Total Maximum Daily Loads for the Upper Little Miami River

Final Report

prepared by

Ohio Environmental Protection Agency
Division of Surface Water

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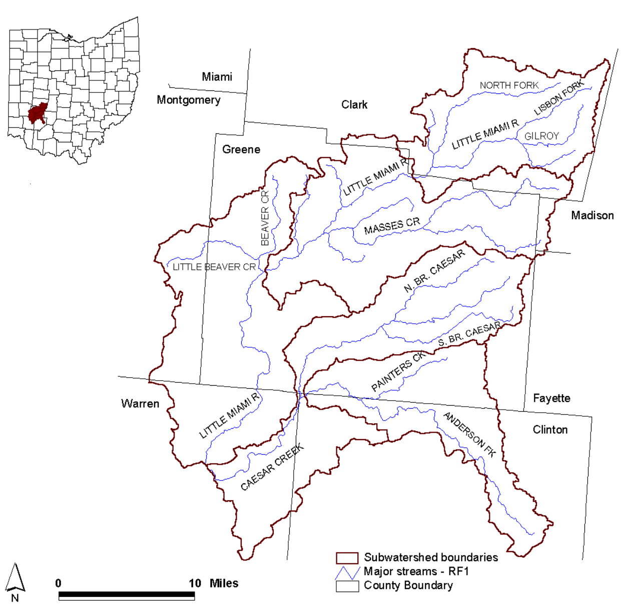
The TMDL in Brief:



Basin:
The Little Miami River in the Ohio River Basin
Study Area:
Upper portion of the Little Miami River watershed and the Caesar Creek watershed; approximately 657 mi^2
Goal:
Attainment of the appropriate Aquatic Life Use
Major Causes:
Nutrient enrichment, low dissolved oxygen, habitat alteration
Major Sources:
Agricultural and urban runoff and municipal discharges.
Measures:
Phosphorus, dissolved oxygen, biological and habitat indices
Restoration Targets:
60% reduction in phosphorus; 30% reduction in sediment; average instream D.O. of 6 mg/l; habitat indices (QHEI) >60
Restoration Options:
Agricultural and urban runoff controls, habitat protection and restoration, septic system improvements, point source controls, and public education

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A key aspect of the project involved a public participation process which revolved around a core group of stakeholders. This Watershed Improvement Group is commended for its patience and commitment and is recognized for the significant contributions the group made to this process. Special thanks go to Greene County for providing the facilities the group met in. In addition, Sarah Hippensteel and Anne Baird are recognized for volunteering to facilitate the group meetings as are Eric Partee and Ron Volkerding for co-chairing the group.

EXECUTIVE SUMMARY

The upper Little Miami River watershed is located in southwestern Ohio, east of the City of Dayton. Seventeen waterbodies within this watershed appeared on Ohio's 1998 303(d) list, fourteen of which are receiving TMDLs in this report, and three are being proposed for removal from the 303(d) list during the next listing cycle as they are now attaining water quality standards. Nutrient and degraded habitats are cited as the primary causes of impairment. Biological and chemical stream surveys conducted in 1993 indicated that the 17 segments were not meeting their designated uses, in part, due to nutrient loadings. Stream surveys conducted in 1998 updated the 1993 information. Nutrients, while essential to the functioning of healthy aquatic ecosystems, can exert negative effects at relatively low concentrations by altering trophic dynamics, increasing algal and macrophyte production, increasing turbidity, decreasing average dissolved oxygen (D.O.) concentrations, and increasing fluctuations in diel dissolved oxygen and pH.

Ohio's water quality standards include numerical biological criteria. These criteria form the basis of the numerical targets for the TMDLs. The success of the implementation actions resulting from the TMDLs will therefore be evaluated by observed improvements in biological scores. Intermediate nutrient targets were identified to complement the biocriteria and to help evaluate the impact of nutrient loadings. These nutrient targets were based on a recent Ohio EPA technical bulletin (OEPA, 1999). Necessary loading reductions for the Little Miami River TMDLs were estimated by comparing the instream 1998 summer concentrations to the desired targets.

Nutrient loading in the upper Little Miami River watershed was simulated using the Generalized Watershed Loading Function or GWLF model. The complexity of this model falls between that of detailed, process-based simulation models and simple export coefficient models which do not represent temporal variability. The GWLF model was calibrated to the watershed and was then used to predict nutrient loadings for each of the subwatersheds listed as impaired for nutrients. The loading capacities of the listed streams were calculated by multiplying the average annual loadings by the estimate of the necessary reduction. The loading capacities were separated into wasteload allocations for point sources, load allocations for nonpoint sources, and natural background for groundwater sources

Habitat was assessed using the Qualitative Habitat Evaluation Index (QHEI). The QHEI is a quantitative composite of six physical habitat variables used to 'score' a stream's habitat. QHEI targets supportive of the appropriate biocriteria have been developed based on statewide and ecoregional reference site data. The analysis of the QHEI provides a framework to develop habitat restoration and improvement strategies.

A stakeholder workgroup representing a wide variety of interests, areas, and expertise has been assisting the Ohio EPA with this project. The workgroup in conjunction with Ohio EPA is currently working on an implementation plan designed to achieve the TMDLs developed in this report. The implementation plan includes agricultural and urban runoff control strategies including a potential public education component, septic system and point source improvements, and habitat restoration strategies. A draft implementation plan is included in this report.

Table 1. Components of the upper Little Miami River TMDL process	
Study Area	Little Miami River basin: headwaters (South Charleston) to downstream of Caesar Ck
1998 303(d) Listed Watersheds ***(see Table 2 for segments)***	05090202 010 Little Miami R (headwaters to above Massie Ck) 05090202 020 Little Miami R (above Massie Ck to below Beaver Ck) 05090202 030 Little Miami R (below Beaver Ck to above Caesar Ck) 05090202 050 Caesar Ck (except Anderson Fork) 05090202 040 Anderson Fork (Caesar Creek watershed)
Target Identification	Nutrients, sediment, dissolved oxygen, and biological and habitat indices.
Applicable Water Quality Criteria	<u>OAC 3745-1-04</u> 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 effect aquatic life. Free from nutrients entering the waters as a result of human activity in concentrations that create nuisance growths of aquatic weeds and algae. <u>OAC 3745-1-07</u> Dissolved oxygen, instantaneous minimum: 4.0 (WWH) or 5.0 (EWH) mg/l; 24-hour average: 5.0 (WWH) or 6.0 (EWH) mg/l Ammonia-nitrogen, outside mixing zone maximum: 9.1 (WWH) or 5.6 (EWH) mg/l; 30-day average: 1.3 (WWH) or 1.2 (EWH) mg/l Ecoregion Biocriteria, refer to Table 4
Current Deviation from Target	Violations of the 24-hour average and minimum dissolved oxygen criteria have been recorded (lowest average, 1.1 mg/l; lowest instantaneous, 0.43 mg/l). Biological communities fail to achieve biocriteria; refer to Table 4.
Sources	Municipal treatment plants, urban and agriculture runoff, septic systems, channelization, lack of riparian zones, and suburbanization.
Load Allocation	Refer to Table 12 on page 40
Critical/Season Conditions	The critical condition for low D.O. and algal blooms occurs when water temperatures are high and the flow is low. These conditions occur in the summer. Annual loads were used to determine the TMDLs.
Safety Margin	Implicit in calculations
Implementation Plan	Currently being developed; a draft copy is in Section 6.1. The implementation plan will involve agricultural and urban runoff control strategies including a potential public education component, septic system and point source improvements, and habitat restoration strategies. An iterative, adaptive implementation approach will be used.
Validation	Tiered approach to validation; assessment progression includes: 1. Confirmation of completion of implementation plan activities 2. Evaluation of attainment of chemical water quality criteria 3. Evaluation of biological attainment
Public Participation	Public information sessions, public notices of report, and a stakeholder group all have contributed to the public participation for this project.

1.0 INTRODUCTION

The Clean Water Act (CWA) Section 303(d) requires States, Territories, and authorized Tribes to list and prioritize waters for which technology-based limits alone do not ensure attainment of water quality standards. Lists of these waters (the section 303(d) lists) are 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 upper Little Miami River watershed as a priority impaired water on the 1998 303(d) list. A summary of the upper Little Miami River watershed portion of the 1998 303(d) list is included in Table 2. A general overview of Ohio's water quality standards is included in Table 3.

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. The process of formulating TMDLs for specific pollutants is therefore, a method by which impaired water body segments are identified and restoration solutions are developed. Ultimately, the goal of Ohio's TMDL process is full attainment of biological and chemical Water Quality Standards (WQS) and, subsequently, removal of water bodies from the 303(d) list. The Ohio EPA believes that developing TMDLs on a watershed basis (as opposed to solely focusing on impaired segments within a watershed) is an effective approach towards this goal.

This report serves to document the upper Little Miami River 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 the upper Little Miami River and to quantitatively assess the factors affecting non or partial attainment of WQS. A draft implementation plan is also included. This plan identifies actions to address these factors and specifies monitoring to ensure actions are carried out and to measure the success of the actions proscribed. The report is organized in sections forming the progression of the TMDL process.

The primary causes of impairment in the upper Little Miami River watershed are nutrient enrichment, low instream dissolved oxygen, sedimentation, and habitat degradation. TMDLs were calculated for total phosphorus and sediment. Habitat degradation and dissolved oxygen depletion are not load based quantities; however, the regulations provide for these types of impairing causes and 'TMDL' numbers were calculated for these as well. The Little Beaver Creek sub-basin is uniquely impaired by metals and organic compounds in addition to the causes listed above. TMDL endpoints for these additional pollutants were also calculated.

Table 2. Summary of the 1998 303(d) listed segments included in this TMDL report[1]

Ident-ification #	Waterbody	Segment Description	Major causes 303(d)	Included in this report? [3]	Notes
05090202 010	Little Miami R (headwaters to above Massie Ck)				Impairment Rank[2] 8
OH 50 23	Little Miami River (LMR)	headwaters to N. Fk. LMR	Nutrients	✓	Total phosphorus (limiting nutrient) only
			Ammonia	✓	Included in point source allocations
			Dissolved Oxygen	✓	Not a load based parameter; allocations included
			Pathogens	No	Elevated levels exist; further study needed to determine if impairing cause or not
OH 50 21	North Fork LMR	headwaters to LMR	Dissolved Oxygen	☺	Full attainment of water quality standards reached based on the 1998 LMR re-assessment; no TMDL needed; delisting recommended.
			Habitat alteration		
OH 50 17	LMR	N. Fork LMR to Massie Ck	Nutrients	✓	Total phosphorus (limiting nutrient) only
			Habitat alteration	✓	Not a load based parameter; allocations included
			Dissolved Oxygen	✓	Not a load based parameter; allocations included
			Metals	No	No violations of criteria found; this cause no longer contributes to the impairment; delisting recommended
			Pathogens	No	Elevated levels exist; further study needed to determine if impairing cause or not
05090202 020	Little Miami R (above Massie Ck to below Beaver Ck)				Impairment Rank[2] 11
OH50 8	Beaver Ck		Ammonia	✓	Included in point source allocations
			Nutrients	✓	Total phosphorus (limiting nutrient) only
			Habitat alteration	✓	Not a load based parameter; allocations included
OH50 16	S. Fork Massie Ck		Habitat alteration	☺	Full attainment of water quality standards reached based on the 1998 LMR re-assessment; no TMDL needed; delisting recommended.
OH50 10	LMR	Massie to Beaver Cks	*Nutrients*	✓	Threatening cause; total phosphorus (limiting nutrient) only
OH50 9	Little Beaver Ck		Cause unknown	Partially	See App F; TMDL endpoints but not allocations included
			Unknown Toxicity	Partially	See App F; TMDL endpoints but not allocations included
			Metals	Partially	See App F; TMDL endpoints but not allocations included
			Ammonia	✓	Included in point source allocations
			Habitat alteration	✓	Not a load based parameter; allocations included
OH50 12-155	Cedarville Reservoir		*Nutrients*	✓	Threatening cause; total phosphorus (limiting nutrient) only
			Suspended Solids	✓	Threatening cause
			Taste/Oder	Partially	Tastes/Odors due to eutrophication should be reduced as nutrients/TSS are
			Metals	No	Threatening cause, will be addressed later if necessary

Table 2. Summary of the 1998 303(d) listed segments included in this TMDL report[1]

Ident-ification #	Waterbody	Segment Description	Major causes 303(d)	Included in this report? [3]	Notes
OH50 12-155 (continued)	Cedarville Reservoir		*Other Inorganics*	No	Threatening cause, will be addressed later if necessary
			Pesticides	No	Threatening cause, will be addressed later if necessary
05090202 030	Little Miami R (below Beaver Ck to above Caesar Ck)				Impairment Rank[2] 8
OH50 4	LMR	Beaver Ck to Glady Run	Ammonia	✓	Included in point source allocations
			Nutrients	✓	Total phosphorus (limiting nutrient) only
			Dissolved Oxygen	✓	Not a load based parameter; allocations included
			Suspended solids	✓	
OH50 1	LMR	Glady Run to Caesar Ck	Nutrients	✓	Total phosphorus (limiting nutrient) only
OH50 5	Glady Run		Chlorine	No	No violations of criteria found; this cause no longer contributes to the impairment
			Nutrients	✓	Total phosphorus (limiting nutrient) only
			Flow alteration	No	This cause no longer contributes to the impairment
OH50 5.1	Glady Run Swale		Nutrients	No	This stream is now captured by Glady Run due to a washout in the old railroad grade. It no longer exists as a separate stream.
			Habitat alteration	No	
OH50 2	Newman Run		Flow alteration	☺	Full attainment of WQS reached based on the 1998 LMR re-assessment; no TMDL needed. Aquatic life use designation improved from WWH to EWH. Delisting recommended.
OH50 1-394	Spring Valley Lake		Dissolved Oxygen	✓	Not a load based parameter; allocations included
05090202 050	Caesar Ck (except Anderson Fork)				Impairment Rank[2] 13
OH51 2	Flat Fork		Nutrients	✓	Total phosphorus (limiting nutrient) only
			Dissolved Oxygen	✓	Not a load based parameter; allocations included
OH51 1	Caesar Ck	Anderson Fk to LMR	Unknown cause	✓	Nutrient enrichment and sediment were identified as the major causes in 1998
05090202 040	Anderson Fork (Caesar Creek watershed)				Impairment Rank[2] 15
OH51 7	Anderson Fork	Grog Run to Caesar Lake	Unknown cause	✓	Sedimentation has been identified as a cause of impairment in 1998

[1] The 1998 303(d) list was based on data collected in 1993. This report also includes more current data collected in 1998 after the 303(d) list was complete.

[2] The impairment rank is Ohio EPA's prioritization of the various impaired subwatersheds; refer to Ohio EPA's 303(d) list available at: http://www.epa.state.oh.us/dsw/tmdl/303dnotc.html for more information.

[3] TMDL numbers are included for total phosphorus and sediment. Low D.O. and altered habitat are not load based causes of impairment. Allocations for factors affecting instream D.O. (TP, NH_3,$cBOD_5$, D.O., shading) and habitat (components of the QHEI scores) are included and are considered to be a parallel concept to a 'TMDL' for load-based parameters.

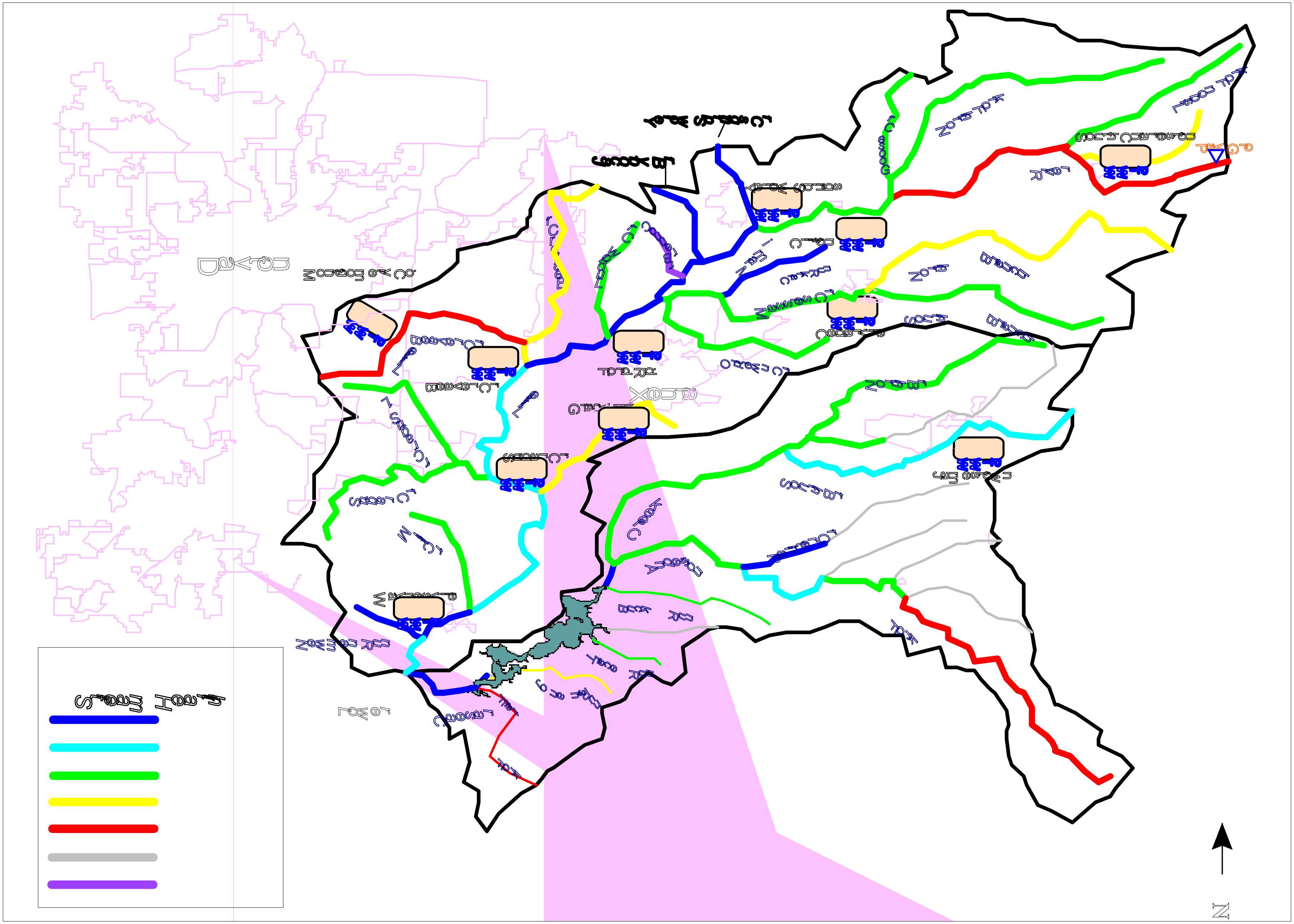


Figure 1. Informational graphic summarizing the 1998 waterbody assessment of the upper Little Miami River basin.

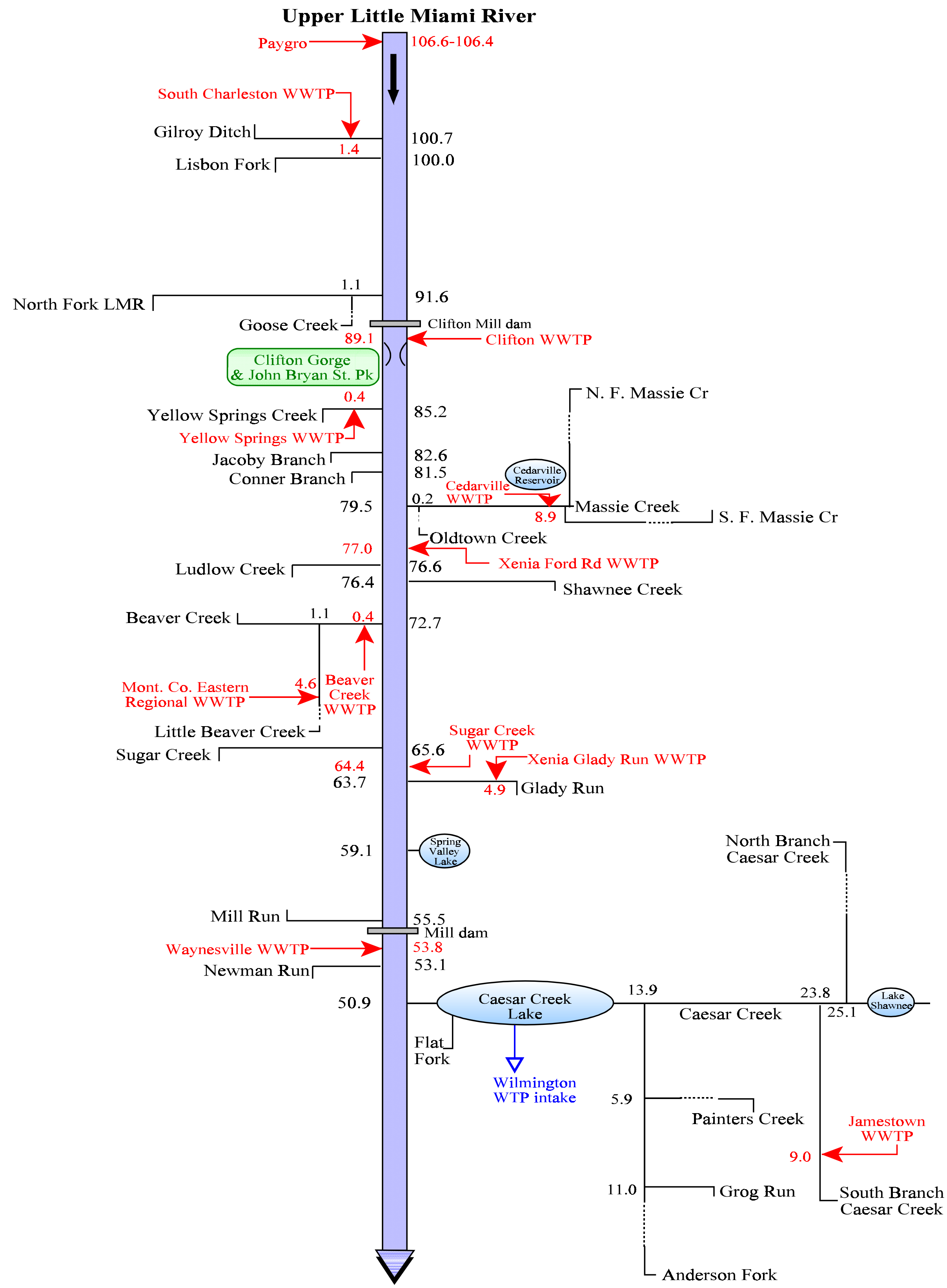


Figure 2. Schematic representation of the upper Little Miami River watershed

2.0 WATERBODY OVERVIEW

2.1 Description of the Study Area

The Little Miami River (LMR) is located in southwestern Ohio in the Ohio River drainage basin. The portion of the LMR basin covered by this TMDL includes the catchment area upstream from, and including, the Caesar Creek subbasin (Figures 1 and 2). Covering portions of six counties (Clark, Greene, Warren, Clinton, Montgomery, and Madison) and draining approximately 657 square miles, the topography of this northern section has been influenced by glaciation which left distinctive land forms and thick deposits of silt, sand, and gravel. Within the Eastern Corn Belt Plains (ECBP) ecoregion, the watershed (excluding Clifton Gorge) is characterized by level to gently sloping land. In addition to Caesar Creek (drainage area of 242 square miles), major tributaries include Massie Creek and Beaver Creek. Impoundments in the watershed include Caesar Creek Reservoir (6,110 acres) and Lake Shawnee (190 acres) on Caesar Creek and the Clifton dam (RM 89.15) and Corwin lowhead dam (RM 55.3) on the LMR mainstem.

Designated a State and National Scenic River, the Little Miami River mainstem contains some of Ohio's most scenic and diverse riverine habitat and is a popular recreational resource. Additionally, the LMR flows atop a buried valley aquifer composed of highly permeable sands and gravel. This aquifer is the major water source for the area and has been designated a Sole Source Aquifer by the United States Environmental Protection Agency (USEPA). The City of Wilmington, located outside the study area, also utilizes water from Caesar Creek Reservoir.

Excluding the Dayton-Xenia corridor where population density and urban land use is highest, land use is comprised mostly of agriculture. Residential and commercial development pressures, however, continue to rapidly increase throughout much of the watershed. This change in land use is reflected in both point and nonpoint source impacts to the watershed.

2.2 Water Quality and Biological Assessment

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 goal of "swimable/fishable" waters. Table 3 provides a brief description of Ohio's water quality standards. Further information is available in Chapter 3745-1 of the Ohio Administrative Code (OAC) (http://www.epa.state.oh.us/dsw/wqs/criteria.html).

In the LMR study area, the aquatic life use designations that apply to various segments are Warmwater Habitat (WWH) and Exceptional Warmwater Habitat (EWH). Waters designated as WWH are capable of supporting and maintaining a balanced integrated community of warmwater aquatic organisms (Note: a Coldwater Habitat is a trout stream). Waters designated as EWH are capable of supporting "exceptional or unusual" assemblages of aquatic organisms which are characterized by a high diversity of species, particularly those which are highly pollutant intolerant and/or are rare, threatened, or endangered. Attainment of aquatic life uses is measured in two ways. The first is criteria in the WQS for various pollutants are compared to measurements taken from the water to determine attainment for

Table 3. Summary of the components and examples of Ohio's Water Quality Standards.

