State of Ohio
Environmental Protection Agency

Division of Surface Water

Total Maximum Daily Loads for the Upper Sandusky River Watershed

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Bob Taft, Governor
Christopher Jones, Director

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Acknowledgment is made of the property owners who allowed Ohio EPA personnel access to the Sandusky River and its tributaries.

EXECUTIVE SUMMARY

The Sandusky River originates in northcentral Ohio and is located in the Lake Erie drainage basin. The watershed lies within the Sandusky Hydrologic Unit (04100011) and encompasses a drainage area of 1,850 $mi.^2$. It is divided into 14 separate 11-digit hydrologic units. The Ohio EPA treats these 11-digit areas as assessment units and evaluates use attainment based on the entire area, rather than by stream segments. The exception is streams that exceed a drainage area of 500 $mi.^2$. These are considered large rivers and are evaluated in a linear context. The Upper Sandusky River Watershed TMDL study area covered 1,034 $mi.^2$, including 8 assessment units and part of the large river assessment unit.

A number of assessment units within the Upper Sandusky River Watershed appear on Ohio's 2002 303(d) list based on monitoring conducted in 2001. The major causes of impairment are organic enrichment, excessive nutrients, bacteria, sedimentation, habitat degradation, and flow alteration.

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 Upper Sandusky River Watershed TMDLs were estimated by comparing the instream summer concentrations during 2001 to the desired targets, by analyzing phosphorus load duration curves prepared for gages located throughout the watershed, and by comparing the export rates of Sandusky watersheds against other Ohio watersheds.

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 Sandusky River Watershed Coalition has prepared a comprehensive resource inventory and watershed management plan, and is working toward state endorsement of the action plan. The plan is designed to implement recommendations of the TMDL report and includes agricultural and urban runoff control strategies including a public education component, septic system and point source improvements, and habitat restoration strategies. The Coalition currently has two Section 319 grants for nonpoint source pollution reduction, and funding from other federal and local sources to address continued watershed planning, drinking water source protection, and recreational resources in the Sandusky River Watershed.

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 even-numbered years. The Ohio Environmental Protection Agency (Ohio EPA) identified the upper Sandusky River watershed as a priority impaired watershed[1], based for the most part on data collected in 2001.

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. Ohio EPA develops TMDLs on a watershed basis as an effective approach towards this goal.

This report documents the upper Sandusky River TMDL process and provides 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 Sandusky River basin and to quantitatively assess the factors affecting non or partial attainment of WQS. A draft implementation plan is not included here. However, a local watershed action plan[2] is being developed by the Sandusky River Watershed Coalition (SRWC), the local watershed stakeholder group.

Beneficial uses assessed for this report are aquatic life and recreation. The primary causes of aquatic life impairment are organic enrichment/low dissolved oxygen, phosphorus, sedimentation, habitat alteration, and flow alteration[3]. The primary cause of recreation use impairment is pathogens. In addition, nitrates have been identified as a concern for surface water supplies of drinking water. Also, a sport fish consumption advisory is in effect for the entire length of the Sandusky River because of PCB and

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[1]Table 6 and Appendix C of *Ohio 2002 Integrated Water Quality Monitoring and Assessment Report*, available at http://www.epa.state.oh.us/dsw/tmdl/index.html or call the Division of Surface Water at (614) 644-2001.

[2]This document is titled the *Sandusky River Watershed Resource Inventory and Management Plan*, available at http://www.riverwatershed.org/srwc/ or call the Sandusky River Watershed Coalition at (419) 334-5016.

[3]Cause and source information was developed from the 2001 data after the 2002 Integrated Report was completed.

mercury levels detected in tissue samples collected in 1997. Ohio does not currently include fish consumption among the codified beneficial uses, so these impairments were not included on the 2002 303(d) list. However, the pollutants are a concern in this watershed.

TMDLs were calculated for total phosphorus, sediment, and pathogens. Habitat alteration 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.

An informational graphic summarizing the 2001 assessment unit scores for the upper Sandusky River basin is presented in Figure 1. The graphic also exhibits locations where monitoring was conducted. Line schematics for parts of the basin studied in 2001 are presented in Figures 2 through 9.

Table 1. Summary of the 303(d) listed assessment units in this TMDL report.

HUC 11 Assessment Unit	Causes of Impairment[1]	Included in this Report?	Comments
Bucyrus 04100011-020 (Sandusky River headwaters to upstream Broken Sword Creek)	Enrichment/D.O.	Yes	Not a load based impairment, but allocations for other causes included
	Nutrients	Yes	Total phosphorus only
	Sedimentation	Yes	Activities implemented to attain nutrient targets will address this
	Habitat Alteration	Yes	Not a load based impairment, but allocations for other causes included
	Pathogens	Yes	
	Flow Alteration	No	Flows during dry weather not sustained because of hydromodification activities
Broken Sword Creek 04100011-030	Nutrients	Yes	Total phosphorus only
	Sedimentation	Yes	Activities implemented to attain nutrient targets will address this
	Habitat Alteration	Yes	Not a load based impairment, but allocations for other causes included
	Flow Alteration	No	Flows during dry weather not sustained because of hydromodification activities
Upper Sandusky 04100011-040 (Sandusky River downstream Broken Sword Creek to upstream Tymochtee Creek)	Enrichment/D.O.	Yes	Not a load based impairment, but allocations for other causes included
	Nutrients	Yes	Total phosphorus only
	Sedimentation	Yes	Activities implemented to attain nutrient targets will address this
	Habitat Alteration	Yes	Not a load based impairment, but allocations for other causes included
	Pathogens	Yes	
	Flow Alteration	No	Flows during dry weather not sustained because of hydromodification activities

Table 1. Summary of the 303(d) listed assessment units in this TMDL report.

HUC 11 Assessment Unit	Causes of Impairment[1]	Included in this Report?	Comments
Upper Tymochtee Creek 04100011-050 (Tymochtee Creek headwaters to upstream Warpole Creek)	Enrichment/D.O.	Yes	Not a load based impairment, but allocations for other causes included
	Nutrients	Yes	Total phosphorus only
	Sedimentation	Yes	Activities implemented to attain nutrient targets will address this
	Habitat Alteration	Yes	Not a load based impairment, but allocations for other causes included
	Pathogens	Yes	
	Ammonia	No	Home septic systems are the source
	Flow Alteration	No	Flows during dry weather not sustained because of hydromodification activities
Lower Tymochtee Creek 04100011-060 (Tymochtee Creek downstream Warpole Creek to mouth)	Enrichment/D.O.	Yes	Not a load based impairment, but allocations for other causes included
	Nutrients	Yes	Total phosphorus only
	Sedimentation	Yes	Activities implemented to attain nutrient targets will address this
	Habitat Alteration	Yes	Not a load based impairment, but allocations for other causes included
	Ammonia	No	Carey WWTP is the source
	Flow Alteration	No	Flows during dry weather not sustained because of hydromodification activities
Mexico 04100011-070 (Sandusky River downstream Tymochtee Creek to upstream Honey Creek, excluding mainstem)	Sedimentation	Yes	Activities implemented to attain nutrient targets will address this
	Habitat Alteration	Yes	Not a load based impairment, but allocations for other causes included
	Flow Alteration	No	Flows during dry weather not sustained because of hydromodification activities

Table 1. Summary of the 303(d) listed assessment units in this TMDL report.

HUC 11 Assessment Unit	Causes of Impairment[1]	Included in this Report?	Comments
Honey Creek 04100011-080	Enrichment/D.O.	Yes	Not a load based impairment, but allocations for other causes included
	Nutrients	Yes	Total phosphorus only
	Sedimentation	Yes	Activities implemented to attain nutrient targets will address this
	Habitat Alteration	Yes	Not a load based impairment, but allocations for other causes included
	Flow Alteration	No	Flows during dry weather not sustained because of hydromodification activities
Tiffin 04100011-090 (Sandusky River downstream Honey Creek to upstream Wolf Creek, excluding mainstem) <u>Note</u>: the 2001 study area did not include Spicer Creek or Sugar Creek	Enrichment/D.O.	Yes	Not a load based impairment, but allocations for other causes included
	Nutrients	Yes	Total phosphorus only
	Sedimentation	Yes	Activities implemented to attain nutrient targets will address this
	Habitat Alteration	Yes	Not a load based impairment, but allocations for other causes included
	Pathogens	Yes	
	Flow Alteration	No	Flows during dry weather not sustained because of hydromodification activities
Large River 04100011-001 (Sandusky River mainstem downstream Tymochtee Creek to mouth) <u>Note</u>: the 2001 study area ended at Seneca County Rd. 38 (RM 36.50)	Sedimentation	Yes	Activities implemented to attain nutrient targets will address this
	Habitat Alteration	Yes	Not a load based impairment, but allocations for other causes included
	Flow Alteration	No	Area of non-attainment was located in St. John's dam impoundment. The dam wwill be removed by Nov. 2004.

