 miles in non-attainment of WWH biological standards. Mining (residual and/or current nonpoint source runoff in the form of sedimentation, low pH, and elevated metals concentrations) was the main source with some agricultural (cattle grazing) and road construction inputs. Most impacts were in the lower six miles.

Pawpaw Creek achieved the EWH biocriteria standards in 10.8 miles of 11.0 miles assessed (93 percent) with 0.6 miles unassessed. There was sedimentation in a short reach above one site sampled that was temporary in nature (private road construction) after bank stabilization would have occurred (also IBI of 44 at impaired site was only two points below EWH absolute minimum score). The Pawpaw Creek subwatershed seems to be one of the least mined basins in the Duck Creek watershed and has recovered where the mining occurred, though there was some nonpoint source sediment accumulation near the Pawpaw Creek mouth at the confluence with East Fork Duck Creek.

Tributaries greater than two square miles in the Duck Creek basin were sampled where some water column chemical, physical and bacteriological data were recorded. Twenty-two of thirty sampled streams (73 percent) had some portion or all of the sampled stream reach that fully attained its designated stream use, and the linear total comprised 85 percent of stream miles evaluated. Most sampled tributaries surveyed throughout the basin improved dramatically from past or perceived impaired water quality from historical legacy mining and other uses. Time, mine land restoration, and, in some areas, remining, contributed to improvements. Most water quality use designations were upgraded based on biological sampling. Where non-attainment (6 percent of stream miles) or partial attainment (9 percent of stream miles) of the assigned aquatic life use designations were documented, various causes and sources of impairment were found, including mining (residual and/or current nonpoint source runoff in the form of habitat or flow alterations, siltation/sedimentation, low pH, and elevated metals concentrations); agriculture (cattle grazing/pastoral use with siltation and loss of riparian buffer with nutrient/bacterial inputs); and organic inputs with low dissolved oxygen (from poor or failing septic treatment (nutrient or bacterial inputs) and agriculture or cattle waste inputs).

3.2 Point Sources

OEPA has issued National Pollutant Discharge Elimination System (NPDES) permits to seven facilities in the Duck Creek watershed that could discharge pollutants of concern. Six of these are mining operations and one is a sewage treatment plant. The mining operations have the potential to discharge iron, manganese, and aluminum. The mine waters are treated in holding ponds but can be released intentionally or unintentionally during either low or high flow events. The Ohio Department of Natural Resources (ODNR) also permits the mining operations. Relevant information on these facilities is shown in Table 7.

Table 7. Point sources in the Duck Creek watershed.

OEPA Permit Number	ODNR Permit Number	Facility Name	Modeling Subbasin	Description	Area (acres)
OG-MO-0077	D-706	B&N Coal	54	Mining	260.5
OG-MO-0187	D-787	B&N Coal	78	Mining	262.5
OG-MO-OO78	D-807	B&N Coal	90*	Mining	34.1
OG-MO-0080	D-958	B&N Coal	78	Mining	324.8
OG-MO-0287	D-1122	B&N Coal	7*	Mining	282.5
OG-MO-0342	D-1194	B&N Coal	7*	Mining	67.5
n/a	D-343	B&N Coal	8*	Mining	133.4
OH0020559	n/a	Village of Caldwell	74	Sewage Treatment	n/a

***Facility is located within an impaired modeling subbasin.**

3.2 Nonpoint Sources

3.3.1 Historically Mined Lands

Water quality in the Duck Creek watershed is impaired by a variety of nonpoint sources. Most of the watershed has been mined for coal at some point during the past century, and AMD continues to affect certain streams. AMD can lower the pH of stream waters, resulting in increased metals concentrations and adverse impacts to aquatic organisms (Figure 7). Benthic organisms are particularly sensitive to the effects of AMD for the following reasons: depressed food supplies, gill clogging, smothering by iron or aluminum precipitates, and toxicity caused by ingesting metals. Even though the degree of degradation may not be severe enough to cause direct acute distress to fish and macroinvertebrates, populations can be eliminated by a decline in available food.

Figure 7. Spring seepage in Duck Creek watershed showing discharged iron.

In addition to elevating metals concentrations, mining can also contribute to sheet and rill erosion by removing vegetation and exposing soil particles to the effects of runoff. Excessive sediments deposited on stream bottoms can choke spawning gravels (reducing survival and growth rates), impair fish food sources, fill in rearing pools (reducing cover from prey and thermal refugia), and reduce habitat complexity in stream channels. Excessive suspended sediments can make it more difficult for fish to find prey, and at high levels can cause direct physical harm such as clogged gills.

AMD is suspected as a cause of impairment in many of the Duck Creek tributaries and portions of the main stem.

3.3.2 Pasture Land

Almost 30 percent of the Duck Creek watershed is classified as pasture land, and cattle can be observed grazing in many locations. Livestock grazing in riparian zones, the thin ribbons of green vegetation that border rivers, streams, and other waterbodies, can be responsible for degraded water quality, damaged fish and wildlife habitat, and decreased recreational opportunities. Although riparian zones are generally part of larger grazing areas, cattle, if left to their own devices, prefer the cooler, more lush environments alongside rivers and streams (Figure 8). If grazing is not limited in such areas through fence construction, the cattle can cause pollution by:

- Trampling banks and increasing sedimentation.
- Removing vegetation, which stabilizes soil, filters sediment and debris, and provides cooling through shade.
- Depositing their wastes directly into the stream.

Cattle grazing is suspected as a cause of impairment in the following Duck Creek tributaries: Dog Run, Schwab Run, Mare Run, and Greasy Run.

Figure 8. Example of unrestricted cattle grazing in Duck Creek watershed.

4.0 TECHNICAL APPROACH

Establishing the relationship between the in-stream water quality targets and source loadings is a critical component of TMDL development. It allows for the evaluation of management options that will achieve the desired source load reductions. The link can be established through a number of techniques, ranging from qualitative assumptions based on sound scientific principles to sophisticated modeling techniques. Ideally, the linkage will be supported by monitoring data that allow the TMDL developer to associate certain waterbody responses to flow and loading conditions. The objective of this section is to present the approach taken to develop the linkage between sources and in-stream response for TMDL development in the Duck Creek watershed.

4.1 Model Framework Selection

Selecting the appropriate approach or modeling technique required considering the following:

- Expression of water quality targets
- Dominant processes
- Scale of analysis

The relevant numeric water quality targets for metals and sediment were presented in Section 2. Numeric criteria, such as those applicable here, require evaluation of magnitude, frequency, and duration. For metals the criteria are expressed as total metals. This dictates that the methodology predict the total metals concentration in the water column of the receiving water. Thresholds of a numeric measure are evaluated for frequency of exceedance: some standards require evaluation over a short period (a 4-day average), while others can be evaluated over an entire month. The approach or modeling technique must permit representation of in-stream concentrations under a variety of flow conditions to evaluate critical periods for comparison to both types of targets.

The approach must also consider the dominant processes regarding pollutant loadings and in-stream fate. For the Duck Creek watershed, primary sources contributing to metals and siltation impairments include an array of nonpoint or diffuse sources, as well as discrete point sources/permitted discharges. Loading processes for nonpoint sources or land-based activities are typically rainfall-driven, and thus relate to surface runoff and subsurface discharge to a stream. Permitted discharges may or may not be dependent on rainfall; however, they are controlled by permit limits. Because they are from a land-based activity, permitted mining discharges are precipitation-driven.

Key in-stream factors that must be considered include routing of flow, dilution, and transport of total metals. In the stream systems of the Duck Creek watershed, the primary physical driving process is the transport of total metals by diffusion and advection in the flow. Significant chemical processes are the speciation and precipitation of metals, followed by sediment adsorption/desorption and reduction-oxidation reactions related to the precipitation reactions.

Scale of analysis and waterbody type must also be considered in the selection of the overall approach. The approach should have the capability to evaluate watersheds at multiple scales, particularly those of a few hundred acres in size. The listed waters in the Duck Creek watershed range from small streams to the main stem of the river. Selection of scale should be sensitive to the locations of key features, such as abandoned mines and point source discharges. At the larger watershed scale, land areas are lumped into subwatersheds for practical representation of the system, commensurate with the available data. Occasionally, site-specific and localized acute problems may require more detailed segmentation or definition of detailed modeling grids.

Based on the considerations described previously, analysis of the monitoring data, review of the literature, and past sediment and metals modeling experience, the Mining Data Analysis System (MDAS) was applied to represent the source-response linkage in the Duck Creek watershed. The MDAS is a comprehensive data management and modeling system that is capable of representing loading from nonpoint and point sources in the Duck Creek watershed and simulating in-stream processes.

4.2 Mining Data Analysis System Overview

MDAS is a system designed to support TMDL development for areas affected by AMD. The system integrates the following:

- Graphical interface
- Data storage and management system
- Dynamic watershed model
- Data analysis/postprocessing system

The graphical interface supports basic geographic information system (GIS) functions such as electronic geographic data importation and manipulation. Key data sets include stream networks, land use, flow and water quality monitoring station locations, weather station locations, and permitted facility locations. The data storage and management system functions as a database and supports storage of all data pertinent to TMDL developmen, including water quality observations, flow observations, and permitted facility monthly operating reports (MORs), as well as stream and watershed characteristics used for modeling. The system also includes functions for inventorying the data sets. The Dynamic Watershed Model, also referred to as the Hydrological Simulation Program C++ (HSPC), simulates nonpoint source flow and pollutant loading as well as in-stream flow and pollutant transport, and is capable of representing time-variable point source contributions. The data analysis/postprocessing system conducts correlation and statistical analyses and enables the user to plot model results and observation data.

The most critical component of the MDAS to TMDL development is the HSPC model, because it provides the link between source contributions and in-stream response. The HSPC is a comprehensive watershed model used to simulate watershed hydrology and pollutant transport as well as stream hydraulics and in-stream water quality. It can simulate flow, sediment, metals, nutrients, pesticides, and other conventional pollutants, as well as temperature and pH for pervious and impervious lands and waterbodies. The HSPC is essentially a recoded C++ version of selected Hydrologic Simulation Program−FORTRAN (HSPF) modules. HSPC's algorithms are identical to those in HSPF. Table 8 presents the modules from HSPF used in HSPC. Refer to the *Hydrologic Simulation Program−FORTRAN User's Manual for Release 11* (Bicknell et al., 1996) for a more detailed discussion of simulated processes and model parameters.

Table 8. Modules from HSPF converted to HSPC.

RCHRES Modules	HYDR	Simulates hydraulic behavior.
	CONS	Simulates conservative constituents.
	HTRCH	Simulates heat exchange and water.
	SEDTRN	Simulates behavior of inorganic sediment.
	GQUAL	Simulates behavior of a generalized quality constituent.
	PHCARB	Simulates pH, carbon dioxide, total inorganic carbon, and alkalinity.
PQUAL and IQUAL Modules	PWATER	Simulates water budget for a pervious land segment.
	SEDMNT	Simulates production and removal of sediment.
	PWTGAS	Estimates water temperature and dissolved gas concentrations.
	IQUAL	Uses simple relationships with solids and water yield.
	PQUAL	Uses simple relationships with sediment and water yield.

Source: Bicknell et al., 1996.

4.3 Model Configuration

The MDAS was configured for the Duck Creek watershed, and the HSPC model was used to simulate the watershed as a series of hydrologically connected subwatersheds. Configuration of the model involved subdivision of the Duck Creek watershed into modeling units, followed by continuous simulation of flow and water quality for these units using meteorological, land use, point source loading, and stream data. The specific pollutants that were simulated were total aluminum, total iron, total manganese, and TSS. This section describes the configuration process and key components of the model in greater detail.

4.3.1 Watershed Subdivision

To represent watershed loadings and resulting concentrations of metals, the Duck Creek watershed was divided into 91 subwatersheds. These subwatersheds are presented in Figure 9 (numbered 1-51, 53-92). The division was based on elevation data (7.5-minute Digital Elevation Model [DEM] from USGS), stream connectivity (National Hydrography Dataset [NHD] stream coverage from USGS), and locations of monitoring stations.

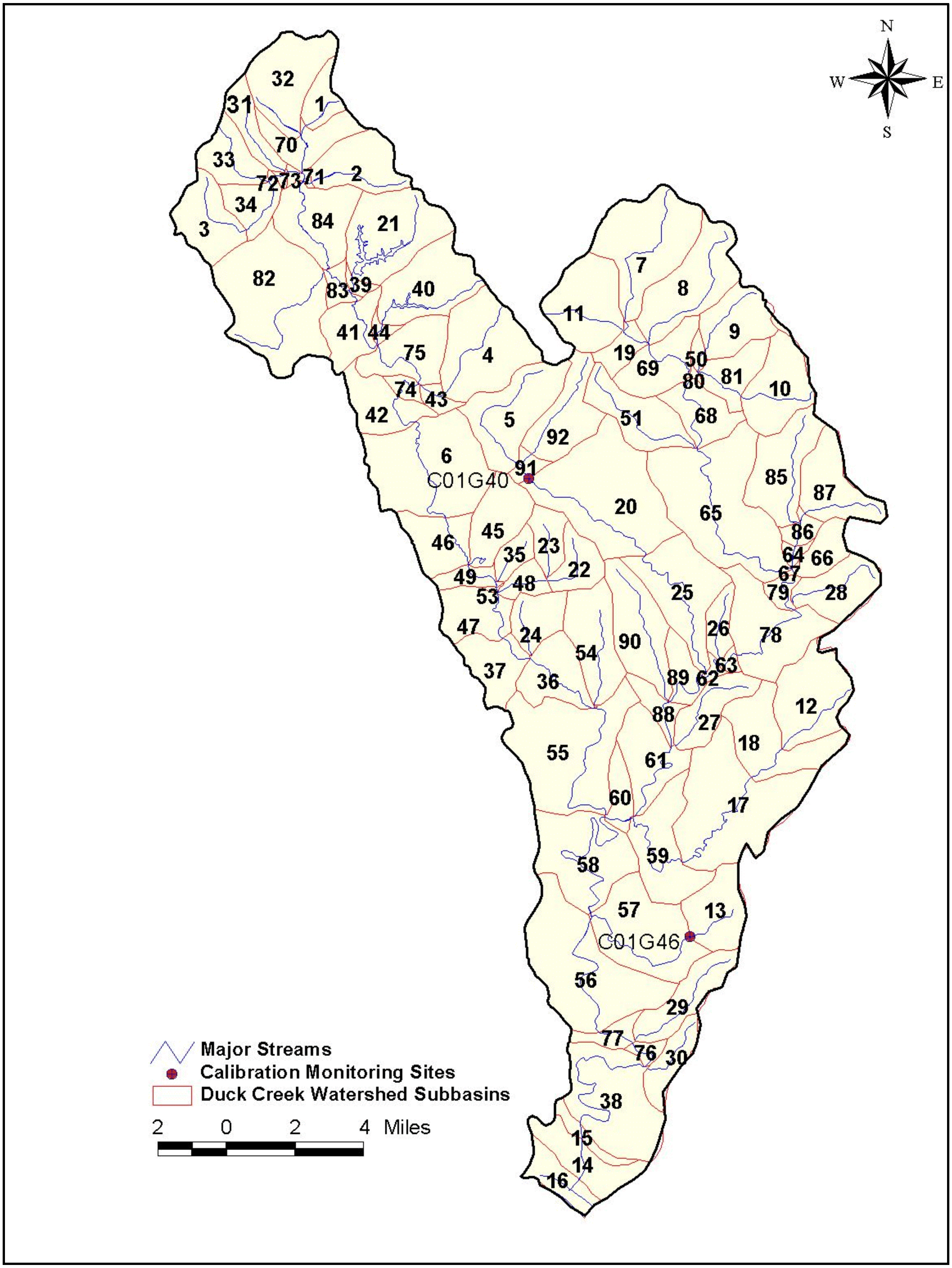

Figure 9. Location of Duck Creek watershed subbasins and monitoring sites used for calibration.

4.3.2 Meteorological Data

Meteorological data are a critical component of the watershed model. Appropriate representations of precipitation, wind speed, potential evapotranspiration, cloud cover, temperature, and dewpoint are required to develop a valid model. Meteorological data from a number of sources were accessed in an effort to develop the most representative data set for the Duck Creek watershed.

In general, hourly precipitation data are recommended for nonpoint source modeling. Therefore, only weather stations with hourly recorded data were considered in developing a representative data set. Long-term hourly precipitation data, available from the National Climatic Data Center (NCDC) weather station at McConnesville Lock 7, were used for the Duck Creek model. For the hydrologic calibration, meteorological data from the Tom Jenkins Dam station were applied to the Raccoon Creek model.

4.3.3 Nonpoint Source Representation

4.3.3.1 Recent Mining

Recent mining areas are associated with OEPA NPDES, or ODNR mining permits that were active between 1998 and 2000.

4.3.3.2 Historic Mining

A large portion of the Duck Creek watershed consists of previously mined lands that are at different levels of recovery. The MRLC land use data categorize much of the previously mined lands as forest cover because revegetation has occurred. These areas were reclassified to historic mining lands for adequate representation in the model, using available information on past mining areas (USGS quad maps, ODNR permit information, personal observations). The historic mines represent either discharge from historical surface mines, or seeping and leaching from other abandoned mine sites.
The following information was used to identify historically mined areas:

- Areas that held a mining or NPDES permit that was inactive from 1998-2000.
- Areas identified as mining or quarries from the MRLC coverage but which did not coincide with active or inactive permits.
- Highwalls, abandoned mines or areas of recent mining that were sighted during field visit and whose location did not coincide with mining permits or the MRLC land use coverage.

4.3.3.3 Other Nonpoint Sources

For modeling purposes, the land uses in the Duck Creek watershed were grouped into 10 categories that describe the watershed conditions and dominant source categories. The model land use categories include mined land, cropland, forest, grassland, urban, and wetlands. The land use grouping is shown in Table 9. This land use coverage provided the basis for estimating and distributing metals and sediment loadings associated with conventional land uses.

Table 9. Model land use grouping.