WQS Components	Examples of:	Description
Beneficial Use Designation	1. Water supply • Public (drinking) • Agricultural • Industrial 2. Recreational contact • Beaches (Bathing waters) • Swimming (Primary Contact) • Wading (Secondary Contact) 3. Aquatic life habitats (partial list): • Exceptional Warmwater (EWH) • Warmwater (WWH) • Modified Warmwater (MWH) • Limited Resource Water (LRW) • State Resource Water	Designated uses reflect how the water is potentially 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 (they are water body specific). Each use designation has an individual set of numeric criteria associated with it, which are necessary to protect the use designation. For example, a water that was designated as a drinking water supply and could support exceptional biology would have more stringent (lower) allowable concentrations of pollutants than would the average stream. Recreational uses indicate whether the water can potentially be used for swimming or if it may only be suitable for wading.
Numeric Criteria	1. Chemical	Represents the concentration of a pollutant that can be in the water and still protect the designated use of the waterbody. Laboratory studies of organism's sensitivity to concentrations of chemicals exposed over varying time periods form the basis for these.
	2. Biological *Measures of fish health:* • Index of Biotic Integrity • Modified Index of Well Being *Measure of bug (macroinvertebrate) health:* 1. Invertebrate Community Index	Indicates the health of the instream biological community by using these 3 indices (measuring sticks). The numeric biological criteria (biocriteria) were developed using a large database of reference sites.
	3. Whole Effluent Toxicity (WET)	Measures the harmful effect of an effluent on living organisms (using toxicity tests).
	4. Bacteriological	Represents the level of bacteria protective of the potential recreational use.
Narrative Criteria (Also known as 'Free Froms')	General water quality criteria that apply to all surface waters. These criteria state that all waters shall 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.	

specific pollutants. The second way attainment is determined is by directly measuring fish and aquatic insect populations to see if they are comparable to those seen in least impacted areas of the same ecological region and aquatic life use. Attainment benchmarks from these least impacted areas are established in the WQS in the form of "biocriteria", which are then compared to the measurements obtained from the study area. If measurements of a stream do not achieve the three biocriteria (fish: Index of Biotic Integrity (IBI) and modified Index of Well-being (MIwb); aquatic insects: Invertebrate Community Index (ICI)) the stream is considered in "non attainment". If the stream measurements achieve some of the biological criteria, but not others, the stream is said to be in "partial-attainment". A stream that is in "partial attainment" is not achieving its designated aquatic life use, whereas a stream that meets all of the biocriteria benchmarks, it is said to be in full attainment.

Another type of use in the WQS is for recreational purposes. The recreational use for the majority of the LMR study area is Primary Contact Recreation (PCR). The criterion for the PCR designation is simply having a water depth of at least one meter over an area of at least 100 square feet or where canoeing is a feasible activity. If a water body is too small and shallow to meet either criterion, the Secondary Contact Recreation (SCR) use applies. The attainment status of PCR and SCR is determined using bacterial indicators; the criteria for each are specified in the Ohio WQS.

For the upper LMR TMDL, Ohio EPA conducted a detailed assessment of chemical (water column, effluent, sediment), physical (flows, habitat), and biological (fish and aquatic insect) conditions in order to determine if streams and rivers in the study area were attaining their designated uses. The basis for the listing of the upper LMR on the 303(d) list is the measurements that were obtained in an assessment conducted in 1993 (OEPA, 1995). Ohio EPA re-assessed the LMR study area in 1998 (OEPA, 2000). This TMDL report addresses both the results in the 303(d) list based on 1993 data and the results of the 1998 assessment. However, greater weight is given to the 1998 data, as it is most reflective of current watershed conditions. An aquatic life use attainment table for the LMR study area (Table 4) is provided and is based on the 1998 sampling results; this data was not available for the 1998 303(d) list but will be used in the next listing cycle. The table is arranged from upstream to downstream and includes sampling locations indicated by river mile (RM), the applicable biocriteria indices, the use attainment status (i.e. full, partial, or non), the Qualitative Habitat Evaluation Index (QHEI) (an indicator of habitat quality), and comments for the sampling location. Where the aquatic life use designation (WWH or EWH), as determined by the 1998 assessment, is different than the use designation in effect prior to the 1998 survey, Table 4 provides the attainment status for both the existing and the recommended use designation.

Table 4. Aquatic life use attainment status for stations sampled in the Little Miami River basin July-September, 1998. The Index of Biotic Integrity (IBI), Modified Index of well being (MIwb), and Invertebrate Community Index (ICI) are scores based on the performance of the biotic community. The Qualitative Habitat Evaluation Index (QHEI) is a measure of the ability of the physical habitat to support a biotic community. This data was not available in time for the 1998 303(d) list.

River Mile Fish/Invert.	IBI	MIwb[a]	ICI[b]	QHEI	Attainment Status[c]	Comment
Little Miami River (11-001)						
Eastern Corn Belt Plain EWH (existing)/WWH proposed						
--/106.8	--	--	P*	--	(NON)/(NON)	Ust Pay Gro (Garick Corp.)
104.9	28*	NA	P*	47.5	NON/NON	Dst Pay Gro (Garick Corp.)
101.3/101.8	41*	NA	18*	44.5	NON/Partial	Dst Pay Gro/ Ust Gilroy D
98.3/98.8	37*	7.6*	44^{ns}	54.0	Partial/Partial	Dst Gilroy Ditch
Eastern Corn Belt Plain EWH (existing)						
92.2/92.1	41*	7.8*	50	67.0	Partial	Ust Clifton WWTP
--/88.0	--	--	G*	--	(NON)	Dst Clifton WWTP
85.4/85.3	38*	7.8*	38*	68.0	NON	Ust Yellow Springs Cr
83.1^{A}	48	9.8	40*	81.5	Partial	Dst Yellow Springs Cr
83.1^{D}	48^{ns}	9.0^{ns}	40*	81.5	Partial	Dst Yellow Springs Cr
80.6^{A}	44^{ns}	9.2^{ns}	48	79.0	Full	Ust Xenia Ford WWTP
80.6^{D}	46^{ns}	9.2^{ns}	48	79.0	Full	Ust Xenia Ford WWTP
--/77.1	--	--	E	--	(Full)	Ust Xenia Ford WWTP
77.0	*39*	*9.0*	*F/G*	--	*NA*	*Xenia Ford WWTP mix zone*
76.8/76.9	47^{ns}	9.3^{ns}	50	79.5	Full	Dst Xenia Ford WWTP
--/74.6	--	--	52	--	(Full)	Ust Beaver Cr
72.3	48	9.2^{ns}	46	82.0	Full	Dst Beaver Cr
69.3/69.9	47^{ns}	9.0*	46	79.0	Partial	
--/66.9	--	--	46	--	(Full)	
65.6/64.5	43*	8.8*	50	77.0	Partial	Ust Sugar Cr WWTP
64.4	*34*	*8.0*	*P/MG*	--	*NA*	*Sugar Cr WWTP mix zone*
64.2	42*	9.2^{ns}	46	74.5	Partial	Dst Sugar Cr WWTP
63.3/63.0	44^{ns}	8.8*	56	78.0	Partial	Dst Glady Run
59.8/60.9	44^{ns}	9.1^{ns}	56	77.0	Full	
54.0/54.3	50	9.5^{ns}	VG	--	Full	Ust Waynesville WWTP
53.6/53.2	39*	8.8*	44^{ns}	65.0	Partial	Dst Waynesville WWTP
51.2/50.7	46^{ns}	9.5^{ns}	48	85.5	Full	
Interior Plateau EWH (Existing)						
45.7/47.5	42*	9.3^{ns}	52	78.5	Partial	
Gilroy Ditch (11-044) *Eastern Corn Belt Plain WWH (existing)*						
1.5	32*	NA	G	62.0	Partial	Ust S. Charleston WWTP
1.3	40	NA	F*	59.0	Partial	Dst S. Charleston WWTP
0.5/0.4	42	NA	28*	49.0	Partial	
Lisbon Fork (11-043) *Eastern Corn Belt Plain WWH (existing)*						
0.4	40	NA	E	52.0	Full	

Table 4. (Continued)

River Mile Fish/Invert.	IBI	MIwb[a]	ICI[b]	QHEI	Attainment Status[c]	Comment
North Fork Little Miami (11-041) *Eastern Corn Belt Plain WWH (existing)*						
7.1	40	NA	G	54.0	Full	
2.6/0.3	42	NA	E	43.0	Full	
Goose Creek (11-042) *Eastern Corn Belt Plain WWH (existing)*						
--/0.8	--	--	MG		(Full)	
Yellow Springs Creek (11-040) *Eastern Corn Belt Plain EWH (existing)*						
0.1	52	NA	50	70.5	Full	Dst Yellow Springs WWTP
Jacoby Branch (11-039) *Eastern Corn Belt Plain WWH (existing)/EWH proposed*						
0.3/0.5	48	NA	E	67.5	Full /Full	
Conner Branch (11-038) *Eastern Corn Belt Plain WWH (existing)/CWH proposed*						
0.1	50	NA	E	76.5	Full /Full	
Massie Creek (11-400) *Eastern Corn Belt Plain WWH (existing)*						
7.7	42	9.1	46	88.0	Full	Dst Cedarville WWTP
5.6/5.5	42	8.4	46	82.5	Full	
4.3/4.4	38[ns]	7.8[ns]	44	88.0	Full	
1.2	42	7.8[ns]	46	80.5	Full	
North Fork Massie Creek (11-403) *Eastern Corn Belt Plain WWH (existing)*						
5.9/7.9	36[ns]	NA	G	33.5	Full	
1.2/1.1	34*	8.6	E	63.5	Partial	
South Fork Massie Creek (11-404) *Eastern Corn Belt Plain WWH (existing)*						
2.3/2.1	40	NA	E	44.5	Full	
0.3/0.2	36[ns]	NA	VG	56.0	Full	
Trib. to Massie Creek @ RM 5.3 (11-405) *Eastern Corn Belt Plain EWH (proposed)*						
--/0.3	--	--	E	--	(Full)	
Clark Run (11-402) *Eastern Corn Belt Plain WWH (existing/EWH proposed)*						
0.5	50	NA	VG	74.0	Full /Full	
Oldtown Creek (11-401) *Eastern Corn Belt Plain WWH (existing)*						
0.1/0.4	50	NA	G	61.5	Full	
Ludlow Creek (11-037) *Eastern Corn Belt Plain WWH (existing)*						
0.2	36[ns]	NA	G	42.5	Full	

Table 4. (Continued)

River Mile Fish/Invert.	IBI	MIwb[a]	ICI[b]	QHEI	Attainment Status[c]	Comment
Shawnee Creek (11-045) *Eastern Corn Belt Plain WWH (existing)*						
0.7	48	NA	G	85.5	Full	
Beaver Creek (11-035) *Eastern Corn Belt Plain WWH (existing)*						
6.1	26*	NA	P*	35.0	NON	
3.9/4.0	38[ns]	NA	36	37.5	Full	
1.6	28*	6.6*	36	57.0	Partial	Ust Little Beaver Cr
0.5	32*	7.4*	48	76.0	Partial	Dst L Beaver Cr/Ust WWTP
0.4	*37*	*7.3*	*F*	*NA*		*Beaver Cr WWTP mix zone*
0.3	30*	7.1*	42	70.5	Partial	Dst Beaver Cr WWTP
Little Beaver Creek (11-036) *Eastern Corn Belt Plain WWH (existing)*						
--/6.1	--	--	P*	--	(NON)	
4.7	30*	NA	30*	58.5	NON	Ust E. Regional WWTP
4.6	*24*	*NA*	*VP/P*	*NA*		*E Regional WWTP mix zone*
3.5	29*	NA	20*	60.0	NON	Dst E Regional WWTP
--/2.0	--	--	22*	--	(NON)	
0.1	31*	6.3*	22*	62.0	NON	
Unnamed trib to Little Beaver @ RM 6.1 (11-056) *Eastern Corn Belt Plain WWH (existing)*						
--/0.3	--	--	P*	--	(NON)	
Trib. to Little Miami River @ RM 69.85 (11-055) *ECBP WWH (proposed)*						
--/0.1	--	--	VG	--	(Full)	
Sugar Creek (11-033) *Eastern Corn Belt Plain WWH (existing)*						
2.4/2.2	46	NA	G	71.5	Full	
0.4/0.3	44	8.2	G	71.5	Full	
Little Sugar Creek (11-034) *Eastern Corn Belt Plain WWH (existing)*						
0.5	50	NA	G	56.5	Full	
Glady Run (11-032) *Eastern Corn Belt Plain WWH (existing)*						
5.8	36[ns]	NA	34[ns]	51.5	Full	Ust Xenia Glady Rn WWTP
4.9	*31*	*NA*	*VP*	*NA*		*Xenia Glady Run WWTP mz*
4.0	33*	NA	28*	66.5	NON	Dst Xenia Glady Rn WWTP
2.1	37[ns]	NA	42	67.5	Full	
Trib. to Little Miami River @ RM 62.01 (11-054) *ECBP WWH (proposed)*						
0.6/0.5	48[ns]	NA	G	71.0	Full	

Table 4. (Continued)

River Mile Fish/Invert.	IBI	MIwb[a]	ICI[b]	QHEI	Attainment Status[c]	Comment
Trib. to Little Miami River @ RM 60.05 (11-053) *ECBP EWH (proposed)*						
0.2	48^{ns}	NA	VG	67.0	Full	
Mill Run (11-031) *Eastern Corn Belt Plain WWH (existing)*						
0.9/--	44	NA	--	61.5	(Full)	
Newman Run (11-030) *Eastern Corn Belt Plain WWH (existing)/EWH proposed*						
0.3	54	NA	VG	61.5	Full /Full	
Caesar Creek (11-300)						
Eastern Corn Belt Plain EWH (existing)/WWH proposed						
26.5	42^{*}	NA	G^{*}	65.5	NON/Full	Shawnee Hills Unsewered
Eastern Corn Belt Plain EWH (existing)						
23.1	36^{*}	7.6^{*}	G^{*}	70.5	NON	
16.6/16.5	48^{ns}	9.8	VG	72.0	Full	
Eastern Corn Belt Plain WWH (existing)/EWH proposed						
0.2	48^{ns}	8.5^{*}	44^{ns}	95.0	Full/Partial	
North Branch Caesar Creek (11-312) *ECBP EWH (existing/WWH proposed)*						
6.1/6.7	36^{*}	NA	G^{*}	61.0	NON /Full	
1.2	48^{ns}	9.5	G^{*}	56.0	Partial/Full	
South Branch Caesar Creek (11-311)						
Eastern Corn Belt Plain WWH (existing)						
--/8.2	--	--	G	--	Full	
Eastern Corn Belt Plain WWH (existing)/EWH proposed						
2.1	56	NA	VG	67.0	Full	
Anderson Fork (11-306)						
Eastern Corn Belt Plain WWH (existing)						
18.8	26^{*}	6.7^{*}	G	46.5	NON	
13.9	38^{ns}	8.6	G	64.0	Full	
Eastern Corn Belt Plain EWH (existing)						
9.4/9.5	50	9.8	G^{*}	74.5	Partial	
5.0/4.9	40^{*}	8.2^{*}	VG	63.0	Partial	
Painters Creek (11-307) *Eastern Corn Belt Plain EWH (existing)/WWH proposed*						
0.4	46^{ns}	NA	VG	64.5	Full /Full	
Buck Run (11-305) *Eastern Corn Belt Plain WWH (existing)*						
1.6/1.2	42	NA	G	73.5	Full	

Table 4. (Continued)

River Mile Fish/Invert.	IBI	MIwb[a]	ICI[b]	QHEI	Attainment Status[c]	Comment
Trace Run (11-303) *Eastern Corn Belt Plain WWH (existing)*						
1.8	44	NA	G	67.0	Full	
Jonahs Run (11-302) *Eastern Corn Belt Plain WWH (existing)*						
1.3/2.1	28*	NA	MG	40.5	Partial	
Flat Fork (11-301) *Eastern Corn Belt Plain WWH (existing)*						
1.7	<u>18</u>*	NA	G	44.0	NON	

	Biological Criteria					
	Eastern Corn Belt Plains (ECBP)			Interior Plateau (IP)		
Index-Site Type	EWH	WWH	MWH	EWH	WWH	MWH
IBI-Headwaters	50	40	24	50	40	24
IBI-Wading	50	40	24	50	40	24
IBI-Boat	48	42	24	48	38	24
MIwb-Wading	9.4	8.3	6.2	9.4	8.1	6.2
MIwb-Boat	9.6	8.5	5.8	9.6	8.7	5.8
ICI	46	36	22	46	30	22

a The Modified Index of Well-being is not applicable (NA) to headwater site types.
b A qualitative narrative evaluation used when quantitative data were not available or unreliable due to current velocities less than 0.3 fps flowing over the artificial substrates (P = Poor, F = Fair, MG = Marginally Good, G = Good, VG = Very Good, E = Exceptional).
c Use attainment status based on one organism group is parenthetically expressed.
A Boat sampling method
D Wading method
* Indicates significant departure from applicable biocriteria (>4 IBI or ICI units, or >0.5 MIwb units). Underlined scores are in the Poor or Very Poor range.
ns Nonsignificant departure from biocriteria (≤4 IBI or ICI units, or ≤0.5 MIwb units).
d Modified Warmwater Habitat criteria for channel modified habitats.

2.3 Causes and Sources of Impairment

The determination of impairment in rivers and streams in Ohio is straightforward – the numeric biocriteria are the principal arbiter of aquatic life use attainment and impairment. The rationale for using biocriteria has been extensively discussed elsewhere (Karr, 1991; OEPA, 1987a,b; Yoder, 1989; Miner and Borton, 1991; Yoder, 1991).

Ohio EPA relies on an interpretation of multiple lines of evidence including water chemistry, sediment, habitat, effluent and land use data, biomonitoring results, and biological response to describe the causes (e.g., nutrients) and sources (e.g. agricultural runoff, municipal point sources, septic systems) associated with observed impairments. The initial assignment of the principal causes and sources of impairment that appear on the section 303(d) list do not necessarily represent a true "cause and effect" relationship. Rather they represent the association of impairments (based on response indicators) with stressor and exposure indicators whose links with the survey data are based on previous experience with similar situations and impacts. The reliability of the identification of probable causes and sources is increased where many such prior associations have been identified.

The Little Miami River watershed is impacted by both point (e.g., municipal wastewater treatment plants) and nonpoint (e.g., runoff from crops and city streets) sources. Table 6 details the causes and sources of impairment per stream and stream segment. Physical habitat attributes in most of the mainstem and tributaries typically include natural stream channels, coarse substrates and wooded riparian corridors. Channelization for agricultural land use in the northern and eastern portions of the TMDL study area has resulted in streams denuded of riparian vegetation, sedimentation, simplified habitat, and has exacerbated nutrient enrichment. Impacts from urban land use typically arise from associated wastewater loadings and storm water runoff. Cumulative annual (median) effluent flow to the upper watershed from eleven municipal wastewater treatment plants approached 28 million gallons per day in 1998 (Table 7). In addition to increasing volumes of wastewater, changing land use patterns are also altering the rates and types of nonpoint pollutants discharged within the watershed. The land use distribution for the watershed is shown in Table 5 and Figure 3. Land cleared for construction can result in greatly accelerated rates of erosion and sedimentation of streams especially when sediment control measures are inadequate. Additionally, increased impervious surface area and stormwater drainage systems typically follow new development and result in increased rates and volume of runoff that contribute a variety of pollutants including solids, nutrients, oils, and pesticides to streams.

<u>*Little Miami River (Headwaters to North Fork) and Gilroy Ditch*</u>

Land use in the headwaters of the Little Miami River is primarily agricultural. This reach is impaired by habitat modifications, unfenced livestock, sedimentation, and lack of riparian buffers. Nutrient enrichment from agricultural runoff, the South Charleston WWTP, and Pay Gro is resulting in wide diel swings in dissolved oxygen concentrations by stimulating algal blooms. Concentrations of dissolved oxygen are falling below the 4.0 ppm needed to support a diverse fish and macroinvertebrate community. The effects of nutrient enrichment throughout this reach are exacerbated by lack of riparian buffers. The same suite of factors (excluding PayGro and the animal feeding operation) are also impairing Gilroy Ditch.

A large animal feeding operation, owned by Ohio Feedlot Acquisition, Inc. is located on the east side of the PayGro facility on Huntington Road. The facility was built in the 1960's and closed for several years in the early-mid 1990s. It is now back in operation and typically houses around 5,000-6,000

feeder cattle. The site currently contains seven buildings that have the capacity to house 9,800 head of cattle, but the owner has submitted a permit application to Ohio EPA requesting an expansion up to 16,100 head. Historically, most of the manure from this facility has been composted and sold off-site by PayGro. Contaminated discharges have been documented from this area, and Ohio EPA has begun working with Ohio Feedlots to minimize the impacts from their site. The two owners (PayGro and Ohio Feedlot Acquisitions, Inc.) are reportedly discussing methods of separating stormwater flows to ensure that future regulatory actions are correctly targeted. Ohio EPA has requested that Ohio Feedlots submit an NPDES permit application, and anticipates working with PayGro to develop their NPDES permit in the near future.

Beaver Creek

Biological communities in the upper reaches of Beaver Creek are impaired by nonpoint pollution derived from intensive land use and poor habitat. Portions of the creek have been historically channelized for drainage, riparian buffers in many sections are narrow or absent, and land use immediately adjacent to the creek channel is intense, ranging from residential, to commercial, to agricultural (including nursery, row crop and livestock production). Loadings from the Montgomery County Eastern Regional WWTP (discharge to Little Beaver Creek) and the Greene County Beaver Creek WWTP contribute to nutrient enrichment and impact the lower reaches of Beaver Creek. The annual median phosphorus loading from these two facilities in 1998 approximated 97 kg/day (~56 percent of the total municipal point source load to the TMDL study area) (OEPA, 2000).

Little Beaver Creek

The Little Beaver Creek is impaired by a variety of factors. In the headwaters, the predominant factors impacting the biological community are urban runoff and channelization. Further downstream, this tributary receives the Montgomery County Eastern Regional WWTP discharge at RM 4.58. The impact on the stream from this facility, the largest discharger in the upper LMR basin with a design flow of 13.0 MGD (Table 7), is evidenced by the elevated levels of nutrients extending downstream of the outfall to the mouth and into Beaver Creek. Additionally, despite no measured significant toxicity in several whole effluent toxicity tests (Aug-1993, Dec-1995, June and Nov-1997, March-1998), a toxic impact to Little Beaver Creek by the Montgomery County Eastern Regional WWTP was evident in the mixing zone macroinvertebrate community during the 1998 survey.

Contaminated sediments were also a cause of biological impairment. A variety of polynuclear aromatic hydrocarbons (PAHs) were detected in sediments collected throughout Little Beaver Creek and were present in concentrations likely to impair the benthic community according to guidelines listed by Persaud et al. (1994). The source of the PAHs is thought to be primarily urban storm water. In addition to PAHs, priority volatile organic compounds (*e.g.*, ethylbenzene, naphthalene, etc.) were detected in Little Beaver Creek sediments immediately downstream from the old Lammars Barrel factory (RM 3.4). Elevated concentrations of metals, including mercury and cadmium, have also been documented in Little Beaver Creek sediments. (TMDL endpoints for metals and organic compounds in the Little Beaver Creek subbasin are modeled and discussed separately (Appendix F)).

Anderson Fork

Sedimentation is the primary cause of biological impairment to Anderson Fork. Secondary effects of nutrient enrichment were also evident as shown by the elevated phosphorus concentrations and low dissolved oxygen concentrations measured in daytime samples. The sediment is derived from agricultural runoff and bank erosion due to removal of riparian vegetation and livestock access.

Little Miami R (N. Fork to Caesar Ck), Spring Valley Lake and Caesar Ck (S. Branch to Caesar Lake)

Nutrient enrichment, and secondarily, sedimentation were factors in the wide-spread partial attainment of the EWH aquatic life use designation for the Little Miami River downstream from the North Fork (river miles 91.64 through 50.9), and for the Caesar Creek EWH designated segment from the South Branch Caesar Creek to Caesar Creek Reservoir. Wide diel swings, or critically low overnight concentrations of dissolved oxygen concentrations resulting from excessive algal abundance were observed in the Little Miami River mainstem from the headwaters downstream to Spring Valley (river mile 60), and in Caesar Creek upstream from the reservoir. The nutrient enrichment and sedimentation effecting these segments is derived from wastewater loadings, failing septic systems, livestock and row crop production, bank erosion, and construction site runoff.

North Fork Massie Creek, Cedarville Reservoir and Glady Run

Portions of the North Fork Massie Creek are impaired by sedimentation resulting from channelization and lack of riparian buffers thereby acting as nutrient-rich sediment conduits to the Cedarville Reservoir. Nutrient enrichment from agricultural runoff is evidenced by algal blooms and daytime supersaturated dissolved oxygen concentrations. The effects of nutrient enrichment are exacerbated by the minimal riparian and open canopy. Wastewater loadings and the resulting nutrient enrichment contribute to the non-attainment in Glady Run.

Flat Fork

A general improvement in water chemistry was observed in the 1998 data from the 1993 data. The 1998 303(d) list (which was based on the 1993 data) indicates that nutrients and organic enrichment/dissolved oxygen are the impairing causes; however, this was not confirmed in the 1998 data. The stream is intermittent and with little flow it is naturally limited. This is the only identified impairing cause based on the most current data available.