1 Cause and source information was not fully available for the 2002 Integrated Report. The impairments included here are based on the subsequent analysis of data collected in 2001. The 2004 Integrated Report included the major causes and sources for each assessment unit.

Figure 1. Informational graphic summarizing the assessment unit scores for the upper Sandusky River basin in 2001.

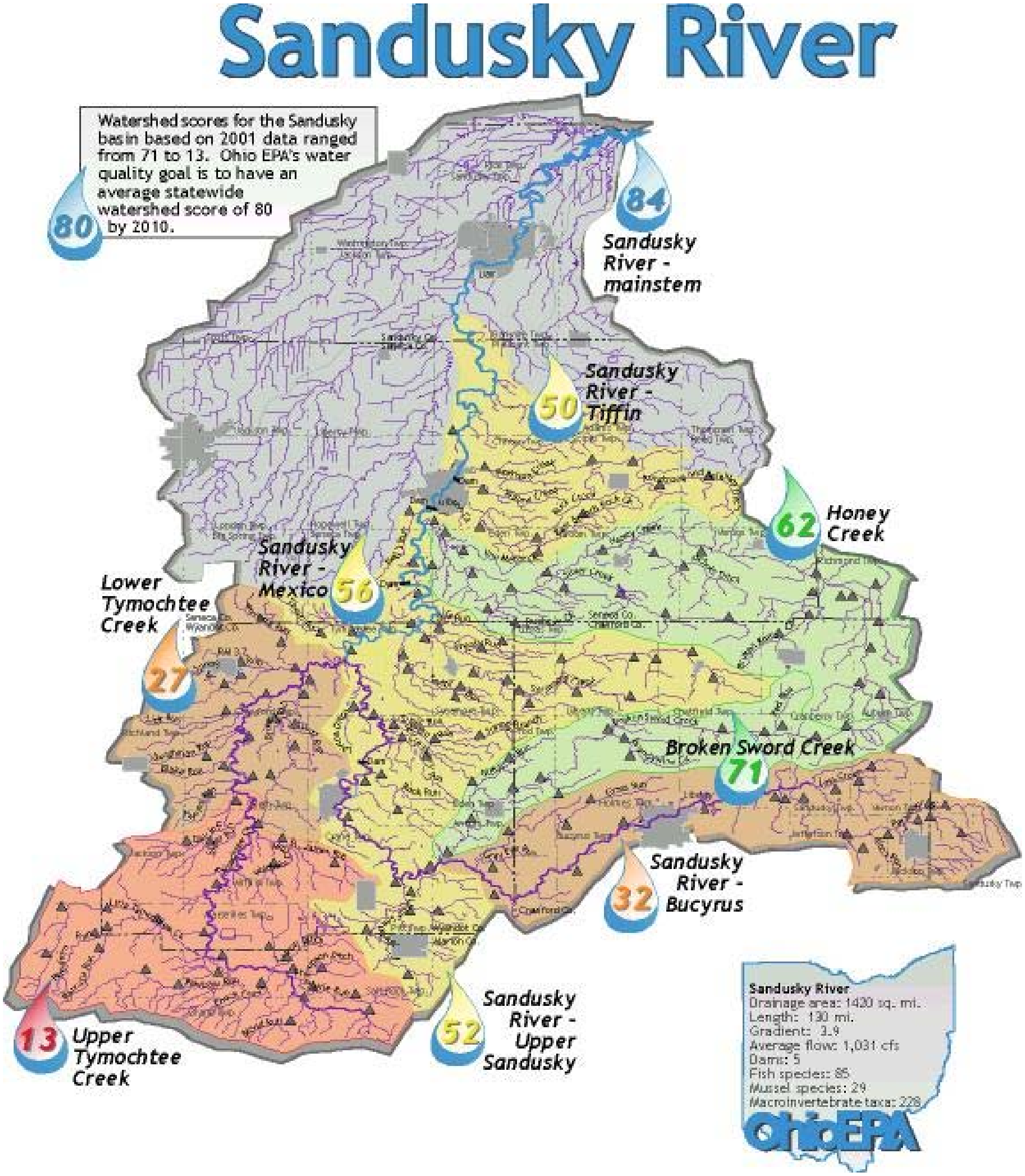


Figure 2. Schematic of the Bucyrus Assessment Unit (04100011-020).

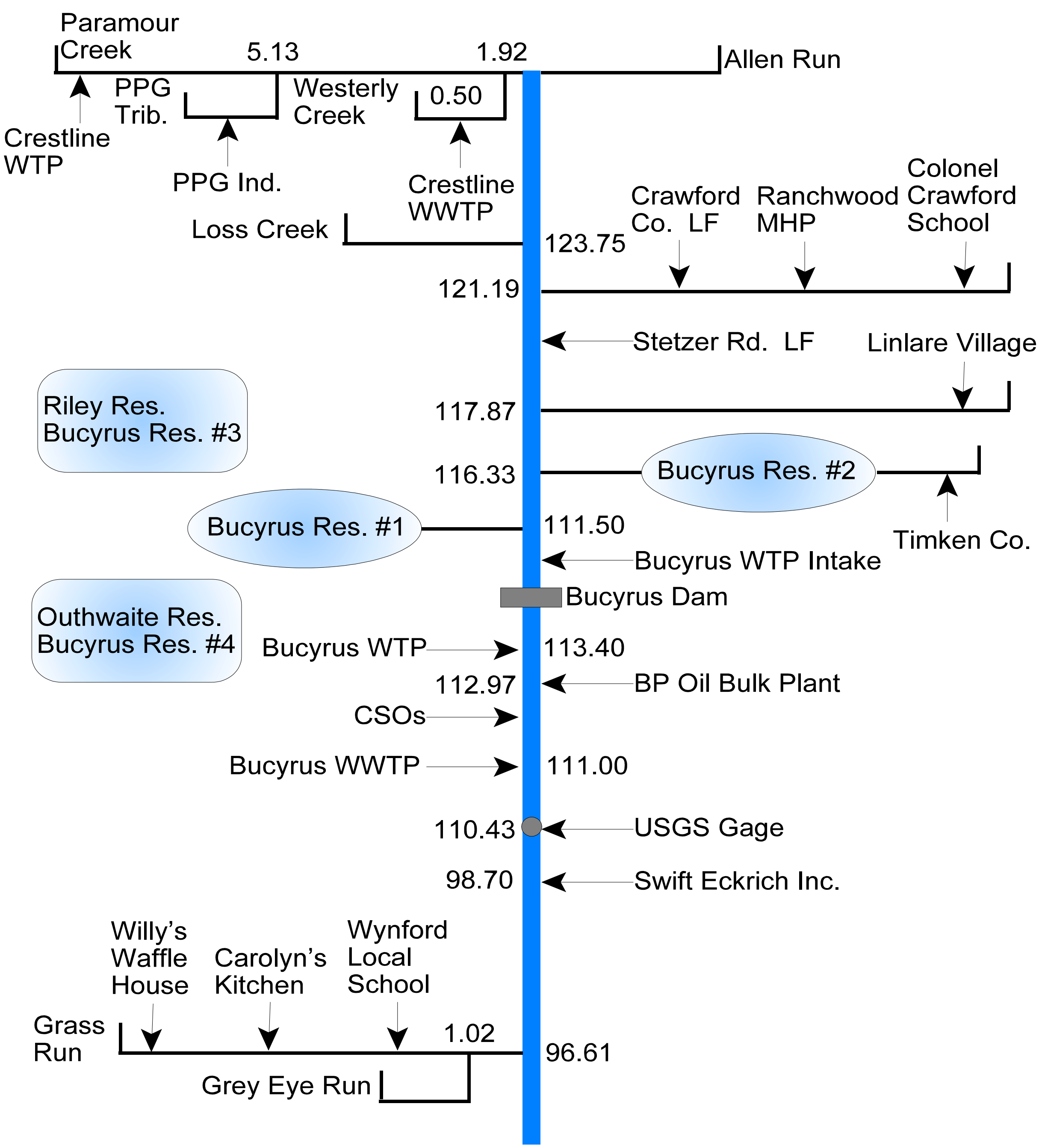


Figure 3. Schematic of the Broken Sword Creek Assessment Unit (04100011-030).