Model Land Use Category	Area (acres)
Historic Mining	76,041
Recent Mining	2,994
Cropland	7,076
Forest	40,945
Grassland	139
Pasture/Hay	52,753
Urban Pervious	1,647
Urban Impervious	1,017
Wetlands	206
Total	**182,818**

4.3.4 Point Sources Representation

4.3.4.1 Permitted Nonmining Point Sources

The only nonmining point source permit in the Duck Creek watershed is the Village of Caldwell wastewater treatment plan (Caldwell WWTP). While this facility is required to report some metal concentrations, it does not report iron, manganese, or aluminum concentrations. NPDES permits are established for parameters found within the waste stream whose concentrations are high enough to have the potential to cause impairment. Therefore, it is assumed that the Caldwell WWTP does not discharge significant amounts of the relevant metals.

The facility does report total suspended solids, however, it discharges into the West Fork of Duck Creek, which was not listed for siltation. Therefore, this facility was not considered in the modeling effort.

4.3.4.2 Permitted Mining Point Sources

Loads from the permitted mining point sources were introduced as both discrete discharges and runoff from disturbed lands. Point sources were represented differently, depending on the stage of modeling for TMDL development. The two major stages, which are described in more detail later in this section and in Section 5, are the calibration condition and the allocation conditions.

4.3.4.2.1 Calibration Condition

To match model results to historical data, it was necessary to represent the existing point sources using available historical data. Historical discharge data were obtained from the ODNR by evaluating the Monthly Operating Reports (MORs) for each facility. The MOR data include monthly averages and maximums for flow, total aluminum, total iron, and total manganese. The monthly average metals concentrations were multiplied by the discharge flows to estimate average loadings for these point sources.

4.3.4.2.2 Allocation Conditions

Modeling for allocation conditions required running multiple scenarios including a baseline scenario, and multiple allocation scenarios. This process is further explained in Section 5. For the allocation conditions, all permitted mining facilities were represented using precipitation-driven nonpoint source processes in the model. Under this nonpoint source representation, flow was estimated in a manner similar to other nonpoint sources in the watershed (based on precipitation and hydrologic properties). This approach is based on the assumption that discharges from most surface mines are precipitation-driven. Flow was typically present at all times and increased during storm events. The metals concentrations were assigned based on permit limits for the baseline condition modeling as well as on required reductions to achieve in-stream TMDL targets for the allocation scenarios.

Mining discharge permits have technology-based limits. Monthly average permit concentrations for technology-based limits are 3.0 mg/L for total iron, 2.0 mg/L for total manganese, and a "report only" limit for total aluminum. Point sources were assigned concentrations based on the appropriate limits. For discharges that are technology based, the waste load concentration for aluminum was assumed to be 4.3 mg/L based on observed data from a large number of mining operations in West Virginia.

4.3.5 Stream Representation

Modeling subwatersheds and calibrating hydrologic and water quality model components required routing flow and pollutants through streams. Each subwatershed was represented with a single stream. Stream segments were identified using USEPA's Reach File 3 (RF3) stream coverage.

To route flow and pollutants, it was necessary to develop rating curves. Rating curves were developed for each stream using Manning's equation and representative stream data. Required stream data include slope, Manning's roughness coefficient, and stream dimensions including mean channel widths and depths. Manning's roughness coefficient was assumed to be 0.05 for all streams (representative of mountain streams). Slopes were calculated based on DEM data and stream lengths measured from the RF3 stream coverage. Stream dimensions were estimated using regression curves that relate upstream drainage area to stream dimensions (Rosgen, 1996).

4.3.6 Hydrologic Representation

Hydrologic processes were represented in the HSPC using algorithms from the PWATER (water budget simulation for pervious land segments) and IWATER (water budget simulation for impervious land segments) modules of HSPF (Bicknell et al., 1996). Parameters associated with infiltration, groundwater flow, and overland flow were designated during model calibration.

4.3.7 Pollutant Representation

In addition to flow, four pollutants were modeled with the HSPC:

- Total aluminum
- Total iron
- Total manganese
- Total suspended solids

The loading contributions of these pollutants from different nonpoint sources were represented in the HSPC using the PQUAL (simulation of quality constituents for pervious land segments) and IQUAL (simulation of quality constituents for impervious land segments) modules in HSPF (Bicknell et al., 1996). Pollutant transport was represented in the streams using the GQUAL (simulation of behavior of a generalized quality constituent) module. The calibrated data set represents existing conditions. Values for the pollutant representation were refined through the water quality calibration process.

4.4 Model Calibration

After the model was configured, calibration was performed at multiple locations throughout the watershed. Calibration is the adjustment or fine-tuning of modeling parameters to reproduce observations. Model calibration focused on two main areas: hydrology and water quality. Upon completion of the calibration at selected locations, a calibrated data set containing parameter values for modeled sources and pollutants was developed. This data set was applied to areas for which calibration data were not available.

Available monitoring data in the watershed were identified and assessed for application to calibration (see Appendix A). The monitoring stations with data representing a range of hydrologic conditions, source types, and pollutants were selected. The locations selected for calibration are presented in Figure 9.

4.4.1 Hydrology Calibration

Hydrology was the first model component calibrated. The hydrology calibration involved a comparison of model results to in-stream flow observations at selected locations, and the subsequent adjustment of hydrologic parameters. Key considerations included the overall water balance, the high-flow/low-flow distribution, storm flows, and seasonal variation.

No daily flow data are available for the Duck Creek watershed. Therefore, the neighboring Raccoon Creek watershed was modeled and calibrated for flows, and the resulting model parameters were applied to the Duck Creek watershed. A comparison of the relevant hydrologic characteristics between the two watersheds is presented in Appendix B. The comparison suggests that the watersheds are sufficiently similar to justify this approach.

To represent a range of hydrologic conditions, the model was calibrated for a 4-year period (1976-1980). Flow-frequency curves, temporal comparisons (daily and monthly), and comparisons of high flows and low flows were developed to support calibration. The calibration involved adjustment of infiltration, subsurface storage, evapotranspiration, surface runoff, and interception storage parameters. Table 10 shows the comparison of simulated versus observed flow for the calibration period.

Table 10. Hydrology calibration: comparison of simulated and observed flow for 1976-1980.

Simulated versus Observed Flow	Percent Error	Recommended Criterion (Percent)
Error in total volume	−5.70	+/− 10
Error in 50% lowest flows	32.20	+/− 10
Error in 10% highest flows	-14.71	+/− 15
Seasonal volume error - Summer	6.20	+/− 30
Seasonal volume error - Fall	16.85	+/− 30
Seasonal volume error - Winter	-22.71	+/− 30
Seasonal volume error - Spring	-16.75	+/− 30
Error in storm volumes	−11.20	+/− 20
Error in summer storm volumes	1.40	+/− 50

Precipitation data for the Raccoon Creek model were obtained from a single available gage, outside the watershed, which limited the calibration process. Calibration therefore focused on the critical aspects for the TMDL. Since the major sources in the Duck Creek watershed are rainfall-driven, the calibration process focused on accurately representing storm flows.

After adjusting the appropriate parameters within the appropriate ranges, acceptable correlations were found between model results and observed data for the comparisons made. Flow-frequency curves and temporal analyses are presented in Appendix C.

Parameter values were validated for an independent, extended time period (between 1981 and 1985) after calibrating parameters at the stations. Validation involved comparing model results and flow observations without further adjusting the parameters. The validation comparisons also showed an acceptable correlation between modeled and observed data. Refer to Appendix C for validation results.

4.4.2 Water Quality Calibration

After hydrology had been sufficiently calibrated, water quality calibration was performed. Modeled versus observed in-stream concentrations were directly compared during model calibration. The water quality calibration consisted of executing the watershed model, comparing water quality time-series output to available water quality observation data, and adjusting water quality parameters within a reasonable range.

The calibration process was limited by the available water quality data. Ideally, water quality data should span several years, with regular sampling during wet and dry weather. The available data for Duck Creek (Appendix A) provided good spatial distribution of water quality information. However, since the data were available for two summer months in 2000 and each station had an average of 7 samples, temporal water quality information was limited. Furthermore, most of these samples were collected during low-flow conditions, whereas most of the sources (runoff from mined areas) were storm driven.

Given these limitations, the water quality calibration depended to some extent on knowledge acquired during the applications of the model to other similar watersheds. In particular, previous model application lead to aluminum, manganese, and iron TMDLs in West Virginia. The calibrated model parameters used for the Stony River, West Virginia TMDL served as the calibration starting point for the Duck Creek watershed.

The calibrated model parameters characterize the buildup and washoff of each modeled constituent for individual land uses. Constituent buildup depends on accumulation rate and the time allotted for constituent storage. Washoff is a nonlinear function of constituent storage, surface flow and parameters that describe susceptibility of the constituent to wash off . High concentration peaks may occur when enough time has transpired for signficant buildup, which then becomes part of the runoff of the next storm.

The approach taken to calibrate water quality focused on matching trends identified during the water quality analysis. Daily average in-stream concentrations from the model were compared directly to observed data. Minimal adjustments to the Stony River model data set were necessary to calibrate the Duck Creek to the 2000 observed water quality data.

Representative stations were selected based on location (distributed throughout the Duck Creek watershed) and source type. The results presented in Appendix B illustrate two scales: Whipple Run, which drains approximately 7.7 square miles, and Middle Fork, which drains approximately 25 square miles. The model results were compared to most sites where water quality data were available. The results showed that the model is a reasonable description of the significant water quality processes in the watershed and is suitable for use in TMDL development.

4.5 Model Application

The calibrated model was applied to simulate water quality response for the Duck Creek watershed to determine allowable loads. The model was run for a 3-year period from 1998 through 2000. The first year of simulation (1998) allowed the model to overcome any initial numerical instabilities. The subsequent years (1999 to 2000) were the basis for determining existing or baseline conditions and testing allocation scenarios.

Using the TSS TMDL developed for Whipple Run as an example, the baseline or existing conditions are depicted by the red line in Figure 10. For this case, the 30-day period prior to and including February 7, 1999, can be considered a critical condition since the model predicts the largest exceedance of the target during this period. Basing the TMDL on this period ensured that the target was met throughout the period of simulation.

The allocation scenario was achieved by reductions in the input loadings to the model. These inputs were reduced systematically as described in a section 5.3 below. When the reductions produced a scenario that met the target (blue line in Figure 10) the annual loads associated with the allocation scenario were calculated.

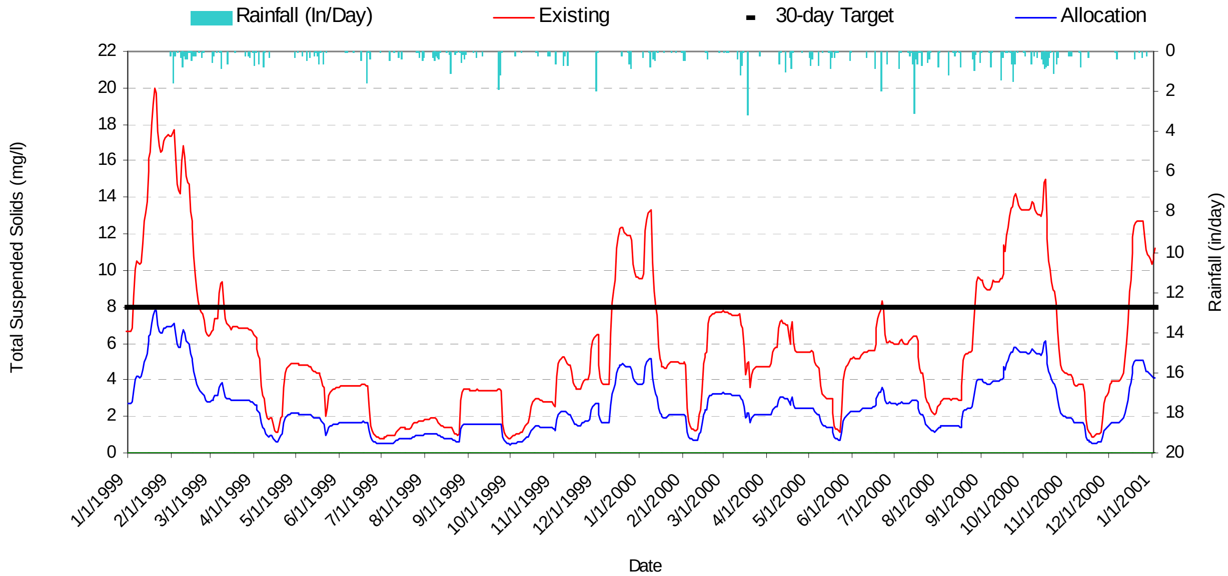

Figure 10. **Predicted and proposed TMDL for TSS for Whipple Run (30-day TSS average versus 30 day target for Whipple Run)**

5.0 ALLOCATION ANALYSIS

A TMDL is the total amount of a pollutant that can be assimilated by the receiving water while still achieving water quality standards. TMDLs can be expressed in terms of mass per time or by other appropriate measures. TMDLs are composed of the sum of individual wasteload allocations (WLAs) for point sources and load allocations (LAs) for nonpoint sources and natural background levels. In addition, the TMDL must include an MOS, either implicitly or explicitly, that accounts for the uncertainty in the relationship between pollutant loads and the quality of the receiving waterbody. Conceptually, this is defined by the equation:

$$\text{TMDL} = \sum \text{WLAs} + \sum \text{LAs} + \text{MOS}$$

To develop aluminum, iron, manganese, and TSS TMDLs for each of the listed waterbodies in the Duck Creek watershed, the following approach was taken:

- Simulate baseline conditions
- Assess source loading alternatives
- Determine the TMDL and source allocations

Components of the TMDLs for aluminum, iron, manganese, and TSS are presented in terms of mass per time in this report.

5.1 Baseline Conditions

The calibrated model provided the basis for performing the allocation analysis. The model calibration was limited to the spring and summer of 2000 by availability of water quality data. The resulting model data set was used to project baseline conditions. Baseline conditions represent existing nonpoint source loading conditions and permitted point source discharge conditions. The baseline conditions allow for an evaluation of in-stream water quality under the "worst currently allowable" scenario.

Permitted conditions for mines were represented using precipitation-driven flow estimations and the metals concentrations presented in Table 11.

Table 11. Metals concentrations used in representing permitted conditions for mines.

Pollutant	Technology-based Permits
Total Aluminum	4.3 mg/L (assumed for "report only")
Total Iron	3.0 mg/L
Total Manganese	2.0 mg/L

Average annual loads associated with baseline conditions were calculated using the predicted in-stream concentrations of aluminum, iron, manganese, and TSS for the impaired waterbodies. To illustrate this calculation, we can consider the TSS case, for which daily concentrations were predicted in milligrams per liter (mg/L) and daily flows in cubic feet per second (cfs). The total annual load in pouds per year (lb/yr) can be calculated by summing the predicted flow multiplied by the concentration. This is described by the following expression.

Load(lb/yr) = Σ(Daily Conc (mg/L)* Daily Flow(cfs)* 28.3 liter/1cf *1 lb/453592.4mg *3600 s/day)

These loads, averaged over the simulation years and classified into three land use categories, are reported under the baseline columns of Tables 12 to15**.**

5.2 TMDLs and Source Allocations

Simulation of baseline conditions provided the basis for evaluating stream response to variations in source contributions. The simulations revealed that, for the Duck Creek watershed, historically mined and agricultural areas are the dominant sources of metals and suspended solids, respectively. These results facilitated developing an effective allocation strategy.

A top-down methodology was followed to develop the TMDLs and allocate loads to sources. Impaired headwaters were analyzed first, because their impact frequently had a profound effect on downstream water quality. Loading contributions were reduced from applicable sources for these waterbodies, and TMDLs were developed. Model results from the selected successful scenarios were then routed through downstream waterbodies. Therefore, when TMDLs were developed for downstream impaired waterbodies, upstream contributions were representing conditions meeting water quality criteria. Using this method, contributions from all sources were weighted equitably. In some situations, reductions in sources affecting unimpaired headwaters were required to meet downstream water quality criteria. In other situations, reductions in sources affecting impaired headwaters ultimately led to improvements far downstream. This effectively decreased required loading reductions from many potential downstream sources.

Contributing land uses are those that were determined to be dominant sources for each pollutant (i.e., historically mined areas for metals and agricultural land for siltation). The following general methodology was used when allocating to sources for the Duck Creek TMDLs:

- For watersheds with contributing land uses but no point sources, loads from contributing land uses were reduced until in-stream water quality criteria were met.

- For watersheds with contributing land uses and point sources, point sources were set at permit limits and loads from contributing land uses were subsequently reduced until in-stream water quality criteria were met. If further reduction was required, point source discharge limits were reduced.

5.2.1 Wasteload Allocations (WLAs)

WLAs were calculated for all permitted facilities and are presented in Tables 12−15. The WLAs are presented on an annual basis (as an average annual load) because they were developed to meet TMDL targets under a range of conditions observed throughout the year.

5.2.2 Load Allocations (LAs)

LAs were made for the dominant source categories, as follows:

- Recent mining
- Historic mining
- Agriculture
- Other nonpoint sources

The LAs for aluminum, iron, manganese, and TSS are presented in Table 12−15. The LAs are presented as annual loads, in pounds per year. They are presented on an annual basis (as an average annual load) because they were developed to meet TMDL targets under a range of conditions observed throughout the year.

5.2.3. Margin of Safety

Section 303(d) of the Clean Water Act and EPA's regulations at 40 CFR 130.7 require that "TMDLs shall be established at levels necessary to attain and maintain the applicable narrative and numeric water quality standards with seasonal variations and a margin of safety which takes into account any lack of knowledge concerning the relationship between limitations and water quality." The margin of safety can either be implicitly incorporated into conservative assumptions used to develop the TMDL or added as a separate explicit component of the TMDL (USEPA, 1991).

A 5 percent explicit MOS was incorporated for the metals TMDLs by basing the allocation decisions on achieving the TMDL targets minus 5 percent. A relatively low MOS was chosen because of the low error associated with the modeling (see section 4.4.1 and Appendix C). The model is therefore reducing the uncertainty associated with the relationship between load limitations and water quality An implicit MOS was incorporated for the TSS TMDLs by basing the target on observed conditions in a stream designated as Exceptional Warmwater Habitat (Pawpaw Creek), even though the TMDLs were developed for streams designated as Warmwater Habitat. A MOS is incorporated because the TMDL attempts to restore water quality to better than necessary to meet the Warmwater Habitat standard.