Table 5. Land use distribution in the upper LMR Basin

Land Use	**Acres**	**% of Total**
Open Water	3784	0.90%
Low Intensity Residential	23508	5.60%
High Intensity Residential	2282	0.54%
Commercial/ Industrial	5066	1.21%
Barren/ Transitional	551	0.13%
Deciduous Forest	45457	10.83%
Evergreen Forest	1209	0.29%
Mixed Forest	159	0.04%
Pasture/Hay	83282	19.84%
Row Crops	247426	58.93%
Urban/ Recreational Grasses	6193	1.48%
Woody Wetlands	689	0.16%
Emergent Herbaceous Wetlands	238	0.06%
Total:	**419844**	**100.00%**

Source: 1992 Ohio National Land Cover Data (NLCD) (based on 1991 data)

Figure 3. Upper Little Miami River Watershed Land Use/Cover Map

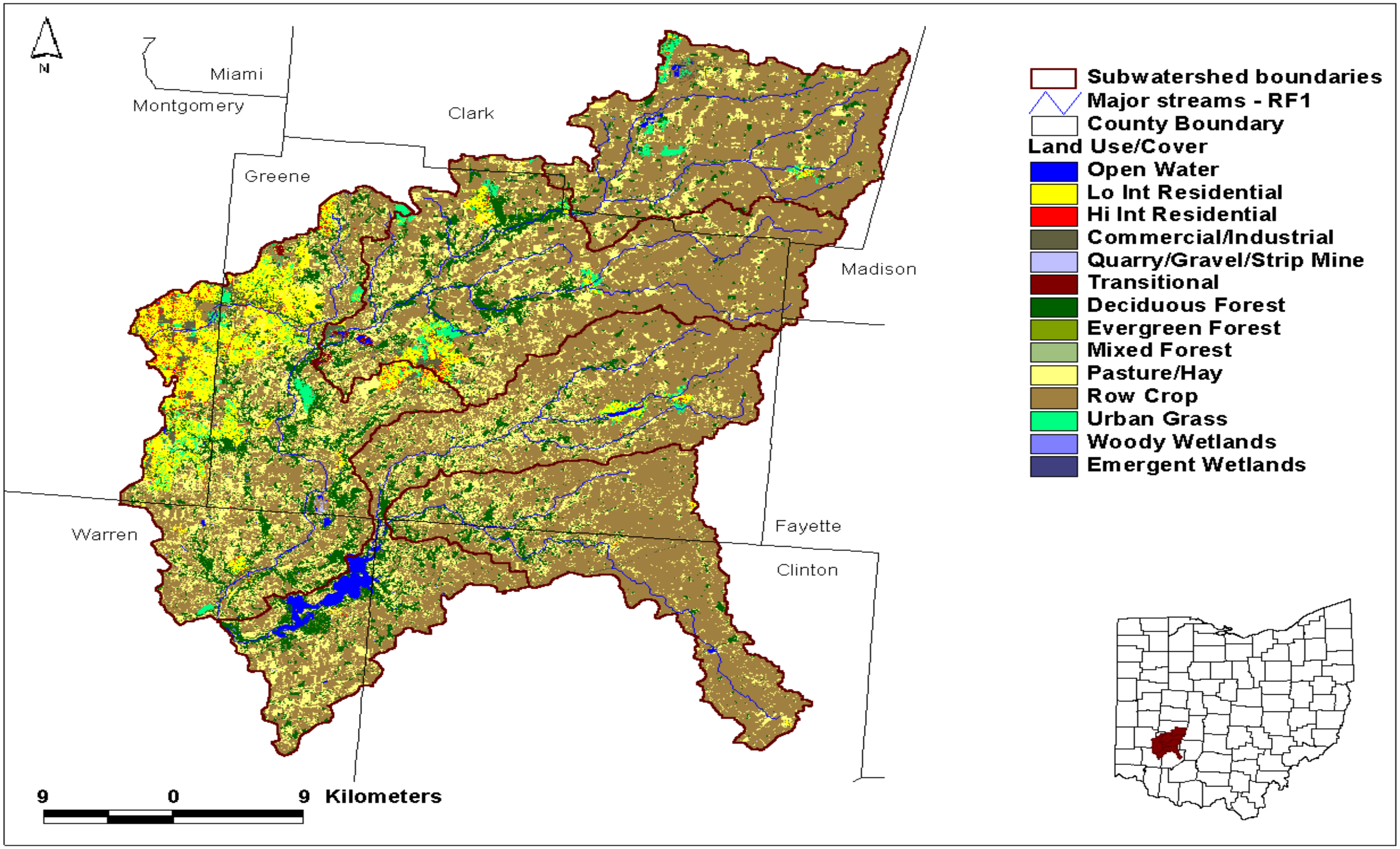


Table 6. Causes and sources of impairment in the upper Little Miami River Basin

Stream Segment \ Water Body ID# [upper River Mile/Lower River Mile]	**Segment Listed in 1998 303 (d)?**	**Aquatic Life Use Designation** [1] <u>*303 (d) list*</u> 1998 survey	**Attainment Status (Miles/Acres)** [1] Full	Full but Threatened	Partial	NON	**Causes of Impairment** [2]	**Sources of Impairment** [2]
Little Miami River \ OH50 23 (Headwaters to North Fork) [106.8/91.64]	YES	<u>*EWH*</u> WWH	*0.00* 0.00	*0.00* 0.00	*10.50* 10.20	*0.00* 5.00	**Nutrients-H** **Organic enrichm't/DO-H** **Siltation-M** **Habitat Alteration-M** **Pathogens**-T *H* Pesticides-S *Ammonia-H* *Chlorine-M* *Suspended Solids-M*	Point Source-M **Minor Muni Point Source**-M *H* **Agriculture-H** Non-irrigated crop production-H **Range land-H** **Removal of riparian vegetat'n-H** Channelization-agriculture-H *Manure Lagoons-H*
Little Miami River \ OH50 17 (North Fork to Massie Creek) [91.64/79.50]	YES	<u>*EWH*</u> EWH	*0.00* 2.80	*5.90* 0.00	*6.20* 1.50	*0.00* 7.80	**Nutrients-H** **Siltation-M** **Pathogens**-T *H* **Pesticides-S** **Organic enrichm't/DO**-M *H* *Metals-H* *Habitat Alteration-H*	**Minor Muni Point Source**-M *H* **Agriculture-H** Non-irrigated crop production-H *Range land-H* *Manure Lagoons-H* *Removal of riparian vegetat'n-H* *Source Unknown-H* **Land devel'mt/suburbanization-T**
Little Miami River \ OH50 10 (Massie Creek to Beaver Creek) [79.50/72.70]	YES	<u>*EWH*</u> EWH	*0.00* 0.00	*6.80* 6.80	*0.00* 0.00	*0.00* 0.00	**Nutrients-T** Siltation-T Pesticides-T	Agriculture-T Non-irrigated crop production-T **Major Muni Point Source-T** **Land devel'mt/suburbanization-T**
Little Miami River \ OH50 4 (Beaver Creek to Glady Run) [72.70/63.70]	YES	<u>*EWH*</u> EWH	*0.00* 3.20	*6.50* 0.00	*2.50* 5.80	*0.00* 0.00	**Nutrients-H** Siltation-M Pesticides-S **Organic enrichm't/DO-**M *H* *Ammonia-H* *Suspended Solids-H*	**Land devel'mt/suburbanization-**M *T* **Major Muni Point Source-H** Agriculture-M Non-irrigated crop production-M

Table 6. Causes and sources of impairment in the upper Little Miami River Basin

Stream Segment \ Water Body ID# [upper River Mile/Lower River Mile]	**Segment Listed in 1998 303 (d)?**	**Aquatic Life Use Designation** [1] <u>303 (d) list</u> 1998 survey	**Attainment Status (Miles/Acres)** [1]				**Causes of Impairment** [2]	**Sources of Impairment** [2]
			Full	Full but Threatened	Partial	NON		
Little Miami River \ OH50 1 (Glady Run to Caesar Creek) [63.70/50.90]	YES	<u>*EWH*</u> EWH	*0.00* 3.40	*0.30* 0.00	*12.50* 9.30	*0.00* 0.00	**Nutrients-H** Siltation-M **Organic enrichm't/DO-M** Pesticides-S *Suspended Solids-M*	**Major Muni Point Source-H** Agriculture-M Non-irrigated crop production-M
Gilroy Ditch \ OH50 25 [7.15/0.00]	NO	WWH	0.00	0.00	2.00	0.00	Nutrients-H Ammonia-M Organic enrichm't/DO-H Habitat Alteration-M	Minor Muni Point Source-H Channelization-agriculture-M Range Grazing-Riparian-S
North Fk Little Miami R \ OH50 21 [13.20/0.00]	YES	<u>*WWH*</u> WWH	*7.00* 7.50	*0.00* 0.00	*0.00* 0.00	*1.00* 0.00	*Organic enrichm't/DO-H* *Habitat Alteration-H* *Siltation-S*	*Agriculture-H* *Channelization-H*
North Fork Massie Cr \ OH50 15 [12.60/0.00]	NO	WWH	7.00	0.00	1.00	0.00	Siltation-H Organic enrichm't/DO-M	Agriculture-H Non-irrigated crop production-H Channelization-agriculture-M Range grazing-M
South Fork Massie Cr \ OH50 16 [9.60/0.00]	YES	<u>*WWH*</u> WWH	*0.00* 3.00	*0.50* 0.00	*1.00* 0.00	*0.00* 0.00	*Habitat Alteration-H*	*Agriculture-H* *Channelization-H*
Cedarville Reservoir \ OH50 12-155 [5 acres]	YES	*EWH*	*0.00*	*5.00*	*0.00*	*0.00*	*Pesticides-T* *Metals-T* *Other Inorganics-T* *Nutrients-T* *Taste and odor-T* *Nitrite-T*	*Combined Sewer Overflow-T* *Non-irrigated crop production-T* *Pasture Land-T* *Range Land-T* *Other urban runoff-T* *Storm sewers-T* *Onsite wastewater systems-T* *Hazardous waste-T*

Table 6. Causes and sources of impairment in the upper Little Miami River Basin

Stream Segment \ Water Body ID# [upper River Mile/Lower River Mile]	**Segment Listed in 1998 303 (d)?**	**Aquatic Life Use Designation** [1] <u>*303 (d) list*</u> 1998 survey	**Attainment Status (Miles/Acres)** [1]				**Causes of Impairment** [2]	**Sources of Impairment** [2]
			Full	Full but Threatened	Partial	NON		
Ludlow Creek \ OH50 11 [5.35/0.00]	NO	WWH	0.00	0.50	0.00	0.00	Siltation-T	Channelization-agriculture-T Removal of riparian vegetat'n-T Land devel'mt/suburbanization-T
Beaver Creek \ OH50 8 [8.40/0.00]	YES	<u>*WWH*</u> WWH	*0.00* 2.10	*0.00* 0.00	*1.60* 2.70	*0.00* 2.20	Siltation-H **Pathogens-**T *M* *Ammonia-H* **Nutrients-H** **Habitat Alteration-**M *H*	Natural (Wetlands)- M Point Source-S **Major Muni Point Source**-M *H* Agriculture-M Range Grazing-Riparian-M Specialty crop production-S Non-irrigated crop production-M Land Disposal-M **Channelization**-M *H* Land devel'mt/suburbanization-M
Little Beaver Creek \ OH50 9 [9.00/0.00]	YES	<u>*WWH*</u> WWH	*0.00* 0.00	*0.00* 0.00	*0.10* 0.00	*4.60* 9.00	Priority organics-M Cadmium-S Mercury-S Total toxics-M Nutrients-H **Ammonia**-M *H* **Pathogens**-T *M* Pesticides-S **Cause Unknown-H** *Unknown Toxicity-H* *Metals-H* **Habitat Alteration-H**	Contaminated sediments-H **Spills-M** Land Disposal-M **Major Muni Point Source-H** Urban Runoff/Storm Sewers-H **Channelization-M** Land devel'mt/suburbanization-S
Trib to Little Beaver Cr \ OH50 9.2 [2.10/0.00]	NO	WWH	0.00	0.00	0.00	0.80	Habitat Alteration-H Oil & Grease-H Flow Alteration-M Pathogens-T	Major Industrial Point Source-H Urban Runoff/Storm Sewers-H Channelization-development-M Other-H Spills-H

Table 6. Causes and sources of impairment in the upper Little Miami River Basin

Stream Segment \ Water Body ID# [upper River Mile/Lower River Mile]	**Segment Listed in 1998 303 (d)?**	**Aquatic Life Use Designation** [1] <u>*303 (d) list*</u> 1998 survey	**Attainment Status (Miles/Acres)** [1]				**Causes of Impairment** [2]	**Sources of Impairment** [2]
			Full	Full but Threatened	Partial	NON		
Sugar Creek \ OH50 6 [9.60/0.00]	NO	WWH	0.00	3.00	0.00	0.00	Siltation-T Nutrients-T	Construction-T Land devel'mt/suburbanization-T
Little Sugar Creek \ OH50 7 [2.10/0.00]	NO	WWH	0.00	1.00	0.00	0.00	Siltation-T Nutrients-T	Construction-T Land devel'mt/suburbanization-T
Glady Run \ OH50 5 [6.30/0.00]	YES	<u>*WWH*</u> WWH	*0.00* 3.10	*0.00* 0.00	*0.50* 1.40	*4.40* 1.80	Ammonia-H Pesticides-S *Chlorine-H* **Nutrients-H** *Flow Alteration-H* *Pathogens-M*	**Major Muni Point Source-H** *Natural-H*
Glady Run Swale [3] \ OH50 5.1 [0.60/0.00]	YES [3]	*WWH*	*0.10*	*0.00*	*0.10*	*0.00*	*Nutrients-H* *Habitat Alteration-H*	*Major Muni Point Source-H* *Channelization-H*
Spring Valley Lake \ OH50 1-394 [58 acres]	YES	*EWH*	*0.00*	*0.00*	*58.00*	*0.00*	*Organic enrichm't/DO-H* *Pesticides-M* *Nutrients-M* *Siltation-M*	*Subsurface Mining-H* *Agriculture-M*
Newman Run \ OH50 2 [4.00/0.00]	YES	<u>*WWH*</u> EWH	*0.00* 1.00	*0.00* 0.00	*0.30* 0.00	*0.00* 0.00	*Flow Alteration-H*	*Natural-H*
Caesar Creek \ OH51 14 (Headwaters to S.Br. Caesar Cr) [33.98/23.78]	NO	WWH	0.00	4.30	0.00	0.00	Siltation-T Pathogens-T	Onsite wastewater systems-T Construction-T Land devel'mt/suburbanization-T Range Grazing-Riparian-T Removal of riparian vegetat'n-T

Table 6. Causes and sources of impairment in the upper Little Miami River Basin

Stream Segment \ Water Body ID# [upper River Mile/Lower River Mile]	**Segment Listed in 1998 303 (d)?**	**Aquatic Life Use Designation** [1] <u>303 (d) list</u> 1998 survey	**Attainment Status (Miles/Acres)** [1]				**Causes of Impairment** [2]	**Sources of Impairment** [2]
			Full	Full but Threatened	Partial	NON		
Caesar Creek \ OH51 13 (S. Br. Caesar Cr. to Caesar Cr Lake) [23.78/13.92]	NO	EWH	4.1	0.00	2.10	2.50	Siltation-H Pathogens-T Nutrients-H Organic enrichm't/DO-M Pesticides-S	Agriculture-M Land Disposal-M Onsite wastewater systems-M Construction-H Land devel'mt/suburbanization-M
Caesar Creek \ OH51 1 (Caesar Cr Lake to LMR) [13.92/0.00]	YES	<u>*WWH*</u> EWH	*0.00* 0.00	*0.00* 0.00	*0.10* 3.00	*0.00* 0.00	*Cause Unknown-H*	*Source Unknown-H*
North Branch Caesar Cr\ OH51 16 [10.00/0.00]	NO	WWH	0.00	7.00	0.00	0.00	Organic enrichm't/DO-T Siltation-T Nutrients-T	Agriculture-T Removal of riparian vegetat'n-T Range Grazing-Riparian-T
South Branch Caesar Cr \ OH51 15 [11.50/4.00]	NO	WWH	0.00	7.50	0.00	0.00	Siltation-T Pathogens-T Ammonia-T Nutrients-T	Minor Muni Point Source-T Removal of riparian vegetat'n-T
Anderson Fork \ OH51 9 (Headwaters to Grog Run) [19.12/11.02]	NO	WWH	4.20	0.00	1.30	2.60	Siltation-H Pathogens-T Nutrients-M Pesticides-S Suspended Solids-S	Agriculture-H Non-irrigated crop production-H
Anderson Fork \ OH51 7 (Grog Run to Caesar Creek Lake) [11.02/0.00]	YES	<u>*EWH*</u> EWH	*0.00* 0.00	*0.00* 0.00	*0.50* 8.90	*0.00* 2.10	Siltation-M Pathogens-T Nutrients-M Suspended Solids-S *Cause Unknown-H*	Agriculture-H Non-irrigated crop production-H *Source Unknown-H*

Table 6. Causes and sources of impairment in the upper Little Miami River Basin

Stream Segment \ Water Body ID# [upper River Mile/Lower River Mile]	**Segment Listed in 1998 303 (d)?**	**Aquatic Life Use Designation** [1] <u>*303 (d) list*</u> 1998 survey	**Attainment Status (Miles/Acres)** [1]				**Causes of Impairment** [2]	**Sources of Impairment** [2]
			Full	Full but Threatened	Partial	NON		
Flat Fork \ OH51 2 [3.70/0.00]	YES	<u>*WWH*</u> WWH	*0.00* 0.00	*0.00* 0.00	*0.00* 0.00	*1.70* 1.70	*Nutrients-H* *Organic enrichm't/DO-H* **Flow Alteration-**H *M*	*Agriculture-H* **Natural-** H *M*

[1] The <u>Aquatic Life Use Designation and corresponding Attainment Status</u> are given:
(a) as provided in the 1998 303(d) list (*upper italicized type*); and
(b) per the <u>proposed/recommended</u> use designation (with corresponding attainment) as determined by the 1998 Biological and Water Quality Study of the Little Miami River Basin (lower plain type).

[2] Causes and sources of impairment in **bold** type are listed in the 1998 303(d) list and were also identified during the 1998 Biological and Water Quality Study of the Little Miami River Basin; items in *italics* are listed in the 1998 303(d) list only; items in plain type were identified during the 1998 Biological and Water Quality Study of the Little Miami River Basin. The magnitude (i.e. relative contribution) of the cause or source of impairment is estimated as follows:
H-High magnitude M-Moderate magnitude S-Slight Magnitude T-identifies a threat

[3] This stream is now captured by Glady Run due to a washout in the old railroad grade.

Table 7. Municipal wastewater treatment plants in the upper Little Miami River Basin.

Entity	Receiving Stream (RM of discharge)	Design Flow (MGD)	Annual 1998 Median Flow (MGD)
Village of South Charleston WWTP	Gilroy Ditch (RM 1.40)	0.24	0.2
Greene County Clifton WWTP	Little Miami River (RM 89.10)	0.029	0.017
Village of Yellow Springs WWTP	Yellow Springs Creek (RM 0.43)	0.600	0.8
Greene County Cedarville WWTP	Massie Creek (RM 8.95)	0.56	0.4
City of Xenia-Ford Rd WWTP	Little Miami River (RM 77.03)	3.60	2.7
Greene County Beaver Creek WWTP	Beaver Creek (RM 0.40)	8.50	6.2
Montgomery County Eastern Regional WWTP	Little Beaver Creek (RM 4.58)	13.0	8.4
Greene County Sugar Creek WWTP	Little Miami River (RM 64.43)	4.90	6.2
City of Xenia-Glady Run WWTP	Glady Run (RM 4.93)	4.00	2.1
Village of Waynesville WWTP	Little Miami River (RM 53.79)	0.710	0.4
Jamestown WWTP	South Branch Caesar Creek (RM 9.00)	0.30 (0.90 proposed)	0.2

NA-Not available

3.0 PROBLEM STATEMENT

The goal of the TMDL process is full attainment of the Water Quality Standards (see Table 3). In particular, attainment of the numerical biological and dissolved oxygen chemical criteria. As described in Section 2 the water quality and biological assessment of the upper Little Miami River watershed indicates that the non-attainment of WQS is primarily due to nutrient and organic enrichment, sedimentation and habitat degradation. These correspond to non-attainment of the criteria for dissolved oxygen and the numeric biocriteria.

Nutrients, except under unusual circumstances, rarely approach concentrations in the ambient environment that are toxic to aquatic life. U.S. EPA (1976) concluded that "levels of nitrate nitrogen at or below 90 mg/l would not have [direct] adverse effects on warmwater fish." However, nutrients, while essential to the functioning of healthy aquatic ecosystems, can exert negative effects at much lower concentrations by altering trophic dynamics, increasing algal and macrophyte production (Sharpely *et al.* 1994), increasing turbidity (via increased phytoplanktonic algal production), decreasing average dissolved oxygen concentrations, and increasing fluctuations in diel dissolved oxygen and pH. Such changes are caused by excessive nutrient concentrations resulting in shifts in species composition away from functional assemblages of intolerant species, benthic insectivores and top carnivores *(e.g.,* darters, insectivorous minnows, redhorse, sunfish, and black basses) typical of high quality warmwater streams towards less desirable assemblages of tolerant species, niche generalists, omnivores, and detritivores *(e.g.,* creek chub, bluntnose minnow, white sucker, carp, green sunfish) typical of degraded warmwater streams (OEPA, 1999). Nutrient concentrations in the upper Little Miami River watershed are excessive in comparison with statewide data from unimpaired streams. Further, depressed dissolved oxygen levels and wide diel swings, excessive algae, and trophic species shifts have been documented which also indicate a nutrient enrichment problem.

Other studies have also found elevated nutrient conditions in the Little Miami River. The United States Geological Survey (USGS) selected the Great and Little Miami River as a study unit for its National Water Quality Assessment program and has documented elevated levels of nutrients. Data and more information on this ongoing study can be found at http://www-oh.er.usgs.gov/miam.html. The Ohio River Valley Water Sanitation Commission published a report in April, 2001 entitled *Evaluation of Nutrient Loads and Sources in the Ohio River Basin* (ORSANCO, 2001). This report found the Little Miami River in Milford (towards the mouth of the LMR and outside of the study area of this TMDL) to have elevated nutrient levels with a mean total phosphorus concentration of 0.24 mg/l. The Little Miami River also had the sixth highest average total phosphorus loading per unit area for the 12 major Ohio River tributaries analyzed. Finally, the water resource managers of various counties and municipalities within the Little Miami River watershed funded a study by the University of Cincinnati entitled *Little Miami River Preliminary Assessment of USE Attainability* (Buchberger *et. al.*, 1997). This study demonstrated:

- the annual phosphorus loads to the LMR exceed the river's assimilative capacity;
- instream total phosphorus concentrations are particularly elevated during the low-flow period when point source discharges are the principal contributor of overall phosphorus load;
- nonpoint sources contribute the highest annual load; and,
- during both high-flow and low-flow periods more than sufficient phosphorus is available for aquatic plant growth.

The effects of nutrient enrichment are exacerbated by poor physical habitat; conversely, high quality habitat can mitigate those effects. High quality riverine habitats with intact riparian zones and natural channel morphology may decrease the potentially adverse effects of nutrients by assimilating excess nutrients directly into plant biomass *(e.g*., trees and macrophytes), by sequestering nutrients into invertebrate and vertebrate biomass, by "deflecting" nutrients into the immediate riparian zone during runoff events (see reviews by Malanson 1993; Barling and Moore 1994), and by reducing sunlight (a principal limiting factor in algal production) through shading. Also, high quality habitats minimize nutrient retention time in the water column during *low flows* because they tend to have high flow velocities in narrow low flow channels *(e.g*., unbraided vs. braided riffles), and coarse substrates with little potential for adsorption. Additionally, a healthy community of aquatic organisms typical of high quality habitats process and utilize nutrients very efficiently.

Poor quality habitat with reduced or debilitated riparian zones (either no riparian zone is present or runoff bypasses the zone via field tiles) and simplified channel morphology generally exacerbate the deleterious effects of nutrients by reducing the riparian uptake and conversion of nutrients, by increased retention time through increased sediment-water column interface via a wide channel and subsequent loss of low flow energy *(e.g*., increased intermittency), retention of nutrients within the channel due to diminished filtering time during overland flow events, and by allowing full sunlight to stimulate nuisance growths of algae. These factors also interact to increase the retention of nutrients in the most available dissolved forms, attached to fine sediments (especially clays and silts) and in planktonic and attached algae (OEPA, 1999).

The habitat quality in the upper Little Miami watershed ranges from poor to excellent. In general, however, the habitat quality is degraded in many of the headwater streams in the watershed (see Appendix B). Headwater habitat quality is a critical component of the assimilative capacity for the protection of downstream uses; poor headwater habitat quality significantly reduces the capacity of a stream to assimilate nutrients and the effect of this is perpetuated throughout the stream system.

The parameters selected for Total Maximum Daily Load development are total phosphorus (the limiting nutrient; see Appendix C) and sediment. In conjunction with modeling the loads for these parameters, the instream dissolved oxygen concentration and stream habitat have also been evaluated. Although not expressed as loads per se, allocations for the factors affecting instream dissolved oxygen and stream habitat have been included analogous to the “TMDL” numbers for total phosphorus and sediment. Finally, the Little Beaver Creek subbasin has additional impairing causes not shared by the rest of the study area. Little Beaver Creek TMDL endpoints were developed for these ‘unique’ causes which include: cadmium, copper, mercury, total PAHs, total PCBs and chlordane. The special assessment of existing conditions, target concentrations and loads for the Little Beaver Creek subbasin is Appendix F of this report. It is important to note that Appendix F is not a formal TMDL report; rather, it is an informational analysis which includes TMDL endpoints but not allocations for these six compounds. It forms a nucleus for a TMDL report but does not currently meet all of the USEPA requirements to be considered an approveable TMDL report.

3.1 Target Identification

The establishment of instream numeric targets is a significant component of the TMDL process. The numeric targets serve as a measure of comparison between observed instream conditions and conditions that are expected to restore the designated uses of the segment. The TMDL identifies the load reductions and other actions that are necessary to meet the target, thus resulting in the attainment of applicable water quality standards.

Nutrients

Numeric targets are derived directly or indirectly from state narrative or numeric water quality standards (OAC 3745-1). In Ohio, applicable biocriteria are appropriate numeric targets (see section 2.2). Determinations of current use attainment are based on a comparison of a stream's biological scores to the appropriate criteria, just as the success of any implementation actions resulting from the TMDLs will be evaluated by observed improvements in biological scores.

Ohio EPA currently does not have statewide numeric criteria for nutrients but potential targets have been identified in a technical report entitled *Association Between Nutrients, Habitat, and the Aquatic Biota in Ohio Rivers and Streams* (OEPA, 1999). This document provides the results of a study analyzing the effects of nutrients on the aquatic assemblages of Ohio streams and rivers. The study reaches a number of conclusions and stresses the importance of habitat and other factors, in addition to instream nutrient concentrations, as having an impact on the health of biologic communities. The study also includes proposed targets for nitrate+nitrite concentrations and total phosphorus concentrations based on observed concentrations at reference sites. Reference sites are relatively unimpacted sites that are used to define the expected or potential biological community within an ecoregion. The total phosphorus targets are shown in Table 8. It is important to note that these nutrient targets are not codified in Ohio's water quality standards; therefore, there is a certain degree of flexibility as to how they can be used in a TMDL setting.

Table 8. Total phosphorus targets

Eastern Corn Belt Plains Criteria	**TP (mg/l)**	
Watershed Size	EWH	WWH
Headwaters (drainage area < 20 mi^2) (**H**)	0.05	0.07
Wadeable (20 mi^2 < drainage area < 200 mi^2) (**W**)	0.08	0.11
Small Rivers (200 mi^2 < drainage area < 1000 mi^2) (**SR**)	0.17	0.17

Ohio's standards also include narrative criteria which limits the quantity of nutrients which may enter waters. Specifically, OAC 3745-1-04 states that all waters of the state shall be free from nutrients entering the waters as a result of human activity in concentrations that create nuisance growths of aquatic weeds and algae.