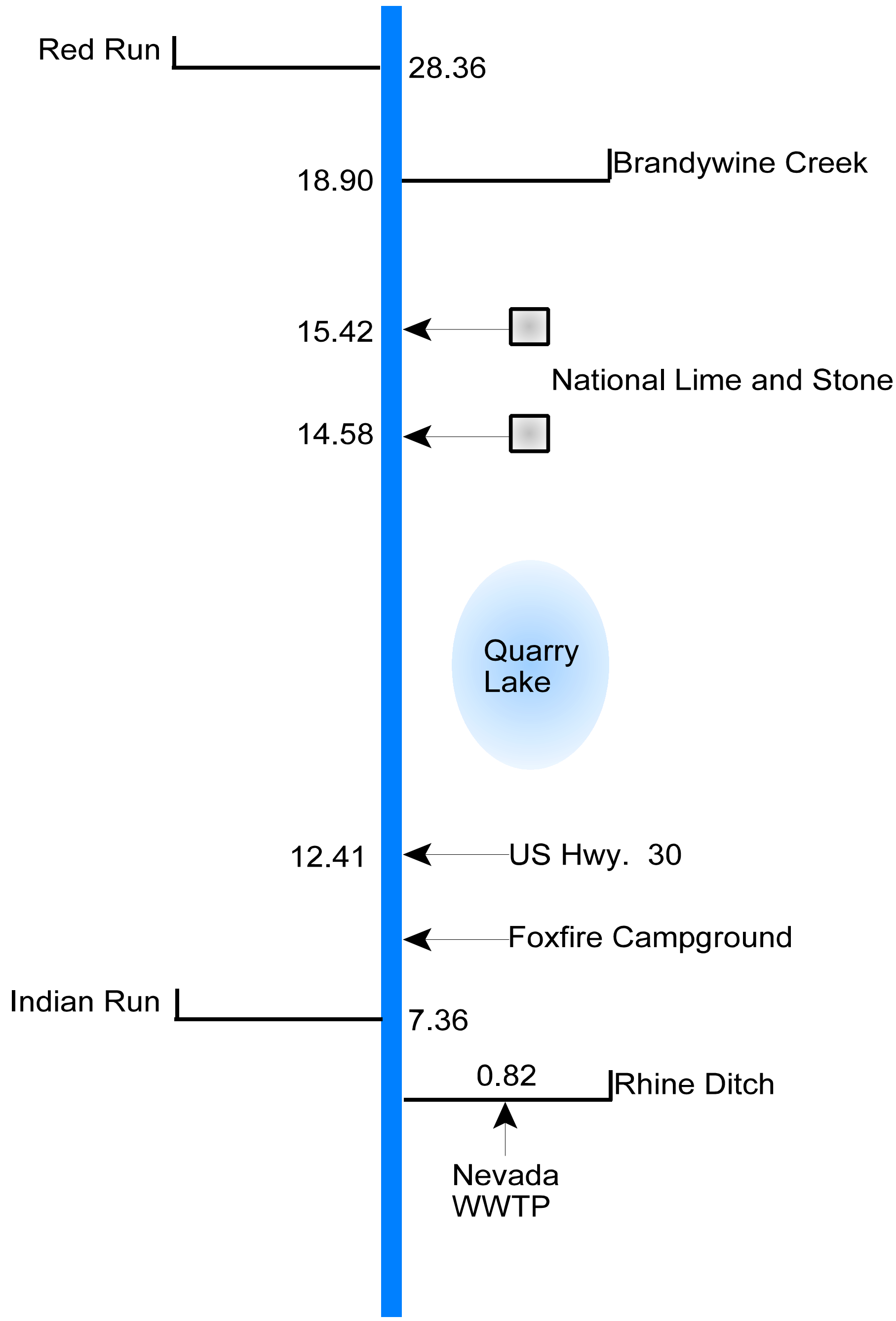


Figure 4. Schematic of the Upper Sandusky Assessment (04100011-040).

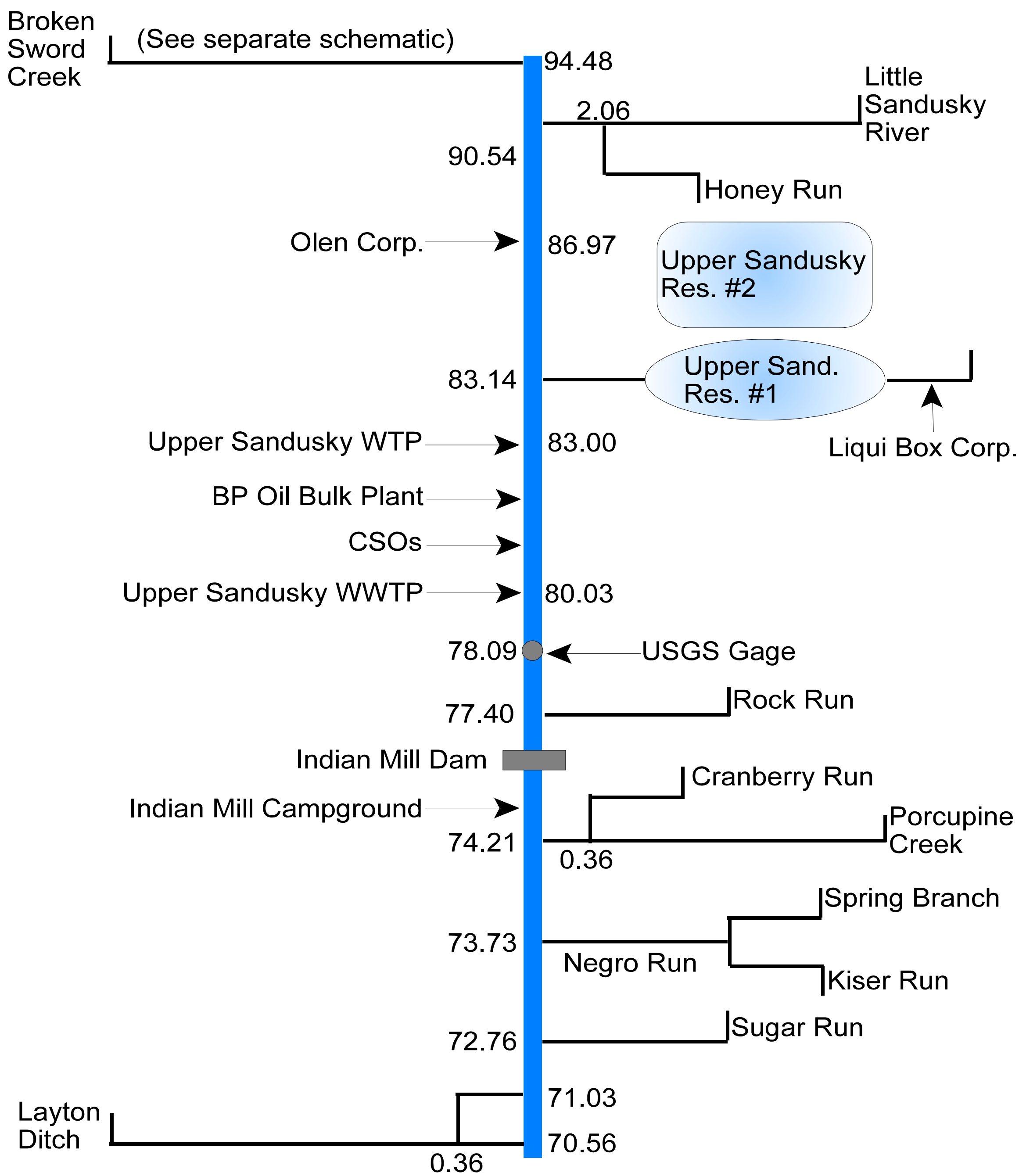


Figure 5. Schematic of the Upper Tymochtee Creek Assessment Unit (04100011-050).