5.2.4 Seasonal Variation

A TMDL must consider seasonal variation in the derivation of the allocation. By using continuous simulation (modeling over a period of several years), seasonal hydrologic and source loading variability was inherently considered. The metals and TSS concentrations simulated on a daily time step by the model were compared to TMDL targets and an allocation that would meet these targets throughout the year was developed.

Table 12. Aluminum TMDL allocations.

Reach Name	Sub-Basin	Load Allocations: Recent Mining Base-line (lb/yr)	Recent Mining Allo-cation (lb/yr)	Historic Mining Base-line (lb/yr)	Historic Mining Allo-cation (lb/yr)	Other Nonpoint Sources Base-line (lb/yr)	Other Nonpoint Sources Allo-cation (lb/yr)	WLA Base-line (lb/yr)	WLA Allo-cation (lb/yr)
East Fork Duck Creek	ONLY REDUCTIONS OF TRIBUTARY LOADS ARE NECESSARY.							1.478	1.478
Middle Fork Duck Creek	25	278.2	222.6	7956.8	6084.7	1490.9	1490.9	0.0	0.0
Otterslide Run	20	87.4	69.9	2104.3	1683.5	767.2	767.2	0.0	0.0
	5	7.1	5.7	1340.4	1072.5	418.6	418.6	0.0	0.0
	91	10.7	8.6	1081.8	868.2	454.3	454.3	0.0	0.0
Mare Run	92	2.7	2.2	1294.2	1037.9	627.5	627.5	0.0	0.0
Wolf Run	39	0	0	27.6	22	3.3	3.3	0.0	0.0
Warren Run	45	488.8	293.3	5850.9	4672.7	551.7	551.7	0.0	0.0
Buffalo Run	48	27.6	6.9	2018.1	522.9	377	377	0.0	0.0
West Fork Duck Creek - Tributary (RM 3.05)	55	0	0	5280.6	2442.9	1213	1213	0.0	0.0
West Fork Duck Creek - Tributary (RM 2.30)	55	0	0	2806.1	1298.1	561.2	561.2	0.0	0.0
West Fork East Fork Duck Creek	11	0	0	7181.3	5026.9	2085	2085	0.0	0.0
Elk Fork	10	2.9	2	6323.9	4426.7	1165.2	1165.2	0.0	0.0
East Fork Duck Creek Tributary (5.73)	90	818.2	327.3	7242.8	2897.1	843.9	843.9	0.541	0.541
East Fork Duck Creek - Tributary (RM 4.15)	27	25.4	7.6	3547.2	1064.2	1564.5	1564.5	0.0	0.0
Road Fork	64	0	0	665.2	237.5	427.7	427.7	0.0	0.0
	86	0	0	1240	224.1	372	372	0.0	0.0
	87	738.3	369.2	5863.1	5863.1	2919.9	2919.9	0.0	0.0
Flag Run	85	0	0	7312.9	2193.9	954.7	954.7	0.0	0.0
Unnamed Tributary	7	1466.7	733.4	12178.8	8098.5	2549.5	2549.5	0.712	0.712
Barnes Run	8	738.3	369.2	10342.1	9783	2899.4	2899.4	0.224	0.224

Table 13. Iron TMDL allocations.

Reach Name	Sub-Basin	Load Allocations: Recent Mine		Historic Mining		Other Nonpoint Sources		WLA	
		Base-line (lb/yr)	Allo-cation (lb/yr)	Base-line (lb/yr)	Allo-cation (lb/yr)	Base-line (lb/yr)	Allo-cation (lb/yr)	Base-line (lb/yr)	Allo-cation (lb/yr)
East Fork Duck Creek	61	ONLY REDUCTIONS OF TRIBUTARY LOADS ARE NECESSARY.							
Middle Fork Duck Creek	25	540.6	432.5	6686.5	5121.6	1210.5	1210.5	0.0	0.0
Otterslide Run	20	12.4	12.4	565.4	565.4	197.9	197.9	0.0	0.0
	5	0.4	0.4	854.9	854.9	265.6	265.6	0.0	0.0
	91	20.8	20.8	638.7	638.7	265.6	265.6	0.0	0.0
West Fork Duck Creek - Tributary (RM 3.05)	55	0	0	4437.5	2056.2	984.9	984.9	0.0	0.0
West Fork East Fork Duck Creek	11	0	0	6002.6	4509	1742.8	1742.8	0.0	0.0
East Fork Duck Creek Tributary (5.73)	90	683.9	504.7	6118.8	4515.9	640.6	640.6	0.378	0.378
Road Fork	64	0	0	338.4	338.4	217.6	217.6	0.0	0.0
	86	0	0	941.4	941.4	282.4	282.4	0.0	0.0
	87	617.1	444.6	5669.5	4084.3	2507.7	2507.7	0.0	0.0
Flag Run	85	0	0	6112.6	4321.5	798	798	0.0	0.0

Table 14. Manganese TMDL allocations.

Reach Name	Sub-Basin	Load Allocations: Active Mining Base-line (lb/yr)	Active Mining Allo-cation (lb/yr)	Historic Mining Base-line (lb/yr)	Historic Mining Allo-cation (lb/yr)	Non Point Sources Base-line (lb/yr)	Non Point Sources Allo-cation (lb/yr)	WLA Base-line (lb/yr)	WLA Allo-cation (lb/yr)
East Fork Duck Creek	61	ONLY REDUCTIONS OF TRIBUTARY LOADS ARE NECESSARY.							
Middle Fork Duck Creek	25	205.1	164.1	9447.7	7575.6	205.1	205.1	0.0	0.0
Otterslide Run	20	548.5	438.8	7570.6	6518	234.2	234.2	0.0	0.0
	5	16.6	13.3	3306.5	2648	16.6	16.6	0.0	0.0
	91	7.9	7.9	865.4	865.4	7.9	7.9	0.0	0.0
Mare Run	92	6.4	5.1	3392.3	2746.1	6.4	6.4	0.0	0.0
West Fork Duck Creek - Tributary (RM 3.05)	55	0	0	5458.2	2529.1	1211.4	1211.4	0.0	0.0
West Fork East Fork Duck Creek	11	0	0	4847.7	1730.7	1983.4	1983.4	0.0	0.0
Elk Fork	10	2.1	1.5	4504.1	3105.6	1016.8	1016.8	0.0	0.0
East Fork Duck Creek (5.73)	90	603.1	603.1	5337.3	2427.2	624.1	624.1	0.25	0.25
East Fork Duck Creek - Tributary (RM 4.15)	27	18.8	18.8	2118.1	2118.1	1650.1	1650.1	0.0	0.0
Road Fork	64	0	0	490.4	490.4	315.3	315.3	0.0	0.0
	86	0	0	1079.3	1079.3	323.8	323.8	0.0	0.0
	87	544.3	272.1	7212	4022	2006.2	2006.2	0.0	0.0
Flag Run	85	0	0	6094.8	2321.1	795.7	795.7	0.0	0.0

Table 15. Total suspended solids TMDL allocations.

Reach Name	Sub-Basin	Load Allocations: Agricultural Base-line (lb/yr)	Agricultural Allo-cation (lb/yr)	Recent Mining Base-line (lb/yr)	Recent Mining Allo-cation (lb/yr)	Other Nonpoint Sources Base-line (lb/yr)	Other Nonpoint Sources Allo-cation (lb/yr)	WLA Base-line (lb/yr)	WLA Allo-cation (lb/yr)
East Fork Duck Creek	ONLY REDUCTIONS OF TRIBUTARY LOADS ARE NECESSARY.							92,662	92,662
Schwab Run	51	130,214	130,214	322	322	91,161	91,161	0	0
Greasy Run	9	169,446	108,720	128,216	82,266	72,480	72,480	0	0
Road Fork	64	3,578	3,578	0	0	10,742	10,742	0	0
East Fork Duck Creek Tributary (RM 5.73)	90	132,354	76,484	100,650	22,770	187,746	187,746	92,662	92,662
East Fork Duck Creek Tributary (RM 4.15)	27	100,636	100,636	297	297	63,484	63,484	0	0
Mare Run	92	173,075	138,993	263	263	78,204	78,204	0	0
Dog Run	44	29,789	15,577	0	0	5,054	5,054	0	0
Whipple Run	57	397,439	207,057	0	0	109,634	109,634	0	0

6.0 POTENTIAL CONTROL OPTIONS

6.1 Metals

There are a number of options for obtaining the load reductions for metals that are identified in this report. One option is to encourage re-mining (mining in previously mined areas) to reclaim abandoned mine sites and eliminate public safety hazards such as dangerous highwalls and subsidence-prone areas. One advantage to re-mining is that virgin lands can be preserved. Mine operators could be required to implement best management practices (BMPs) to clean up water pollution and ensure that pollutant levels meet the TMDL targets. Successful re-mining operations have already occurred in Duck Creek (personal communications, Gary Novak, Ohio Department of Natural Resources, September 4, 2002). Specific re-mining BMPs include:

- Passive treatment facilities encompass a series of engineered treatment facilities that require little to no maintenance once constructed and operational. Passive treatments use physical, biochemical, and geochemical actions and reactions including calcium carbonate dissolution, sulfate/iron reduction, bicarbonate alkalinity generation, and oxidation, hydrolysis, and metal precipitation. Frequently, more than one passive treatment facility or systems of treatment technologies are employed to treat mine drainage. Passive treatments systems are designed to raise pH and decrease dissolved metal concentrations and include natural wetlands, constructed wetlands including aerobic and anaerobic wetlands, successive alkalinity producing systems (SAPS), anoxic limestone drains (ALD), oxic limestone drains (OLD), limestone ponds, open limestone channels (OLC), diversion wells, limestone sand treatment, and bioremediation.
- Constructed wetlands are capable of removing dissolved metals through formation and precipitation of metal hydroxides, formation of metal sulfides, organic complexation reactions, cation exchange, plant uptake, nuetralization by carbonates, attachment to substrate, adsorption and exchange of metal onto algal mats, and microbial dissimilatory reductions of iron hydroxides and sulfates. A general wetland treatment system consists of a serious of settling ponds, baffles, and cells.
- Anoxic limestone drains (ALD) are buried cells or trenches of limestone into which anoxic water is introduced. Similar to anaerobic wetland systems, limestone dissolves in the acid water, raises pH, and adds alkalinity. However, this system is not recommended for waters containing concentrations of DO, ferric iron, and aluminum greater than one mg/L because the system does not contain a mechanism for removing oxygen and preventing iron and aluminum hydroxide armoring.
- Successive alkalinity-producing systems (SAPS) utilize the alkalinity production of anaerobic wetlands and ALDs to remove metas from mine water, while greatly increasing the alkalinity production over either of the two systems working singly. Contrary to the ALD, SAPS does not require anoxic mine water and ferrous iron. An oxygen sink is created by anaerobic sulfate reduction which will reduce any ferric iron to soluble ferrous iron.

6.2 Siltation

Several possible BMPs can be implemented to reduce erosion and subsequent sediment loading in the Duck Creek watershed. Loads could be reduced by installing vegetated filter strips along streams to trap pollutants before they enter the stream. If vegetated buffers are designed correctly, they can prevent suspended solids and other pollutants from entering a stream.

An effort should also be made to exclude livestock from riparian areas with siltation problems. This will allow the stream buffer to become more vegetated and stable, which can reduce the risk of streambank erosion, provide shade and habitat for aquatic species, and filter nutrients and sediments from runoff.

Livestock are usually excluded by fencing. Several alternatives are available for providing water to animals that can no longer obtain it directly from the stream. These include pipelines, ponds, wells, troughs, and tanks. Options are also available for providing livestock stream crossings and alternative shade areas.

REFERENCES

Bicknell, B.R., J.C. Imhoff, J. Kittle, A.S. Donigian, and R.C. Johansen. 1996. *Hydrological Simulation Program–FORTRAN, User's Manual for Release H*. U.S. Environmental Protection Agency, Environmental Research Laboratory, Athens, GA.

Government of British Columbia. 2001. Ambient Water Quality Guidelines For Manganese. Overview Report. Prepared pursuant to Section 2(e) of the Environment Management Act, 1981. Available at: <http://wlapwww.gov.bc.ca/wat/wq/BCguidelines/manganese.html> Accessed July 18, 2003.

MRLC (Mult-Resolution Land Characterization). 2000. National Land Cover Data–Ohio. Multi-Resolution Land Characterization Consortium, Sioux Falls, SD.

NCDC (National Climatic Data Center). 2001. Weather Data Purchased for McConnesville Lock 7 Precipitation Station.

River Assessment Monitoring Project. 2003. Water Quality Parameters. Available at: <http://water.nr.state.ky.us/ww/ramp/rmtests.htm> Accessed July 18, 2003.

Rosgen, D. 1996. *Applied River Morphology*. Wildland Hydrology, Pagosa Springs, CO.

U.S. Census Bureau. 2000. *United States Census 2000.* U.S. Census Bureau, Washington, DC.

USEPA (U.S. Environmental Protection Agency). 1991. *Guidance for water quality-based decisions: The TMDL process.* EPA 440/4-91-001. U.S. Environmental Protection Agency, Assessment and Watershed Protection Division, Washington, DC.

USEPA. 1999. *National Recommended Water Quality Criteria – Correction.* EPA 822-Z-99-001. U.S. Environmental Protection Agency, Office of Water, Washington, DC.

APPENDIX A

RESULTS OF BIOLOGICAL AND WATER QUALITY SAMPLING

Table 1. Aquatic life use attainment status of sites sampled in the Duck Creek basin from June- October, 2000. The Index of Biotic Integrity (IBI), Modified Index of well being (MIwb), and the Invertebrate Community Index (ICI) are scores based on the performance of the biotic community. The Qualitative Habitat Evaluation Index (QHEI) measures the ability of the physical habitat to support a biotic community. Aquatic life uses for the Duck Creek basin were based on biological sampling conducted during June - October 2000.

RIVER MILE Fish/Invert.	IBI	MIwb	ICI[a]	QHEI	Attainment Status[b]	Site Location
Duck Creek (06-300) 2000 Western Allegheny Plateau (WAP) - WWH (existing)						
21.2 w	50	9	48	51.5	FULL	
16.1 b / 16.4	53	8.8	50	58	FULL	
11.2 b / 11.3	51	9.3	48	72.5	FULL	
5.5w	43[ns]	6.7*	44	59.5	PARTIAL	**manure spill**
3.2 b	43	8.5	--	60	(FULL)	**influenced by Ohio R dam & barge traffic**
-- / 2.5	--	--	F*		**(NON)**	ust. Cytec "impounded"
1.8 b	38	6.3*	P*	59.5	**NON**	dst. Cytec "impounded"
0.5 b / --	42	7.6*	--	57.5	(PARTIAL)	near mouth / recovery
Duck Creek (1997) (WAP) - WWH (existing)						
-- / 3.7	--	--	40		(FULL)	ust. landfills
3.5 b / 3.5	30*	7.1*	44	65.5	PARTIAL	ust. landfills (& last riffle area)
-- / 3.3	--	--	38		(FULL)	dst. Vandale Landfill Trib.
3.2 b	31*	7.2*	32[ns]	67	PARTIAL	dst. possible second landfill Trib.
Duck Creek 1984 (WAP) - WWH (existing)						
21.1	40[ns]	7.5*	40		PARTIAL	
West Fork Duck Creek (06-340) 2000 (WAP) - WWH (existing)						
34.2	54	--	VG	51	FULL	
33.3	48	--	VG	58.5	FULL	
31.4	47	8.7	40	74.5	FULL	
28	46	8.9	46	61.5	FULL	
23.1	50	8.7	--	63.5	FULL	
22.99/23.00	46	9.5	P		--	Acute Mix zone effluent was not acutely toxic
22.9/22.3	44	8.8	MG[ns]		FULL	dst. Caldwell WWTP
20.7	46	9.2	44	60	FULL	dst. Dana / recovery
16	51	9.9	32[ns]	74	FULL	adjacent SR 821 nr. I-77 crossover
12.8	48	9.6	48	65.5	FULL	ust. Dexter
9.1	49	9	42	59	FULL	dst. Macksburg
4.6	45	8.9	48	75	FULL	
0.1	49	8.6	E	59	FULL	nr. mouth
East Fork Duck Creek (06-320) 2000 (WAP) - LWH (existing); WWH (proposed)						
29.9 / 30.3	44	--	E	66.5	FULL	adj. CR 6
28.4	42[ns]	--	G	56	FULL	adj. CR 6
26.3	44	--	40	46.5	FULL	from SR 78
20.7	55	9.7	40	80	FULL	dst. TR 263
14.3 / 14.1	46	7.9[ns]	VG	68.5	FULL	dst. CR 48
9.6	53	9	E	72	FULL	CR 47 (Harrietsville)