Dissolved Oxygen
The instream dissolved oxygen (D.O.) is the primary chemical specific parameter not fully attaining WQS. The measurable endpoint of this TMDL process is to attain the D.O. water quality criterion at all times including summer, low flow critical conditions. The D.O. criteria for the Warmwater Habitat segments is a 5.0 mg/l average over a 24-hour period and a 4.0 mg/l minimum. For the Exceptional Warmwater Habitat segments the criteria is a 6.0 mg/l average over a 24-hour period and a 5.0 mg/l minimum.

Ammonia-N
Ohio's water quality standards for ammonia nitrogen are based on the stream's designated use, pH and temperature. The standards are tabularized and can be found in OAC 3745-1-07, Tables 7-2 through 7-8 and are protective of aquatic toxicity. Table 10 of this report details the standards and existing conditions as measured in 1998 for those segments with ammonia as a cause of impairment in Ohio's 1998 303(d) list for this study area.

Sedimentation and Habitat
Sedimentation was identified as a major cause of impairment. OAC 3745-1-04 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 effect aquatic life. In addition, total suspended sediment (TSS) concentrations were positively related to total phosphorus concentrations in the Little Miami River as shown in Figure 4 indicating the need to include this component in the TMDL. However, no statewide numeric criteria have been developed specifically for sediment or TSS. Instead, target Qualitative Habitat Evaluation Index (QHEI) scores, based on reference data sites for some of the aquatic life use designations, can be used as surrogates. The QHEI is a quantitative composite of six physical habitat variables used to 'score' a stream's habitat. The variables are: substrate, instream cover, riparian characteristics, channel characteristics, pool/riffle quality, and gradient and drainage area. It can be used to assess and evaluate a stream's aquatic habitat, and determine which of the 6 habitat components need to be improved to reach the QHEI target score. The substrate variable incorporates sediment quality and quantity and therefore, provides a numeric target for sedimentation. The Warmwater Habitat use designation QHEI target is $\geq$60. The Exceptional Warmwater Habitat use designation QHEI target is $\geq$75. In addition, since habitat is strongly correlated with the IBI biocriterion, the QHEI provides a target and format to evaluate how habitat issues and impairments effect attainment of the aquatic use designations.

Biocriteria
The biocriteria are the final arbiter of attainment of a use designation. After the control strategies have been implemented, biological measures including the IBI, ICI, QHEI and MIwb will be used to validate biological improvement and biocriteria attainment. The current attainment of the biocriteria along with the applicable standards is listed in Section 2.0, Table 4.

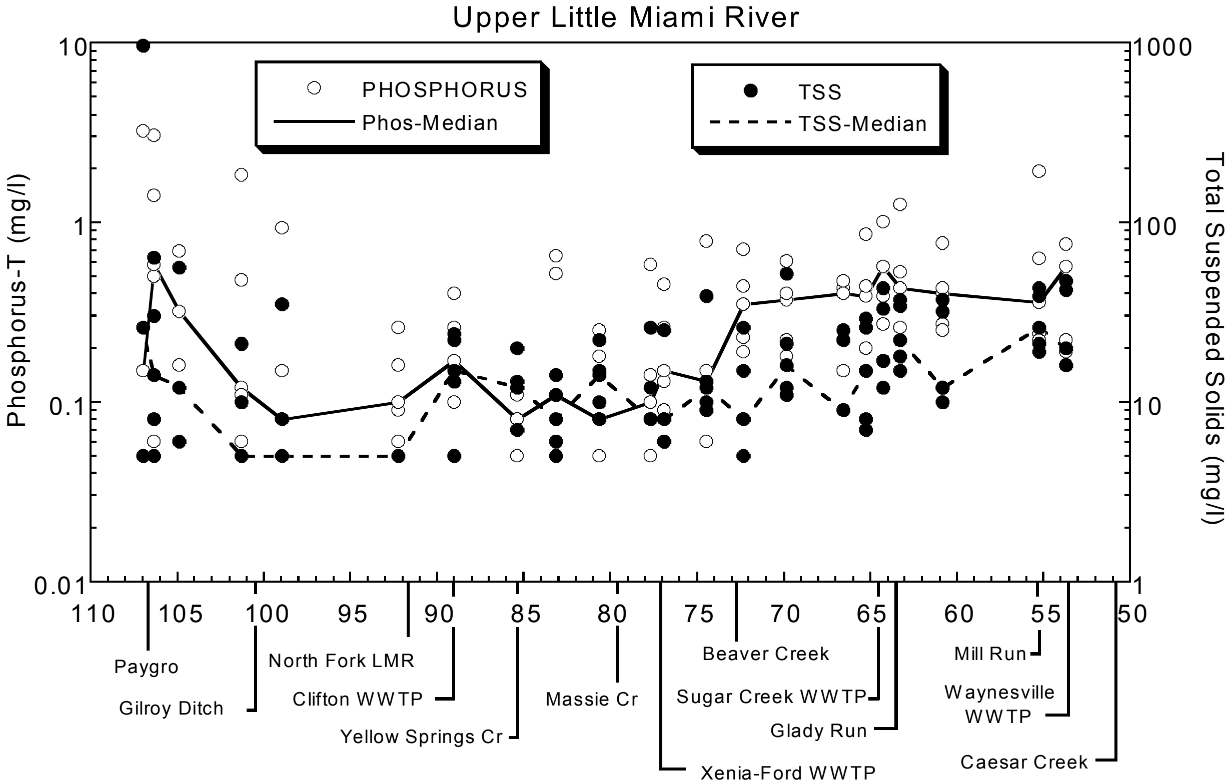


Figure 4. Total phosphorus and total suspended solids concentration profile for the upper Little Miami River based on data collected in 1998.

3.2 Current Deviation from Target

Nutrients (Total P)
As described in the preceding section, target values for total phosphorus are based upon the drainage area of a given stream segment. Table 9 illustrates the median concentrations compared to the target values for the nutrients.

Dissolved Oxygen
Dissolved oxygen data were collected under various flow and loading conditions in 1998. It is important to note that none of the data collection surveys were conducted under critical conditions; therefore, it is difficult to present a firm current deviation from the target as current critical condition instream D.O. concentrations have not been measured. The existing data, however, do give an estimate of the current deviation. The graphs on the next page give a picture of this deviation.

Ammonia-N
Table 10 suggests that ammonia nitrogen is no longer a specific cause of impairment in those segments cited in the 1998 303(d) list as impaired due to ammonia nitrogen. However, ammonia nitrogen is a component of the dissolved oxygen depletion and as such will still be indirectly included in this TMDL report.

Sedimentation, Habitat, & Biocriteria

As previously noted, the deviation or the attainment of the IBI, ICI, MIwb and QHEI is detailed in Section 2.0, Table 4.

Table 9. Median and target values of total phosphorus in the upper Little Miami River Basin [4]

Stream Segment \ Water Body ID# [Upper River Mile / Lower River Mile]	**Aquatic Life Use Designation [1]**	**Drainage Area [2]**	**Median** - mg/l (# samples)	**Target [3]** - mg/l
Little Miami River \ OH50 23 Headwaters to North Fork [106.8/91.64]	WWH	H -W	0.16 (26)	**0.07-0.11**
Little Miami River \ OH50 17 North Fork to Massie Creek [91.64/79.50]	EWH	W	0.09 (20)	**0.08**
Little Miami River \ OH50 10 Massie Creek to Beaver Creek [79.50/72.70]	EWH	SR	0.13 (15)	**0.17**
Little Miami River \ OH50 4 Beaver Creek to Glady Run [72.70/63.70]	EWH	SR	0.39 (25)	**0.17**
Little Miami River \ OH50 1 Glady Run to Caesar Creek [63.70/50.90]	EWH	SR	0.42 (20)	**0.17**
Gilroy Ditch \ OH50 25 [7.15/0.00]	WWH	H	0.185 (10)	**0.07**
North Fork Little Miami River \ OH50 21 [13.20/0.00]	WWH	H -W	0.09 (10)	**0.07-0.11**
North Fork Massie Creek \ OH50 15 [12.60/0.00]	WWH	H -W	0.065 (10)	**0.07-0.11**
South Fork Massie Creek \ OH50 16 [9.60/0.00]	WWH	H	0.065 (10)	**0.07**
Ludlow Creek \ OH50 11 [5.35/0.00]	WWH	H	0.10 (5)	**0.07**
Beaver Creek \ OH50 8 [8.40/0.00]	WWH	H -W	0.315 (24)	**0.07-0.11**
Little Beaver Creek \ OH50 9 [9.00/0.00]	WWH	H -W	1.14 (29)	**0.07-0.11**
Trib to Little Beaver Creek \ OH50 9.2 @ LBC RM 6.12 [2.10/0.00]	WWH	H	0.05 (5)	**0.07**
Sugar Creek \ OH50 6 [9.60/0.00]	WWH	H -W	0.205 (10)	**0.07-0.11**
Little Sugar Creek \ OH50 7 [2.10/0.00]	WWH	H	0.05 (5)	**0.07**

Table 9. Median and target values of total phosphorus in the upper Little Miami River Basin [4]

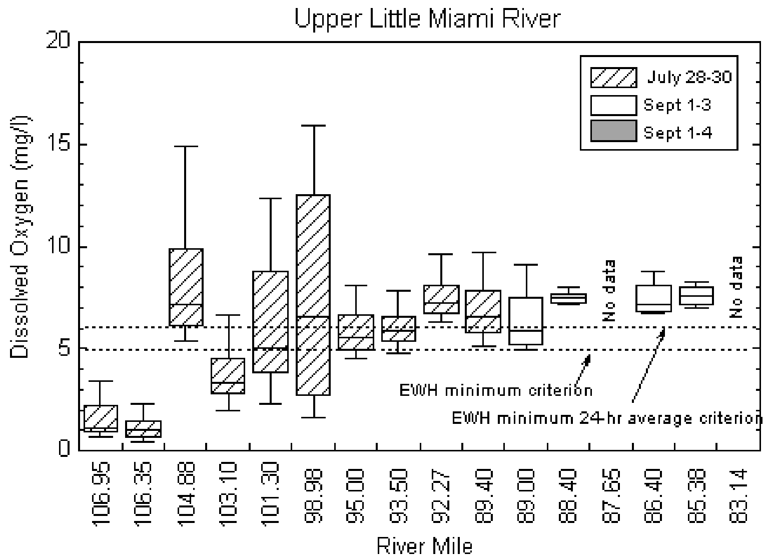
Stream Segment \ Water Body ID# [Upper River Mile / Lower River Mile]	**Aquatic Life Use Designation [1]**	**Drainage Area [2]**	**Median** - mg/l (# samples)	**Target [3]** - mg/l
Glady Run \ OH50 5 [6.30/0.00]	WWH	H	0.63 (15)	**0.07**
Newman Run \ OH50 2 [4.00/0.00]	EWH	H	0.17 (4)	**0.05**
Caesar Creek \ OH51 14 Headwaters to S.Br. Caesar C [33.98/23.78]	WWH	H -W	0.09 (5)	**0.07-0.11**
Caesar Creek \ OH51 13 S. Br. Caesar to Caesar Lake [23.78/13.92]	EWH	W	0.255 (10)	**0.08**
Caesar Creek \ OH51 1 Caesar Lake to Little Miami R [13.92/0.00]	EWH	SR	0.07 (4)	**0.17**
North Branch Caesar Creek \ OH51 16 [10.00/0.00]	WWH	H -W	0.145 (10)	**0.07-0.11**
South Branch Caesar Creek \ OH51 15 [11.50/4.00]	WWH	H	0.585 (10)	**0.07**
Anderson Fork \ OH51 19 Headwaters to Grog Run [19.12/11.02]	WWH	H -W	0.225 (10)	**0.07-0.11**
Anderson Fork \ OH51 7 Grog Run to Caesar Creek Lake [11.02/0.00]	EWH	W	0.23 (10)	**0.08**
Flat Fork \ OH51 2 [3.70/0.00]	WWH	H	0.30 (5)	**0.07**

1 Aquatic Life Use Designations are based on the proposed/recommended use designations as determined by the 1998 biological and water quality survey of the Little Miami River Basin.

2 Per➜ Association Between Nutrients, Habitat, and the Aquatic Biota in Ohio Rivers and Streams (Ohio EPA Technical Bulletin MAS/1999-1-1) H=Headwater (0-20 mi^2) W=Wadeable (>20-200 mi^2) SR=Small River(>200-1000 mi^2) LR=Large River (>1000 mi^2)

3 Per➜ Association Between Nutrients, Habitat, and the Aquatic Biota in Ohio Rivers and Streams (Ohio EPA Technical Bulletin MAS/1999-1-1): ECBP (Eastern Corn Belt Plains) Ecoregion Criteria -- Table 2 - TP

4 Median values are from 1998. The biocriteria and chemical criteria determine the impairment not the total phosphorus target. Therefore, the target may be exceeded yet the segment be in attainment if the biocriteria attains; or, the target may be met but the biocriteria does not so the segment is considered impaired. The target is a guideline to meet biocriteria, not an absolute reference.



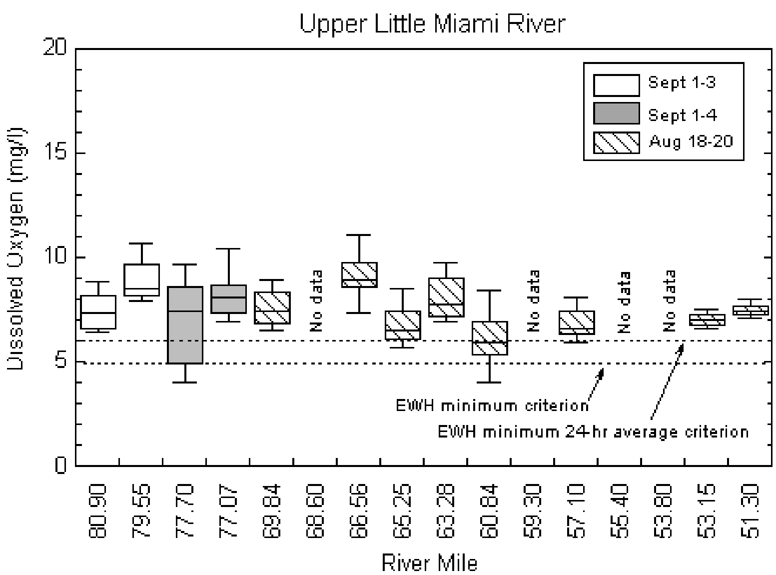


Figure 5. Dissolved oxygen instream concentration profile of the Upper Little Miami River as recorded with Datasonde™ continuous monitors in 1998.

Table 10. Ammonia-N targets and existing conditions

Stream Segment \ Water Body ID# [Upper River Mile/ Lower River Mile]	**Aquatic Life Use Designation** [1] *303 (d) list* 1998 survey	Ammonia-N Criteria (mg/l)		Instream Ammonia-N (mg/l)[2]	
		Outside Mixing Zone Maximum [ph/temp]	Outside Mixing Zone Average [ph/temp]	Maximum (# samples)	Mean (# samples)
Little Miami River \ OH50 23 (Headwaters to North Fork) [106.8/91.64]	*EWH* WWH	3.6 5.8 [8.2/20]	0.8 0.9 [8.2/20]	0.23 (26)	≤ 0.07 (26)
Little Miami River \ OH50 4 (Beaver Creek to Glady Run) [72.70/63.70]	*EWH* EWH	3.6 [8.2/21]	0.8 [8.2/21]	0.20 (25)	≤ 0.06 (25)
Little Beaver Creek \ OH50 9 [9.00/0.00]	*WWH* WWH	9.1 [8.0/21]	1.3 [8.0/21]	1.03 (29)	≤ 0.21 (29)
Beaver Creek \ OH50 8 [8.40/0.00]	*WWH* WWH	6.7 [8.14/19]	1.0 [8.14/19]	0.13 (24)	≤ 0.06 (24)

1 The Aquatic Life Use Designation are given:
(a) as provided in the 1998 303(d) list (*upper italicized type*); and
(b) per the proposed/recommended use designation as determined by the 1998 Biological and Water Quality Study of the Little Miami River Basin (lower plain type).

2 Based on the 1998 survey data.

3.3 Source Identification

The major sources of oxygen demanding substances and nutrients during the critical low flow periods are the municipal wastewater treatment plants located throughout the study area. Nonpoint sources are the predominant source of nutrients on a yearly average basis and are the largest source of sediment resulting in siltation and sedimentation. Lack of riparian cover and channelization, particularly in the upper reaches, also contributes to non-attainment. Source identification is covered in more detail in Section 2. Allocation of loads follows in Section 4.

4.0 TOTAL MAXIMUM DAILY LOADS

A TMDL is a means for recommending controls needed to meet water quality standards (USEPA, 1991). 40 CFR 130.2(i) states that a TMDL calculation is the sum of the individual wasteload allocations for point sources and the load allocations for nonpoint sources and natural background in a given watershed, and that TMDLs can be expressed in terms of either mass per time, toxicity, or other appropriate measure. Aquatic organisms are affected by a combination of variables that are not limited to load based pollutants. Therefore, the attainment of WQS in Ohio requires that both pollutant loads and environmental conditions (pollution, or non-load based parameters such as habitat) be addressed when identified as impairing causes.

Phosphorus and sediment, two of the identified impairing causes in this watershed, are load based parameters and TMDLs are calculated for them (see Table 12). Dissolved oxygen is a condition of the water column and is not a load based parameter; however, a low level of dissolved oxygen is an impairing cause particularly during the low flow, high temperature summer months. The TMDL numbers proposed for phosphorus and sediment will improve the level of D.O. by reducing algal growth, but these reductions on their own would not be sufficient to attain the D.O. criteria during critical conditions. Reductions in oxygen-demanding substances are needed, particularly for those loads that are consistently discharged to the streams during low-flow conditions. Namely, ammonia nitrogen (NH_3-N) and carbonaceous material which exerts a biochemical oxygen demand (CBOD). Wasteload allocations for these parameters are included in Table 17 of this report. In addition, D.O. levels can be increased by improving various aspects of the stream and stream corridor itself. Certain improvements to the stream habitat can have the additional benefit of increasing the level of D.O. in the stream (e.g., riffles). The combination of reducing the load of oxygen-demanding substances, reducing algal growth and increasing the capacity of the stream to hold dissolved oxygen is a means for recommending controls to meet the D.O. water quality criteria and is, therefore, a D.O. 'TMDL'.

Degraded or poor habitat is another non-load based impairing cause in the upper Little Miami River watershed. Identification of which aspects of the habitat are degraded at particular points in the watershed is provided in this report as are benchmarks which can be used to set habitat goals. This is analogous to allocations of loads for pollutants. These recommended habitat 'allocations' are a necessary means to meet biocriteria and water quality standards (in combination with the other TMDLs described above) and as such are a habitat 'TMDL'.

The TMDL calculation must also include either an implicit or explicit margin of safety that accounts for the uncertainty concerning the relationship between pollutant load or the pollution (the non-load causes of impairment) and water quality. The calculations, then, provide a numeric basis for addressing the impairing causes.

4.1 Method of Calculation

Three different analysis techniques were selected; each to address one of the following three issues:

1. Determine the nonpoint and point source loading contributions **to** the stream network. Predict future loadings based on implementation actions. This method determined the total phosphorus and sediment existing loads to the system.
2. Determine that water quality criteria and other numeric targets are achieved **in** the stream when the stream flow is not rapidly changing. This method was primarily used for dissolved oxygen.
3. Establish current habitat conditions and quantify desired habitat goals.

Multiple methods were needed given resource constraints (time and data availability) and applicability. A model which incorporated two or more of the above issues would have had exhaustive data requirements while providing little or no additional benefit to the process. The techniques selected are the most appropriate and applicable available methods for the goals and needs of this project. Table 11 summarizes the modeling approach selected for this TMDL project.

4.1.1 Loads to the stream

Nutrient loading to the Little Miami River watershed was simulated using the Generalized Watershed Loading Function or GWLF model (Haith et al., 1992). The complexity of this model falls between that of detailed, process-based simulation models and simple export coefficient models which do not represent variations over time. GWLF simulates precipitation-driven runoff and sediment delivery. Solids load, runoff, and ground water seepage can then be used to estimate particulate and dissolved-phase pollutant delivery to a stream, based on pollutant concentrations in soil, runoff, and ground water. GWLF has been used for TMDL development in Donegal Creek, Pennsylvania; Rock Creek Lake, Iowa; and Peña Blanca and Arivaca Lakes, Arizona and is a recommended model in USEPA's Protocol for Developing Nutrient TMDLs (USEPA, 1999).

GWLF simulates runoff and streamflow by a water-balance method, based on measurements of daily precipitation and average temperature. Precipitation is partitioned into direct runoff and infiltration using a form of the Natural Resources Conservation Service's (NRCS) Curve Number method (SCS, 1986). The Curve Number determines the amount of precipitation that runs off directly, adjusted for antecedent soil moisture based on total precipitation in the preceding 5 days. A separate Curve Number is specified for each land use by hydrologic soil grouping. Infiltrated water is first assigned to unsaturated zone storage where it may be lost through evapotranspiration. When storage in the unsaturated zone exceeds soil water capacity, the excess percolates to the shallow saturated zone. This zone is treated as a linear reservoir that discharges to the stream or loses moisture to deep seepage, at a rate described by the product of the zone's moisture storage and a constant rate coefficient.

Flow in streams may come from surface runoff during precipitation events or from ground water pathways. The amount of water available to the shallow ground water zone is strongly affected by evapotranspiration, which GWLF estimates from available moisture in the unsaturated zone, potential evapotranspiration, and a cover coefficient. Potential evapotranspiration is estimated based on mean daily temperature and the number of daylight hours.

The user of the GWLF model must divide land uses into "rural" and "urban" categories that determine how the model calculates loading of sediment and nutrients. For the purposes of modeling, "rural" land uses are those with predominantly pervious surfaces, while "urban" land uses are those with predominantly impervious surfaces. It is often appropriate to divide certain land uses into pervious ("rural") and impervious ("urban") fractions for simulation. Monthly sediment delivery from each "rural" land use is computed from erosion and the transport capacity of runoff, whereas total erosion is based on the universal soil loss equation (USLE) (Wischmeier and Smith, 1978), with a modified rainfall erosivity coefficient that accounts for the precipitation energy available to detach soil particles (Haith and Merrill, 1987). Thus, erosion can occur when there is precipitation, but no surface runoff to the stream; delivery of sediment, however, depends on surface runoff volume. Sediment available for delivery is accumulated over a year, although excess sediment supply is not assumed to carry over from one year to the next. Nutrient loads from rural land uses may be dissolved (in runoff) or solid-phase (attached to sediment loading as calculated by the USLE).

For 'urban' land uses, soil erosion is not calculated, and delivery of nutrients to the water bodies is based on an exponential accumulation and washoff formulation. All nutrients loaded from urban land uses are assumed to move in association with solids.

The GWLF model was calibrated to the Little Miami River watershed by comparing observed data from water year 1989 through 2000 to predicted data for the same time period. The model effectively predicts monthly streamflows ($R^2 = 0.87$; ratio of predicted values to observed = 1.003). The annual nutrient loading for the upstream subwatershed was also calibrated. Lack of appropriate data prevented further calibration of the other subwatersheds. Once the model had been calibrated, it was used to predict nutrient loadings during the 1991 to 2000 period for the entire watershed and each of 5 subwatersheds comprising the study area. These loadings are summarized in Table 12. The 1991 to 2000 period was selected because it is fairly recent data and it includes 2 years of intensive survey data (1993 and 1998). Several years were modeled to smooth out the effects of unusually wet or dry years thereby increasing the reliability of the model results. Refer to Appendix A for more details on the GWLF modeling.

4.1.2 Response in the stream

The GWLF model only predicts loads to the stream; it does not predict the chemical response that occurs within the stream to such input loads. The Enhanced Stream Water Quality Model (QUAL2E) predicts the instream chemical concentration response to various inputs and stream conditions. QUAL2E represents the stream as a series of computational elements grouped together within a specified stream reach. A reach is defined as a length of stream that has similar physical properties (gradient, cross section, etc.) and rate constants (decay, settling, source). QUAL2E conceptualizes the stream as a sequential series of completely mixed reactors (the computational elements) (Brown and Barnwell, 1987). It calculates the output from each computational element based on the input from the previous element and on reactions that occur within the element itself.

QUAL2E has been used extensively for many years and is a USEPA-approved model. It is appropriate for use only with steady, non-variable stream flows. It was used in this project to predict the instream concentration of dissolved oxygen, nitrogen compounds, and phosphorus during low-flow, summer conditions. These conditions are considered very stressful to stream biota, and therefore, allocations of loads need to be protective of this critical state. QUAL2E simulates instream concentrations which can

then be compared to water quality criteria to evaluate if violations of these numeric criteria have the potential to occur. Inputs such as point source loads can be adjusted until the predicted instream concentrations meet the water quality criteria. This provides a means of developing the wasteload allocation portion of the TMDL equation.

The model was calibrated using several data sets collected in various years since 1988. Each complete data set represents a particular section or tributary of the Little Miami River. Hydraulic variables were calibrated first followed by the chemical parameters (biochemical oxygen demand, the nitrogen compounds, and phosphorus) and lastly by dissolved oxygen. The model accuracy (how well the model results compare with observed data) was good; the median relative error in dissolved oxygen was 8%. This compares favorably to the results of a study of the median dissolved oxygen relative error of approved models for various rivers around the country (Thomann, 1980) which showed that fifty percent of the models had median relative error in D.O. of greater than 10%. Refer to Appendix A for more details on the QUAL2E modeling.

4.1.3 Habitat goals

Physical habitats were evaluated using the Qualitative Habitat Evaluation Index (QHEI) developed by the Ohio EPA for streams and rivers in Ohio (Rankin, 1989, 1995). Various attributes of the habitat are scored based on the overall importance of each to the maintenance of viable, diverse, and functional aquatic faunas. The type(s) and quality of substrates, amount and quality of instream cover, channel morphology, extent and quality of riparian vegetation, pool, run, and riffle development and quality, and gradient are some of the habitat characteristics used to determine a QHEI score from 20 to less than 100. The QHEI is used to evaluate the characteristics of a stream segment, as opposed to the characteristics of a single sampling site. As such, individual sites may have poorer physical habitat due to a localized disturbance yet still support aquatic communities closely resembling those sampled at adjacent sites with better habitat, provided water quality conditions are similar. QHEI scores from hundreds of segments around the state have indicated that values greater than 60 are *generally* conducive to the existence of warmwater faunas whereas scores less than 45 generally cannot support a warmwater assemblage consistent with the WWH biological criteria. Scores greater than 75 frequently typify habitat conditions having the ability to support exceptional warmwater faunas.