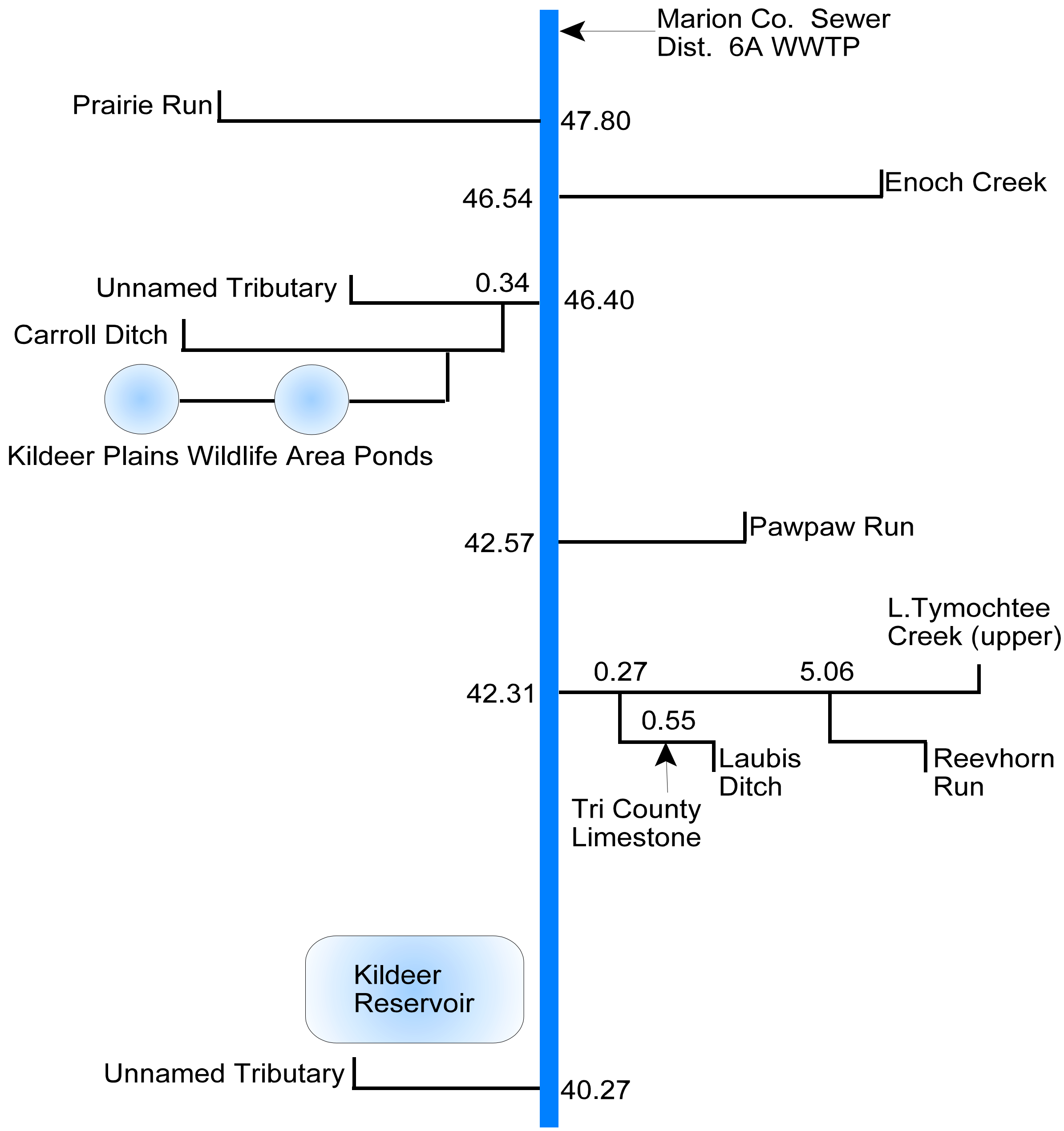


Figure 6. Schematic of the Lower Tymochtee Creek Assessment Unit (04100011-060).

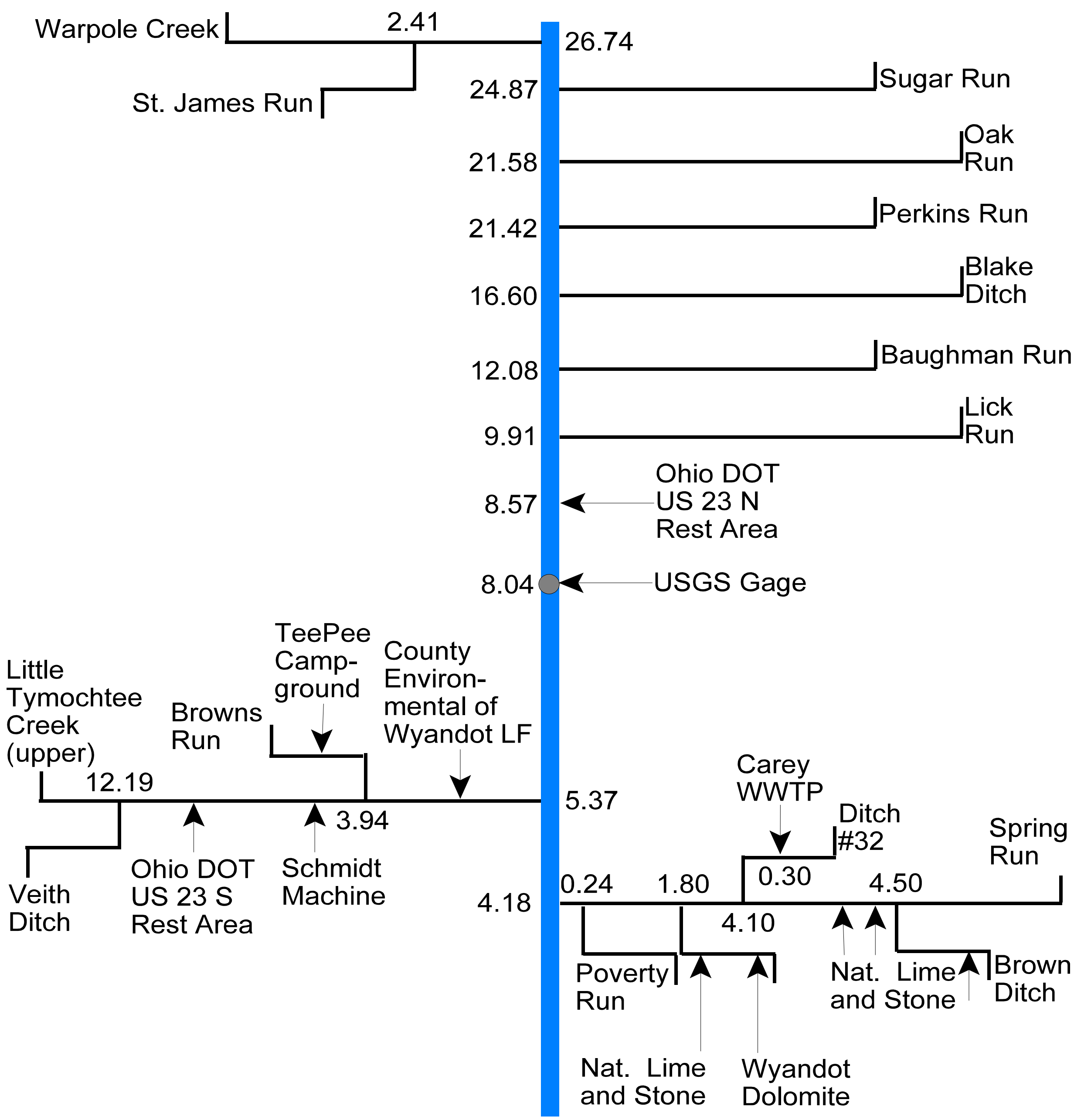


Figure 7. Schematic of the Mexico Assessment Unit (04100011-070).