RIVER MILE Fish/Invert.	IBI	MIwb	ICI[a]	QHEI	Attainment Status[b]	Site Location
4.2	40[ns]	6.6*	46	42.5	PARTIAL	ust. TR 313
0.1 / 0.9	46	8.4	G	51	FULL	ust. SR 821 & dst. Pawpaw Cr. confl
Middle Fork Duck Creek (06-322) 2000 (WAP) - WWH (existing)						
11.8	44	--	G	37.5	FULL	adj. SR 564
10.8	48	--	E	44	FULL	SR 564 and CR 15
– / 10.4	--	--	P*		(**NON**)	adj. SR 564 (new road construction)
9.8	40[ns]	--	VG	60.5	FULL	SR 564
5.4	26*	--	48	50	PARTIAL	ust. SR 564 (Middleburg)
0.1	32*	--	P*	54	**NON**	SR 564 & SR 145 (AMD trib. ust. & NPS)
Pawpaw Creek (06-321) 2000 WAP - EWH (existing)						
11	50	--	E	59.5	FULL	adj. SR 564
9.6	56	--	E	66.5	FULL	CR 30 and CR 15
8.2	52	--	E	71.5	FULL	from CR 15
3.8	44*	--	E	72	PARTIAL	TR 324 or 460 (active “401" during sample)
Pawpaw Creek (06-321) (1998) - EWH (existing)						
0.3	52	10.1	E	70.5	FULL	near mouth
Whipple Run (06-306) 2000 (WAP) - WWH (existing)						
4.6	48	--	E	65.5	FULL	
4	52	--	VG	65.5	FULL	
0.2 / 0.1	48	--	F*	63.5	PARTIAL	town of Whipple septic? NPS silt, RR?
Nelots Creek (06-360) 2000 (WAP) - WWH (proposed)						
1.6 / 1.1	48	--	VG	61.5	FULL	
0.2 / 0.1	42[ns]	--	G	60.5	FULL	
Coal Run (06-366) 2000 (WAP) - WWH (proposed)						
3.6	54	--	MG[ns]	47	FULL	cattle, NPS sedimentation/nutrients
2.9	50	--	MG[ns]	51	FULL	cattle, NPS sedimentation/nutrients
0.8 / 1.0	54	--	G	55	FULL	siltation
Dog Run (06-346) 2000 (WAP) - WWH (existing)						
2.6	28*	--	MG[ns]	59	PARTIAL	ust. Lk Caldwell/interstitial pool/NPS
1	32*	--	F*	35.5	**NON**	dst Lk Caldwell/NPS silt, more lentic
Wolf Run (06-347) 2000 (WAP) - WWH (existing)						
2.7 / 2.5	40[ns]	--	MG[ns]	59	PARTIAL	ust. Lake Caldwell
-- / 0.5	--	--	F*		**(NON)**	dst Wolf Run Res releases/ town NPS
0.4 / --	50	--	--	46.5	(FULL)	dst. Wolf Run Reservoir
Johnny Woods River (06-348) 2000 (WAP) - LWH (existing); WWH (proposed)						
1.6 / 1.4	50	--	G	54	FULL	
0.4 / 0.3	48	--	G	70	FULL	
Horse Run (06-363) 2000 (WAP) - WWH (proposed)						
2.5 / 2.2	48	--	G	56	FULL	
1.1	48	--	G	57	FULL	

RIVER MILE Fish/Invert.	IBI	MIwb	ICI[a]	QHEI	Attainment Status[b]	Site Location
Trib. to Horse Run (confluence @ RM 2.25) (06-347) 2000 (WAP) - WWH (proposed)						
0.2 / 0.1	44	--	MG^{ns}	50.5	FULL	
Patty Creek (06-368) 2000 (WAP) - EWH (proposed)						
0.1	58	--	E	75	FULL	
Salt Run (06-362) 2000 (WAP) - WWH (existing)						
2.1 / 2.2	42^{ns}	--	MG^{ns}	55	FULL	
0.8 / 0.9	42^{ns}	--	MG^{ns}	46.5	FULL	
– / 0.2	--	--	MG^{ns}	66	(FULL)	
Trib to West Fork Duck Creek (confl.@ RM 9.35)(Macksburg Run)(06-361)2000 (WAP)						
0.3	42^{ns}	--	E	49.5	FULL	WWH (proposed)
Buffalo Run (06-342) 2000 (WAP) - LRW (existing); WWH (proposed)						
1.6	28*	--	26*	53	**NON**	likely AMD/gray slag/coagulent present on rocks
0.2 / 0.1	44	--	G	42	FULL	
Warren Run (06-343) 2000 (WAP) - LWH (existing); WWH (proposed)						
0.5 to 0.3 /0.1	31*	--	F*	52	**NON**	irregular pulse AMD/bugs recovering
Trib. to West Fork Duck Cr. (confluence @ RM 3.05) (06-359) 2000 (WAP) - WWH (proposed)						
0.2	12*	--	F*	49.5	**NON**	AMD impacts
Trib. to West Fork Duck Cr. (confluence @ RM 2.30) (06-358) 2000 (WAP) - WWH (proposed)						
0.2	28*	--	E	42	PARTIAL	MH ust.-Wetland/pool-mining repair?
Sugar Creek (06-304) 2000 (WAP) - WWH (existing)						
0.2 / 0.1	48	--	E	61	FULL	
Killwell Run (06-301) 2000 (WAP) - WWH (existing)						
0.2 / 0.1	44	--	VG	47.5	FULL	
Otterslide Run (06-301) 2000 (WAP) - LWH (existing); WWH (proposed)						
0.2 / 0.1	34*	--	G	65	PARTIAL	mined/had mining recovery, roadwork
Mare Run (06-324) 2000 (WAP) - LWH (existing); WWH (proposed)						
0.7	48	--	F*	42.5	PARTIAL	NPS nutrients enriched,silt/cows open
– / 0.1	--	--	G		(FULL)	
West Fork East Fork Duck Cr. (06-335) 2000 (WAP) - LWH (existing); WWH (proposed)						
1.4	30*	--	MG^{ns}	40.5	PARTIAL	
0.1	48	--	G	61.5	FULL	
Trib. to East Fork Duck Cr. (confluence @ RM 5.73) (06-353) 2000 (WAP) - WWH (proposed)						
0.2 / 0.1	12*	--	VP*	40	**NON**	AMD & NPS siltation & w'coal fines
Trib. to East Fork Duck Cr. (confluence @ RM 4.15) (06-352) 2000 (WAP) - WWH (proposed)						

RIVER MILE Fish/Invert.	IBI	MIwb	ICI[a]	QHEI	Attainment Status[b]	Site Location
0.2 / 0.1	38*	--	G	57	PARTIAL	NPS siltation, there is coal mining nr.
Barnes Run (06-334) 2000 (WAP) - LWH (existing); WWH (proposed)						
1.5	48	--	VG	65	FULL	
0.1	52	--	G	47.1	FULL	
Schwab Run (06-330) 2000 (WAP) - LWH (existing); WWH (proposed)						
2.8 / 3.0	28*	--	E	56	PARTIAL	NPS ag. siltation/ open cow pasture
Greasy Run (06-332) 2000 (WAP) - LWH (existing); WWH (proposed)						
2.1 / 1.2	38*	--	MG[ns]	62.5	PARTIAL	
0.7	56	--	F*	35	PARTIAL	NPS agri., open canopy/open pasture
Elk Fork (06-331) 2000 (WAP) - LWH (existing); WWH (proposed)						
2.5 / 2.2	50	--	F*	61	PARTIAL	pulsed AMD from 1 mi.[2] trib ust.
1.8	48	--	MG[ns]	55	FULL	
0.2 / 0.1	50	--	P*	59	**NON**	NPS nutrients & poss. AMD(coal dust
Creighton Run (06-327) 2000 (WAP) - LWH (existing); EWH (proposed)						
0.8	50	--	E	62	FULL	
Flag Run (06-329) 2000 (WAP) - LWH (existing); WWH (proposed)						
1.0 / 0.8	36*	--	VG	54.5	PARTIAL	gas line const. ust./ old mining area
– / 0.4	--	--	E	54	(FULL)	
0.1	40[ns]	--	E	58.5	FULL	
Road Fork (06-328) 2000 (WAP) - LWH (Existing); WWH (proposed)						
2	42[ns]	--	E	60.5	FULL	
1.5 / 1.4	34*	--	G	63	PARTIAL	past mining/coal fines,silt/gravel load
0.7	48	--	E	61.5	FULL	

Biological Criteria for Western Allegheny Plateau (WAP)

Site Type INDEX	IBI Headwaters	IBI Wading	IBI Boat	MIwb Wading	MIwb Boat	ICI (all sites)
EWH Habitat	50	50	48	9.4	9.6	46
WWH Habitat	44	44	40	8.4	8.6	36
MWH	24	24	24	6.2	5.8	22
LRW	18	18	18	4.0	4.0	8

* Significant departure from ecoregion biocriterion; poor and very poor results are underlined.
ns Nonsignificant departure from biocriterion (<4 IBI or ICI units; <0.5 MIwb units).
a Narrative evaluation used in lieu of ICI (E=Exceptional; G=Good; MG=Marginally Good; F=Fair; P=Poor).
b Use attainment status based on one organism group is parenthetically expressed.
c Sampled or evaluated in 2000.
NA Not Applicable. The MIwb (Modified Index of Well-being) is not applicable to headwater sites.

Table 2. Water quality data for aluminum.

Station	Avg (µg/l)	Min (µg/l)	Max (µg/l)	Count	Start Date	End Date
C01G01	987	544	1770	7	7/11/2000	9/18/2000
C01G02	1695	530	4760	5	7/11/2000	9/18/2000
C01G03	309	200	464	3	8/16/2000	9/18/2000
C01G04	686	249	1300	6	7/11/2000	9/18/2000
C01G05	835	216	2560	9	7/11/2000	9/18/2000
C01G06	355	201	487	6	7/11/2000	9/18/2000
C01G07	337	200	732	9	7/11/2000	9/18/2000
C01G08	809	365	1840	6	7/11/2000	9/18/2000
C01G09	1094	544	2050	6	7/11/2000	9/18/2000
C01G10	859	620	1140	10	7/11/2000	9/18/2000
C01G11	548	200	1020	6	7/11/2000	9/18/2000
C01G12	511	323	827	10	7/11/2000	9/18/2000
C01G13	259	200	390	9	7/11/2000	9/18/2000
C01G14	221	200	324	11	7/11/2000	9/18/2000
C01G15	305	201	369	7	7/11/2000	9/18/2000
C01G16	731	358	1130	6	7/11/2000	9/18/2000
C01G17	274	200	791	8	7/11/2000	9/18/2000
C01G18	1694	200	4510	8	7/11/2000	9/18/2000
C01G19	200	200	200	7	7/11/2000	9/18/2000
C01G20	200	200	200	5	7/11/2000	9/18/2000
C01G21	200	200	200	6	7/11/2000	9/18/2000
C01G22	615	366	1400	7	7/11/2000	9/18/2000
C01G23	599	200	2370	7	7/11/2000	9/18/2000
C01G24	414	200	1430	11	7/11/2000	9/18/2000
C01G25	224	200	303	6	7/11/2000	9/18/2000
C01G26	221	200	282	9	7/11/2000	9/18/2000
C01G27	200	200	200	6	7/11/2000	9/18/2000
C01G28	448	209	954	9	7/11/2000	9/18/2000
C01G29	231	200	433	9	7/11/2000	9/18/2000
C01G30	320	200	426	7	7/11/2000	9/18/2000
C01G31	209	200	246	7	7/11/2000	9/18/2000
C01G32	200	200	200	7	7/11/2000	9/18/2000
C01G33	18745	200	108000	6	7/11/2000	9/18/2000

Station	Avg (μg/l)	Min (μg/l)	Max (μg/l)	Count	Start Date	End Date
C01G34	200	200	200	7	7/11/2000	9/18/2000
C01G35	200	200	200	4	7/11/2000	8/1/2000
C01G36	204	200	231	7	7/11/2000	9/18/2000
C01G37	200	200	200	6	7/11/2000	9/18/2000
C01G38	200	200	200	7	7/11/2000	9/18/2000
C01G39	200	200	200	11	7/11/2000	9/18/2000
C01G40	239	200	326	8	7/11/2000	9/18/2000
C01G41	288	200	726	6	7/11/2000	9/18/2000
C01G42	214	200	350	11	7/11/2000	9/18/2000
C01G43	326	200	1080	7	7/11/2000	9/18/2000
C01G44	218	200	307	6	7/11/2000	9/18/2000
C01G45	495	200	1620	6	7/11/2000	9/18/2000
C01G46	200	200	200	6	7/11/2000	9/18/2000
C01G49	91300	88000	94600	2	8/30/2000	9/18/2000
C01S06	1393	812	2080	6	7/11/2000	9/18/2000
C01S08	719	547	972	6	7/11/2000	9/18/2000
C01S09	213	200	266	8	7/11/2000	9/18/2000
C01S15	365	200	1160	6	7/11/2000	9/19/2000

Table 3. Water quality data for iron.

Station	Avg (µg/l)	Min (µg/l)	Max (µg/l)	Count	Start Date	End Date
C01G01	1140	537	1980	7	7/11/2000	9/18/2000
C01G02	2129	596	6360	5	7/11/2000	9/18/2000
C01G03	350	205	500	3	8/16/2000	9/18/2000
C01G04	774	428	1410	6	7/11/2000	9/18/2000
C01G05	963	357	2880	9	7/11/2000	9/18/2000
C01G06	464	353	543	6	7/11/2000	9/18/2000
C01G07	350	122	830	9	7/11/2000	9/18/2000
C01G08	865	383	2020	6	7/11/2000	9/18/2000
C01G09	1183	511	2490	6	7/11/2000	9/18/2000
C01G10	874	545	1270	10	7/11/2000	9/18/2000
C01G11	507	76	913	6	7/11/2000	9/18/2000
C01G12	809	508	1230	10	7/11/2000	9/18/2000
C01G13	334	187	650	9	7/11/2000	9/18/2000
C01G14	294	80	476	11	7/11/2000	9/18/2000
C01G15	429	331	523	7	7/11/2000	9/18/2000
C01G16	962	391	1750	6	7/11/2000	9/18/2000
C01G17	263	97	1040	8	7/11/2000	9/18/2000
C01G18	2216	182	6080	8	7/11/2000	9/18/2000
C01G19	196	76	256	7	7/11/2000	9/18/2000
C01G20	206	50	340	5	7/11/2000	9/18/2000
C01G21	82	50	121	6	7/11/2000	9/18/2000
C01G22	120	50	177	7	7/11/2000	9/18/2000
C01G23	515	50	2430	7	7/11/2000	9/18/2000
C01G24	346	129	728	11	7/11/2000	9/18/2000
C01G25	159	101	257	6	7/11/2000	9/18/2000
C01G26	241	105	339	9	7/11/2000	9/18/2000
C01G27	145	56	195	6	7/11/2000	9/18/2000
C01G28	678	310	1490	9	7/11/2000	9/18/2000
C01G29	397	135	811	9	7/11/2000	9/18/2000
C01G30	446	342	566	7	7/11/2000	9/18/2000
C01G31	305	160	465	7	7/11/2000	9/18/2000
C01G32	115	70	182	7	7/11/2000	9/18/2000
C01G33	36549	197	213000	6	7/11/2000	9/18/2000

Station	Avg (µg/l)	Min (µg/l)	Max (µg/l)	Count	Start Date	End Date
C01G34	90	50	165	7	7/11/2000	9/18/2000
C01G35	109	50	183	4	7/11/2000	8/1/2000
C01G36	205	55	426	7	7/11/2000	9/18/2000
C01G37	149	50	272	6	7/11/2000	9/18/2000
C01G38	70	50	91	7	7/11/2000	9/18/2000
C01G39	106	50	306	11	7/11/2000	9/18/2000
C01G40	267	85	486	8	7/11/2000	9/18/2000
C01G41	270	50	989	6	7/11/2000	9/18/2000
C01G42	178	86	494	11	7/11/2000	9/18/2000
C01G43	431	161	1730	7	7/11/2000	9/18/2000
C01G44	476	341	676	6	7/11/2000	9/18/2000
C01G45	1091	549	2790	6	7/11/2000	9/18/2000
C01G46	153	82	241	6	7/11/2000	9/18/2000
C01G49	6915	5440	8390	2	8/30/2000	9/18/2000
C01S06	1246	946	1530	6	7/11/2000	9/18/2000
C01S08	652	394	972	6	7/11/2000	9/18/2000
C01S09	103	50	173	8	7/11/2000	9/18/2000
C01S15	489	200	1590	6	7/11/2000	9/19/2000

Table 4. Water quality data for manganese.

Station	Avg (µg/l)	Min (µg/l)	Max (µg/l)	Count	Start Date	End Date
C01G01	382	148	708	7	7/11/2000	9/18/2000
C01G02	395	264	498	5	7/11/2000	9/18/2000
C01G03	108	94	127	3	8/16/2000	9/18/2000
C01G04	179	149	233	6	7/11/2000	9/18/2000
C01G05	109	81	158	9	7/11/2000	9/18/2000
C01G06	105	83	141	6	7/11/2000	9/18/2000
C01G07	146	89	197	9	7/11/2000	9/18/2000
C01G08	169	127	238	6	7/11/2000	9/18/2000
C01G09	211	155	275	6	7/11/2000	9/18/2000
C01G10	176	132	217	10	7/11/2000	9/18/2000
C01G11	181	110	276	6	7/11/2000	9/18/2000
C01G12	240	98	321	10	7/11/2000	9/18/2000
C01G13	149	91	329	9	7/11/2000	9/18/2000
C01G14	152	95	280	11	7/11/2000	9/18/2000
C01G15	296	232	392	7	7/11/2000	9/18/2000
C01G16	681	409	1070	6	7/11/2000	9/18/2000
C01G17	196	63	543	8	7/11/2000	9/18/2000
C01G18	644	168	1080	8	7/11/2000	9/18/2000
C01G19	400	197	650	7	7/11/2000	9/18/2000
C01G20	1301	608	2080	5	7/11/2000	9/18/2000
C01G21	75	20	128	6	7/11/2000	9/18/2000
C01G22	532	356	1020	7	7/11/2000	9/18/2000
C01G23	225	87	398	7	7/11/2000	9/18/2000
C01G24	238	105	1020	11	7/11/2000	9/18/2000
C01G25	493	326	711	6	7/11/2000	9/18/2000
C01G26	127	102	143	9	7/11/2000	9/18/2000
C01G27	64	55	74	6	7/11/2000	9/18/2000
C01G28	291	139	483	9	7/11/2000	9/18/2000
C01G29	229	93	486	9	7/11/2000	9/18/2000
C01G30	393	245	688	7	7/11/2000	9/18/2000
C01G31	594	301	761	7	7/11/2000	9/18/2000
C01G32	61	41	78	7	7/11/2000	9/18/2000
C01G33	2768	467	12600	6	7/11/2000	9/18/2000

Station	Avg (µg/l)	Min (µg/l)	Max (µg/l)	Count	Start Date	End Date
C01G34	13	10	20	7	7/11/2000	9/18/2000
C01G35	20	10	26	4	7/11/2000	8/1/2000
C01G36	94	10	137	7	7/11/2000	9/18/2000
C01G37	73	10	184	6	7/11/2000	9/18/2000
C01G38	21	10	29	7	7/11/2000	9/18/2000
C01G39	122	60	185	11	7/11/2000	9/18/2000
C01G40	141	67	209	8	7/11/2000	9/18/2000
C01G41	257	111	537	6	7/11/2000	9/18/2000
C01G42	29	16	41	11	7/11/2000	9/18/2000
C01G43	217	154	414	7	7/11/2000	9/18/2000
C01G44	521	361	648	6	7/11/2000	9/18/2000
C01G45	625	300	1040	6	7/11/2000	9/18/2000
C01G46	22	10	40	6	7/11/2000	9/18/2000
C01G49	46150	44400	47900	2	8/30/2000	9/18/2000
C01S06	135	96	158	6	7/11/2000	9/18/2000
C01S08	133	92	154	6	7/11/2000	9/18/2000
C01S09	82	11	253	8	7/11/2000	9/18/2000
C01S15	87	65	114	6	7/11/2000	9/19/2000

Table 5. Water quality data for total suspended solids.