The three methods selected were used in conjunction to determine the load(s) and the habitat condition(s) that need to exist in order to attain the WQS. QUAL2E determined the point source loads under low flow critical conditions. These permitted loads then defined the point source loads in GWLF. GWLF was used to calculate nonpoint source loads and to determine the impact of strategies to reduce loads. The QHEI was used as a guide to direct restoration efforts for habitat and provides a monitoring tool to measure progress towards habitat goals.

4.2 Critical Conditions and Seasonality

TMDL development should specify the environmental conditions assumed to define allowable loads. Determinations of TMDLs must take into account critical conditions for stream flow, loading, and water quality parameters (40 CFR 130.7(c)(1)). The critical condition is defined as the set of environmental conditions that, if controls are designed to be protective of them, will ensure attainment of objectives for all other conditions. For example, the critical condition for control of a continuous point source discharge is the drought stream flow. Point source pollution controls designed to meet water quality standards for drought flow conditions will ensure compliance with standards for all other conditions. The critical condition for a wet weather-driven source may be a particular rainfall event, coupled with the stream flow associated with that event.

Nutrient sources in the Little Miami River watershed arise from a mixture of continuous and wet weather-driven sources. The critical condition for dissolved oxygen and nutrient instream concentrations is expected to be the summer low-flow period. This is the period that is most conducive to algal growth, instream temperatures are high, and the stream flows are low. Further, the Little Miami River is effluent dominated during lower flow conditions typical of the summer season. Therefore, the observed summer concentrations have been compared to the targets and used to estimate the necessary loading reductions.

Seasonality is addressed in the TMDL by using the GWLF model to predict monthly and annual loadings over a multi-year period using actual weather conditions and observed seasonal point source loadings. The estimated loads are therefore reflective of seasonal changes in weather, treatment facility operating practices, and other conditions that can vary over the course of a year (e.g., agricultural practices).

Table 11. Modeling approach summary

Model or Method	Parameters Analyzed	Goals	How was it used?
Generalized Watershed Loading Functions (GWLF)	• Phosphorus • Sediment • Nitrogen (not included as a TMDL)	Quantify the total phosphorus and sediment loads to the receiving streams in the study area. Evaluate and compare nutrient loadings between sub-watersheds and between point and nonpoint sources Evaluate the effect of land use changes on loadings during the implementation plan phase	• Quantify the existing loads from both point and nonpoint sources. • Using the workgroup's input, vary the land use and other factors to simulate control actions to determine when targeted load value is achieved.
Enhanced Stream Water Quality Model (QUAL2E)	• Dissolved Oxygen • CBOD • Ammonia • Nitrite • Nitrate • Phosphate • Organic phosphorus	Evaluate the instream water quality under non-varying flow conditions. Determine the loading level that the impaired streams can receive and still achieve water quality standards under low flow, critical conditions.	• Determine what load the impaired streams in the study area can accept and maintain water quality standards under non-varying flows. • Nonpoint source effects can be incorporated into the model by the incremental inflow option. Accumulated effects of NPS loads are seen in sediment oxygen demand, algal blooms and in hydraulic and hydrologic conditions. Changing these inputs to reflect BMPs allows NPS management options to be incorporated and evaluated.
Ecological Assessment Techniques and Models	• Phosphorus • TSS • IBI • ICI • QHEI 1. Substrate 2. Instream cover 3. Riparian quality	Establish targets for parameters with no criteria. Evaluate parameters which are not directly incorporated in the other models. **Directly address the biocriteria impairment issues.**	• Determine numeric targets for phosphorus and habitat where no criteria exists • Compare attaining reference sub-watersheds to impaired sub-watersheds in the upper LMR basin. Assist in determining needed changes in the impaired sub-watershed • Determine effects of habitat characteristics on instream concentrations of nutrients, TSS, and dissolved oxygen.

4.3 Margin of Safety

The statute and regulations require that a TMDL include a margin of safety to account for any lack of knowledge concerning the relationship between load and wasteload allocations and water quality (CWA § 303(d)(1)(C), 40 C.F.R. § 130.7(c)(1)). EPA guidance explains that the margin of safety (MOS) may be implicit, i.e., incorporated into the TMDL through conservative assumptions in the analysis, or explicit, i.e., expressed in the TMDL as loadings set aside for the MOS. If the MOS is implicit, the conservative assumptions in the analysis that account for the MOS must be described. If the MOS is explicit, the loading set aside for the MOS must be identified.

A margin of safety is incorporated implicitly into these TMDLs. There are several areas where an implicit margin of safety is incorporated including: the 303(d) listing process, the target development, the model inputs and application. An explanation for each of these areas is provided below.

4.3.1 TMDL priority 303(d) listing

It is important to keep in mind during the evaluation of the TMDL a major difference in Ohio's program from other regional programs. In Ohio, one way a stream segment is listed on the 303(d) list is for failure to attain the appropriate aquatic life use as determined by direct measurement of the aquatic biological community. Many other regional or state programs rely solely on chemical samples in comparison to chemical criteria to determine water quality and designated use attainment. However, relying solely on chemical data does not take into account any of the parameters or other factors for which no criteria exist but that affect stream biology nor does it account for multiple stressor situations. Therefore, the chemical specific approach misses many biologically impaired streams and may not detect a problem until it is severe. Ohio's approach incorporates an increased level of assurance that Ohio's water quality problems are being identified. Likewise, de-listing requires attainment of the aquatic life use determined by the direct measurement of the aquatic biological community. This provides a high level of assurance (and an implicit margin of safety) that if the TMDL allocations do not lead to sufficiently improved water quality then the segments remain on the list until true attainment is achieved.

4.3.2 Target development

The use of nutrient targets that are based on data from relatively unimpacted reference sites provides an additional implicit safety factor. These data constitute a background concentration of nutrients in a stream; unimpacted streams generally have nutrient levels well below those needed to meet biological water quality standards. As the stream becomes impacted, nutrient levels can rise, but the stream can still meet water quality standards based on other factors such as the presence of good habitat. Once the nutrient levels rise high enough or other factors change which no longer mitigate the affects of nutrients then the biological community is impacted, and the stream is impaired. By using nutrient targets based on data from relatively unimpacted sites (or sites that are conservatively in attainment of biological water quality criteria) the targets themselves are set at a conservative level. In other words, water quality attainment is likely to occur at levels higher than these targets and the difference between this actual level where attainment can be achieved and the selected target is an implicit margin of safety.

A further conservative assumption implicit in the target development lies in the selection of the statistic used to represent the phosphorous target which corresponds to an unimpaired biological community. Since Ohio EPA's evaluation of phosphorus data for generating target values is based on measured performance of aquatic life and since full attainment can be observed at concentrations above this target (reinforcing the concept that habitat and other factors play an important role in supporting fully functioning biological communities), it would be valid to argue that a 95th percentile of these values (to exclude outliers) would be protective of the respective aquatic life use. Instead, Ohio EPA selected the median value associated with measured aquatic life performance. The selection of this statistic is an implicit margin of safety in these TMDLs. Refer to Appendix C for more information on how the nutrient targets were derived.

The habitat targets were selected using a method analogous to the nutrients method. The habitat targets and the specific aspects of the habitat that are degraded as provided with the QHEI model combine to add another layer of potential protection to achieving the WQS by providing additional guidance on an alternate means to reduce the nutrient load to the stream, mitigate the impacts of the nutrients in the stream, and directly improve an aspect of stream ecology vital to the biological community. Ohio EPA's ability to add habitat targets, and provide guidance on the improvement of the habitat is an implicit margin of safety made possible through extensive ecosystem monitoring and analysis, and should be recognized as a margin of safety in these TMDLs.

4.3.3 Model inputs and application

Conservative modeling assumptions also implicitly incorporate a margin of safety into the project especially for the dissolved oxygen "TMDL". Some of these conservative assumptions include:

- Setting the point source inputs at the full design or permit value per entity (as opposed to using the current discharge flows) or the median, whichever is higher. This incorporates an extra 10.3 MGD of effluent flow (27% of the total effluent flow) that the system is not currently receiving, and given that census statistics forecast little growth in the area, it is unlikely this additional flow will actually be in the system for several decades to come;

- Including an incremental inflow component per reach at water quality concentrations representative of elevated background levels. Assigning higher loads to this source incorporates potential nonpoint source inputs such as higher levels of nitrate in the groundwater due to current agricultural or urban fertilization practices (which are expected to decrease as part of the watershed action/implementation plan actions);

- Assuming a low flow condition (7Q10) which has a very small recurrence interval (water quality criteria generally do not apply to flow conditions that have a statistical recurrence interval lower than the lowest 7 day consecutive flow in any 10 year period (the 7Q10); and,

- Using moderately high instream temperatures.

Individually, these decisions reflect conservatism; taken together, this set of circumstances is unlikely to occur concurrently and therefore, provide an additional buffer to account for uncertainty in the modeling process.

One additional aspect that decreases the uncertainty associated with the wasteload allocations and the resultant water quality is that the point sources will, in general, achieve better quality effluent than they are allowed in their NPDES permits. Since the upper LMR is effluent dominated this is a significant factor during lower flow time periods. A random sampling of Lake Erie Basin dischargers with total phosphorus limits of 1 mg/l showed that on average these facilities discharged at 0.65 mg/l total phosphorus. This is 35% less then their allocation and represents a margin of error for the facility and a margin of safety for the stream. Further, a reserved total phosphorus load of 4.3 kg/d was unallocated to allow for future growth.

4.4 TMDL Calculations

4.4.1 Load-based calculations: total phosphorus and sediment

Necessary loading reductions were estimated by comparing the median instream 1998 summer concentrations at the most downstream sampling location in the study area to the appropriate target (see Table 9). The overall needed phosphorus reduction basin-wide was estimated to be 60% based on the difference between the appropriate target (0.17 mg/l) and the median observed concentration (0.43 mg/l) at the most downstream point. This is the deviation from the phosphorus target as listed in Table 9 for the waterbody segment OH50 1 Little Miami River from Glady Run to Caesar Ck. The most downstream segment was used to determine the basin-wide needed reduction because all other segments contribute loads to this point and this downstream location also reflects the assimilation of phosphorus into the river system. Individual segments may deviate from the total phosphorus target more or less than the 60% targeted reduction and this could be used to assist guiding implementation actions; however, from a watershed perspective, an average 60% reduction is a desirable and attainable reduction. This reduction in combination with the other recommendations of this report (improved habitat and D.O. conditions) should attain standards in all segments if these improvements are targeted to the critical areas and matched with appropriate implementation actions.

This approach assumes a direct relationship between loadings and concentrations and a constant assimilation factor (i.e., the instream concentrations of total phosphorus will respond to future changes in loading in the same manner as they respond to current loads). These simplifying assumptions are warranted by the fact that it is the cumulative, rather than the acute, loadings of nutrients that are impairing the biologic communities. Please refer to *Association Between Nutrients, Habitat, and the Aquatic Biota in Ohio Rivers and Streams* (OEPA, 1999) for a full discussion of the cumulative impacts of nutrients on Ohio rivers and streams.

The upper LMR watershed GWLF model was calibrated to the entire watershed area and TMDL numbers for the basin as a whole are given in Table 12. The watershed was also divided up into five sub-basins to increase the resolution (especially helpful during the implementation phase). These divisions were based on physical and geological characteristics and drainage area size. Subwatershed 1 covers the headwaters of the Little Miami River to Clifton Mill Dam. Subwatershed 2 begins at this dam and ends just upstream of Beaver Creek. Subwatershed 3 contains Beaver Creek and ends at Caesar Creek. Subwatershed 4 is the Caesar Creek basin excluding Anderson Fork. Subwatershed 5 is Anderson Fork (refer to Figure 2). Separate model runs for each of these subwatersheds were completed based on the calibrated model for the entire watershed. TMDL numbers per subwatershed are provided in Table 12.

Subwatersheds 1 through 3 combined match the combination of the listed watersheds 05090202 010-030; however, although the subwatershed boundaries approximate the listed watershed boundaries, they do not match up exactly. Subwatershed 4 is listed watershed 05090202 050 and subwatershed 5 is listed watershed 05090202 040. All listed segments in the study area are included in one of these 5 subwatersheds. Unlisted and attaining stream segments are also included because they are sources of load regardless if they are locally impaired or not. Attainment of Ohio's WQS cannot be reached if a stream segment by stream segment approach to TMDL projects is taken.

Table 12 lists the existing loads, the needed reduction, the TMDL value, and the allocations for total phosphorus and sediment for the entire watershed and per subwatershed; figure 6 shows a graphic representation of these quantities for total phosphorus. The existing NPS category covers agricultural, urban, groundwater and natural background inputs. The TMDL was divided up based on the background conditions (natural), waste load allocations (WLA) for point sources and load allocations (LA) for nonpoint sources. The background or natural conditions were calculated by modeling a 'pristine' or non-impacted condition in the subwatershed. All point sources and septic inputs were removed, and urban and row crop land uses were converted to forest or pastureland. The point source nutrient allocations were based on a sixty percent reduction of their existing total phosphorus load. The rest of the TMDL was then allocated to nonpoint sources.

Sediment listed in Table 12 is based on the sheet and rill erosion and is calculated using a sediment delivery ratio (the percentage of eroded sediment that actual is delivered to a stream). The total nonpoint source sediment load to the stream would also include bank and gully erosion. GWLF does not have the ability to calculate this part of the sediment load and the data needed to quantify it using another method was not available. The QHEI does take this type of erosion into account and will be used to guide implementation actions to address bank and gully erosion.

Table 12. TMDLs and allocations for the upper Little Miami River Watershed[1]

SUBWATERSHED (IDENTIFICATION #)	EXISTING LOADS			REDUCTION %	TMDL[2]	TMDL ALLOCATIONS[3]		
	NPS[4]	PS	TOTAL			NATURAL	WLA	LA
Total Phosphorus (*kg/day*)								
Entire Area (05090202 010-050)	684	186	870	60	**348**	**65.6**	**74.4**	**208**
1 (~ 05090202 010)	*97*	*1*	*98*	*60*	*39.2*	*3.7*	*0.4*	*35.1*
2 (~ 05090202 020)	*153*	*25*	*178*	*60*	*71.2*	*8.3*	*10.0*	*52.9*
3 (~ 05090202 030)	*209*	*158*	*367*	*60*	*146.8*	*11.6*	*63.2*	*72.0*
4 (05090202 050)	*130*	*2*	*132*	*60*	*52.8*	*12.0*	*0.8*	*40.0*
5 (05090202 040)	*95*	*0*	*95*	*60*	*38.0*	*30.0*	*0.0*	*8.0*
Sediment[5] (*1000 kg/day*)								
Entire Area (05090202 010-050)	56.2	0.4	56.6	30	**39.6**	*in LA*	0.2800	39.3
1 (~ 05090202 010)	*3.3*	*0.004*	*3.3*	*30*	*2.3*	*in LA*	*0.0031*	*2.3*
2 (~ 05090202 020)	*2.2*	*0.075*	*2.3*	*30*	*1.6*	*in LA*	*0.0528*	*1.5*
3 (~ 05090202 030)	*18.78*	*0.32*	*19.1*	*30*	*13.4*	*in LA*	*0.2219*	*13.2*
4 (05090202 050)	*22.6*	*0.004*	*22.6*	*30*	*15.8*	*in LA*	*0.0028*	*15.8*
5 (05090202 040)	*20.0*	*0*	*20.0*	*30*	*14.0*	*in LA*	*0.0000*	*14.0*

1 NPS = Nonpoint Source; PS = Point Source; TMDL = Total Maximum Daily Load; WLA = Wasteload Allocation (i.e., point source allocation); LA = Load Allocation (nonpoint source allocation less the natural background); Natural = Background.

2 TMDL = (1 - (% Reduction/100)) * Existing total load

3 WLA = (1 - (% Reduction/100)) * 5 year average point source load; LA = TMDL - Natural - WLA

4 The existing NPS load includes the existing natural background load.

5 Sediment from sheet and riIl erosion (using a sediment delivery ratio) and point source solids only (gully and stream bank erosion not included). The sediment delivery ratio is dependent on drainage size of the area being modeled; therefore, there is some variation between the entire area numbers and the subwatershed results.

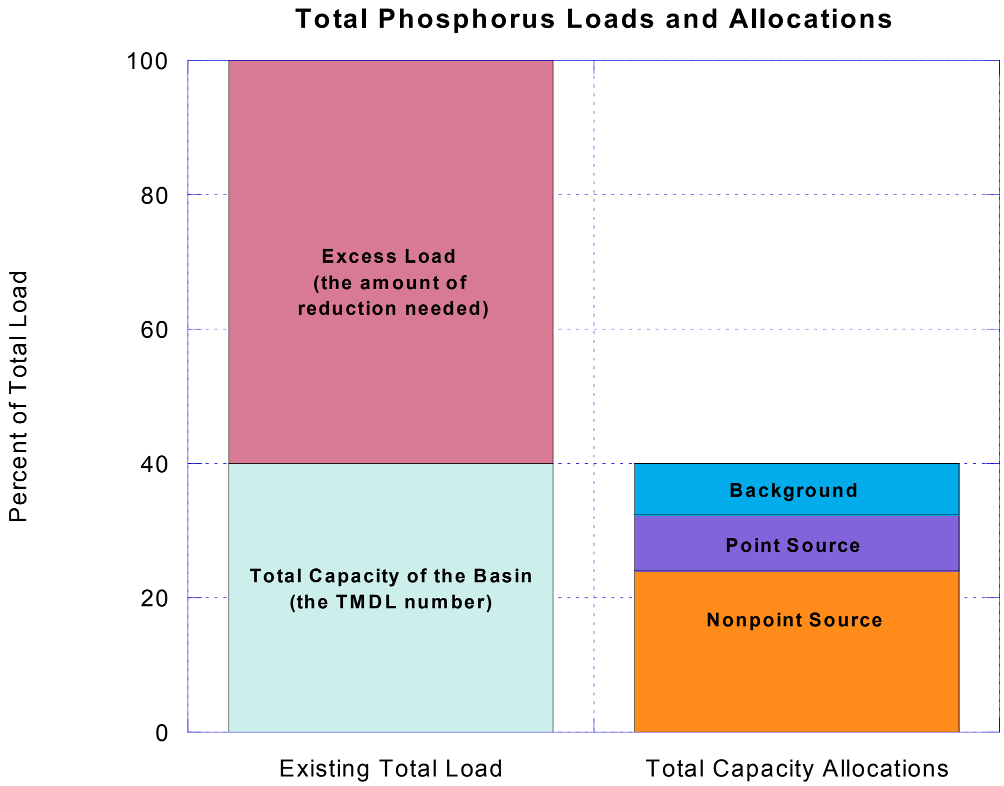


Figure 6. Graphical representation of the total phosphorus existing load and TMDL allocations.

4.4.2 Habitat calculations

The detailed QHEI results are presented in Appendix B, and the QHEI scores per river mile are shown graphically in figures 7 through 9. These three figures show the cumulative QHEI score in the top graphic and the deviation of the QHEI score from the target in the bottom graph per sampling site. Figure 7 presents the information for the upper Little Miami mainstem from the headwaters to just upstream of Caesar Ck. Figures 8 and 9 presents this information for the tributaries with figure 9 showing Massie Ck and Caesar Ck and figure 8 depicting all other measured tributary sites. This figures highlight where the habitat is degraded and to what extent. The detailed results (Appendix B) show that two patterns are apparent. First, the headwaters upstream from Clifton, including the North Fork and Lisbon Fork, possess a greater number of anthropogenically (influenced by humans) derived habitat attributes than natural attributes. Row crop agriculture strongly influences this part of the basin. The QHEI scores for the four sites sampled upstream from Clifton suggest that the potential to achieve EWH is limited by the number of modified habitat attributes (mean QHEI = 53 ± 10 SD). High influence modified habitat attributes (i.e., those strongly associated with impaired biological

performance (Rankin, 1995) encountered in the reach upstream from Clifton included sparse cover, no sinuosity, and channelization. An accumulation of two high influence attributes is likely to preclude fish communities from meeting WWH, and only rarely allow the fish community to meet EWH. Moderate influence attributes have less effect on the fish community, such that five to six moderate influence attributes can sometimes be present without precluding a WWH fish community, especially when the influence extends to only a small reach. The four sites sampled upstream from Clifton each had four to eight moderate influence attributes, with riffle and substrate embeddedness, fair to poor channel development and low sinuosity being common to nearly all of the sites.

The other pattern evident in the QHEI matrix is that all the riffles are at least moderately embedded with fine gravel, sand and silt. These two patterns are related as the practices resulting in modified habitat attributes in the headwaters and tributaries result in the bedload of sediment that infiltrates the riffles throughout the mainstem. Two other pervasive sources of sediment loads affecting the mainstem are eroding banks, especially where the riparian buffers have been removed, and suburban development. In and downstream from Clifton, the habitat is otherwise capable of supporting EWH communities, with the habitat characterized by natural features derived from a free flowing channel interacting with glacial till and a mature riparian corridor. A free flowing river allows for channel development *(i.e.*, riffle-pool-run sequences and sinuosity), glacial till provides a variety of substrate sizes, and woody debris augment structural complexity and cover. These characteristics generally exist downstream from Clifton.

Habitat quality was also evaluated for tributaries to the Little Miami River. Four clusters were noted with degraded habitat. These include the entire Beaver Creek subbasin, the headwaters of Massie Creek, Anderson Fork, and the headwater tributaries of the Little Miami River (Lisbon Fork, Gilroy Ditch, North Fork LMR, Goose Creek). The common thread running through these groups is that they have either been channelized, are subjected to poor agricultural land use practices, or both. With respect to the Little Miami River mainstem, the Beaver Creek subbasin (which includes the Little Beaver Ck) and the headwater LMR tributaries are likely the greatest sources of sediment (excluding mainstem bank erosion), and therefore should be the focus of remedial action. Caesar Creek Reservoir acts as a sediment sink for Anderson Fork. Ludlow Creek is the only other tributary sampled in the upper LMR watershed that stands out as having the potential to export high sediment loads. Possible sources of sediment loads in the Ludlow Creek basin include land development (e.g., suburbanization), limestone quarrying, and poor agricultural practices.

Massie Creek (see Figure 9) is a good example of how high quality instream habitat and mature riparian buffers can help mitigate adverse affects from upstream and assimilate pollutant loadings. Massie Creek drains intensively farmed land, and the North and South Branches of Massie are channelized and contain a heavy sediment load. However, substrates in Massie Creek are relatively clean. This is because the flood plain and stream channel are not disconnected by channelization, and the wooded flood plain filters and sequesters sediments during runoff and flood events. Massie Creek also demonstrates that agricultural land use in close proximity to the stream can be sustained if certain practices are followed. The stream habitat at RM 1.2 was excellent, showing no modified traits and having a QHEI score of 80.5; despite flowing through a dairy farm with row crops. Here, the landowner, Dave Linkhart, practices good stewardship by fencing his cows out of the stream, and maintaining a wooded buffer along the margins.