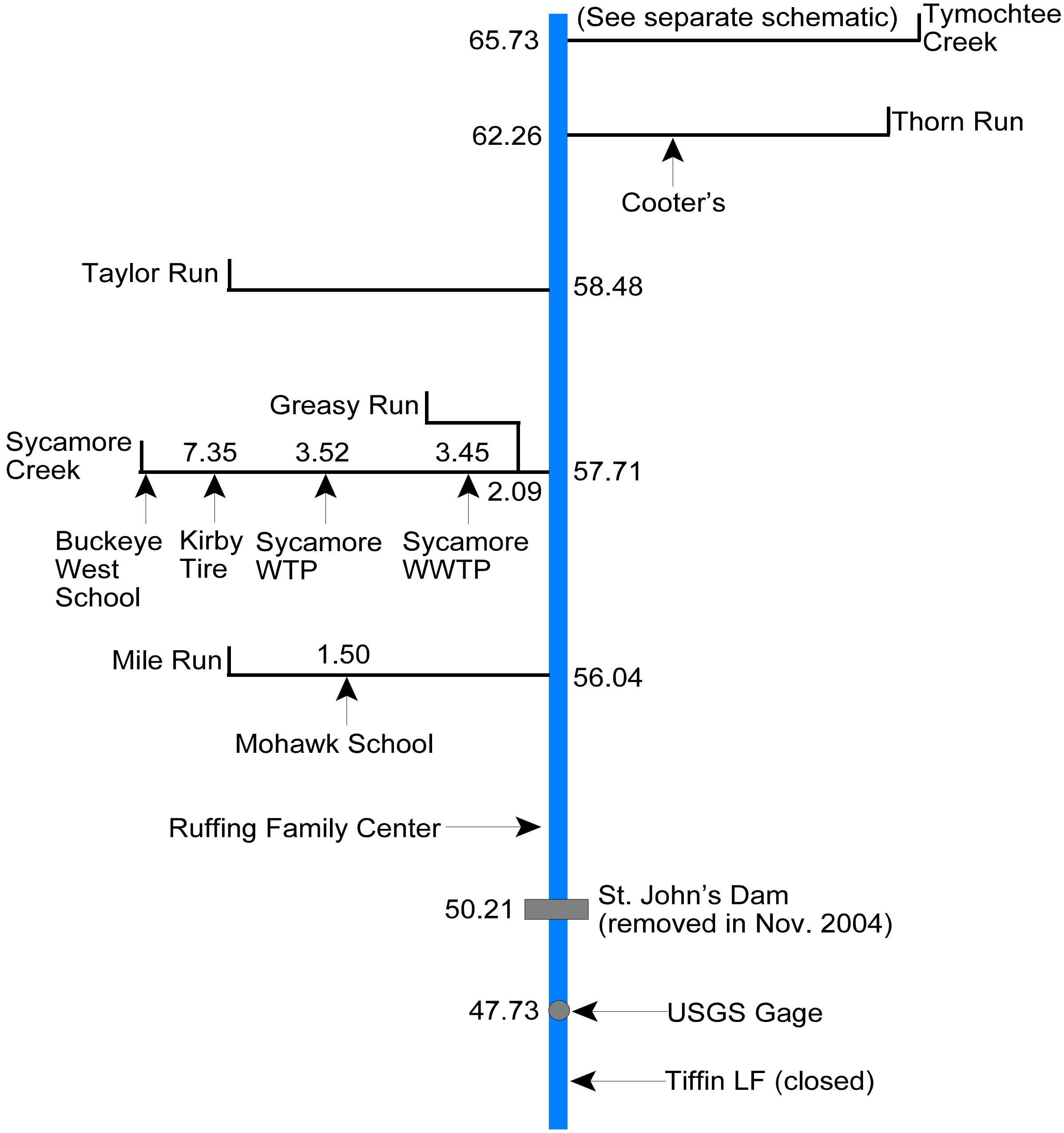


Figure 8. Schematic of the Honey Creek Assessment Unit (04100011-080).

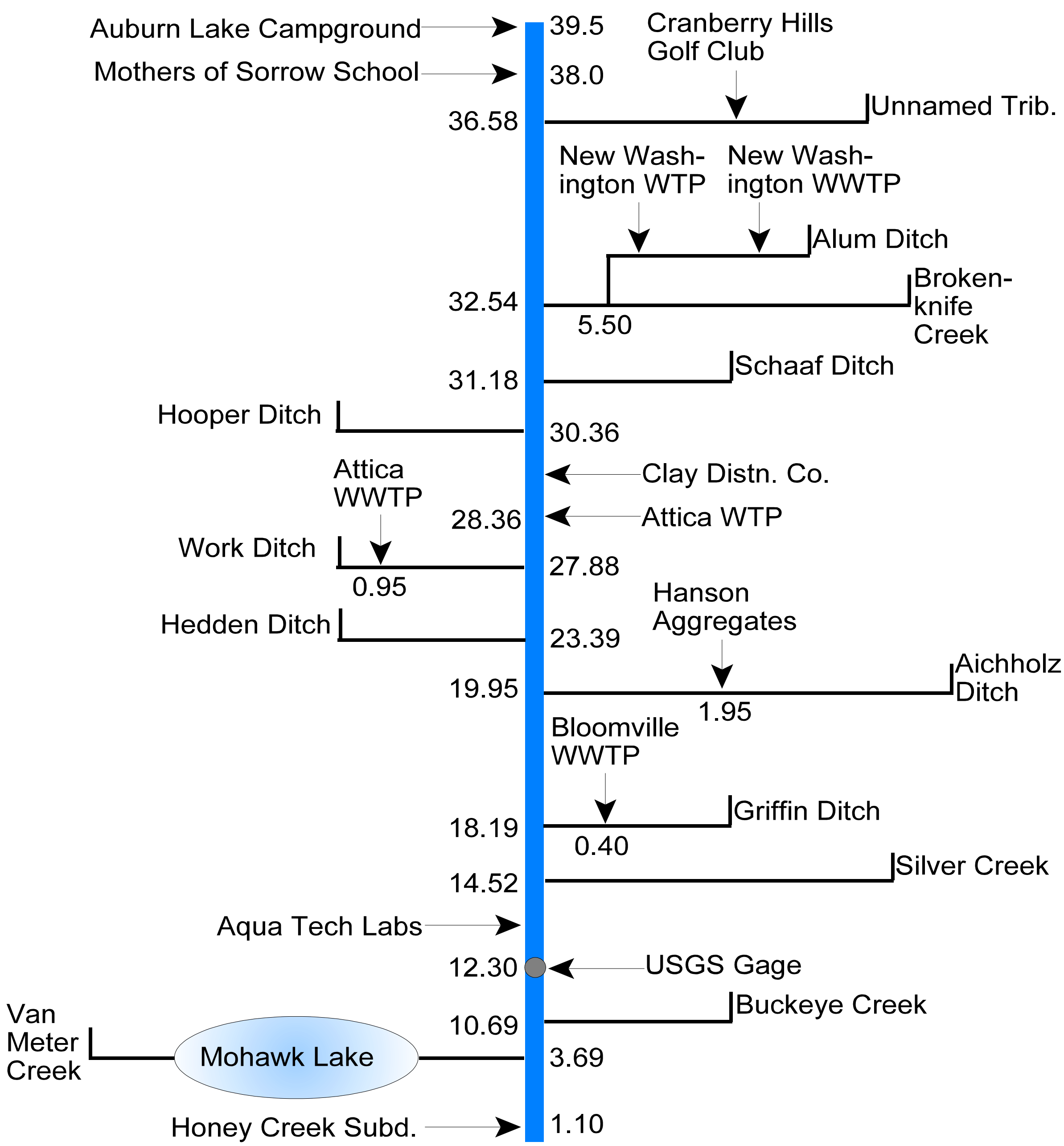
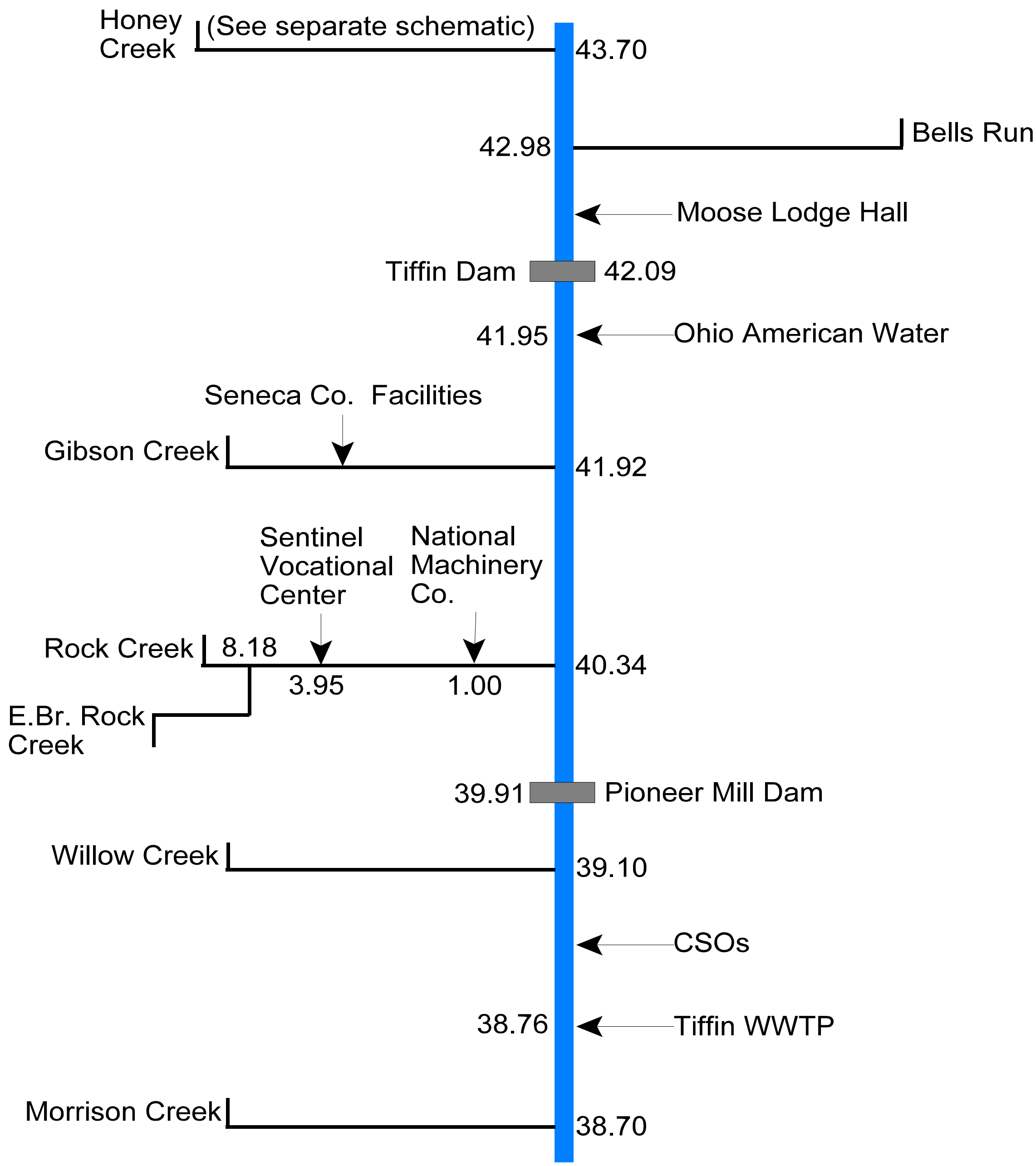


Figure 9. Schematic of the Tiffin Assessment Unit (04100011-090).