Station	Avg (mg/L)	Min (mg/L)	Max (mg/L)	Count	Start Date	End Date
C01G01	27	13	45	7	7/11/2000	9/18/2000
C01G02	102	11	387	5	7/11/2000	9/18/2000
C01G03	6	5	8	3	8/16/2000	9/18/2000
C01G04	20	6	46	6	7/11/2000	9/18/2000
C01G05	25	5	66	9	7/11/2000	9/18/2000
C01G06	11	5	16	6	7/11/2000	9/18/2000
C01G07	9	5	23	9	7/11/2000	9/18/2000
C01G08	24	8	63	6	7/11/2000	9/18/2000
C01G09	37	8	116	6	7/11/2000	9/18/2000
C01G10	19	13	30	10	7/11/2000	9/18/2000
C01G11	12	5	20	6	7/11/2000	9/18/2000
C01G12	16	13	22	10	7/11/2000	9/18/2000
C01G13	9	5	32	9	7/11/2000	9/18/2000
C01G14	6	5	9	11	7/11/2000	9/18/2000
C01G15	11	5	14	7	7/11/2000	9/18/2000
C01G16	21	14	26	6	7/11/2000	9/18/2000
C01G17	7	5	17	8	7/11/2000	9/18/2000
C01G18	37	5	89	8	7/11/2000	9/18/2000
C01G19	5	5	5	7	7/11/2000	9/18/2000
C01G20	5	5	5	5	7/11/2000	9/18/2000
C01G21	5	5	5	6	7/11/2000	9/18/2000
C01G22	6	5	7	7	7/11/2000	9/18/2000
C01G23	19	5	64	8	7/11/2000	9/18/2000
C01G24	9	5	18	11	7/11/2000	9/18/2000
C01G25	5	5	5	6	7/11/2000	9/18/2000
C01G26	6	5	10	9	7/11/2000	9/18/2000
C01G27	5	5	5	6	7/11/2000	9/18/2000
C01G28	16	5	33	9	7/11/2000	9/18/2000
C01G29	7	5	12	9	7/11/2000	9/18/2000
C01G30	10	6	17	7	7/11/2000	9/18/2000
C01G31	7	5	12	7	7/11/2000	9/18/2000
C01G32	5	5	5	7	7/11/2000	9/18/2000
C01G33	1,002	5	5880	6	7/11/2000	9/18/2000

Station	Avg (mg/L)	Min (mg/L)	Max (mg/L)	Count	Start Date	End Date
C01G34	5	5	5	7	7/11/2000	9/18/2000
C01G35	5	5	5	4	7/11/2000	8/1/2000
C01G36	5	5	5	7	7/11/2000	9/18/2000
C01G37	5	5	5	6	7/11/2000	9/18/2000
C01G38	5	5	5	7	7/11/2000	9/18/2000
C01G39	5	5	5	11	7/11/2000	9/18/2000
C01G40	7	5	12	8	7/11/2000	9/18/2000
C01G41	11	5	32	6	7/11/2000	9/18/2000
C01G42	5	5	9	11	7/11/2000	9/18/2000
C01G43	12	5	51	7	7/11/2000	9/18/2000
C01G44	8	5	16	6	7/11/2000	9/18/2000
C01G45	21	7	70	6	7/11/2000	9/18/2000
C01G46	5	5	5	6	7/11/2000	9/18/2000
C01G49	7	5	8	2	8/30/2000	9/18/2000
C01S06	28	22	35	6	7/11/2000	9/18/2000
C01S08	14	6	20	6	7/11/2000	9/18/2000
C01S09	5	5	7	8	7/11/2000	9/18/2000
C01S15	14	5	55	6	7/11/2000	9/19/2000

APPENDIX B

JUSTIFICATION FOR USE OF RACCOON CREEK IN HYDROLOGIC CALIBRATION

Since there was no continous flow data for the Duck Creek watershed, hydrologic model parameters had to be calibrated by applying the model to a neighboring watershed. This is a standard practice when developing TMDLs for ungaged watersheds and is appropriate when the two watersheds are located close to one another and have similar land use and soil characteristics.

The Upper Raccoon Creek watershed was chosen for its proximity to the Duck Creek watershed and its similar hydrologic characteristics. Both watersheds are located in southeast Ohio (Figure 1) and the centers of each watershed are approximately 60 miles from one another. Land use in both watersheds is mostly forest and pastureland (Table 1)

The Natural Resources Conservation Service (formerly the Soil Conservation Service) has classified all soils according to their hydrologic characteristics (Table 2). Soils in the same group have similar runoff potential under similar storm and cover conditions. For both the Duck Creek and Raccoon Creek watersheds, soil hydrologic group C is the dominant soil type. Soils in this hydrologic group have slow infiltration rates when thoroughly wetted.

Figure 1. Location of the Raccoon Creek and Duck Creek Watersheds.

Table 1. Land Use Distribution for the Duck Creek and Raccoon Creek Watersheds

MRLC Land Use Name	Duck Creek		Raccoon Creek	
	Area (acres)	*%*	*Area (acres)*	*%*
Deciduous Forest	108163	58.7	26479	69.4
Pasture/Hay	52753	28.6	6240	16.4
Evergreen Forest	7377	4.0	665	1.7
Row Crops	7076	3.8	2665	7.0
Mixed Forest	2679	1.5	137	0.4
Low Intensity Residential	1659	0.9	355	0.9
Open Water	1361	0.7	103	0.3
Transitional	1330	0.7	968	2.5
High Intensity Commercial	823	0.4	59	0.2
Quarries/Strip Mines/Gravel Pits	429	0.2	347	0.9
Other Grasses	316	0.2	55	0.1
High Intensity Residential	182	0.1	33	0.1
Woody Wetlands	139	0.1	10	0.03
Emergent Herbaceous Wetlands	67	0.0	20	0.1
Total:	**184354**	**100.0**	**38136**	**100**

Table 2. Characteristics of Hydrologic Soil Groups

Soil Group	Characteristics	Minimum Infiltration Capacity (in./hr)
A	Sandy, deep, well drained soils; deep loess; aggregated silty soils	0.30-0.45
B	Sandy loams, shallow loess, moderately deep and moderately well drained soils	0.15-0.30
C	Clay loam soils, shallow sandy loams with a low permeability horizon impeding drainage (soils with a high clay content), soils low in organic content	0.05-0.15
D	Heavy clay soils with swelling potential (heavy plastic clays), water-logged soils, certain saline soils, or shallow soils over an impermeable layer	0.00-0.05

APPENDIX C

HYDROLOGY AND WATER QUALITY CALIBRATION RESULTS

HYDROLOGY CALIBRATION

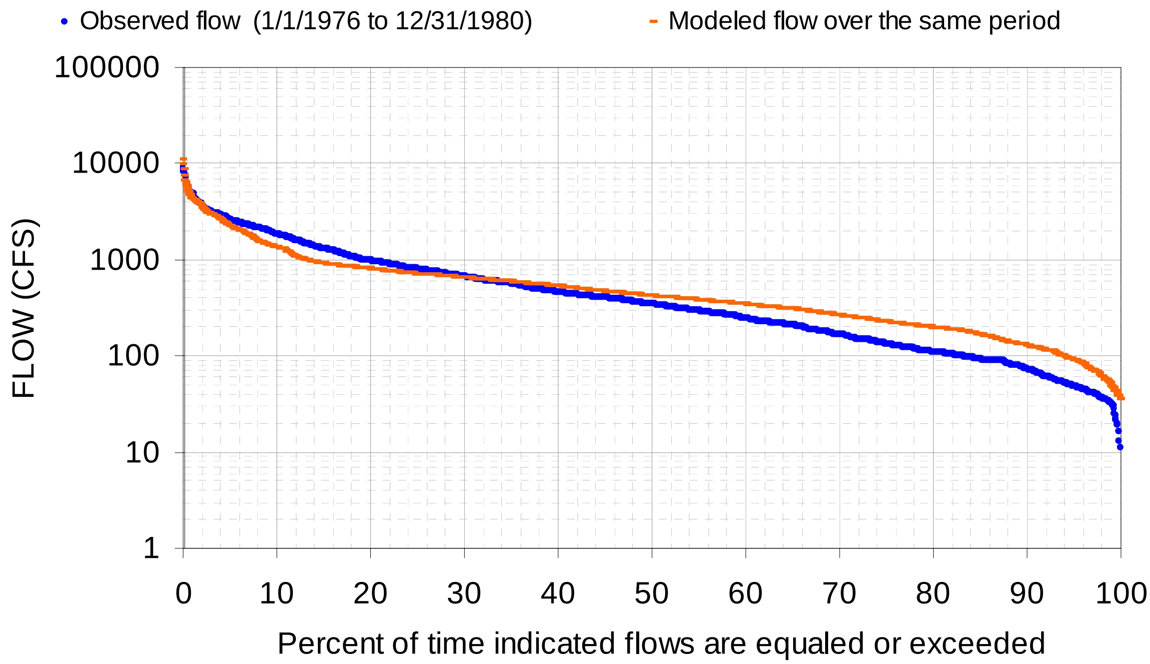

Figure 1. Raccoon Creek at Adamsville, Ohio, flow-frequency curve for 1976 - 1980.

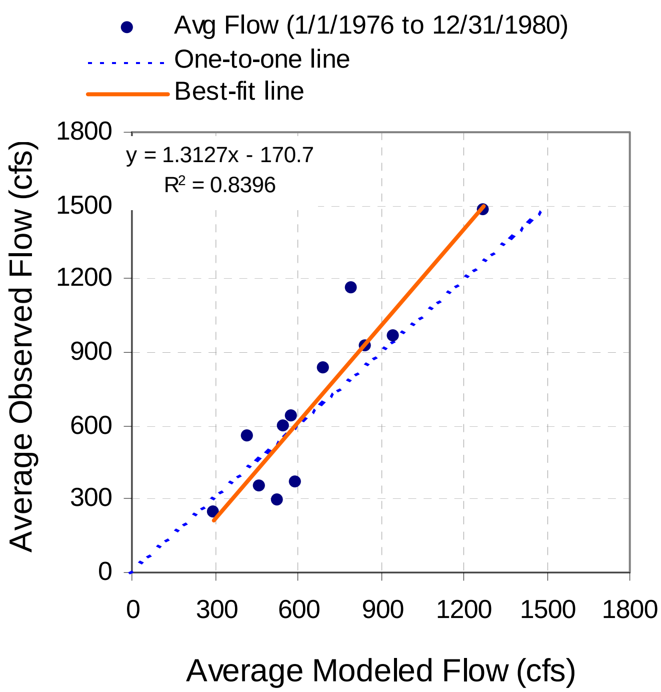

Figure 2. Temporal calibration results for Raccoon Creek for year 1980.

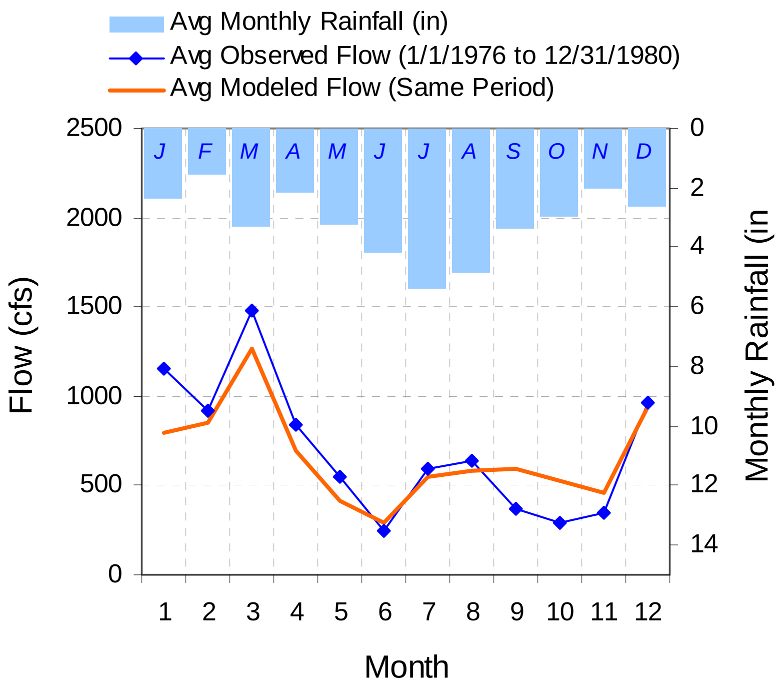

Figure 3. Temporal calibration results for Raccoon Creek for year 1980.

HYDROLOGY VALIDATION

Table 1. Hydrology calibration: comparison of simulated and observed flow for 1981 to 1985.

Simulation Name:	Raccoon Creek	**Simulation Period:**	
		Watershed Area (ac):	158595.00
Period for Flow Analysis			
Begin Date:	**01/01/81**	**Baseflow PERCENTILE:**	2.5
End Date:	**12/31/85**	*Usually 1%-5%*	
Total Simulated In-stream Flow:	**146.06**	Total Observed In-stream Flow:	**147.97**
Total of highest 10% flows:	**67.65**	Total of Observed highest 10% flows:	**67.40**
Total of lowest 50% flows:	**15.67**	Total of Observed Lowest 50% flows:	**11.59**
Simulated Summer Flow Volume (months 7-9):	**9.39**	Observed Summer Flow Volume (7-9):	**5.97**
Simulated Fall Flow Volume (months 10-12):	**40.32**	Observed Fall Flow Volume (10-12):	**25.53**
Simulated Winter Flow Volume (months 1-3):	**42.79**	Observed Winter Flow Volume (1-3):	**53.79**
Simulated Spring Flow Volume (months 4-6):	**53.56**	Observed Spring Flow Volume (4-6):	**62.68**
Total Simulated Storm Volume:	**141.61**	Total Observed Storm Volume:	**145.47**
Simulated Summer Storm Volume (7-9):	**8.28**	Observed Summer Storm Volume (7-9):	**5.35**
Errors (Simulated-Observed)		*Recommended Criteria*	Last run
Error in total volume:	**-1.31**	10	
Error in 50% lowest flows:	**26.01**	10	
Error in 10% highest flows:	**0.36**	15	
Seasonal volume error - Summer:	**36.37**	30	
Seasonal volume error - Fall:	**36.68**	30	
Seasonal volume error - Winter:	**-25.69**	30	
Seasonal volume error - Spring:	**-17.03**	30	
Error in storm volumes:	**-2.73**	20	
Error in summer storm volumes:	**35.39**	50	

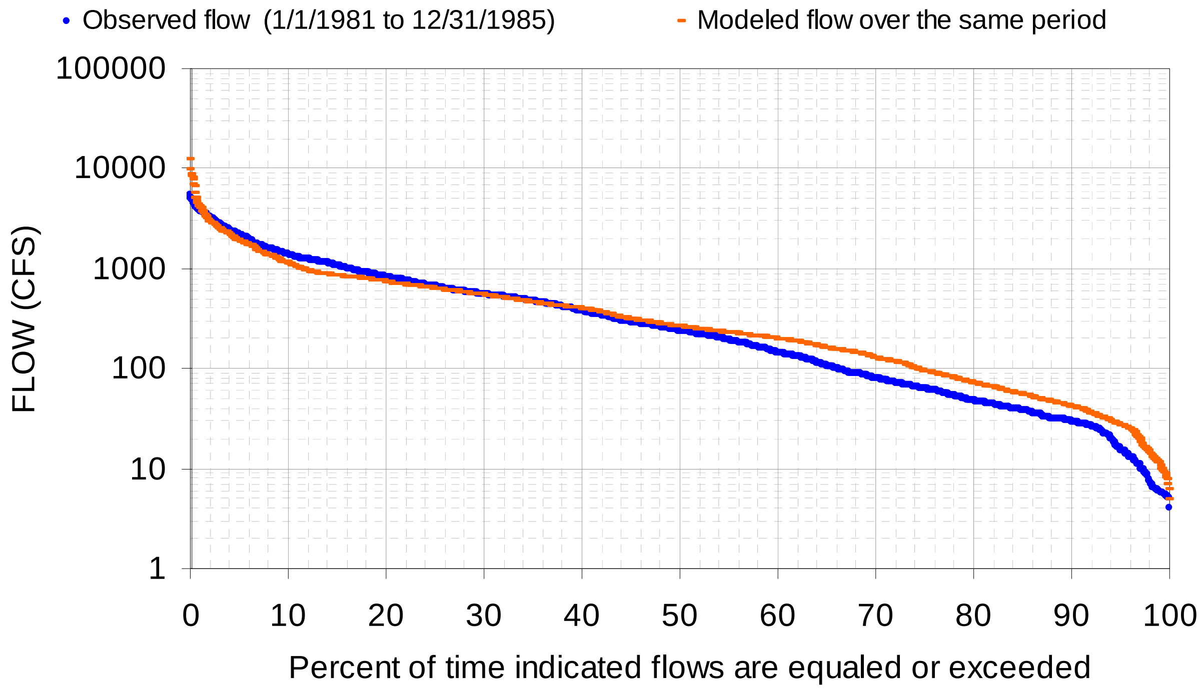

Figure 4. Raccoon Creek at Adamsville, Ohio, flow-frequency curve for 1981 to 1985.