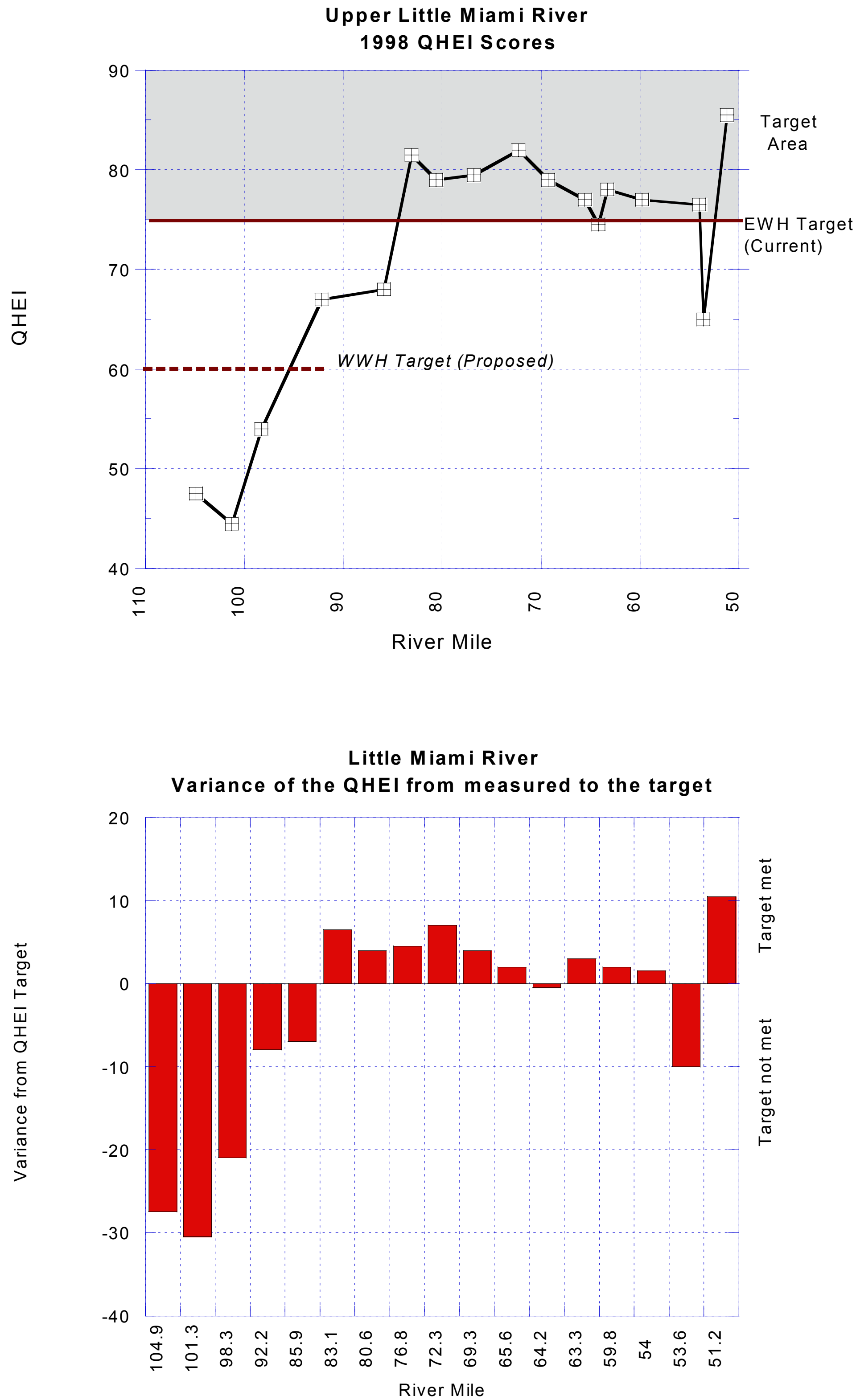
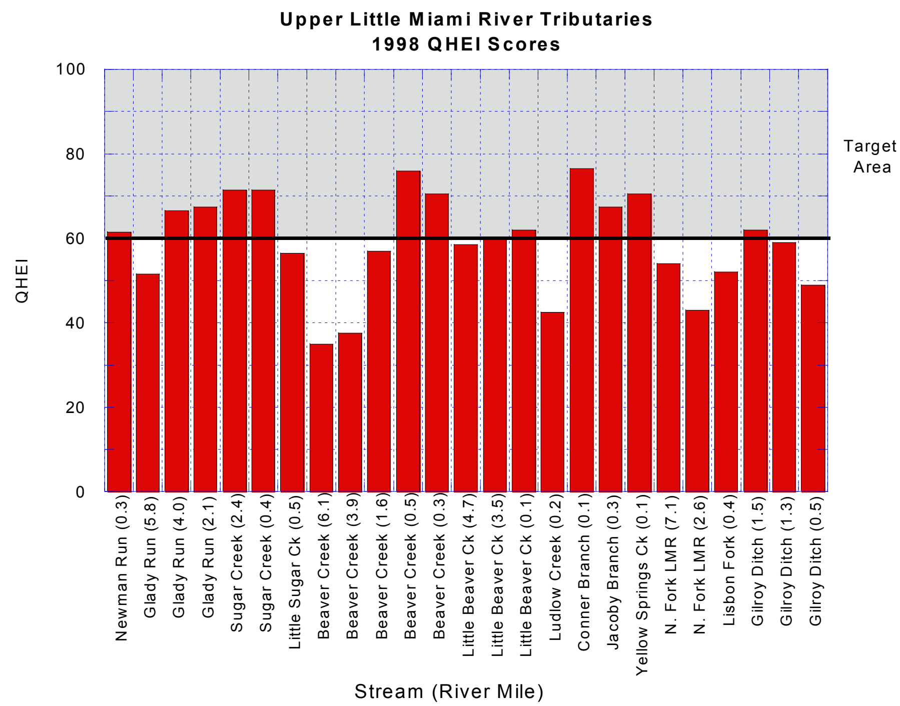


Figure 7. QHEI scores and deviation from the target for the upper Little Miami River (mainstem)



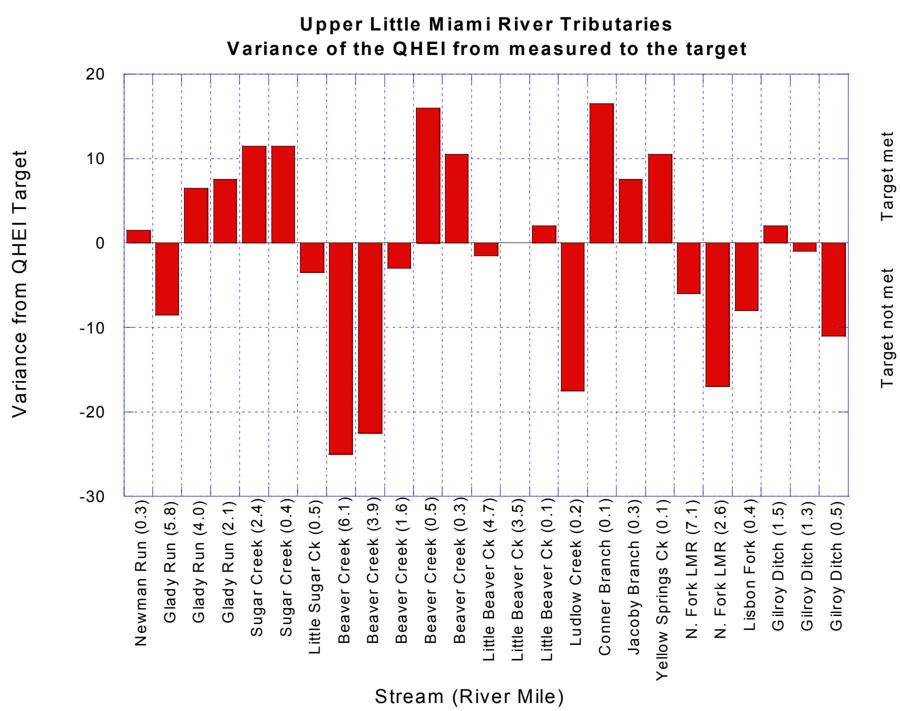


Figure 8. QHEI scores and deviation from the target for various tributaries in the upper LMR basin.

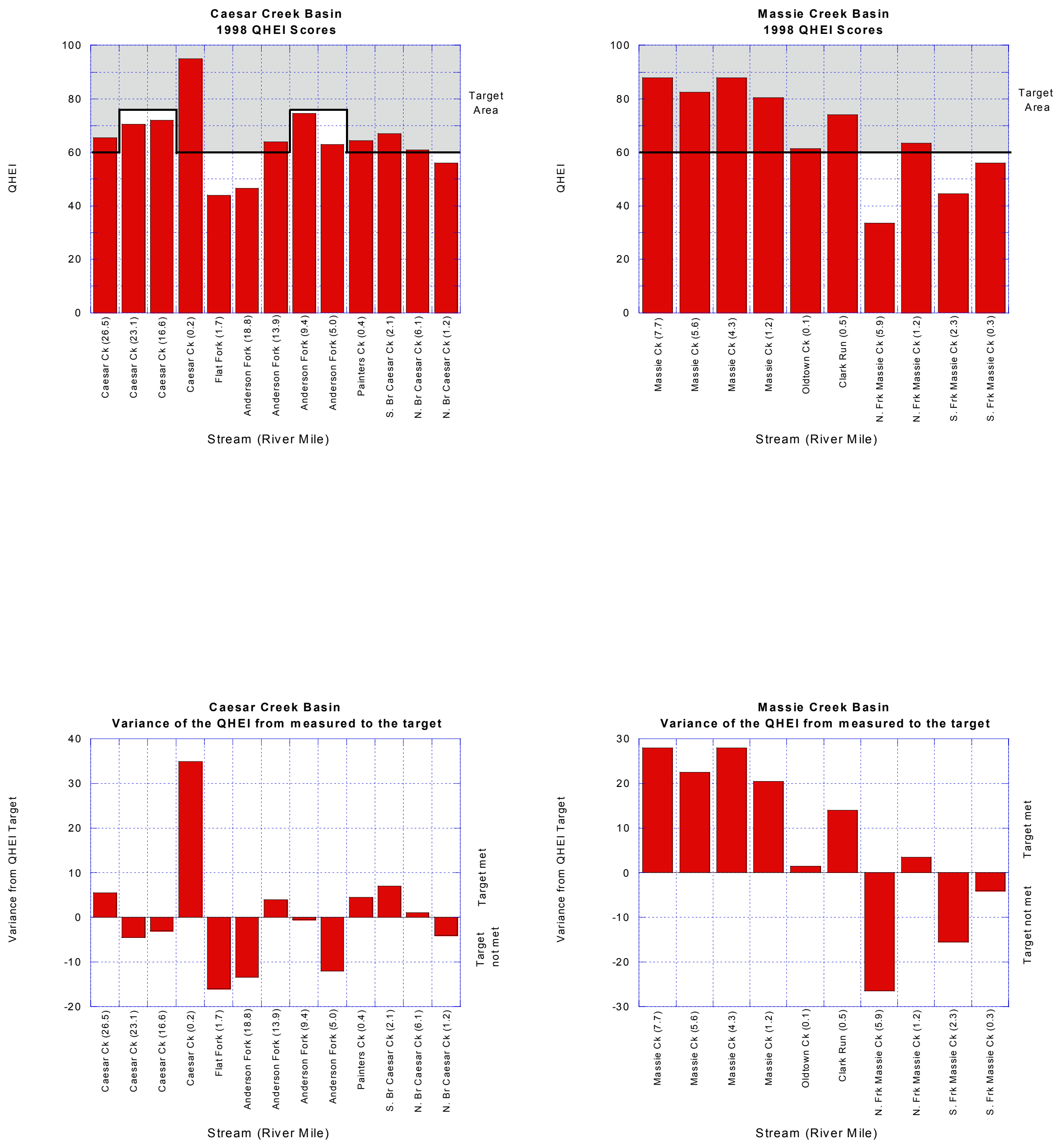


Figure 9. QHEI scores and deviation from the target for the Massie and Caesar Creek basins.

5.0 PUBLIC PARTICIPATION

Public participation associated with this TMDL began with the release of the results of the 1995 Biological and Water Quality Study of the Little Miami River and Selected Tributaries Report (Ohio EPA, 1995). An Ohio EPA Public Meeting was held on May 24, 1995, to provide an overview of the results of the report and provide an opportunity for public comment and discussion of the results. In an effort to further discussions on the major water quality issues (e.g., nutrients) and arrive at a consensus with affected parties, Ohio EPA employed the services of an independent mediator, the Institute of Environmental Sciences, Miami University, Oxford, Ohio, to help establish a forum for discussing many of the issues. The result of this collaboration was the Ohio EPA-sponsored "Little Miami River Cooperative Watershed Management Workshop" held on May 17, 1996 in Waynesville, Ohio. This day-long workshop, open to the public and attended by approximately 90 people, included panel discussions, small group breakout sessions, and expert speakers on various water quality issues. These and other public involvement events listed in Table 13b (prior to 1999) occurred before the initialization of the TMDL project for the upper Little Miami River. However, they laid the foundation for future stakeholder interest and involvement in the TMDL process.

The 1998 303(d) list public comment period, and the selection of the upper Little Miami River 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.).

Informal public comments were received, and incorporated into the TMDL project, through conversations with landowners and recreational enthusiasts met during the 1998 field surveys. The experiences and concerns of these citizens complemented the data collected by the Ohio EPA. Due to the significant interest and concerns of wastewater industry professionals regarding the TMDL process, Ohio EPA presented information to the Southwest Section of the Ohio Water Environment Association at their May 18, 2000 meeting at the Greene County Beavercreek Water Resource Reclamation Facility. The presentation included a general overview of a TMDL project, assessment of the current conditions of the Little Miami River and principal tributaries, opportunities for stakeholder involvement, and upcoming tasks specific to the TMDL project for the upper Little Miami River. The issue of phosphorus controls for point sources was discussed at this meeting. The presentation generated considerable questions and feedback, with a significant interest in continued involvement in the TMDL project.

Early and ongoing stakeholder involvement generally leads to a more successful and effective TMDL development and implementation process. Ohio EPA's desire was to continue to encourage and support a substantial role for stakeholders in the process. As a result, Ohio EPA, Division of Surface Water, held a Public Information Session on the upper Little Miami River on June 6, 2000, in Xenia (Greene County). The purpose of this informal public meeting was to provide data on the current "health" of the upper Little Miami River, explain why it was selected for a TMDL project, describe steps and methods to restore and protect water quality, and request the participation of the public in this process. From this meeting, the upper Little Miami River TMDL Stakeholders Workgroup was established. The Workgroup originally consisted of approximately 25 members with a wide range of knowledge, interests, and concerns regarding the river. Interests represented by the Workgroup included private citizens/landowners, agricultural community (farmers), municipal officials,

recreational uses, government entities, environmental interest/advocacy groups, academic, regional planning, land development, and the industrial community.

Because the upper Little Miami River watershed presents a unique and complex set of problems, it was apparent that a mix of regulatory and voluntary actions was needed to solve them. This required a workgroup composed of individuals and organizations who actually use the water resource, or contribute or control pollution to the watershed, to help design and carry out the TMDL project.

A series of Workgroup meetings were held (refer to Table 13a) to provide a forum where water quality issues could be discussed openly. At the request of the stakeholders, Ohio EPA contracted the services of a private, professional facilitator (Fred Bartenstein and Associates, Yellow Springs, Ohio; and Roberta F. Garber Consulting, Columbus, Ohio) to provide nonpartisan assistance in conducting the meetings. The meetings were structured to strive for understanding and cooperation among the stakeholders. The primary purpose was to share the knowledge of existing water quality conditions and discuss and evaluate the sources and causes of water quality impairments, and look for workable solutions. A list of the Stakeholders Workgroup members and other interested parties is contained in Appendix D. All the meetings were hosted by Greene County and were open to any interested party; the meetings were periodically attended by private citizens, consultants, and USEPA (Bernie Daniels, National Exposure Research Laboratory, Cincinnati). In May, 2001, the Workgroup decided to move forward with the implementation phase of the TMDL project with a change in the organizational structure of the group. The Workgroup decided to continue working under the coordination and facilitation of the Little Miami River Partnership (LMRP), a local, nonprofit watershed improvement organization. Ohio EPA's role shifted from administrative support, provider, and catalyst to one of a collaborative stakeholder. LMRP has facilitated and sought financial resources for the continuing activities of the watershed stakeholder group, especially involving implementation and monitoring. The workgroup is now referred to as the upper Little Miami Watershed Improvement Group (uLMR WIG), and it continues to meet the second Wednesday of every month to work on the watershed action plan/TMDL implementation plan.

Ohio EPA also met with several groups separately to present the results of the TMDL study and to discuss each group's concerns. For example, meetings were held with Montgomery County officials to discuss unique issues associated with the Little Beaver Creek and the Eastern Regional Wastewater Treatment Plant. These meetings are listed in Table 13b. Several of the regulated communities requested that Ohio EPA delay finalization of the TMDL report until a review of the science underlying the report could be completed by a consulting firm retained by the communities' legal representative. The Ohio EPA complied with this request and devoted resources to assist this review process.

The public outreach activities also include two public comment periods associated with the review of the draft TMDL report prior to its submittal to U.S. EPA Region 5. The first draft TMDL report was public noticed on January 26th, 2001, and a copy of the report was posted on Ohio EPA's web page (http://www.epa.state.oh.us/dsw/tmdl/index.html). In addition, copies of the report were distributed to local libraries. The first draft TMDL report was revised based on comments received and this second revised report was public noticed on December 5, 2001. The second revision is available at the same

web site, and copies of the report were distributed to local libraries as well. A summary of the comments received and the associated responses is included in Appendix E.

Public involvement is the keystone 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 this section of the Little Miami River watershed into attainment.

Table 13a. Upper Little Miami River Watershed Stakeholders Workgroup Forum

Date	Time	Subject(s)
6/27/00	9:00 a.m.	Workgroup organizational issues; Stream ecology
7/12/00	1:30 p.m.	Biosurvey results; Causes and sources of impairment; Wrkgrp make-up
8/3/00	1:30 p.m.	Nonpoint source issues; Riparian status; Modeling parameters
8/23/00	1:30 p.m.	Water quality modeling; Selected causes of impairment
9/27/00	1:30 p.m.	Nonpoint source controls; Additional parameters; Wrkgrp feedback
10/11/00	1:30 p.m.	Modeling recommendations; Restoration strategies; Project time line
10/25/00	1:30 p.m.	Discussion and evaluation of restoration strategies
11/22/00	1:30 p.m.	Status of modeling; Restoration details required; Revised project time line
12/14/00	1:30 p.m.	Model predictions for restoration strategies; Urban storm water
1/2/00	9:00 a.m.	Septic system subgroup; septic system and septage issues
1/4/00	1:00 p.m.	Urban stormwater runoff (NEMO) presentation; Subgroup updates
1/22/00	9:00 a.m.	Septic system subgroup meeting; Implementation plan details
2/1/01	1:30 p.m.	Subgroup updates; Implementation plan development
2/14/01	1:30 p.m.	Subgroup reports; Implementation tables; Review draft report
2/28/01	1:30 p.m.	Ohio EPA technical session/presentation; Q & A's
3/29/01	1:30 p.m.	DEFA presentation on funding sources; implementation plan
4/2/01	10:20 am	Ohio EPA meeting with Point Sources Subgroup Re: PS strategy
5/2/01	1:30 p.m.	Merged implementation plan; Transfer of coordination to LMRP
6/6/01	1:30 p.m.	Workgroup organizational issues; Additional stakeholder involve.
7/11/01	1:30 p.m.	Review additional stakeholders; review draft brochure and website
8/8/01	1:30 p.m.	Partner update; Brochure and website review; Implementation plan
9/12/01	1:30 p.m.	Point source strategy review; Implementation plan subcommittees
10/10/01	1:30 p.m.	Update on peer review of OEPA modeling; finalizing implementation plan
The upper LMR Watershed Improvement Group continues to meet the 2nd Wednesday of each month		

Table 13b. Meetings with Ohio EPA concerning the upper Little Miami River

Date	Time	Organization
4/19/95	10:00 a.m.	NPDES officials from communities in Little Miami R. (LMR) watershed
5/24/95	6:00 p.m.	Public meeting RE: 1995 LMR Survey Report
7/31/95	7:00 p.m.	Presentation to Little Miami Inc. on 1995 LMR Survey Report
5/17/96	8:30 a.m.	Cooperative Watershed Management Workshop RE: Status of LMR
5/13/99	7:00 p.m.	Presentation to Little Miami Inc. RE: Preliminary results of 1998 survey
5/18/00	2:00 p.m.	Presentation to SWOWEA RE: upper LMR Watershed Restoration
5/23/00	7:00 p.m.	Presentation to Little Miami Inc. RE: 2000 LMR Survey Report
6/6/00	7:00 p.m.	Public Information Session RE: upper LMR Watershed Assessment
10/12/00	9:30 a.m.	Meeting with Montgomery County officials RE: Little Beaver Creek issues
10/24/00	10:00 a.m.	Meeting with Greene County officials RE: Shawnee Hills project
12/13/00	11:00 a.m.	Presentation to Little Miami River Partnership RE: upper LMR TMDL
1/8/01	1:00 p.m.	Meeting with Montgomery County Sanitary Engineering officials RE: proposal for septage receiving station
1/16/01	2:45 p.m.	Presentation to OFSWCD RE: Case Study of the upper LMR TMDL
5/8/01	8:00 a.m.	Meeting with regulated community consortium (Greene and Montgomery Counties and City of Xenia) to discuss NPDES/TMDL issues.
6/18/01	2:00 p.m.	Meeting with Jamestown WWTP representatives concerning the S. Br Caesar Ck
8/2/01	10:00 a.m.	Meeting with consulting firm reviewing TMDL modeling work

6.0 IMPLEMENTATION AND MONITORING RECOMMENDATIONS

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 Section 2.0, the causes of impairment in the upper Little Miami River are primarily nutrient enrichment, sedimentation, and stream habitat degradation. 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.

The upper Little Miami River TMDL Stakeholders Workgroup (now the upper LMR Watershed Improvement Group) has developed a list of potential restoration strategies. These strategies have been screened and evaluated using selected criteria (including feasibility, acceptability, sustainability, economical, reasonable assurance, and measurability) to identify the actions to be used to achieve the TMDL restoration targets. The proposed strategies are as follows (listed in no particular order):

- Stormwater management plans
- Reduce the use of residential fertilizers and pesticides
- Riparian buffers; agricultural erosion control (bioremediation)
- Erosion control in urban/residential areas
- Septic system management and maintenance
- Corridor protection ordinances and zoning regulations to protect scenic river
- Public education for appreciation of watersheds
- Increase no-till farming practices
- Enforcement of storm water regulations, especially for residential and commercial development
- Point source controls - permit effluent limitations (numerical restrictions and/or BMPs)
- Limit and reuse point source discharge water
- Ban the sale of detergents with phosphorus
- Eliminate point source discharges

Based on a straw poll conducted by Workgroup members, the strategies receiving the most favorable consideration appear to be habitat improvement (e.g., riparian buffers), no-till and precision farming practices, septic system management, and point source controls. The implementation plan will strongly recommend the use of existing 319 grant-funded projects and other funding sources to assist in carrying out the nonpoint source controls. Two 319-funded projects currently exist in the upper Little Miami River area covered by this TMDL project. The first is the 1999 upper Little Miami River Nonpoint Source Pollution Control Project, scheduled to run through March, 2003. The geographic area covered in this project in the upper Little Miami River watershed upstream from Caesar Creek. The second 319 project is the 2000 Caesar Creek Watershed Water Quality Project, extending to June, 2004. These 319 projects fund a coordinator, Heather Buckles, who oversees the 319 project actions and is a member of the upper LMR Watershed Improvement Group. The Little Miami River Partnership secured additional 319 funds to retain Sarah Hippensteel as a watershed coordinator; she is

currently facilitating the upper LMR Watershed Improvement Group and has a lead role in developing a watershed action plan for the Little Miami River.

Point source controls (particularly nutrient effluent limits) have been discussed in Workgroup meetings and at other meetings between Ohio EPA and NPDES permit holders. Figures 10 and 11 demonstrate the need for point source controls even though the majority of the annual load is nonpoint source in nature. Figure 10 shows that during low flow months there is a consistent base level of total phosphorus in the system not associated with runoff events. Figure 11 shows that point sources account for 45% of the total phosphorus load basin-wide and 64% of the total phosphorus load in subwatershed 3 during the month of September. Issuance of NPDES permits with nutrient (e.g., phosphorus) and dissolved oxygen associated parameter effluent limitations is a part of the implementation plan; section 6.1.2 discusses this in more detail.

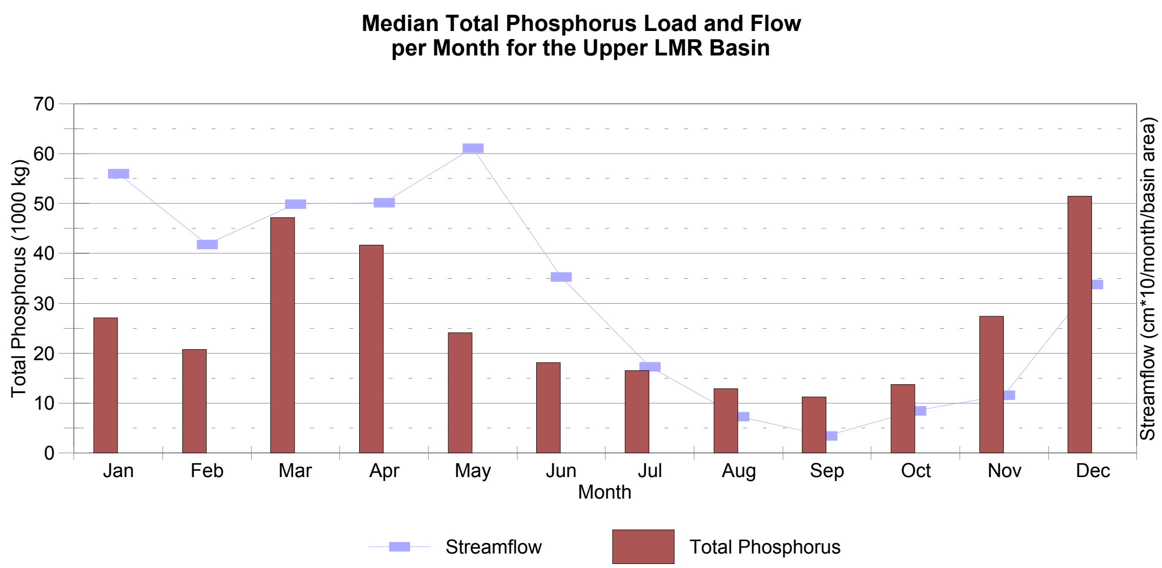
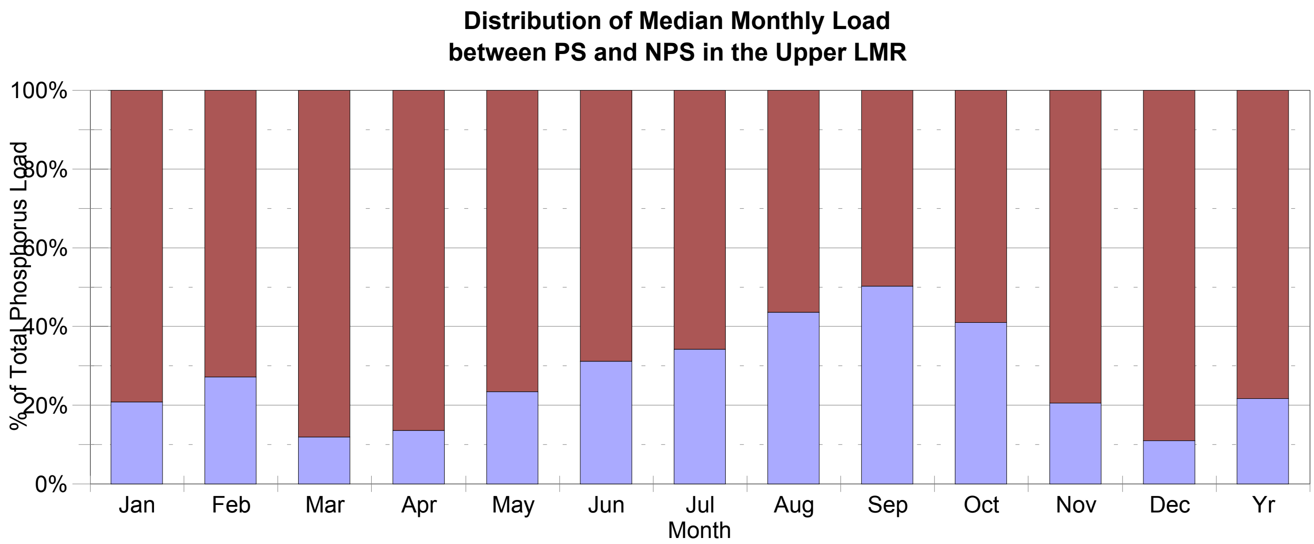


Figure 10. Comparison of the calculated mean monthly total phosphorus load and total streamflow.