2.0 WATERBODY OVERVIEW

2.1 Description of the Study Area

The Sandusky River watershed is located in Northcentral Ohio in the Lake Erie watershed of the Great Lakes Region, which is one of 21 specific hydrologic regions in the United States. The Sandusky River hydrologic unit has the 8-digit code 04100011, which is how the Ohio EPA and Sandusky River Watershed Coalition (SRWC) describe the watershed. The Sandusky River Watershed Coalition has published a Resource Inventory and Management Plan[1] (SRWC, 2001). Much useful information on the land, water, and biological resources of the watershed is found in this document published in 2001. A map of the upper Sandusky River watershed is shown in Chapter 1.

The Sandusky Hydrologic Unit has a drainage area of 1,850 $mi.^2$ and it is subdivided into fourteen 11-digit hydrologic units. The upper Sandusky River watershed TMDL covered a drainage area of 1,034 $mi.^2$ within 8 of these assessment units. The Ohio EPA identifies the Sandusky River downstream from the confluence of Tymochtee Creek as a large river (>500 $mi.^2$ drainage area) and it is evaluated as a separate assessment unit. The TMDL study area contains nearly 77% of the Sandusky River watershed, mainly in Crawford, Wyandot, and Seneca counties. Table 1 describes the hydrologic units covered in the 2001 assessment.

The Sandusky River watershed provides a home for a population of 222,280. It contains 2,200 miles of streams, tributaries, and ditches and 1,168,035 acres of land from 12 counties in northwest Ohio. The surface waters supply drinking water for 136,180 residents and 86,000 people drink from ground water supplies (SRWC, 2002).

The Sandusky River watershed is also home to Ohio's largest inland population of the endangered Bald Eagle, and it maintains thriving and diverse communities of riparian birds, mammals, fish and other aquatic organisms. In January 1970, the director of the Ohio Department of Natural Resources designated approximately 70 miles of the Sandusky River as Ohio's second scenic river. The area of designation begins at U.S. Route 30 in Upper Sandusky and continues to the Roger Young Memorial Park in Fremont. Southern sections of the scenic stretch of river flow through the rich farmlands of Wyandot and Seneca counties, carving a valley through dolomite and limestone outcrops, and small ridges associated with the Defiance, Fort Wayne and Wabash end moraines. Northern stretches of the river flow through extensive flats of bedrock, forming impressive, long riffle areas (SRWC, 2001).

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[1] *Sandusky River Watershed Resource Inventory and Management Plan* at http://www.riverwatershed.org/srwc/ or call the Sandusky River Watershed Coalition at (419) 334-5016.

History and Culture

The Sandusky River, which takes its name from the Wyandot Indians; “San-uh-dus-kee” meaning “clear water within pools,” was an important early transportation and trading route. The Sandusky played an important role in the War of 1812, and early forts along the river were the sites of important battles in American history. As recently as 1840, Wyandots were housed in the last Indian reservation in Ohio, encompassing more than 15,000 acres from Upper Sandusky to Fremont (SRWC, 2001).

Ecoregion and Geologic Characteristics

The upper Sandusky River TMDL study area is located entirely within the eastern corn belt plains (ECBP) ecoregion, which is characterized by broad, nearly level glacial till plains and low gradient streams. There are some wet prairies behind the end moraines in Wyandot and Marion county portions of the watershed. Corn, soybean, wheat and livestock farming is dominant and has replaced the original beech forests and scattered elm-ash swamp forests. The parent material for soils in the upper part of the Sandusky River Watershed is primarily late Wisconsin-age glacial till. Limestone bedrock is close to the surface in some areas, and is often exposed in the bed of the river. Limestone in the bedrock controlled area is prone to dissolution, and sinkholes are abundant in parts of Thompson, Reed, Scipio, and Bloom Townships in Seneca County.

Soils

In the upper Sandusky watershed, most soils were formed in glacial till with some small areas formed in glacial lake deposited material, including some beach ridges in Seneca County. Common soils series in the clayey, high lime glacial till areas of the ECBP ecoregion are widespread Blount, Pewamo, Glynwood, and Morley. In the east we find Bennington and Cardington, and on lake plains the Nappanee and Milford series. Topography is gently rolling to nearly flat with occasional moderately steep areas, especially along stream channels. For more information on soils in the study area, refer to the Soil Survey of Crawford County (1979), the Soil Survey of Wyandot County (1982), and the Soil Survey of Seneca County (1980). The Sandusky River and its tributaries export, on average, 250,000 tons of soil to Sandusky Bay along with tons of nutrients and other chemicals (SRWC, 2002).

Land Use

Agriculture is the predominant land use in the Sandusky River Watershed at 84.0%. Land use distribution in the upper Sandusky River watershed TMDL is displayed in Table 2. More information on land use is located in Chapter 2 of the SRWC Resource Inventory and Management Plan. Data from agricultural statistics for the state confirms assessments from satellite imagery. If you were to fly over the watershed, about 69% of the time you would be over soybean, corn, or wheat fields. Extensive grain and livestock production in the ECBP ecoregion has affected stream chemistry and turbidity.

This area, along with other agricultural areas in northwestern Ohio, represents the most intensively tile-drained crop land in the United States.

The remnants of earlier beech and ash-elm swamp forests occupy 12.6% of the land area in the Sandusky River watershed and urban lands comprise about 1.2%. Non-forested wetlands make up 1.1% and are primarily located in state and privately owned wildlife areas, such as Killdeer Plains and the Willard Marsh. These areas are remnants of the much more extensive wetlands prevalent in this area prior to their conversion to crop land. Other land uses (shrub, water, and barren) each make up less than 1% of the land area. The barren areas are primarily quarries from which limestone and dolomite are extracted. Water areas represent stream systems, upground reservoirs, and farm ponds.

Regulated Point Source Discharges

Ohio EPA has the authority to regulate the discharge of pollutants to waters of the state from municipal, commercial, and industrial facilities. Chapter 6111 of the Ohio Revised Code requires these discharges to have a National Pollutant Discharge Elimination System (NPDES) permit that limits the types and loads of pollutants entering the streams, lakes, and groundwater of Ohio. Permits are classified as Individual and General.

Individual Permits

Individual permits are unique to each facility. The discharge limits imposed in the permit are based on the type of operation, volume of discharge, receiving stream characteristics, and other factors. There are a total of 26 industrial and 23 municipal facilities that hold individual NPDES permits in the upper Sandusky River watershed and they are listed in Table 3. Information regarding location of discharge, design flow, and average flow is included where available. Some discharges are new and had no data, while those with controlled releases simply make it difficult to calculate a meaningful average flow.

Table 2. Land use distribution in the upper Sandusky River watershed (SRWC, 2001)

Unit	**Total Area**	**Urban**		**Agriculture**		**Shrub**		**Wooded**		**Water**		**Marsh**		**Barren**	
	acres	acres	%	acres	%	acres	%	acres	%	acres	%	acres	%	acres	%
-020	87,920	1,685	1.9	72,006	81.9	402	0.5	12,534	14.3	314	0.4	960	1.1	19	0.0
-030	60,545	87	0.1	50,592	83.6	240	0.4	8,755	14.5	41	0.1	572	0.9	258	0.4
-040	77,693	356	0.5	62,562	80.5	664	0.9	12,281	15.8	409	0.5	1,348	1.7	73	0.1
-050	109,857	75	0.1	94,931	86.4	865	0.8	11,484	10.5	331	0.3	2,097	1.9	74	0.1
-060	83,321	617	0.7	71,967	86.4	483	0.6	8,483	10.2	178	0.2	554	0.7	1,039	1.2
-070	77,978	110	0.1	62,686	80.4	413	0.5	13,743	17.6	245	0.3	764	1.0	17	0.0
-080	115,090	586	0.5	97,577	84.8	241	0.2	15,424	13.4	62	0.1	1,010	0.9	190	0.2
-090	74,690	1,693	2.3	59,681	79.9	436	0.6	12,089	16.2	266	0.4	487	0.7	38	0.1

Table 3. Individual NPDES permits in the upper Sandusky River watershed.