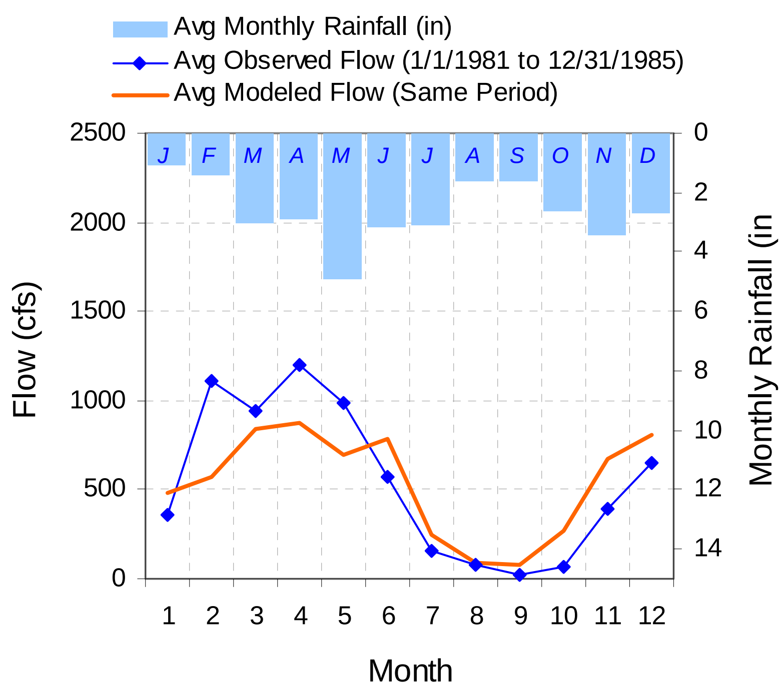

Figure 5. Raccoon Creek at Adamsville, Ohio, average versus modeled flow for 1981 to 1985.

WATER QUALITY CALIBRATION

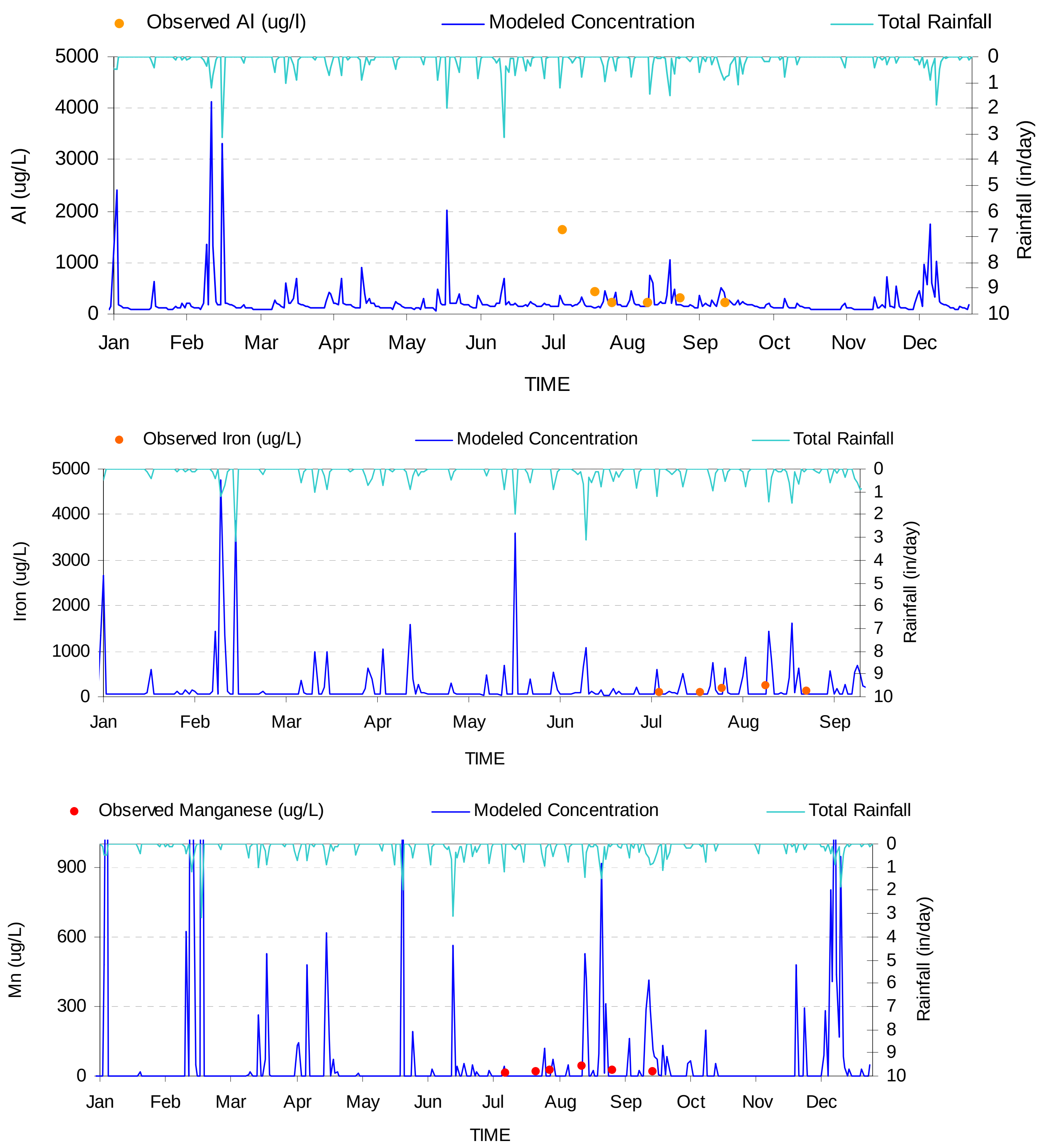

Figure 6. Water quality calibration for Whipple Run (station C01G46).

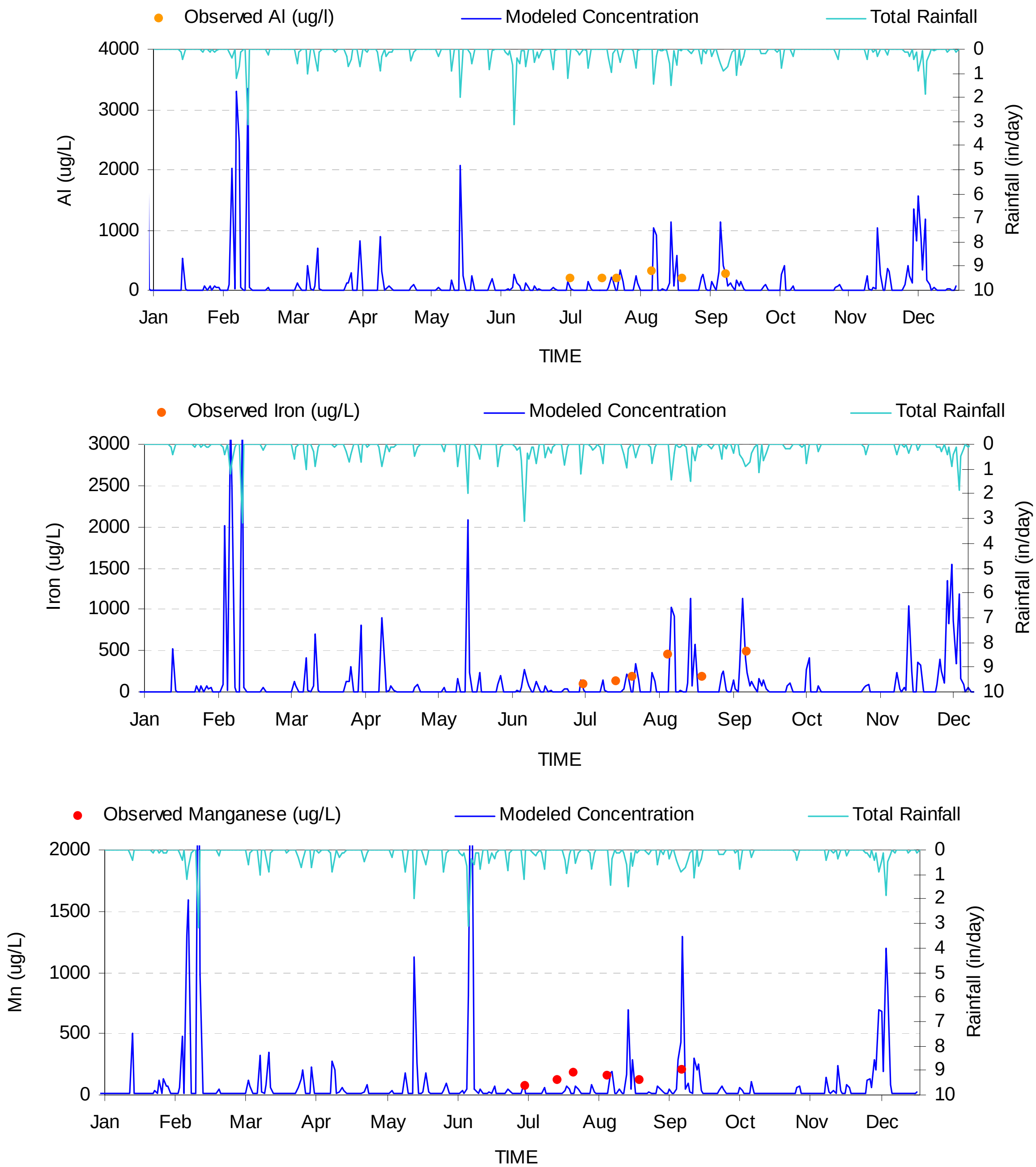

Figure 7. Water quality calibration for Middle Fork Duck Creek (station C01G40).

ATTACHMENT 3

ORGANIC ENRICHMENT/DO IMPAIRMENT MODELING

Table of Contents

1.0 Organic Enrichment/DO Impairment Modeling

1.1 Source Assessment and D.O. Target

Five tributaries in the Duck Creek watershed are impaired due to organic enrichment (OE) /dissolved oxygen (DO), based on measurements at a single site on each tributary. The sources vary but potential ones include manure runoff, faulty home treatment sewage systems (HSTS), open canopy, removal of riparian corridor, elevated BOD and COD, storm water discharges, bacterial contamination, high Fecal coliform, decreased riffle functions and sediment in pools, nitrogen sources and anoxic conditions. The problems are evident in the biological scores but not obvious in the chemical sample data, most likely because the chemical data was collected during low summer flow conditions but the loading occurs during storm wash offs. The modeling outputs show that during storm washoffs, instream dissolved oxygen may be as low as 0 mg/l. The Ohio Water Quality Standard for dissolved oxygen of 5.0 mg/l (average) is the target.

Of the five impaired tributaries, modeling was completed for three using the method described in section 1.2. The other two will be or have been addressed by other means, as discussed in section 1.3.

1.2 Technical Approach

1.2.1 FecalTool Model

Because the sources of DO impairments are grossly obvious, as are their cures, a simple model was employed to demonstrate the potential improvement in DO if the source of Fecal coliform loading is eliminated or reduced from the streams. FecalTool (FCLET), a spreadsheet model that calculates the build up Fecal coliform (FC) from all sources such as wildlife, livestock, and failing HSTSs was used to determine BOD5 and ammonia buildup for impaired sections of streams with impairment caused by organic enrichment/DO. FecalTool is a good way to simulate the build up of bacteria (Fecal coliform) over time. The model was used to simulate the buildup of FC from manure, or in the case of Whipple Run from failing HSTSs. Then the FC totals were converted to BOD5 and NH3-N buildup. The results of FecalTool (BOD5 and NH3-N) were then used as inputs for the MultiSMP model, a DO model for multiple point sources.

1.2.2 MultiSMP Model

Because a point source model (MultiSMP, 1986) is used for a nonpoint source problem, for the sake of the model the sum of the nonpoint source runoff is routed to the stream at single points, represented as discharges, at the most downstream point in the subbasin. The rainfall in each subbasin is assumed to be collected along with all the BOD5 and ammonia buildup and discharged at points as a concentration to the stream.

The model assumes that BOD5 and ammonia buildup and rainfall are distributed evenly throughout the basin, therefore the concentration from the discharges are the same.

Once the existing, or preimplementation, manure buildup conditions were defined by the FecalTool and MultiSMP models, the Fecal Tool model inputs were adjusted to reflect the exclusion of cattle from streams and the addition of a riparian corridor. The model shows that these actions greatly reduce the runoff from the pastures and thus greatly reduce the runoff of BOD5 and ammonia. The FecalTool model was sensitive to these inputs: number of cattle in stream, assumed percentage of nutrients that run off, and assumed percentage of nitrogen that is converted to ammonia (see Table 3.0). Reduced BOD5 and ammonia inputs in the the MultiSMP model results in higher DO outputs.

Table 3.0 FecalTool Model Sensitive Inputs

	No. of Cattle in Stream		**Assumed % of Nutrients that run off (> is more conservative**)**		**Assumed % of Nitrogen that is converted to NH3-N (> is more conservative***)**	
	Pre-Imp.	**Post Imp.**	**Pre-Imp.**	**Post Imp.**	**Pre-Imp.**	**Post Imp.**
Elk Fork	244	0	83	5	46*	46
Mare Run	69	0	83	30	46*	80
Whipple Run	NA	NA	NA	NA	NA	NA

* the rate of conversion from N, total to NH3-N is not important for pre-implementation conditions since in both scenarios the DO is zero.
** If a lot of nutrients can runoff and WQS still be met the scenario is conservative.
*** If a lot of the total Nitrogen is converted to NH3-N and the WQS is still met it is a conservative scenario.

The reduced concentrations of BOD5 and ammonia developed from Fecal Tool are then input into MultiSMP as post implementation conditions to show the resulting increase in DO. The instream DO target of 5.0 mg/l is based on Ohio EPA's warmwater habitat water quality standard.

For model inputs, the existing or preimplementation conditions were defined using available data, text book defaults, census data and assumptions.

In summary, the output from the FecalTool model is total Fecal coliform which is converted to BOD5 and ammonia. These outputs were then used as inputs for MultiSMP, a model used for the simulation of DO. The MultiSMP model was then used to demonstrate the DO before and after Best Management Practices (BMPs) are implemented.

1.3 Allocation Analysis and Implementation

1.3.1 Elk Fork (tributary to East Fork Duck Creek)

Elk Fork of East Fork Duck Creek is a 10.3 square mile basin in the upper portion of the East Fork Duck Creek basin near the Village of Carlisle. The terrain is hilly with farms which are mostly pasture and forest. Cattle have direct access to the streams which has created wide, broken-banked channels.

The area is divided into four subbasins with the loading of the three main subbasins expressed as discharges at the beginning of their respective subbasins. The BOD5 and ammonia buildups calculated by Fecal Tool and an assumed amount of rainfall (flow) were used as the loading for the discharges. The results of the preimplementation conditions in MultiSMP show very high BOD5 and ammonia concentrations and zero DOs. This is reasonable given that during field measurements in 2000 during low summer flows, field staff noted that the stream water was black, the two day DO concentration was 1.83 mg/l and biological scores showed impairments due to low DOs. The model is simulating a rainfall event which would exacerbate conditions by moving high loads of BOD and ammonia to the water.

Restoration will depend on fencing out livestock from the stream and riparian zone to allow the banks and riparian zone to revegetate. Riparian revegetation will help to filter runoff sediment and will ultimately shade the stream thus reducing daily D.O. swings.

Table 3.1 shows the pre and post implementation loading Fecal Tool model results and amount of reduction the implementation will yield. The loads were calculated by multiplying the assumed flow by the concentration and a conversion factor to convert mg/l to kg/d. For example in Elk Fork the assumed storm event resulted in stream flow of 5 cfs and a high instream BOD5 concentration from built up manure of 403 mg/l. The resulting load: 5 cfs * 2.4467 cf * 403 mg/l = 4930 kg/d. The post implementation calculations are based on implementation reduced instream BOD5 and ammonia concentrations. The pre to post reduction values are calculated by subtracting load with the margin of safety from the preimplementation load. This is the amount by which the implementation actions reduce the instream loads. Table 3.1 also includes a 5% margin of safety (MOS).

Table 3.1 Comparison of Pre and Post Implementation Parameters for Elk Fork

	Pre-imp.	Post-imp. w/ 5% MOS	Load w/o 5% MOS	Pre to Post Reduction
BOD5 (kg/d) max	4930	440	462	4490
ammonia (kg/d) max	502	49	51	453
DO (mg/l) min	0	5.17	5.05	na

1.3.2 Mare Run (tributary to Middle Fork Duck Creek)

Mare Run of Middle Fork Duck Creek is a 4.3-square-mile basin in the upper portion of the Middle Fork Duck Creek basin upstream from the Village of Middleburg. It has hilly to steep terrain with farms which are mostly pasture and forest. Cattle have direct access to the streams which have created wide, broken-banked channels.

The model area is divided into two subbasins with the loading expressed as discharges at the beginning of their respective subbasins. The BOD5 and ammonia buildups calculated by Fecal Tool and an assumed amount of rainfall (flow) were used to calculate the loading for the discharges. The results of the preimplementation conditions in MultiSMP show very high BOD5 and ammonia concentrations and zero DOs. The model is simulating a rainfall event which would exacerbate already poor conditions at low flow by moving high loads of BOD and ammonia to the water.

For restoration to occur, fencing out livestock from the stream and riparian zone will be needed to allow the banks and riparian zone to revegetate. Riparian revegetation will help to filter runoff sediment and will ultimately shade the stream thus reducing daily D.O. swings. Table 3.2 is a comparison of pre-implementation to post-implementation results.

Table 3.2 Comparison of Pre and Post Implementation Parameters for Mare Run

	Pre-imp.	Post-imp. w/ 5% MOS	Load w/o 5% MOS	Pre to Post Reduction
BOD5 (kg/d) max	415	167	175	248
ammonia (kg/d) max	40.5	29.4	31	11
DO (mg/l) min	0	5.21	5.03	na

Table 3.2 shows the pre and post implementation loading Fecal Tool model results and amount of reduction the implementation will yield. The loads were calculated by multiplying the assumed flow by the concentration and a conversion factor to convert mg/l to kg/d. For example in Mare Run the assumed storm event resulted in stream flow of 2.07 cfs and a high instream BOD5 concentration from built up manure of 82 mg/l. The resulting load: 2.07 cfs * 2.4467 cf * 82 mg/l = 415 kg/d. The post implementation calculations are based on implementation reduced instream BOD5 and ammonia concentrations. The pre to post reduction values are calculated by subtracting load with the margin of safety from the preimplementation load. This is the amount by which the implementation actions reduce the instream loads.