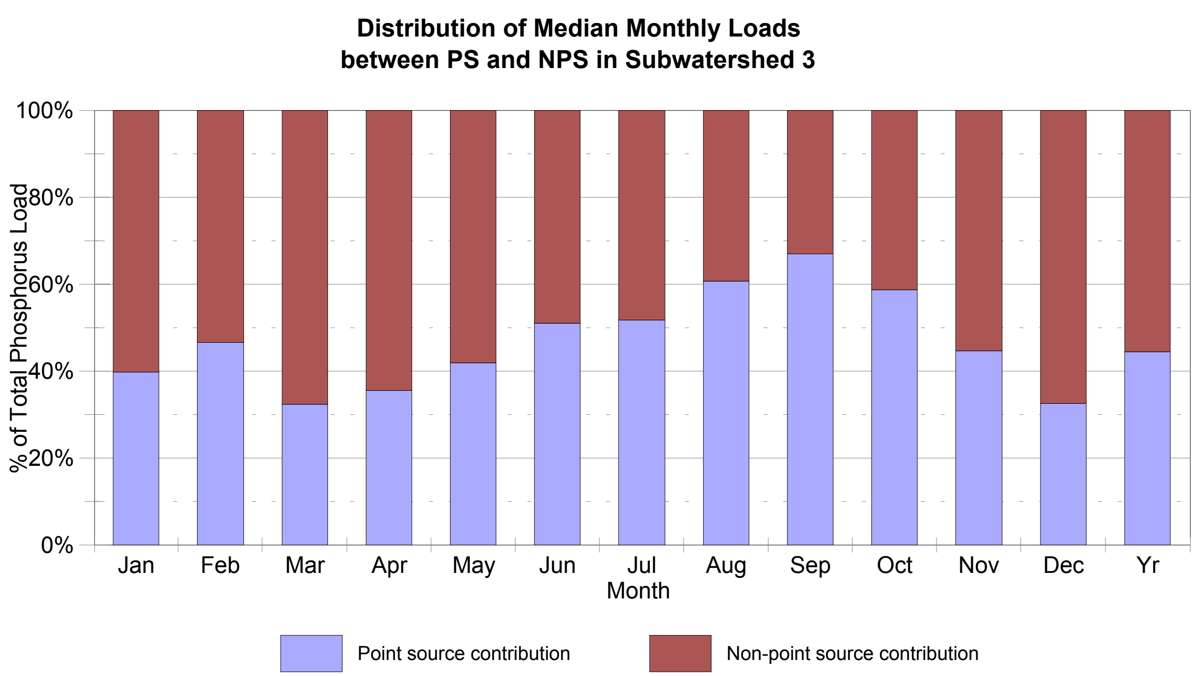


Figure 11. Relative contribution of monthly load for total phosphorus from point and nonpoint sources in the entire watershed (upper) and in the effluent-dominated subwatershed 3 (lower).

Ohio EPA is taking an iterative, adaptive approach to implementation for this TMDL project. NPDES permits will be issued such that:

- reasonable reductions of total phosphorus and instream monitoring of phosphorus and other TMDL parameters will be required;
- enough time will be incorporated into the permit process to allow for nonpoint source controls to become effective and additional data to be collected;
- trends in instream concentrations will be tracked, and the NPDES permits will include an option for permit modifications should data indicate instream total phosphorus levels have achieved stable and desirable levels or that the use designations are being fully met.

Following verification and acceptance of the selected restoration scenario, the Stakeholders Workgroup will prepare a final implementation (watershed action) plan by documenting the actions of the selected scenario that will be implemented to achieve the TMDL restoration target. For point sources, the NPDES permits will describe the required restoration actions; the final implementation plan may include some additional voluntary actions as well. For nonpoint sources, the implementation plan will describe the management practices or control actions necessary to attain the load allocations. A draft implementation plan is included in section 6.1.1. The involvement of the Stakeholders Workgroup will be critical to the implementation of nonpoint source BMPs.

Generally, implementation of BMPs relies on voluntary and incentive programs, such as government cost-sharing. Therefore, the implementation plan should show: 1) there is reasonable assurance that nonpoint source controls will be implemented and maintained; or 2) nonpoint source reductions are demonstrated through an effective monitoring program. Long-term watershed water quality monitoring will also be important in evaluating the effectiveness of BMPs. The implementation plan will include a time schedule describing when the activities necessary to implement the TMDL will occur. This would include a schedule for issuance of NPDES permits consistent with the TMDL and a time line for implementation of BMPs and/or control actions. The plan should also contain reasonable assurances the implementation activities will occur. A draft implementation plan is included in the following section; the final implementation plan (watershed action plan) will be forwarded to USEPA as an addendum to this report.

6.1 Reasonable Assurances

As part of an implementation plan, reasonable assurances provide a level of confidence that the wasteload allocations and load allocations in TMDLs will be implemented by Federal, State, or local authorities and/or by voluntary action. The stakeholders will develop and document a list that differentiates the enforceable and non-enforceable selected actions necessary to achieve the restoration targets. Reasonable assurances for planned point source controls, such as wastewater treatment plant upgrades and changes to NPDES permits, will be a schedule for implementation of planned NPDES permit actions. For non-enforceable actions (certain nonpoint source activities), assurances must include 1) demonstration of adequate funding; 2) process by which agreements/arrangements between appropriate parties (e.g., governmental bodies, private landowners) will be reached; 3) assessment of the future of government programs which contribute to implementation actions; and 4) demonstration of anticipated effectiveness of the actions. It will be important to coordinate activities with those

governmental entities that have jurisdiction and programs in place to implement the nonpoint source actions (e.g., county soil and water conservation district offices, county health departments, local Natural Resource Conservation Service offices of the U.S. Department of Agriculture, municipalities and local governmental offices).

A summary of the regulatory, non-regulatory and incentive based actions applicable to or recommended for the upper LMR basin:

Regulatory:
- basin wide phosphorus limit of 1 mg/l for NPDES dischargers
- basin wide ammonia nitrogen, dissolved oxygen, and CBOD limits for NPDES dischargers
- new requirements for household sewage treatment systems (statewide requirement)
- sewage sludge disposal standards to regulate sludge application rates (statewide)
- phase I and II stormwater requirements

Non-regulatory:
- finalization of an implementation plan (see 6.1.1) which includes:
  - education activities
  - stormwater management
  - septic system improvements
  - agricultural controls and riparian initiatives
- the upper LMR Watershed Improvement Group and other non profit groups to promote the implementation plan and other activities contributing to the goals of the TMDL project
- periodic stream monitoring to measure progress

Incentive-based:
- 319-funded projects for the entire upper LMR basin which support the goals of this TMDL
- 319-funded (in part) watershed coordinator to promote watershed improvement activities
- various loan opportunities for WWTP, septic system, and riparian/habitat improvements

6.1.1 The upper LMR Watershed Improvement Group DRAFT Implementation Plan

The upper Little Miami River TMDL Workgroup recognized five important strategies to focus efforts in developing an implementation plan. They are: 1) storm water management, 2) septic system management, 3) agriculture and riparian corridors, 4) public education, and 5) point source controls. Five committees or "subgroups" were formed to develop implementation actions for these strategies, including actions and management measures, time lines, reasonable assurances, and monitoring plans. This implementation plan is in its formative phase at the time of this report; it is expected that the draft plan and proposed actions included here will evolve further as the Watershed Improvement Group continues to develop it.

Stormwater Management
Stormwater runoff is a significant source of nonpoint source pollution in the upper Little Miami River watershed. Implementation actions to address this would include drafting ordinances for stormwater and sediment and erosion control, creating and publishing a list of acceptable stormwater BMPs, and expanding existing programs (i.e. Soil and Water Conservation Districts (SWCDs)) to include stormwater monitoring. Public education, such as developing an adult education program about stormwater pollution, would be an important and necessary part of the implementation plan.

Septic System Management
Septic systems impact water quality in the upper Little Miami River watershed through both point and nonpoint discharges from failed, faulty, or discharging systems and improper disposal of wastes (septage) from septic systems. Implementation actions to address these sources of pollution would include oversight of septic tank waste haulers, identification of faulty septic systems, elimination of on-site septic systems through extension of municipal sanitary sewers, and public education on septic system maintenance.

Agriculture and Riparian Corridors
The upper Little Miami River watershed is a predominately agricultural area used mostly for row crop production and, to a smaller degree, livestock production. In the past few decades, conservation efforts by farmers, local partnerships and units of government have reduced nonpoint sources of pollution significantly, and efforts in this direction continue. However, nonpoint contributions from agriculture still exist. Landowners can take advantage of several incentive programs that will cover significant portions of the cost of adopting Best Management Practices on farmland, while educational initiatives exist to boost participation in these programs.

Public Education
An Education Committee would be formed by inviting all the NPS/watershed related education programs to be partners. This Committee would be charged with the research and compilation of information about current NPS/Watershed related educational programs. The Committee would then work to make these programs more effective, and create programs that would fill in where current programs fell short/don't exist. The primary focus would be on a healthy watershed/NPS elimination.

Point Source Controls
Water quality impairment in the upper Little Miami River watershed is caused by both nonpoint and point source pollution. Implementation actions to address point source impacts have been considered by the regulated community subgroup and have been taken under consideration by the Ohio EPA. NPDES language follows in section 6.1.2.

6.1.1.1 Minimum Elements of an Approvable Implementation Plan
Whether an implementation plan is for one TMDL or a group of TMDLs, it must include at a minimum the following eight elements:

- *Implementation actions/management measures:* a description of the implementation actions and/or management measures needed to implement the allocations contained in the TMDL, along with a description of the effectiveness of these actions and/or measures in achieving the required pollutant loads or reductions. (Table 14)

- *Time line:* a description of when activities necessary to implement the TMDL will occur. It must include a schedule for revising NPDES permits to be consistent with the TMDL. The schedule must also include when best management practices and/or controls will be implemented for source categories, subcategories and individual sources. Interim milestones to judge progress are also required. (Table 15)

- *Reasonable assurances:* reasonable assurance that the implementation activities will occur. Reasonable assurance means a high degree of confidence that wasteload allocations and /or load allocations in TMDLs will be implemented by Federal, State or local authorities and /or voluntary action. For point sources, reasonable assurance means that NPDES permits (including coverage under applicable general NPDES permits) will be consistent with any applicable wasteload allocation contained in the TMDL. For nonpoint sources, reasonable assurance means that nonpoint source controls are specific to the pollutant of concern, implemented according to an expeditious schedule and supported by reliable delivery mechanisms and adequate funding. (Table 15)

- *Legal or regulatory controls:* a description of the legal authorities under which implementation will occur (as defined in 40 CFR 130.2(p)). These authorities include, for example, NPDES, Section 401certification, Federal Land Policy and Management programs, legal requirements associated with financial assistance agreements under the Farm Bills enacted by Congress and a broad variety of enforceable State, Territorial, and authorized Tribal laws to control nonpoint source pollution. (Table 15)

- *Time required to attain water quality standards:* an estimate of the time required to attain water quality targets. The estimates of the time required to attain and maintain water quality standards must be specific to the source category, subcategory or individual source and tied to the pollutant for which the TMDL is being established. It must also be consistent with the geographic scale of the TMDL, including the implementation actions. (Table 16)

- *Monitoring plan:* a monitoring or modeling plan designed to determine the effectiveness of the implementation actions and to help determine whether allocations are met. The monitoring or modeling plan must be designed to describe whether allocations are sufficient to attain water quality standards and how it will be determined whether implementation actions, including interim milestones, are occurring as planned. The monitoring approach must also contain an approach for assessing the effectiveness of best management practices and control actions for nonpoint sources. (Table 16)

- *Milestones for attaining water quality standards:* a description of milestones that will be used to measure progress in attaining water quality standards. The milestones must reflect the pollutant(s) for which the TMDL is being established and be consistent with the geographic scale of the TMDL, including the implementation actions. The monitoring plan must contain incremental, measurable milestones consistent with the specific implementation action and the time frames for implementing those actions. (Table 16)

- *TMDL revision procedures:* a description of when or under what conditions a TMDL revision would be triggered. EPA expects that the monitoring plan would describe when failure to meet specific milestones for implementing actions or interim milestones for attaining water quality standards will trigger a revision of the TMDL. (Narrative)

6.1.1.2 Implementation Actions, Time line, and Reasonable Assurances

The implementation actions and measures are described in Table 14. The implementation actions proposed by the regulated community representatives involved with the watershed improvement group is included in section 6.1.1.3. The reasonable assurances are described in Table 15. A time line for implementation actions is included in both Tables 15 and 16.

Table 14. Description of Implementation Actions and Measures

#	Implementation Actions & Management Measure	Effected Stream/Party	Parameters Effected/Benefits	Estimated Effectiveness[1]
1	Draft model sediment and erosion control ordinances	uLMR	Sediment and P reductions, improve habitat	
2	Draft model stormwater ordinances: Use critical storm method of determining basin size	LMR	Reduce instream erosion, reduce Urban NPS loadings	
3	Create a list of acceptable stormwater BMPS	LMR	Reduce Urban NPS loadings	60-80% based on BMPs selected
4	Coordinate a field day to showcase SEC/SW BMPs	LMR	Increase use of BMPs (reduce NPS loadings)	
5	Draft model stormwater ordinances: Use non-structural BMPs preferentially	LMR	Reduce Urban NPS loadings	60-80% based on BMPs selected
6	Create and implement adult NPS education program	LMR	Reduce Urban NPS loadings, increase public participation	

Table 14. Description of Implementation Actions and Measures

#	Implementation Actions & Management Measure	Effected Stream/Party	Parameters Effected/Benefits	Estimated Effectiveness[1]
7	Expand existing SWCD programs to include SW monitoring	LMR	Increase public participation	
8	Recommend switching existing permits for sites from general to individual stormwater permit	uLMR	Site specific pollutant reduction	Site specific
9	Phase II Compliance for Jurisdictions in the Urbanized Area -	LMR, Beaver Cr, Massie Cr	Reduce Urban NPS loadings	60-80% based on BMPs selected
10	Creation of a TMDL stakeholder group to coordinate activities and oversee progress	LMR	Increase public participation	
11	Develop conservation plans on 90,000 acres of cropland in the watershed over 4 years. Conservation plans are documents listing decisions by landowners to implement BMPs listed in this table.	LMR and tribs	Sediment, phosphorus, nitrogen reductions, improved wildlife habitat	Effectiveness listed for each BMP, see following items in Table 14.
12	Establish 50 acres of new grassed waterways per year in the watershed	LMR and tribs	Sediment, phosphorus reductions	95% reduction in areas treated.
13	Establish 75 acres of new grassed filter strips per year in the watershed	LMR and tribs	Sediment, phosphorus, nitrogen reductions, improved habitat	60-80% reductions in treated fields once established
14	Establish 20 acres of new tree planting per year in the riparian corridors of the watershed	LMR and tribs	Sediment, phosphorus, nitrogen reductions, improved habitat	70-90% reductions in treated areas, once established
15	Promote the adoption of evolving technologies (residue management, prescription farming, etc.) in the watershed.	LMR and tribs	Sediment, phosphorus, nitrogen reductions.	Highly variable
16	Develop manure nutrient management plans for farmers with livestock (Regulations will drive demand for those over 300 animal units)	LMR and tribs	Organic material (OM), phosphorus, nitrogen reductions.	20-40% reductions in planned areas, estimated 10 per year
17	Exclude livestock from streams and other water sources on 6 farms per year.	LMR and tribs	Sediment, Organic material, BOD	80% reduction on treated farms.
18	Conservation easements, land ownership by non profit civic groups, i.e. Beavercreek Wetlands, LMRP	LMR and tribs	Sediment, phosphorus, nitrogen reductions, improved habitat	60% reduction in treated areas
19	Health Department manifest program for septic tank handlers	Watershed entire	Sediment, CBOD, TSS, phosphorus, ammonia, bacteria, heavy metals	Proper land application of haulers is the manifest program 60-90% complnc

Table 14. Description of Implementation Actions and Measures

#	Implementation Actions & Management Measure	Effected Stream/Party	Parameters Effected/Benefits	Estimated Effectiveness[1]
20	Education, canoeing, etc. report in areas identified as to septic tank leach field runoff into streams	Watershed entire	Sediment, CBOD, TSS, phosphorus, ammonia, bacteria, heavy metals	10 years minimum 50% reduction
21	General education program, or septic tank maintenance - GIS, etc. - ongoing	Watershed	Sediment, CBOD, TSS, phosphorus, ammonia, bacteria, heavy metals	3 years survey - 319 grant - 40% reduction
22	800 septic tanks taken off line and sanitary sewer w/treatment provided - as sanitary sewers are extended more septic tanks will be removed	Caesar Creek	Elimination	100% - 2006
23	25 septic tanks taken offline and sanitary sewer w/treatment provided	Glady Run	Elimination	100% - 2001
24	Hold field day to show sediment erosion control/stormwater BMPs	All stakeholders	ALL	Cross reference with #4
25	Create and implement adult NPS education program	All stakeholders	ALL	Cross reference with #6
26	Educate septic tank handlers - manifest program	Septic tank handlers	ALL	Cross reference with #19
27	Septic tank maintenance education program	Homeowners	ALL	Cross reference with #21
28	Formation of a LMR/NPS education subcommittee that pursues/oversees/ supplements/funds educational opportunities	All stakeholders All major educational partners	ALL	
29	Educate the agricultural community about evolving technologies	Agriculture	ALL	Cross reference with #15
30	Educate landowners about the benefits of grassed waterways/filter strips	Agriculture /Rural	ALL	Cross reference with #13/14
31	Educate landowners about why livestock should be excluded from waterways	Agriculture	ALL	Cross reference with #17
32	Conduct survey of stakeholders to assess their level of knowledge on watersheds and NPS	All stakeholders	ALL	

[1] The effectiveness of actions and measures will be measured in whatever way is appropriate to that action or measure. Percent reductions of loads, buffer zones in meters or feet, conversion of acreage to fallow or forest, etc.

Table 15. Time line and Reasonable Assurances

#	Action	Managing Party	Schedule		Reasonable Assurance Description/Specifics	Type[1]
1	Draft sediment erosion ordinances	Stakeholder group	Spring 2001	Summer 2002	Counties already have SEC, push to get municipalities to adopt and enforce (as incentive for all; alternative to expensive WWTP upgrades)	Education
2	Draft SW ordinances	Stakeholder group	Spring 2001	Spring 2002	Committee to write model ordinances, push to get all jurisdictions to adopt and enforce	Education
3	Stormwater (SW) BMPs	Stakeholder group	Spring 2001	Spring 2002	ODNR updating RALD…pay for printing for all engineering departments in Watershed	Incentive Education
4	Field day	Stakeholder group	Summer 2001	Summer 2001	Conduct field day to showcase SEC/SW BMPs	Education
5	Draft SW ordinances	Stakeholder group	Spring 2001	2002	Committee to write ordinances, through education and language use non-structural BMP's preferentially	Education
6	Adult NPS education	Stakeholder group	Summer 2001	Ongoing	SWCDs/NEMO have existing programs: expand scope of SWCD program to include adults	Education
7	SW monitoring SWCD	Stakeholder group	Summer 2001	Ongoing	Already a push by DNR, offer equipment incentive to do monitoring in the WS, publish quarterly results newsletter coupled with Action 6	Incentive
8	Individual SW permits	Ohio EPA	Spring 2001		Ohio EPA is permitting authority for Storm water permits	Regulatory
9	SW Ph. II - Urban Areas	Ohio EPA w/ regulated jurisdiction	Dec. 2002	2007	Ohio EPA is permitting authority for storm water permits. Federal regulations require Phase II programs to be developed and implemented by end of first permit round.	Regulatory, Education
10	Coordinate education	Stakeholder group	Spring 2001	Ongoing	Include representatives from more populous counties, SWCD education personnel, interested groups	Education
11	Conser-vation Plans	NRCS	4/1/01	3/31/05	NRCS and SWCD partners established a goal to complete plans on 90,000 acres by the end of the 319 project period.	Existing Staff
12	Grassed Waterways	NRCS SWCD	8/1/01	9/15/05	Financial incentives are in place to encourage landowners to construct waterways, continuing education efforts.	Incentives, Education
13	Grass Filter Strips	NRCS SWCD	4/1/01	9/15/05	Financial incentives are in place to encourage landowners to construct filter strips, continuing education efforts.	Incentives, Education
14	Riparian Tree Planting	NRCS SWCD ODNR	4/30/01	4/30/06	Financial incentives are in place to encourage landowners to plant trees, continuing education efforts.	Incentives, Education

Table 15. Time line and Reasonable Assurances

#	Action	Managing Party	Schedule		Reasonable Assurance Description/Specifics	Type[1]
15	Residue Mgmt., Prescription Farming, etc.	OSU, Ag Business, NRCS, SWCD	4/1/01	3/31/05	Economic trends, educational field days, financial incentives will drive the adoption of these BMPs	Incentives, Education
16	Manure Nutrient Mngmnt	NRCS SWCD OSU ODA ODNR	4/1/01	3/31/05	Assistance will be provided to landowners who wish, or are required to have detailed management plans. Education programs will be accelerated.	Regulation Incentives Education
17	Livestock Exclusion	NRCS, SWCD, ODNR	4/1/01	3/31/05	Financial incentives are in place to encourage landowners to install fencing and reconstruct riparian corridor.	Existing staff, regulations
18	Civic groups actions	Non-profit groups: BCWA, LMI, TLT LMRP	4/01/01	4/30/06	Non-profit groups raising funds to continue acquiring conservation easements and/or land purchases on sensitive areas along LMR	Existing non-profit groups
19	Septic manifest	Health Districts	Summer 2001	Annual renewal	Monitoring permits and hauler dump sites	Registra-tion fee increase
20	Educate, survey septic systems	LM Inc., realtors, canoe rentals, etc.	Summer 2001	Fall 2011	Quarterly meetings,	319 funding
21	Educate-septic maintained	LMRP GC Soil & Water	Spring 2001	Fall 2005	Quarterly meetings	319 funding
22	Eliminate. 800 septic systems-Shawnee Hills	Greene County Board of Commissioners	In progress	Winter 2006	Greene County Board of Commissioners design and specifications w/PTI approval by Ohio EPA and property owners have up to one year to connect to new sanitary sewer	Sewer revenues & assessment
23	Eliminate 25 septic systems	City of Xenia	Spring 2001	Summer 2002	City of Xenia design and specifications w/PTI approval by Ohio EPA and property owners have up to one year to connect to new sanitary sewer	City of Xenia - sewer fund
24	#4	SWCD			Coordinate field day to showcase Sediment Eros. Control/Stormwater BMPs	

Table 15. Time line and Reasonable Assurances

#	Action	Managing Party	Schedule		Reasonable Assurance Description/Specifics	Type[1]
25	#6	SWCD NEMO			Create and implement adult NPS education program	
26	# 19	Health Districts			Educate septic tank handlers - manifest program; Monitoring permits and Dump sites	Registra-tion fee increase??
27	#21	LMRP SWCD			Septic Tank maintenance education program; 319 Funding	Existing
28		LMRP			Formation of a LMR/NPS education subcommittee that pursues/updates/oversees educational opportunities; Part of current grant obligation	
29	#29	OSU, Ag Business, Farm Bureau, NRCS, SWCD			Educate the agricultural community about evolving technologies; Field days Financial incentives Economic trends?	Existing
30	#13/14	NRCS SWCD			Educate landowners about the benefits of grassed waterways/filter strips; Financial incentives	Existing
31	#17	NRCS SWCD ODNR			Educate landowners about why livestock should be excluded from waterways; Financial incentives	Existing
32					Conduct survey of stakeholders to assess their level of knowledge on watersheds and NPS	

[1] Types of assurances include legal or other regulatory actions and authority, funding, incentive programs, etc.

Table 16. Time line: Monitoring, Tracking and Implementation (see key below)

Action Year	2001				2002				2003				2004				2005				2006	2007	2008	2009	2010
Quarter	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4					
1 (adopt)		A					C	M							E				V						
2 (write)		A				C	M																		
2 (adopt)							A				C	M			E				V						
3		A				C	M								E				V						
4			A	C	M										E				V						
5 (write)						C	M																		
5 (adopt)							A								E				V						
6							C								E				V						
7															E				V						
8				A				C			E	C				C			V						
9								A				C					M					M, E	V		
10		A	C																						
12 Waterways				A	C			A	C			A	C			A	C			A	E				
13 Buffers		A		A	C	A		A	C	A		A	C	A		A	C	A		A	E				
14 Trees			A	C			A	C			A	C			A	C			A	E					
15 Technology				C				C				C				C				C					
16 MNMPs		A	A	C		A	A	C		A	A	C		A	A	C		A	A	E					
19 Health Dept. Manifest			A		C		E																		A
20 Education on stream site discharges		A				C				C				C				C			C	C	C	C	E
21 General education		A			M			M				M				E									
22 Greene County												A				C					C				
23 City of Xenia		A	E																						

Key:
A - Action completed/installed/incorporated
C - Check point to track action implementation (did action get completed?)
M - Monitoring of indicators begins (indicators specified in monitoring plan)
E - Expected target attainment
V - Validation; biological survey to determine if targets are attained

Note:
This is a working document. Schedules for some of the implementation actions have not been developed yet.

6.1.1.3 The POTW Proposed Implementation Plan (as of 4/23/01)

The following language was proposed by the regulated community involved with the watershed improvement group. The ideas contained below were taken into consideration by Ohio EPA; however, the implementation of the TMDL wasteload allocations will consist of special conditions in the permits as described in section 6.1.2. The regulated community proposal for their permit conditions is as follows:

Prior to finalization of the upper Little Miami TMDL and issuance of modifications to existing NPDES permits, the following activities will be conducted by the POTW. These activities will lead to an enhancement of the draft TMDL and build additional consensus on the proper course of action.

1. Check river impairment through data review once the data becomes available – 6 months
2. Peer review the TMDL models and science and verify models in the field – 6 months
3. Conduct internal wastewater treatment plant studies to identify operational opportunities for phosphorus reduction without capital expenditures.
4. Develop Quality Assurance Plan with Ohio EPA. POTWs will assist with sample collection and analyses – 3 years
5. Prepare detailed comments of TMDL Draft Report – 6 months
6. Assess economic impacts – 6 months
7. Bring results to a TMDL committee for incorporation into an overall TMDL cost/benefit prioritization to ensure funds are spent appropriately.
8. Pursue 319 grants and other funding.

These activities require a "pause" in the current TMDL process and an extension of existing NPDES permits for five (5) years.