Entity (Ohio EPA permit no.)	**Receiving Stream (RM of discharge)**	**Design Flow (MGD)**	**Annual 2001 Average Flow (MGD)**
04100011-020 Bucyrus Assessment Unit			
Village of Crestline WTP 2IY00092-001	Paramour Creek	0.014	
PPG Industries 2IE00004-001	PPG Tributary	0.238	0.06
Village of Crestline WWTP 2PC00006-001	Westerly Creek RM 0.50	0.95	1.25
Crawford County Landfill 2IN00127-001, 002, 003	Sandusky Trib. at 121.19		
Ranchwood Mobile Home Park WWTP 2PY00029-001	Sandusky Trib. at 121.19	0.009	
Linlare Village WWTP 2PG00089-001	Sandusky Trib. at 117.87	0.025	0.01
Timken Company 2IC00046-001	Sandusky Trib. at 116.32 RM 1.55	0.4	0.19
City of Bucyrus WTP 2IW00020-001	Sandusky River RM 113.40	0.08	0.08
BP Oil Company 2IN00172-001	Sandusky River RM 112.97	0.008	
City of Bucyrus WWTP 2PD00021-001	Sandusky River RM 111.00	3.4	2.92
Swift Ekrich Inc. WWTP 2IH00088-001	Sandusky River RM 98.70	0.16	0.08
Wynford Local School WWTP 2PT00028-001	Grass Run	0.025	0.02
04100011-030 Broken Sword Creek Assessment Unit			
National Lime and Stone 2IJ00020-003	Broken Sword Creek RM 15.42	0.4	
National Lime and Stone 2IJ00020-001	Broken Sword Creek RM 14.58	1.0	1.0
Village of Nevada WWTP 2PA00070-001	Rhine Ditch RM 0.35	0.09	0.05
04100011-040 Upper Sandusky Assessment Unit			
Olen Corp. 2IJ00067-001	Sandusky River RM 86.98	1.5	1.03
Liqui Box Corp. WWTP 2IQ00009-002	Sandusky Trib. at 83.14	0.02	
Upper Sandusky WTP 2IW00270-001	Sandusky River RM 83.00	1.0	

Table 3. Individual NPDES permits in the upper Sandusky River watershed.

Entity (Ohio EPA permit no.)	**Receiving Stream (RM of discharge)**	**Design Flow (MGD)**	**Annual 2001 Average Flow (MGD)**
BP Oil Co. 2IN00169-001	Sandusky River RM 82.60	0.008	
Upper Sandusky WWTP 2PD00039-001	Sandusky River RM 80.02	2.0	1.51
04100011-050 Upper Tymochtee Creek Assessment Unit			
Marion County Sewer Dist. 6A WWTP 2PG00030-001	Tymochtee Creek RM 53.79	0.006	0.004
Tri County Limestone Co. 2IJ00045-001	Laubis Ditch RM 0.55	1.0	
Agri General Co. LP 2IX00010-001	Tymochtee Trib.		
04100011-060 Lower Tymochtee Creek Assessment Unit			
Ohio DOT US 23N Rest Area WWTP 2PP00021-001	Tymochtee Creek RM 8.57	0.007	
National Lime and Stone 2IJ00008-001	Brown Ditch RM 0.28	0.6	0.6
National Lime and Stone 2IJ00008-002	Spring Run RM 4.40	1.0	1.0
National Lime and Stone 2IJ00008-003	Spring Run 3.60	1.0	1.0
National Lime and Stone 2IJ00008-004	Spring Run Trib. at 1.80 RM 1.95	1.0	1.0
Wyandot Dolomite 2IJ00068-001	Spring Run Trib. at 1.80 RM 1.80	0.4	0.4
Village of Carey WWTP 2PD00038-001	County Ditch #32 RM 0.30	0.91	0.53
County Environmental of Wyandot 2IN00121-007, 009, 002	Little Tymochtee Creek RM 2.12, 2.35, 2.59		
County Environmental of Wyandot 2IN00121-004, 003, 012	Little Tymochtee Creek RM 3.22, 3.55, 3.55		
Schmidt Machine Co. WWTP 2IM00011-001	Little Tymochtee Creek RM 5.20	0.0015	
Ohio DOT US 23S Rest Area 2PP00020-001	Little Tymochtee Creek RM 7.36	0.007	
04100011-070 Mexico Assessment Unit			
Kirby Tire 2IN00197-001	Sycamore Creek RM 7.35	0.03	
Sycamore WTP 2IV00102-001	Sycamore Creek RM 3.52	0.014	0.01

Table 3. Individual NPDES permits in the upper Sandusky River watershed.

Entity (Ohio EPA permit no.)	Receiving Stream (RM of discharge)	Design Flow (MGD)	Annual 2001 Average Flow (MGD)
Sycamore WWTP 2PB00000-001	Sycamore Creek RM 3.45	0.16	0.03
Mohawk High School WWTP 2PT00014-001	Mile Run RM 1.50	0.0125	0.002
04100011-080 Honey Creek Assessment Unit			
Village of New Washington WTP 2IW00200-001	Alum Ditch RM 2.12	0.001	
Village of New Washington WWTP 2PB00060-001	Alum Ditch RM 0.30	0.15	
Beck Suppliers 2IN00188-001	Honey Creek RM 28.32	0.001	0.001
Village of Attica WTP 2IV00000-001	Honey Creek RM 28.36	0.01	
Village of Attica WWTP 2PB00001-001	Work Ditch RM 0.95	0.20	0.22
Hanson Aggregates 2IJ00016-001	Aichholz Ditch RM 1.95	0.8	
Village of Bloomville WWTP 2PB00053-001	Griffin Ditch RM 0.40	0.10	0.08
Aqua Tech Laboratories WWTP 2PR00177-001	Honey Creek RM 12.30	0.0015	
Honey Creek Subdivision WWTP 2PR00107-001	Honey Creek RM 1.10	0.015	0.002
04100011-090 Tiffin Assessment Unit			
Seneca County Facilities WWTP 2PG00088-001	Gibson Creek RM 2.80	0.032	0.03
Sentinel Vocational Center WWTP 2PT00017-001	Rock Creek RM 3.95	0.007	
National Machinery Co. 2IS00009-001	Rock Creek RM 1.00	0.007	
National Machinery Co. 2IS00009-002	Rock Creek RM 0.95	0.0005	
Village of Republic 2PA00087-001	Morrison Creek Tributary	0.075	
Ohio American Water 2IW00023-001	Sandusky River RM 41.95	0.16	
City of Tiffin WWTP 2PD00025-001	Sandusky River RM 38.77	4.0	3.08

General Permits

General permits are designed so that one permit is appropriate for facilities that have similar operations. Types of wastewater covered include industrial stormwater, construction site stormwater, municipal separate storm sewer systems (MS4), non contact cooling water, petroleum corrective action sites, small sanitary sources, and coal mines. An MS4 is any public entity (city, village, transportation department, university, military base, etc.) that owns or operates a separate storm sewer system. In December 1999, USEPA promulgated Phase II stormwater rules that required designated MS4 entities to submit permit applications. No entities met this criteria in the upper Sandusky River watershed, but Phase II also required Ohio EPA to develop criteria to determine if MS4 entities with a population of 10,000 or more or a population density of 1,000/mi.^{2} must obtain permit coverage. The Ohio EPA anticipates designating the cities of Bucyrus and Tiffin as Phase II MS4 in early 2004. There are a total of 28 industrial facilities that hold general NPDES stormwater permits in the upper Sandusky River watershed and they are listed in Table 4. There is one general permit issued for a petroleum corrective action site and approximately 55 construction stormwater permits. Most of these are for roadway projects and development of residential subdivisions.

Table 4. Industrial stormwater permits in the upper Sandusky River watershed.

Entity	Ohio EPA permit no.	Receiving Stream
04100011-020 Bucyrus Assessment Unit		
GE Lighting, Inc.	2GR00334	Sandusky River
Carlisle Engineered Products Inc.	2GR00434	Westerly Creek
William Dauch Concrete Co.	2GG00230	Sandusky River
Campbell Technological Resources	2GR00465	Easterly Creek
Campbell Technological Resources	2GR00464	Easterly Creek
Ryder Heil Bronze, Inc.	2GR00515	Sandusky River
Imasen Technology, Inc.	2GR00561	Sandusky River
04100011-030 Broken Sword Creek Assessment Unit		
Stoneco, Inc.- Spore Asphalt Plant	2GR00483	Broken Sword Creek
04100011-040 Upper Sandusky Assessment Unit		
North Coast Fertilizer, Inc.	2GR00384	Little Sandusky River
A.O. Smith, EPC	2GG00072	Sandusky River
Coupled Products Inc.	2GG00086	Sandusky River
Blackhawk Automotive	2GR00225	Sandusky River

Table 4. Industrial stormwater permits in the upper Sandusky River watershed.