1.3.3 Whipple Run (tributary to Duck Creek)

Whipple Run, which flows to the south of the Village of Whipple, is a direct tributary to the mainstem of Duck Creek and has a drainage area of 9.6 square miles. Stormwater and septic runoff from Whipple likely is the main source of anoxic conditions. Also, a small tributary which loops northeast around Whipple and enters Whipple Run at river mile (RM) 0.45 may be delivering storm runoff from HSTSs and/or town runoff. The result is low dissolved oxygen concentrations and poor biological scores.

For modeling purposes the area around Whipple was divided into three reaches and two discharge points. The first discharge is near the mouth of the unnamed tributary to Whipple Run. This discharge point assumes a percentage of the total runoff from that portion of the village. The second discharge point occurs near the mouth of Whipple Run at RM 0.2 and assumes the percentage of runoff from the remainder of the village.

For implementation an effort needs to be made to locate and correct any failing HSTSs in the area. See Attachment 4, Section 2.3, Home Sewage Treatment System Upgrades/Replacements, for an explanation of help programs available. Below is a comparison of pre-implementation to post-implementation results (see Table 3.3).

Table 3.3 Comparison of Pre and Post Implementation Parameters for Whipple Run

	Pre-imp.	Post-imp. w/ 5% MOS	Load w/o 5% MOS	Pre to Post Reduction
BOD5 (kg/d) max	5.4	0*	0.0149**	5.4
ammonia (kg/d) max	1.2	0*	0.00213**	1.2
DO (mg/l) min	4.42	5.58	5.44	na

* This assumes all of the flow from failing home sewage treatment systems (HSTSs) are removed.
** This assumes all but 5% (or .000527) MGD of the flow from failing HSTSs are removed.

Table 3.3 shows the pre and post implementation loading Fecal Tool model results and amount of reduction the implementation will yield. The loads were calculated by multiplying the assumed flow by the concentration and a conversion factor to convert mg/l to kg/d. For example in Whipple Run the assumed storm event resulted in stream flow of .297 cfs and a high instream BOD5 concentration, due to failing HSTSs, of 7.49 mg/l. The resulting load: .297 cfs * 2.4467 cf * 7.49 mg/l = 5.4 kg/d. The post implementation calculations are based on implementation reduced instream BOD5 and ammonia concentrations. The pre to post reduction values are calculated by subtracting load with the margin of safety from the preimplementation load. This is the amount by which the implementation actions reduce the instream loads.

1.3.4 Duck Creek Mainstem (lower section)

Assessment: The unmodeled causes of impairment include unknown toxicity, unionized ammonia and organic enrichment/DO. A company named Cytec, which made specialty organic chemicals, such as pesticides (DDT), synthetic dyes, a rocket fuel burn regulator, and fire retardants, contributed to a hazardous waste site and was the source of DDT affecting this reach. The facility is no longer in operation and the source area has recently been excavated and the contaminated soils removed. Fish sampling was also done in 2000 by Ohio EPA and to date there are no fish advisories for Duck Creek. This work, along with future cleanup activities at Cytec should eliminate the toxicity problem.

The lowest three miles of Duck Creek lie within (or very close to) the eastern boundary of the City of Marietta. In the vicinity of Marietta the source of the organic enrichment/DO problem is most likely failing aerator systems which are tied directly to storm sewers.

Implementation: Non point source runoff and urban runoff upstream are contributing to the unionized ammonia and organic enrichment/DO impairments or chronic toxicity stress, the source listed as "other". The specific sources of ammonia in this reach of Duck Creek are probably HSTS discharges to storm sewers. For BMPs for failing aerator systems which are tied directly to storm sewers, see section 2.3.

Additional information is needed to assess if air deposition of ammonia in the Marietta area is contributing to the use impairment in Duck Creek via stormwater outfalls. The Phase 2 stormwater program may provide an opportunity for the City of Marietta to screen for ammonia in stormwater flows, as part of their assessment.

1.3.5 Wolf Run (tributary to West Fork Duck Creek)

Assessment: unmodeled causes include unknown toxicity and organic enrichment/DO.

Implementation: To address the HSTS problems along Wolf Run in Noble County a four- phase project to provide centralized sewers for the areas between Belle Valley and Caldwell, tying to the existing WWTP in Caldwell, has been developed by the Ohio State University Extension Service. Phase 1 is included in the projects to be considered under a funding program for small governments, and is currently awaiting a decision. The other phases are still in the design stage but could be ready for submission as a complete unit in 2003. If these sewer plans are implemented the sources of unknown toxicity and organic enrichment should be transfered to a treatment plant where they can be treated. For this reason the area was not modeled and therefore no TMDL is included for this impairment.

1.4 Margin of Safety

For Elk Fork and Mare Run the BOD5 and ammonia loads were reduced such that the DO Water Quality Standard (WQS) of 5 mg/l is achieved, however a margin of safety exits such that the loads could be 5% higher and the DO WQS would still be met, see Tables 3.1 and 3.2.

For Whipple Run where failing HSTSs are the issue the post implementation scenario assumes all HSTSs are corrected and a flow of zero occurs from them. However, even if 5% of the existing failing HSTS flow continues to exist the DO does not drop below the WQS of 5.0 mg/l, see Table 3.3.

2.0 Addendum to Tetra Tech's Modeling, Total Suspended Solids

Tetra Tech performed the modeling work for the metals and total suspended solids impairments, see Attachment 2. However, as discussed in the main body of this report, their modeling work occurred before Ohio EPA could provide a complete assessment of the entire basin. As a result, impairments were discovered after Tetra Tech's report was finalized. Table 3.4 below is an addendum to Attachment 2's Table 15, Total Suspended Solids TMDL Allocations. It shows the TMDLs for TSS for impaired sites not included in Tetra Tech's Table 15. The loading results come from Tetra Tech's original modeling work.

Table 3.4 Addendum to Attachment 2, Table 15: Total suspended solids TMDL allocations

		Load Allocations						**Wasteload Allocations**	
		Agricultural		**Recent Mining**		**Other NPS**			
Reach Name	**Sub-Basin**	**Base-line** (lb/yr)	**Allo-cation** (lb/yr)	**Base-line** (lb/yr)	**Allo-cation** (lb/yr)	**Base-line** (lb/yr)	**Allo-cation** (lb/yr)	**Base-line** (lb/yr)	**Allo-cation** (lb/yr)
Elk Fork	*10*	76690	76690	34	34	111269	111269	0	0
Middle Fork Duck Creek	*25*	140416	140416	3528	3528	145760	145760	0	0
Duck Cr. (lower mainstem)	*38*	582	6	0	0	64	64	0	0
West Fork Duck Creek RM 3.05	*55*	409	54	15	5	90	90	0	0
Flag Run	*85*	61493	61493	0	0	128929	128929	0	0

References

FCLET was originally developed by Tetra Tech, Inc. in conjunction with U.S.EPA Office of Science and Technology.

MULTI-SMP, 1986 revised December 1992, Simplified Method Program for Multiple Discharges prepared for U.S.EPA Monitoring and Data Support Division, Washington, D.C. prepared by Limno-Tech, Inc.

ATTACHMENT 4

IMPLEMENTATION

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1.0 IMPLEMENTATION STRATEGIES

The major causes of impairment in the Duck Creek basin are nonpoint source (NPS) in nature. Past mining in the headwaters and on tributaries, coupled with habitat degradation, other agricultural operations, and failing or inadequate home sewage treatment systems (HSTSs) have resulted in impaired biological community performance in the Duck Creek basin. This report identifies pollutant reduction and other targets that are expected to allow restoration of the aquatic life uses of the Duck Creek basin.

Restoration methods to bring an impaired waterbody into attainment with water quality standards generally involve an increase in the waterbody's capacity to assimilate pollutants, a reduction of pollutant loads to the waterbody, or some combination of both. As described in Attachment 2, Chapter 3.0, Source Assessment, the causes of impairment in the Duck Creek are primarily AMD pollutants (metals), sedimentation, stream habitat degradation and organic enrichment. Therefore, an effective restoration strategy would include habitat improvements and reductions in pollutant loads potentially combined with some additional means of increasing the assimilative capacity of the stream.

2.0 POTENTIAL CONTROL OPTIONS

This chapter lists the more commonly used BMPs for the different types of impairment sources listed within the Duck Creek basin. These BMPs should guide the watershed coordinator when planning specific implementation methods for impairments, however he/she should not be limited to these. Any restoration scenario that is viable from a financial and feasibility standpoint should be considered.

2.1 Mining

The source of a number of impaired stream segments is abandoned mine areas. A good method for reclaiming these areas is through re-mining. An excellent source of control options for remining and mining related BMPs including sediment control and revegetation, geochemical BMPs, operational BMPs, passive treatment technologies, BMP costs and more is available at http://www.epa.gov/ost/guide/coal/manual/bmpmanual1.pdf. As described by U.S. EPA, "The manual provides information on many hydrologic and geochemical control BMPs which can be used to prevent or reduce pollutant loading from abandoned mine lands during remining operations. This manual provides the best management practices and controls, provides guidance on how, where and when to use them and recommends maintenance procedures" (USEPA, 2000).

2.2 **Sediment** (Agriculture, non-irrigated crop production, mining, surface mining, pasture land, removal of riparian vegetation, stream bank modification/destabilization)

Sediment control is another major issue within the basin. Abandoned mine areas and agricultural practices contribute to the sediment problem in the Duck Creek basin. Abandoned mine BMPs are addressed above in section 2.1. BMPs for agricultural related practices can include reducing cattle access to streams specifically through the use of stream bank fencing, relocating feedlots away from streams, constructing roofs over concentrated feeding areas, controlling roof runoff, establishing filter strips, and riparian buffers, developing alternative livestock watering options such as (ramp pumps, cattle activated pasture pumps, solar activated water pumps, limited access watering points, use of modern electric fencing components, drilling livestock wells), stabilizing critical eroding areas and rotational grazing. Fencing cattle out of the stream will allow the stream banks to revegetate and thus ultimately allow the bank to restabilize.

Implementation for metals and siltation are also discussed in Attachment 2, Chapter 6.0.

2.3 Home Sewage Treatment System Upgrades/Replacements

Failing home sewage treatment systems (HSTS) are the identified source of water quality impairments on the Whipple Run, Wolf Run and Elk Fork tributaries to Duck Creek. Whipple Run is located in the Washington County portion of the Duck Creek watershed, whereas Wolf Run and Elk Fork are located in the Noble County portion of the watershed. Solutions to HSTS problems have traditionally fallen into two general categories: individual HSTS repairs/upgrades or replacement of individual HSTS with a centralized collection and treatment system. With the implementation of the Phase 2 stormwater program, a solution for the third potential HSTS problem exists: elimination of illegal HSTS discharges to the local storm water system. Phase 2 stormwater planning is required for the City of Marietta in the Duck Creek watershed. Marietta's city limits fall outside of Whipple Run, Wolf Run and Elk Fork watersheds.

Individual HSTS repairs or upgrades are feasible where local soils, groundwater, and bedrock conditions are favorable and lot sizes are adequate for on-site treatment. Where the above-mentioned local conditions are not available, the only feasible long-term solution to pollution problems is centralized wastewater collection and treatment. However, the small number of homes among which the cost of such a project must be distributed often makes this option cost-prohibitive, unless there is already a local centralized system nearby that can serve the area.

In 2000, the Washington County Commissioners contracted with a consultant to study the wastewater needs in the entire county. Although the study focused primarily on problems in areas that are already served by centralized treatment, a summary of unsewered areas identifies 1,300 homes, out of a total of 13,000 homes served by

HSTS throughout the county, where the worst HSTS problems exist. Approximately 200 of these homes, in the villages of Macksburg, Warner, Lower Salem and Whipple, are listed as having problem HSTS draining directly to Duck Creek, local storm sewers, or to area ditches nearby. Specifically, the wastewater feasibility study states the following:

> "The village of Macksburg has small residential lots with old septic tanks and inoperable aerators. These systems drain into storm sewers that eventually discharge to Duck Creek. The Warner area in Salem Township has small lots with old septic tanks and aerators. These systems drain into road ditches and storm drains. The village of Lower Salem has small lots with old septic tanks and aerators. These systems drain to storm sewers that discharge to Duck Creek. The Whipple area in Salem and Fearing townships has old septic tanks and a few aerators with leach lines. These systems drain into ditches and pipes that eventually discharge to Duck Creek."

Ohio EPA is not aware of any published information regarding the details of the HSTS situation adjacent to Elk Fork in Noble County. However, the action plan currently being developed for the Duck Creek Watershed is expected to address specific pollution problems in this area, as described in the next section.

Future Planning

The Ohio Nonpoint Source Program provided a fiscal year 2001 grant to the Washington County Soil and Water Conservation District (SWCD) to hire a Duck Creek watershed coordinator. A combination of funds from the Ohio EPA 319 program and the Ohio Department of Natural Resources (ODNR)-Division of Mineral Resources Management and Division of Soil and Water Conservation are used to fund this and six other watershed coordinator positions in Ohio watersheds with recognized nonpoint sources of water quality impairment. State grant funds finance 100% of the personnel costs for the watershed coordinator position in year one and then decrease to a level where the local watershed group finances 100% of the position in year six.

The purpose of the watershed coordinator program is to fund watershed action plan development and implementation to solve priority nonpoint source pollution problems. In March 2002, the watershed coordinator was introduced to local stakeholders with an interest in Duck Creek water quality. Local citizens raised and discussed their water quality concerns. Top on the list of issues were failing HSTS, acid mine drainage, and lack of/destruction of a vegetated riparian corridor. A summary of the TMDL development process and the linkage to watershed action plan development was provided at the meeting by Ohio EPA.

To obtain Ohio EPA endorsement of a final watershed action plan, the following key items must be included: a) a watershed inventory section that provides enough information to identify and quantify the sources of pollution impairing water resource quality in the watershed; b) problem statements that link each water quality impairment cause with its source(s), the load estimate, or relative pollutant contribution from each source by stream segment; the problem statement is expected to contain an actual projected loading number and units (i.e., gallons of untreated waste); and c) impairment reduction goals for each stressor on each individual stream segment to move that segment towards water quality improvement.

It is expected that the local watershed group will expand on the general HSTS information provided in the TMDL to provide a more detailed picture of causes, sources and solutions to existing HSTS-related water quality impairments identified in Duck Creek tributaries, particularly along Elk Fork in Noble County. This will require research into local health department records and coordination with the health department personnel who conduct HSTS inspections in the impaired sub-watersheds. The results of this research and analysis of local conditions will provide the data necessary to determine if HSTS upgrades/repairs, a centralized wastewater collection and treatment system, and/or elimination of illegal discharges to the storm sewer system are feasible solutions to identified problems.

Because of the local interest in solving existing HSTS problems, the Duck Creek and Wolf Creek (Morgan and Washington Counties) watershed coordinators requested that the Ohio EPA Divisions of Surface Water (DSW) and Environmental and Financial Assistance (DEFA) do a presentation regarding HSTS planning and available funding. The watershed coordinators from both watersheds, some members of the local watershed groups, and representatives from the Washington and Morgan County Health Departments attended a presentation on April 16, 2002. A summary of key points from the presentation is outlined below.

Ohio EPA has two sources of funding available to address failing or poorly maintained HSTSs that result in water quality problems:

- Section 319 grant funds administered by the Division of Surface Water (DSW) Nonpoint Source Section available over a three year implementation period.

- Low interest loan funds from the Ohio Water Pollution Loan Fund (WPCLF) linked deposit loan program administered by the Division of Environmental and Financial Assistance (DEFA). Through the linked deposit system, local banks can offer interest rates that are generally 5% below market rates to credit-worthy homeowners for the upgrade or replacement of home sewage treatment systems, as approved by the County Health Department. Terms of the loan are typically three, five, or seven years.

There are differences in the way the two funding sources are administered, but the key to accessing these funds is the same for both programs. Funding is available only to counties that have produced an Ohio EPA approved county-wide or watershed-wide HSTS Plan. The approved contents of the plan will drive the activities which occur during the entire 319 grant/ WPCLF loan project and will be used to evaluate the county's progress during the funding period.

The purpose of this plan is to:
a) outline a county-wide system for the identification, inventory, and correction of improperly located, badly maintained, malfunctioning, and/or failing home sewage treatment systems in a county, particularly where this is causing a water quality impact;
b) outline a long-term plan for ongoing inspection, corrective action, tracking progress and success, and monitoring of the county-wide system both during and after the funding period ends.

The timing of HSTS Plan submission, in relation to funding availability, will vary depending on whether grant only, loan only, or a grant/loan combination will be used by the county to pay for HSTS improvements.

The Washington County Health Department has not yet decided whether they will produce a HSTS plan and/or pursue Ohio EPA funding. They are not sure if they have adequate resources to produce the plan and oversee its implementation. In addition, there is concern that detailing the local HSTS situation in the county will result in enforcement action by Ohio EPA. And finally, Ohio EPA does not provide funding for HSTS upgrades or repairs that result in a discharging system. Of the estimated 13,000 HSTS in Washington County, 80% are currently discharging systems. It is therefore unclear whether homeowners with either failing HSTS or HSTS providing inadequate wastewater treatment will be able to access sources of funding provided by Ohio EPA.

The Duck Creek watershed coordinator has recently requested the same Ohio EPA HSTS planning/funding presentation be given to the Noble County Health Department.

2.4 Organic Enrichment/DO

Organic Enrichment/DO impairments in the Duck Creek basin are the result of livestock waste or failing HSTSs. The BMPs for livestock tend to be the same as those for livestock sediment control. Fence the livestock out, allow the banks to revegetate and allow trees to grow in the riparian zone to filter runoff and shade the water to prevent severe DO daily swings. For failing HSTSs refer to section 2.3 above.