Rationale

The rationale behind the POTW Implementation Plan is:

1. A reduction of phosphorus discharges through POTW NPDES permits is only one of several methods to implement a TMDL.
2. The draft TMDL needs to be fully evaluated through peer review before selecting any implementation method.
3. The target restoration values should be based on sound scientific data and conclusions.
4. There is sparse data on cause and effects of various TMDL implementation programs.
5. Funds to restore the river must be spent well and must make a difference. Sound cost/benefit analyses supported by science are required.
6. Creative options to meet the targets and improve the river must be thoroughly explored. These options include: education, outreach, regional cooperation, formation of control districts, etc.
7. Finalization of NPDES permits with phosphorus limits does not allow adequate time to thoroughly explore the options.
8. The POTWs have already engaged a consultant. A peer review will commence within one (1) month.

6.1.1.4 Monitoring Plan

Stormwater Monitoring Plan:
Outside of Phase II and Individual Storm Water permits, the remaining storm water control Actions are voluntary. The formation of a Stakeholder based advisory group to guide the progress of the Implementation Plan (Action 10) would be an important first step. The upcoming Phase II regulations require affected jurisdictions to have both public education and involvement control measures. A TMDL Stormwater Advisory Group would help fill this Phase II need also.

Action Items 1, 2, 5 require coordination between TMDL Stakeholders to review existing SEC ordinances and enabling legislation to model effective ordinances that jurisdictions would be willing and able to enact and enforce. The TMDL Stakeholder group would manage the review and development of a new model ordinance. Progress would be tracked by how many separated ordinances are reviewed, toward the target of providing alternative ordinance updates for jurisdictions.

Action 3 requires the Stakeholder Group to review current list of BMP's and determine which may be most appropriate for this watershed. Sources for BMP lists include the ODNR RALD, and US EPA Storm water toolbox. A diverse selection of watershed appropriate BMP's allow many stressors to be addressed through the implementation of BMP's, and the flexibility in choosing practices would increase the likelihood of implementation. The target would be a published list of BMP's that could be published and distributed to jurisdictions and SWCD's and all other land use decision makers in the watershed.

Action 4 should be modeled from SWCD alternative agriculture practice field days. The Stakeholder group would identify several existing or planned storm water abatement BMP's in the watershed. A tour of successful practices could highlight the effectiveness of BMP's and SEC enforcement as a model for other stakeholders to incorporate into their own land use decisions. Annual field days could be held in each County, if enough BMPS are located. Annual field days would allow attendees to re-visit sites every few years to see how the BMP is maintained and how effective the practice is over time. This Action could be coordinated with education actions.

Action 6 can be coordinated with other education actions. Adult NPS education can be modeled from existing NEMO and SWCD programs. Measures include number of education programs held and number of attendees. The target should be to have programs held in each county and at least 60% of the individual jurisdictions. Once the program is developed, it can be presented annually to each County and jurisdiction to try to increase and maintain education on Stormwater issues among adults in the watershed.

Action 7 has momentum from ODNR to expand SWCD programs. In order to enable monitoring programs, equipment incentives could be offered by OEPA or ODNR. Results from instream monitoring would be published quarterly in newsletters coupled with Action 6.

Action 8 [need recommendation from Ohio EPA on this Action]

Action 9 relates to Phase II regulations which will affect Jurisdictions in the Census defined Urbanized Areas of the watershed. Although Ohio EPA has yet to finalize the State regulations, the Federal regulations require storm water management plans which must include 6 minimum control measures. The

control measures include public education and involvement, and implementing BMP's for construction and post-construction erosion controls, and pollution prevention for MS4s. Construction sites the disturb less than 1 acre are also included. The broad scope of the Phase II requirements will reduce urban NPS loading.

Agriculture and Riparian Corridors Monitoring Plan:

Implement-ation Action	Stressor, Indicator or Impairing Cause[1]	Measure	Managing Party	Location or Applicable Area	Frequency or Schedule
Waterways	Gully Erosion	Depth, Width	NRCS SWCD	Cropland, Pasture	50 acres per year
Grass Buffers	Sheet/Rill Erosion	Visual	NRCS SWCD	Cropland by streams	75 acres per year
Riparian Tree Planting	Sheet/Rill Erosion	Visual	NRCS ODNR	Adjacent to streams	20 acres per year
Evolving Technologies	Various	Various	Various	All Ag Land	Various
Manure Nutrient Plans	Livestock, manure management, fertility programs	Various	NRCS, SWCD, EPA, ODA	All Ag Land	10 per year
Livestock Fencing	Manure in streams, channel degradation	Miles Protected	NRCS, SWCD, ODNR	All Ag Land	6 per year
Land/easement purchase	Sheet/Rill Erosion	Visual	LMRP LMI, TLT, BCWA Others	Adjacent to streams and other areas	Various

1 A stressor is anything that causes stress on the environment and usually refers to stress to the biology of the stream. An indicator is something that is measurable and can be used to track a condition. Often and indicator is used as a surrogate measure to track progress on something that is not as easily measured. For example, total suspended solids in the water column of a stream or the depth or type of stream substrates are both indicators of erosion. An impairing cause is any condition that is resulting in an impairment to a stream use. Abnormally high concentrations of a pollutant or alack of habitat are both considered potential impairing causes.

Key
BCWA- Beaver Creek Wetlands Association
LMI- Little Miami Incorporated
LMRP- Little Miami River Partnership
TLT- Tecumseh Land Trust

6.1.2 Draft NPDES language and allocations

Implementation of the TMDL for the upper Little Miami River watershed permit holders will consist of special conditions in the NPDES permits. Tables 17 and 18 show the individual allocations per facility. Example permit language to achieve the total phosphorus wasteload allocations associated with the TMDL for each individual permit holder in the watershed is as follows:

As soon as possible, but not later than the dates developed in accordance with the following schedule, the permittee shall achieve the final effluent limits described below, and an allowable total phosphorus load of X kg/day during the months of May through October. The permittee may achieve the allowable phosphorus load by reducing phosphorus loads discharged through their final outfall(s) and/or by implementing nonpoint source load reduction projects that are reviewed by and are acceptable to Ohio EPA.

The allowable total phosphorus load may be expressed as:

$$WLA = (Q_{med} \bullet P_{med} \bullet CF) - LR$$

where:

WLA	=	total phosphorus wasteload allocation (kg/d); see Table 18 for entity-specific value
Q_{med}	=	daily effluent flow rate during May - October (MGD)
P_{med}	=	median daily effluent total phosphorus concentration during May - October (mg/l)
CF	=	conversion factor = 3.7854(kg)(l)/(MG)(mg)
LR	=	estimated average daily total phosphorus load reductions during May - October achieved since 1998

1. The permittee shall immediately begin an evaluation of the capability of the existing treatment facilities to reduce the effluent loadings of total phosphorus. Both operational procedures, unit process configuration, and other appropriate measures shall be evaluated.

2. Not later than 12 months from the effective date of the permit, the permittee shall implement measures identified in the evaluation that can reasonably be expected to maximize the ability of the existing treatment facilities to achieve a final effluent limit of 1.0 mg/l total phosphorus (30-day average) during the months of May - October. Permits To Install shall be obtained if necessary.

3. If the reduction target of 1.0 mg/l total phosphorus (30-day average) during the months of May - October is not achieved by implementing measures identified in the evaluation, not later than 18 months from the effective date of the permit, the permittee shall submit a general plan to the Ohio EPA Southwest District Office to achieve the final effluent limit.

   The general plan for achieving the final effluent limit shall address, as a minimum, the following:

   a. The treatment technology required to achieve the final effluent limit.

b. Cost estimates of required improvements and operation, maintenance, and replacement costs for the improved facility.
c. A fixed date compliance schedule for meeting the final effluent limit for phosphorus. As a minimum, this schedule should include dates for: submission of approvable detail plans; completion of construction; attainment of operational level; notification of the Ohio EPA Southwest District Office within 14 days of attaining operational level; and achieving the final effluent limit for phosphorus not later than 36 months from the effective date of the permit.
d. The financial mechanism to be used to fund the required improvements, operation, maintenance, and replacement costs.

4. The permittee shall attain compliance with the final effluent limit of 1.0 mg/l total phosphorus (30-day average) during the months of May - October not later than 36 months from the effective date of the permit.

5. By complying with the final effluent limit of 1.0 mg/l total phosphorus (30-day average) during the months of May - October, the permittee will be authorized to discharge a total phosphorus load that is greater than the final allowable load. To achieve the final allowable total phosphorus load, the permittee will need to achieve additional average loading reductions or assimilative capacity increases of total phosphorus during the months of May - October:

6. Not later than 24 months from effective date of the permit, the permittee shall submit a general plan for achieving the additional loading reduction. In developing the plan, the permittee shall evaluate various alternatives for achieving the additional loading reduction. The alternatives may include, but are not limited to: implementation of nonpoint source loading reduction projects; implementation of projects that increase the capacity of the receiving waters to assimilate total phosphorus loads; entering into cooperative agreements with other parties to implement projects that will achieve the cumulative, basin-wide point source loading reductions identified in the report "Total Maximum Daily Loads for the Upper Little Miami River"; and/or upgrading the existing wastewater treatment facilities.

   Any nonpoint source projects or other initiatives identified and undertaken by the permittee to achieve the additional phosphorus loading reductions must comply with the wasteload allocations (WLA) and load allocations (LA) assigned in the Upper Little Miami River TMDL report. Loading reductions achieved by the permittee must be applied to meeting the point source WLA for phosphorus. Loading reductions achieved by other stakeholders to meet the nonpoint source LA for phosphorus may not be applied to meeting the point source WLA.

   The general plan for achieving the additional loading reductions shall address, as a minimum, the following:

   a. The alternative(s) chosen to achieve the loading reductions.
   b. Cost estimates of implementing the chosen alternatives, including any applicable operation, maintenance, and replacement costs.
   c. A fixed date compliance schedule for meeting the reduction targets for total phosphorus during the months of May - October. As a minimum, this schedule should include dates for:

submission of approvable detail plans (if applicable); completion of implementation /construction; attainment of operational level; notification of the Ohio EPA Southwest District Office within 14 days of attaining operational level (if applicable); and achieving the reduction target for total phosphorus not later than 118 months from the effective date of the permit.

d. The financial mechanism to be used to fund the required improvements, operation, maintenance, and replacement costs (if applicable).

e. For alternatives other than upgrading the existing wastewater treatment facilities, demonstrate reasonable assurance by providing information that: the proposed projects are technically feasible based on accepted modeling, data from similar projects, and commonly accepted professional expectations; there is a reasonable expectation that the proposed controls will be implemented; and other appropriate measures identified by the permittee.

7. The permittee shall achieve the final allowable total phosphorus load not later than 118 months from the effective date of the permit.

This Schedule of Compliance includes items that extend beyond the term of the permit. The requirements of Schedule of Compliance Items 6 and 7, including the compliance dates, will be included in the facility's permit when it is renewed.

In the event that evidence becomes available demonstrating to the Director's satisfaction that biological indices applicable to the upper Little Miami River Basin are in full attainment, or that sufficient monitoring data collected at the lower end of the TMDL study area show that the May - October median total phosphorus concentration measured at this site is less than or equal to the 0.17 mg/l instream target for two consecutive years, the Director will evaluate any proposed modification of the TMDL Implementation Schedule included in the NPDES permit.

The permit may be modified or revoked and reissued for the following reasons:

- To include new or revised conditions based on new information resulting from implementation of the TMDL recommendations.

- To include new or revised conditions based on plans submitted by the permittee to upgrade the existing wastewater treatment facilities to achieve the allowable total phosphorus load.

Table 17. Individual permit limits for NPDES permit holders in the upper LMR Basin

Facility	Parameter	Season	Concentration (mg/l)		Load (kg/d)		Basis[1]
			30-Day Average	7-Day Average	30-Day Average	7-Day Average	
Montgomery County Eastern Regional WWTP Permit #: 1PL00001 Design Flow: 13.0 MGD	Dissolved Oxygen	Summer	7.0 minimum		--		TMDL
		Winter	5.0 minimum		--		CWQR, EP
	$CBOD_5$	Summer	10	15	492	738	TMDL
		Winter	25	38	1232	1873	CWQR, EP
	Suspended Solids	Summer	20	30	986	1478	BEJ, EP
		Winter	30	45	1478	2218	BEJ, BPT, EP
	Ammonia-N	Summer	1.5	2.3	74	113	TMDL, EP
		Winter	3.5	5.3	172	261	WLA, EP
	Copper	Annual	0.025	0.040[2]	1.23	1.97[2]	WLA
	Mercury	Annual	0.000013	0.0018[2]	0.0006	0.089[2]	WLA
	Total Phosphorus	May - October	1.0	1.5	49	74	TMDL
City of Xenia Ford Road WWTP Permit #: 1PD00015 Design Flow: 3.6 MGD	Dissolved Oxygen	Summer	7.0 minimum		--		TMDL
		Winter	6.0 minimum		--		WQS
	$CBOD_5$	Summer	10	15	136	204	TMDL
		Winter	25	40	341	545	BPT
	Suspended Solids	Summer	20	30	273	409	ABS, EP, PD
		Winter	30	45	409	613	BPT
	Ammonia-N	Summer	1.5	2.3	20.4	31.3	TMDL
		Winter	12	18	164	245	ABS, EP, PD
	Total Phosphorus	May - October	1.0	1.5	13.6	20.4	TMDL
Greene County Clifton WWTP Permit #: 1PA00023 Design Flow: 0.029 MGD	Dissolved Oxygen	Year Round	6.0 minimum		--		BADCT/PD
	$CBOD_5$	Year Round	10	15	1.1	1.6	BADCT/PD
	Suspended Solids	Year Round	12	18	1.3	2.0	BADCT/PD
	Ammonia-N	Summer	1.0	1.5	.11	.16	BADCT/PD
		Winter	3.0	4.5	.33	.49	BADCT/PD

Table 17. Individual permit limits for NPDES permit holders in the upper LMR Basin

Facility	Parameter	Season	Concentration (mg/l)		Load (kg/d)		Basis[1]
			30-Day Average	7-Day Average	30-Day Average	7-Day Average	
City of Xenia Glady Run WWTP Permit #: 1PD00016 Design Flow: 4.0 MGD	Dissolved Oxygen	Annual	6.0 minimum		--		PD
	$CBOD_5$	Summer	9.8	14.9	148	226	PD
		Winter	16.3	26.0	246	394	PD
	Suspended Solids	Summer	13	19.5	197	295	PD
		Winter	19.5	29.3	295	443	PD
	Ammonia-N	Summer	0.65	1.0	10	15	PD
		Winter	1.95	2.93	30	44	PD
	Total Phosphorus	May - October	1.0	1.5	15.1	22.7	TMDL
Village of South Charleston WWTP Permit #: 1PB00028 Design Flow: 0.24 MGD	Dissolved Oxygen	Year Round	5.0 minimum		--		WLA
	$CBOD_5$	Summer	10	15	9.1	13.6	WLA
		Winter	15	22.5	13.6	20.4	WLA
	Suspended Solids	Summer	20	30	18.2	27.3	PD/EP
		Winter	30	45	27.3	40.9	PD/EP
	Ammonia-N	Summer	2.0	3.0	1.8	2.7	WLA
		Winter	10.0	15.0	9.1	13.6	WLA
	Total Phosphorus	May - October	1.0	1.5	0.9	1.4	TMDL
Village of Yellow Springs WWTP Permit #: 1PC00013 Design Flow: 0.6 MGD	Dissolved Oxygen	Year Round	5.0 minimum		--		WQS/CWQR
	$CBOD_5$	Summer	15	23	34	52	PD/CWQR
		Winter	25	40	57	91	PD/CWQR
	Suspended Solids	Year Round	18	30	41	68	PD/EP
	Ammonia-N	Summer	1.5	2.3	3.4	5.2	PD/CWQR
		Winter	4.0	6.0	9.1	13.6	PD/CWQR
	Total Phosphorus	May - October	1.0	1.5	2.3	3.4	TMDL

Table 17. Individual permit limits for NPDES permit holders in the upper LMR Basin

Facility	Parameter	Season	Concentration (mg/l)		Load (kg/d)		Basis[1]
			30-Day Average	7-Day Average	30-Day Average	7-Day Average	
Greene County Cedarville WWTP Permit #: 1PB00006 Design Flow: 0.56 MGD	Dissolved Oxygen	Year Round	5.0 minimum		--		WLA
	$CBOD_5$	Summer	10	15	21.2	31.8	WLA/PD
		Winter	15	22.5	31.8	47.7	WLA/PD
	Suspended Solids	Summer	12	18	25.4	38.2	EP/BADCT
		Winter	20	30	42.4	63.6	EP
	Ammonia-N	Summer	0.9	1.4	1.9	2.9	WLA
		Winter	3.0	4.5	6.4	9.5	BADCT
	Total Phosphorus	May - October	1.0	1.5	2.1	3.2	TMDL
Greene County Beaver Creek WWTP Permit #: 1PK00003 Design Flow: 8.5 MGD	Dissolved Oxygen	Annual	6.0 minimum		--		PD
	$CBOD_5$	Summer	10	15	322	483	TMDL
		Winter	25	40	804	1287	BPT
	Suspended Solids	Summer	11	16	354	515	ABS, EP, AD
		Winter	16	24	515	772	ABS, EP, AD
	Ammonia-N	Summer	1.1	1.6	35.4	51.5	PD
		Winter	3.8	5.7	122	183	PD
	Total Phosphorus	May - October	1.0	1.5	32.2	48.3	TMDL
Greene County Sugar Creek WWTP Permit #: 1PK00014 Design Flow: 4.9 MGD	Dissolved Oxygen	Summer	7.0 minimum		--		TMDL
		Winter	6.0 minimum		--		WQS
	$CBOD_5$	Summer	10	15	185	278	TMDL
		Winter	25	40	464	742	BPT
	Suspended Solids	Summer	20	30	371	556	ABS, EP, PD
		Winter	30	45	556	835	BPT
	Ammonia-N	Summer	1.5	2.3	27.8	42.7	TMDL
		Winter	12	18	223	334	ABS, EP, PD
	Total Phosphorus	May - October	1.0	1.5	18.5	27.8	TMDL

Table 17. Individual permit limits for NPDES permit holders in the upper LMR Basin

Facility	Parameter	Season	Concentration (mg/l)		Load (kg/d)		Basis[1]
			30-Day Average	7-Day Average	30-Day Average	7-Day Average	
Village of Waynesville WWTP Permit #: 1PB00032 Design Flow: 0.71 MGD	Dissolved Oxygen	Year Round	6.0 minimum		--		WQS
	$CBOD_5$	Year Round	15	22.5	40.3	60.5	PD/EP
	Suspended Solids	Year Round	20	30	54	81	PD/EP
	Ammonia-N	Year Round	2.5	5.0	7.0	13.4	PD/EP
	Total Phosphorus	May - October	1.0	1.5	2.7	4	TMDL
Jamestown WWTP Permit #: 1PB00015 Design Flow: 0.3 MGD existing **0.9 MGD proposed**	Dissolved Oxygen	Year Round	5.0 minimum/ **6.0 minimum**		-- --		WQS/ **BADCT**
	$CBOD_5$	Year Round	10	15	11.4/**34.1**	17.1/**51.1**	BADCT/PD
	Suspended Solids	Year Round	12	18	13.6/**40.9**	20.5/**61.3**	BADCT/PD
	Ammonia-N	Summer	1.5/**1.0**	2.3/**1.5**	1.7/**3.4**	2.6/**5.1**	BADCT/PD
		Winter	5.0/**3.0**	7.5/**4.5**	5.7/**10.2**	8.5/**15.3**	BADCT/PD
	Total Phosphorus	May - October	1.0	1.5	1.1	1.7	TMDL

1 ABS = Antibacksliding Rule (OAC 3745-33-05(E) and 40 CFR Part 122.44(l));
BADCT = Best Available Demonstrated Control Technology;
BEJ = Best Engineering Judgment;
BPT = Best Practicable Waste Treatment Technology, 40 CFR Part 133, Secondary Treatment Regulation;
CWQR = *Comprehensive Water Quality Report for Little Beaver Creek* (Ohio EPA, 1986);
EP = Existing Permit;
PD = Plant Design Criteria;
TMDL = Total Maximum Daily Load for the upper Little Miami River watershed;
WLA = Wasteload Allocation procedures (OAC 374 5-2), calculated outside this TMDL project;
WQS = Ohio Water Quality Standards (OAC 3745-1-07).

2 These quantities are daily maximum values not 7-day averages.

Table 18. Phosphorus loads for wastewater treatment plants in the upper Little Miami River Basin

Entity	Design Flow (MGD)	Current Flow[1] (MGD)	Current Load[2] (kg/day)	Load at 1.0 mg/l P[3] (kg/day)	Wasteload Allocation (kg/day)
Montgomery County Eastern Regional WWTP	13.0	8.00	74.5	30.3	24.6
Greene County Beavercreek WWTP	8.5	4.34	37.5	16.4	16.1
Greene County Sugarcreek WWTP	4.9	5.00	26.5	18.9	9.3
City of Xenia Glady Run WWTP	4.0	2.05	13.9	7.8	7.6
City of Xenia Ford Road WWTP	3.6	2.35	16.5	8.9	6.8
Village of Jamestown WWTP	0.9	0.26	1.1	1.0	1.7
Village of Waynesville WWTP	0.71	0.65	6.4	2.5	1.3
Village of Yellow Springs WWTP	0.6	0.7	5.6	2.6	1.1
Greene County Cedarville WWTP	0.56	0.23	2.7	0.9	1.1
Village of South Charleston WWTP	0.24	0.14	0.6	0.5	0.5
Village of Clifton WWTP[4]	0.029	0.013	–	–	–
Reserve Load					4.3
Totals			185.3	89.8	74.4

1 May - October median flow, 1995 - 1999
2 Based on current flow and 1998 median phosphorus concentration
3 These loads are based on current flow. Permit loads are based on design flow; see Table 17.
4 Phosphorus load reduction not required

6.1.3 Expected effectiveness of one example restoration scenario

The effectiveness of various potential implementation actions was estimated using the developed models and literature values of the effectiveness of various actions from *A Study of the Relative Effectiveness of Best Management Practices for Controlling Agricultural Nonpoint Source Pollution* (Barton, 1999). An example restoration scenario and an estimate of its potential to reduce the total phosphorus load is included in Table 18. It is important to note that this is an example strategy only; the percent reductions are based on annual loads and are averaged for all five subwatersheds; and it is an estimate. The critical season for nutrient reduction is the summer season due to the presence of conditions favorable to eutrophication processes. The percent of the total load attributable to septic and point sources is higher during the summer months given the reduction in frequency of runoff events; therefore, the percent reduction due to improvements in these areas will be higher during the summer then the numbers indicate in the Table 18. This table is included to highlight that significant reductions in the total phosphorus load are achievable and that the 60% reduction of total phosphorus load is not unreasonable particularly during the summer months.

Table 19. Total phosphorus average annual load after various actions are implemented

Implementation Action/Condition	Total Phosphorus Average Annual Load (mt/yr)					
Subwatershed:	**1**	**2**	**3**	**4**	**5**	**Average % Effect[1]**
Existing	35.6	65	133	48	34.5	NA
Pristine	1.3	3	4	4.3	10.9	NA
Septic Improvements:						
all are working	30.6	59	121	42	30	12%
all to PS	34	65	127	46	33	4%
Point Source Reductions:						
60%	35	59	98	47.5	NA	10%
Land Use Changes:						
URBAN changes:						
10% to FOREST	35.6	64.7	117	48	34.5	2%
ROW CROP changes:						
1% to FOREST	35	64	129	47	33	3%
10% to FOREST	32.6	63	124	43	30	8%
Non Point Source Reductions:						
100% conservation tillage	34	62	128	46	33	4%
100% nutrient management	33	59	123	44	32	8%
fencing	35	63	129	47	33	3%
sediment basins	34	62	128	46	33	4%
grass filter strips	35	63	131	48	34	2%
streambank management	35	63	129	47	33	3%

[1] Average % effect is the percent reduction of total phosphorus load based on that particular implementation action averaged over all five subwatersheds.

Example Restoration Strategy:	% change
All septic systems are normal	12
60% PS reductions	10
10% Ag/Urban to Forest change	10
Exclusively no tillage	4
Nutrient management	8
Total expected TP reduction:	**44**

6.2 Process for Monitoring and Revision

An initial monitoring plan to determine whether the TMDL has resulted in attainment of water quality standards and to support any revisions to the TMDL that might be required begins with instream water quality chemical monitoring. This sampling will be done at a minimum by NPDES permit holders at locations upstream and downstream of their outfalls and at ambient monitoring stations to be collected by Ohio EPA. A more detailed and inclusive monitoring plan could be developed by the Watershed Improvement Group which would describe steps in a monitoring program, including timing and location of monitoring activities, parties responsible for monitoring, and quality assurance and quality control procedures. It may include a method to determine whether actions identified in the implementation plan are actually being carried out and criteria for determining whether these actions are effective in reaching the TMDL targets. It is recommended that the Stakeholders Workgroup work with the Ohio EPA to develop the monitoring plan. A biological and water quality study of the Little Miami River, similar to those conducted by the Ohio EPA in 1993 and 1998, is tentatively scheduled for 2003. This full survey will proceed only if indications exist that major changes in the watershed have occurred. In addition, interim and/or surrogate measures that document progress in water quality improvement are recommended. Consideration must be given to the lag time between source control actions (habitat improvements and loading reductions) and observable/measurable instream effects, especially for nonpoint sources.

A tiered approach to monitoring progress and validating the TMDL will be followed; the tiered progression includes:
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. If the implementation plan activities are not being carried forth within a reasonable time frame as specified in the implementation plan then an intercession by the Watershed Improvement Group or other 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.

The stormwater subcommittee of the Watershed Improvement Group asserts that most of the stormwater actions are voluntary as there is a lack of exercised authority to regulate stormwater. Phase II regulated communities will be required to develop storm water management programs. There is legal authority given to local governments (Article XVIII, Section 3 Ohio Constitution, Chapter 1511 Ohio Revised Code, Chapter 519 Ohio Revised Code) to adopt regulations that would abate soil erosion and water pollution by soil sediments and to enact zoning regulations to control the drainage of surface water, but they are not often exercised in the interest of water quality. If, after a period of time the stormwater implementation plan does not meet its goals, Ohio EPA could offer greater financial incentives for adoption and enforcement of such regulations. In some cases, where applicable, Ohio EPA could withhold permits until some sort of reasonable assurance is met.

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