2.5 Construction and Bridge Construction

In the Duck Creek stream assessment any observed source of impairment was listed. In some cases such as bridge or other construction the source is temporary, affects a short distance, and little can be done in terms of implementation. Four streams listed bridge construction and/or construction as a long term source of impairment. The implementation suggested for Paw Paw Creek in the biologists' field notes narrative (see several paragraphs following; emphasis added to highlight construction issue) should be addressed perhaps through the efforts of the watershed coordinator. The others are more temporary and will be ignored with the assumption that with the completion of the construction will come an end to the source of impairment.

Paw Paw Creek: The basin has largely recovered from surface mining from approximately 25-30 years ago. There are still sporadic high runoff total suspended solids (TSS) values. D.O.s are adequate for EWH, though possible sporadic low 24-hour mean concentration < 6mg/l (10 Aug. = 5.61 mg/l). There were no minimum D.O.s < 5.0 mg/l (minimum EWH standard). The overall mean was 6.16 mg/l for 8-11 August 2000. **Non-attainment was due to dozer work widening a farm/pasture lane adjacent to stream with quite a bit of sediment in the stream. This caused temporarily increased embeddedness, siltiness, and turbidity. Increasing riparian widths where needed will keep stream substrates more free from sediment, decrease temperatures and siltation, and increase base stream D.O.s. Protection of the riparian corridor will ensure continued EWH attainment for Pawpaw Creek.**

Elk Fork: Upstream impairment was definitely originating from McBride Run. Elk Fork scored an IBI of 50 (exceptional) upstream from McBride Run confluence). Also, historical mining was a source (possible lower pHs, higher conductivity, and/or metal precipitate on bottom substrates.) High concentrations of ammonia, phosphorus and nitrite led to nutrient/organic enrichment, promoting nusiance algal growth. Low D.O. values of 0.6 to 3.4 mg/l, and a BOD concentration of 15 mg/l were measured during August 8 -11, 2000. Higher temperatures (from some open areas) exacerbates water quality conditions at RM 0.1. Coinciding with this low D.O./high BOD was a fecal coliform spike of approximately 10,000/100 ml. at RM 0.1. All of these are indications of a large slug of organic material. Possible sources were a septic sewage slug from Carlisle or slug from field-applied manure fertilizer application through tile, or immediate runoff. **Also, bridge construction at the same time stirred bottom sediments and caused huge suspended solids (TSS= approximately 6000 mg/l) and potentially toxic concentrations of sediment metals into solution that were latent, deposited long before from NPS mine land runoff. A positive indicator of no recent significant silty sedimentation (excluding the bridge construction during sampling) in the basin was the presence of Redfin Shiners. Field sheet comments confirm relatively clean (no silt) substrates at most of the subbasin sites on Elk Fork and Greasy Run.**

Middle Fork Duck Creek: The upper reaches to the confluence of Mare Run (at RM 10.14) were attaining Warmwater Habitat criteria, though sometimes channels were clogged with sandy bedload, and open access cow pastures with open canopies allowed for some nutrient enrichment and D.O. fluctuations. The fish community ranged from good to very good. Macroinvertebrate narrative scores were rated good and exceptional (which was downstream from a cow pasture in present hay field). **There was a short segment (RM 10.4 to 10.3) that was affected by bridge construction, and was rated poor. Despite some organic enrichment, occassional low diel D.O.s, and heavy NPS old mine lands sediment load runoff, the biological scores attained criteria. The fish community decreased at RM 9.8 [IBI=40 (moderately good)] in open pasture, and the macroinvertebrate narrative score of "very good" was improved (recovered from bridge work upstream but lower than Exceptional narrative upstream where cattle in recent past were not utilizing pasture).** The reach upstream from Middleburg (active mining) caused a decrease in habitat quality and very elevated mine-runoff related parameters. Also, a wide D.O. range (6.4-11.1) with some fecal coliform bacteria present, a higher TKN input, and a CBOD20 of 4.7 mg/l (>95th %ile of Western Allegheny Plateau headwater streams) indicate some likely D.O. depletion periodically in pools. This, plus mine effects hinder certain portions of the fish community by the bedload limiting habitat, and by various chemical effects (decreasing headwater species, sensitive or intolerant species, simple lithophils, and overall fish biomass - likely decreasing spawning success, recruitment, and by habitat limitations). Fair quality continued within this segment downstream to the AMD seep at RM 0.6 (high TDS, metals, conductivity and acid pH inputs). Poor to very poor quality was present at the mouth (mining inputs cause chemical toxic effects or NPS runoff bedload).

East Fork Duck Creek Tributary (RM 5.73): was listed as impaired due to bridge construction, however the biologist did not mention the details in the narrative assessment.

2.6 Hydromodification, Hydromodification Urban Related Flow and Upstream Impoundment

Hydromodification occurs when a stream channel is altered such as when it is rerouted for bridge construction or maintenance, dammed, mined through or when the banks are trampled and reduced by livestock. In the case of bridge construction the problem is temporary and for the purposes of this report, as a source, it will be ignored with the assumption that the stream will return to normal after construction. There are two dams in the Duck Creek watershed, Caldwell Lake and Wolf Run Lake. These are permanent structures and for the purposes of this report will also be ignored as a source of impairment. Mining is another activity that can cause hydromodification. Streams can be mined through and this can inextricably change the stream's natural channel, sometimes even closing outlets and creating impoundments. The impounding or filling of streams by mining can create a source of acidity. In order to determine the most appropriate BMP each mining related impairment must be carefully reviewed. Mining BMPs are discussed above in section 2.1, Potential Control Options for mining. When livestock have access to streams they tend to knock the banks down and smooth them out. Simply fencing them out and adding vegetation or letting the banks naturally revegetate will reduce sedimentation and ultimately allow the stream to recreate natural banks.

2.7 Urban Runoff/Storm Sewers

Urban runoff occurs when the build up of lawn chemicals, such as fertilizers, herbicides and insecticides are flushed into the local stream from storm sewers. BMPs include educating local homeowners on lawn chemical useage in order to eliminate or reduce residual lawn chemicals. Urban runoff can also result when home sewage aerator systems, which are tied into storm sewers, fail. See section 2.3 for BMPs.

2.8 Flow Regulation/Modification

Flow regulation and modification occur when the natural movement of water to a stream is disrupted. The specific sources for the Duck Creek basin are urban settings and mining. In an urban environment water tends to runoff quickly which causes higher than natural flows. Because it runs off quickly less water is stored in the water table and the low flows can be lower than natural low flows. Or, if discharges are present the low flows may be higher than natural. BMPs include reducing the runoff water by disconnecting roof down spouts from the sewers and adding permeable infiltration (unpaved ground) between runoff sources and streams. Mining can also cause modification, see section 2.6 above.

2.9 Land Disposal

This is listed as a source when something applied or buried enters the water and causes an impairment. Another example is when lawn applications of fertilizer, herbicides or insecticides enter from lawns. This is suspected to be the case for a number of tributaries in the basin. These can accumulate then flush in during the first storm after an extended semi dry period. See section 2.8 for BMPs.

References

USEPA. 2000, March. *Coal Mining Best Management Practices Guidance Manual.* Doc. No. EPA 821-R-00-007. U.S. Environmental Protection Agency, Office of Science and Technology, Washington, DC.

ATTACHMENT 5

PUBLIC INVOLVEMENT AND REASONABLE ASSURANCE

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1.0 PUBLIC PARTICIPATION

The Ohio EPA convened an external advisory group (EAG) in 1998 to assist the Agency with the development of the TMDL program in Ohio. The EAG met multiple times over eighteen months and in July, 2000, issued a report to the Director of Ohio EPA on its findings and recommendations. The recommendations included an endorsement of the process Ohio EPA uses to complete TMDL projects.

The 2002 303(d) list public comment period, and the selection of Duck Creek as a priority watershed for TMDL development, provided an additional opportunity for public input concerning information contained in the list (e.g., causes and sources of impairment, priority, restorability, etc.).

1.1 Duck Creek Public Involvement Activities

There are a number of methods for handling AMD metals and siltation problems. As with any large stream restoration project the most difficult problem is having the means to oversee and implement it. The Washington County Soil and Water Conservation District was awarded a fiscal year 2001 watershed coordinator grant. Funds for the coordinator come from a combination of Ohio EPA 319 grants and state funding from the ODNR, Divisions of Soil and Water Conservation and Mineral Resources Management.

The watershed coordinator is housed at the Washington County Soil and Water District Office and has been an integral part of the project. It will be the coordinator's duty to get the local landowners involved with the development and decision making associated with the final watershed plan. The coordinator's advisory committee consists of people which hold positions within the community that will enable him to work closely with the local landowners in order to carry out implementation activities, including the Ohio State University Extension Agent in Noble County, Washington County Commissioner, Noble County Health Department, Noble County Sewer Board, Noble County Soil and Water Conservation Dist. Board, Noble County Resident, Noble County Trustee, Keepers of Duck, Noble County Emergency Medical Agent Director, Noble County Soil and Water Conservation Employee, Ohio Department of Natural Resources Program Specialist, Ohio Department of Natural Resources Employee, Ohio Environmental Protection Agency (South East District Office), Washington County Soil and Water Conservation Dist. Program Administrator, Washington County Soil and Water Conservation Dist. Employee, Washington County Development Office, Ohio Department of Natural Resources (Div. of Mines and Reclamation) Employee, Washington County Community Action, Baker and Noon Coal County, Ohio State University Extension Watershed, Washington County Emergency Medical Agent. These people attended the July 16 and November 7, 2002 public participation (PP) meetings.

Public involvement is key to the success of this TMDL project. Ohio EPA will continue to support the implementation process and will facilitate to the fullest extent possible an

agreement acceptable to the communities and stakeholders in the study area and Ohio EPA. Ohio EPA is reluctant to rely solely on regulatory actions and strongly upholds the need for voluntary actions to bring the Duck Creek watershed into attainment.
The local leadership provided by the Duck Creek coordinator and advisors will be instrumental in promoting further public involvement and implementation of the TMDL project.

Table 1. Duck Creek Watershed Partnership and Other Public Participation

Date	Time	Subject(s)
4/15/02		Duck Creek Watershed Coordinator Meeting, OEPA introduced Kaabe Shaw, watershed coordinator, to the TMDL process and TMDL work
4/30/02		Duck Creek Planning Meeting
5/6/02		Duck Creek Advisory Committee Meeting
6/26/02		Duck Creek Advisory Committee Meeting
8/14/02		Duck Creek Advisory Committee Meeting
10/23/02		Duck Creek Advisory Committee Meeting
7/16/02	1:00 p.m	Initial OEPA public meeting concerning TMDL project; overview of TMDL and the biological study processes and review of the current status of the biological, habitat, chemical and modeling results.
10/8/02		(Noble Co.) Trustees and Mayors within Duck Creek Basin-Public Meeting
10/15/02 -10/16/02		Fall Foliage Tour of Washington Co.: Duck Creek Tour Stop; Ohio Minelands Partnership Tour and Panel Discussion. Tour was of reclaimed sites within Duck Creek my stop was on Otterslide Run comparing pre-reclamation water quality to post reclamation water quality. Discussion was a PowerPoint of what been going on and what is planned in the watershed.
10/17/02		(Washington Co.) Trustees and Mayors within Duck Creek Basin-Public Meeting
11/7/02	1:00 p.m.	Second public meeting concerning TMDL project; overview of finalized bioassessment results, modeling results and implementation (BMPs and funding).
11/14/02		(Noble Co.) Planned General Public Meetings
11/19/02		(Washington Co.) Planned General Public Meetings

1.2 Public Comment

Public outreach activities also include a public comment period associated with the review of the draft TMDL report prior to its submittal to U.S. EPA Region 5. Consistent with Ohio's current Continuing Planning Process (CPP), Ohio EPA released the draft Duck Creek TMDL report for 30 days of public comment on July 8, 2003. A copy of the report was posted on Ohio EPA's web page (http://www.epa.state.oh.us/dsw/tmdl/index.html).

1.3 Responsiveness Summary to Public Comments

One comment was received during the public comment period.

Date	Name	Organization
8/6/2003	Bonnie Arnold	Citizen

Comment: **1.** I am interested in the water quality and flooding issues of Duck Creek. Following the flood of 1998, I am so happy that we are seeing activity in our watershed. It is going to take a lot of education to alert our residents to the importance of watershed issues and how much it affects our way of life.

Response: Ohio EPA encourages citizens to become involved in watershed issues through various activities. We believe that this TMDL, along with the upcoming watershed plan being developed by the watershed coordinator, will result in restoration of the Duck Creek watershed if acted upon by local stakeholders.

2.0 REASONABLE ASSURANCE

U.S. EPA guidance calls for reasonable assurances when TMDLs are developed for waters impaired by both point and NPSs and for waters impaired solely by NPSs. The purpose of the reasonable assurances requirement is for U.S. EPA to be comfortable that the identified activities will in fact be implemented. Reasonable assurances for reductions in NPS loadings may be non-regulatory, regulatory, or incentive based, and should be consistent with applicable laws and programs. Because Ohio EPA does not have direct authority/jurisdiction over many of the identified NPSs, it will be important to coordinate activities with those governmental agencies that do (e.g., county health departments, municipalities, county soil and water conservation districts, local NRCS offices).

Existing federal regulations do not require implementation planning for an approvable TMDL, however implementation of the TMDL project is important to affect positive change in water quality. As discussed in the next section, a mechanism to ensure implementation planning for the Duck Creek TMDL is in place. Local leadership provided by the Duck Creek watershed coordinator and the watershed coordinator advisory group coupled with grant requirements for the completion of a watershed action plan will ensure that implementation planning is performed. Once implementation planning has been completed, projects can be developed based on that plan that will accomplish the needed load reductions and habitat improvements identified in this TMDL project.

Implementation may be funded for through a variety of grants procured by the watershed coordinator. Potential funding sources for the types of implementation called for in this report include CWA Section 319 funds, state revolving loan funds, and other public and private grant and loan sources.

Table 2. Implementation Time Line

Date	**Activity**
Nov. 2002	Watershed coordinator holds two public meetings, one each in Washington and Noble counties, to discuss the TMDL report findings, BMPs, funding and what changes they may bring.
Dec. 2002	Watershed coordinator meets with advisory subcommittee to review draft TMDL implementation plans and to make a list of landowner contacts in the impaired stream segment areas.
Jan. 2003	Watershed coordinator receives finalized TMDL.
Jan. - Jun. 2003	Watershed coordinator studies impaired stream segment areas, does drive by surveys and walks streams to select appropriate BMPs.
Spring 2003	Watershed coordinator applies for BMP funding for projects specified in the WMP.
Summer-Fall 2003	Watershed coordinator writes up BMP implementation plan and inputs it into the Watershed Management Plan (WMP).
Mar. 2004	Watershed coordinator submits WMP.
Jun. 2004	Watershed coordinator and advisory committee starts directing implementation of BMP actions.

2.1 Watershed Management Plan

Through matching funds between USEPA, OEPA and Ohio DNR (FY 2001 319 grant #EPA-01(h) E-30), a watershed coordinator has been hired to complete a community-based Watershed Management Plan (WMP) for the entire Duck Creek watershed by March of 2004. The WMP will build upon the TMDL work. The WMP will link local and state priorities for action in the watershed with the identified water quality targets outlined in the TMDLs and BMPs. A key component of the WMP will be an estimate of the loading reductions and habitat improvements that can be expected as a result of implementing the recommended restoration actions.

Through the development of the WMP, the watershed coordinator will assist the watershed coordinator advisory committee with identification of strategies and setting of goals, coordinate implementation, and develop a monitoring program to ensure local efforts are sustained to improve water quality. The WMP will identify local project sponsors for recommended restoration actions and will provide the road map for future project applications to the two major funding sources for implementation the 319 grant program and the Water Pollution Control Loan Fund (WPCLF). Both sources of funding provide for voluntary implementation of agricultural best management practices, upgrades/replacements of failing home sewage treatment systems (HSTSs), and stream restoration. However, the amount of funding available through the 319 grant program is far smaller (approximately $7M annually for the entire program), is available only once per year on a competitive basis, and is subject to funding caps per project ($500,000 in FY 2002). In contrast, approximately $200M of low interest loan funding is available annually through the WPCLF. WPCLF funding is available throughout the year and there are no funding caps per project. In addition, WPCLF funding is available to solve both point and NPS pollution problems.

2.2 Failing Home Sewage Treatment Systems

As mentioned in Attachment 4 Implementation, section 2.3, Ohio EPA and the watershed coordinator are working to convince the county health agencies to take on the task of creating a county wide Home Sewage Treatment Plan. The hurdles to overcome include fear about involving a state agency (OEPA) and under staffing to take on the project of writing the plan. The Noble County Health Department feels that if they could get around the staffing shortage and get a plan written, then it would be possible to find the means to carry out the plan. OEPA NPS personnel did hold a meeting in Washington County (Wolf Creek) to inform them of the program and its advantages and hopefully dispel fears about involving a state agency. OEPA will continue to dispel fears about applying for State funding. At the same time the watershed coordinator will work towards this end and also directly help Noble County with part of the plan write up and help to find a way around the staff shortage to get the plan written. For more detail on HSTS improvement efforts see Attachment 4, section 2.3.

3.0 Process for Monitoring and Revision

Monitoring of the Duck Creek watershed will be necessary to ensure that the pollutant reduction targets and habitat improvements are accomplished so as to ultimately result in attainment of the Biological Criteria, which will result in restoration of the aquatic life uses in this basin. A tiered approach to monitoring progress and validating the TMDL will be followed:

1. Confirmation of completion of implementation plan activities
2. Evaluation of attainment of chemical water quality criteria
3. Evaluation of biological attainment.

A TMDL revision will be triggered if any one of these three broad validation steps is not being completed or if the WQS are not being attained after an appropriate time interval. Following development of the implementation plan, if the planned activities are not being carried forth within a reasonable time frame as specified in the implementation plan then an intercession by appropriate parties would be needed to keep the implementation activities on schedule. Once the majority of or the major implementation plan items have been carried out and/or the chemical water quality has shown consistent and stable improvements then a full scale biological and chemical watershed assessment would be completed to evaluate attainment of the use designations. If chemical water quality does not show improvement and/or waterbodies 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.