Entity	Ohio EPA permit no.	Receiving Stream
CNF, Inc.	2GR00284	Rock Run
Engineered Wire Products, Inc.	2GG00122	Sandusky River
Bradley	2GR00494	Sandusky River
04100011-050 Upper Tymochtee Creek Assessment Unit		
Shelly Co.- Plant No. 88	2GG00105	Tymochtee Creek
04100011-060 Lower Tymochtee Creek Assessment Unit		
Mueller Plastic Corp.	2GR00071	Veith Ditch
Toledo Molding and Die, Inc.	2GR00169	Spring Run
Tower Automotive	2GR00489	Tymochtee Creek
Budd Co.-Plastics Division	2GR00506	Spring Run
Mineral Processing of Ohio	2GR00544	Spring Run
04100011-070 Mexico Assessment Unit		
Toledo Molding and Die, Inc.	2GR00170	Sycamore Creek
04100011-080 Honey Creek Assessment Unit		
Mansfield Brass and Aluminum Corp.	2GR00358	Alum Ditch
Stumps Auto Wrecking	2GR00567	Honey Creek
04100011-090 Tiffin Assessment Unit		
American Standard, Inc.	2GR00337	Sandusky River
National Machinery Co.	2GR00339	Willow Creek
Horizon Properties	2GR00486	Sandusky River
Toledo Molding and Die, Inc.	2GR00569	Detention Pond

Unregulated Point Source Discharges

Some point source facilities located in the study area are not regulated by the NPDES permit system. Many of these will eventually be issued a permit and some will be eliminated by sewer extensions. A list of these facilities is presented in Table 5.

Table 5. Point source facilities not regulated by a NPDES permit.

Entity	Receiving Stream	Design Flow (MGD)
04100011-020 Bucyrus Assessment Unit		
Colonel Crawford High School	Sandusky Trib. at 121.19	0.02
Willy's Waffle House	Grass Run	0.004
Carolyn's Kitchen	Grass Run	0.007
04100011-030 Broken Sword Creek Assessment Unit		
Foxfire Campground	Broken Sword Creek	0.009
04100011-040 Upper Sandusky Assessment Unit		
Indian Mill Rec Area Campground	Sandusky River	0.007
04100011-060 Lower Tymochtee Creek Assessment Unit		
Tee Pee Campground	Browns Run	0.005
04100011-070 Mexico Assessment Unit		
Cooters	Thorn Run	0.0015
Buckeye West Elementary School	Sycamore Creek	0.0025
Walnut Grove Campground	Sandusky River	0.006
Camp Glen	Sandusky River	0.005
Ruffing Family Care Center	Sandusky River	0.01
04100011-080 Honey Creek Assessment Unit		
Auburn Lake Campground	Honey Creek	0.01
Mother of Sorrows School	Honey Creek	
Cranberry Hills Golf Course	Honey Creek Tributary	0.002
Mohawk Country Club	Van Meter Creek	0.02
04100011-090 Tiffin Assessment Unit		
Moose Lodge Hall	Sandusky River	0.01

Unsewered Areas

Home sewage treatment systems are found mainly in rural areas and small villages. One common system employs a septic tank followed by a leaching tile field. The septic tank is a concrete box that provides primary treatment. It allows solids to settle and also promotes some decomposition. Solids will eventually fill the tank and routine cleaning is necessary. Water that overflows from the septic tank is distributed to a leaching tile field. This consists of pipe laid in trenches of gravel and sand that the wastewater slowly seeps into. Tile fields require a sufficient land area with well drained soils for them to operate effectively and they have a short life span. Home sewage treatment systems have minimal surface water impact if they are properly designed, installed, and maintained. Sometimes failed tile fields are bypassed into a storm sewer system or the nearest stream to prevent backing-up in yards and basements. This results in the presence of raw and poorly treated sewage in the stream and can be a major source of impairment, especially in larger communities and subdivisions. A list of unsewered villages located in the study area is presented in Table 6.

Table 6. List of unsewered communities in the upper Sandusky River watershed.

HUC 11 Assessment Unit	Communities
Bucyrus 04100011-020	West Liberty, Middletown, Leesville, and North Robinson
Broken Sword Creek 04100011-030	Dekalb, Sulphur Springs, Ridgeton, Brandywine, Brokensword, Spore, Oceola, and Edenville
Upper Sandusky 04100011-040	Lemert, Seal, Smithville, Harpster, Morral, and Little Sandusky
Upper Tymochtee Creek 04100011-050	Big Island, DeCliff, Meeker, Marseilles, and Brownstown
Lower Tymochtee Creek 04100011-060	Kirby, Lovell, Crawford, and Tymochtee
Mexico 04100011-070	Deunquat, Belle Vernon, McCutchenville, Mexico, Chatfield, Lykens, Benton, and Plankton
Honey Creek 04100011-080	Tiro, Mechanicsburg, Waynesburg, Auburn Center, North Auburn, Carrothers, Caroline, Scipio Siding, St. Stephens, and Melmore
Tiffin 04100011-090	Rockaway

2.2 Water Quality and Biological Assessment

Under the CWA, 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. A brief description of Ohio’s WQS is presented in Table 7. Further information is available in Chapter 3745-1 of the Ohio Administrative Code (Ohio EPA, 1993).

In the upper Sandusky River watershed, the aquatic life use designations that apply are Warmwater Habitat (WWH), Modified Warmwater Habitat (MWH), and Limited Resource Water (LRW). 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 MWH have been found to be incapable of supporting and maintaining a balanced integrated community of warmwater aquatic organisms due to irretrievable modifications of the physical habitat. Waters designated as LRW have been found to lack the potential for any resemblance of any other aquatic life habitat.

Attainment of aquatic life uses is determined 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 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 upper Sandusky River watershed is Primary Contact Recreation (PCR). This designation is appropriate for streams that have 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. Waters that are designated as Bathing Waters (BW) are suitable for swimming where a lifeguard and/or bathhouse facilities are present.

The method used by Ohio EPA to evaluate attainment of recreation uses is currently under development. For this report, fecal coliform were used as the indicator organism. An assessment unit is considered impaired if, when all the raw data are pooled, the geometric mean value exceeded the primary contact recreation (PCR) minimum criterion (1000 CFU/100 ml) or the 90^{th} percentile value exceeded the PCR average criterion (2000 CFU/100 ml).

Table 7. Summary of Ohio's Water Quality Standards.

Components	Examples	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:* • 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. These criteria are the basis for determining aquatic life use attainment.
	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.	

2.2.1 Aquatic Life Use Attainment

For the upper Sandusky River TMDL, the Ohio EPA conducted a detailed assessment in 2001 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. Results of this study are reported in the *Biological and Water Quality Study of the Sandusky River and Selected Tributaries*[2] (Ohio EPA, 2003).

This TMDL addresses the results from the 2001 assessment. Aquatic life use attainment status for the study is provided in Appendix A. 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 determined appropriate by the 2001 assessment is different than the use designation in effect prior to the survey, the attainment status for the recommended use designation is provided.

2.2.1.1 Habitat Quality

Figure 10 is a first look at the basin wide condition of streams in the upper Sandusky River basin. A lower drainage area limit of 20 mi.^{2} was set for the data used since this is the minimum drainage area for a wadeable stream. This size stream also tended to have water in the channel unlike many of the smaller drainage sites. An upper limit of 500 mi.^{2} excludes the mainstem Sandusky sites downstream from Tymochtee Creek. The horizontal line in each graph is the index score for WWH attainment. The two vertical lines accentuate the principal conclusions made from the data. First, note that the sites with drainage areas of greater than about 225 mi.^{2} generally met WWH expectations. Secondly, nearly all of the sites between 20 and 50 mi.^{2} had sub par fish results. Results for both organism groups from sites of between 50 mi.^{2} and 225 mi.^{2} are mixed.

Overall, the macroinvertebrate community met expectations at a higher frequency than did either fish index at sites of less than 225 mi.^{2}. The macroinvertebrates tend to score better than the fish when water chemistry is acceptable but the macrohabitat is degraded. Additional substantiation of this is that there are a number of poor habitat sites (triangles on the graphs) where the macroinvertebrates met WWH expectations. Conversely, none of the poor habitat sites had IBI or MIwb scores that attained. Few of the IBI scores and none of the MIwb scores for sites between 20 mi.^{2} and 50 mi.^{2} attained or exceeded the WWH criterion. Degraded habitat was the most pervasive cause although nutrients certainly negatively affected certain of the sites. The assessment unit summaries provide more site specific appraisals of causes and

[2] *Biological and Water Quality Study of the Sandusky River and Selected Tributaries* at http://www.epa.state.oh.us/dsw/documents/2001SanduskyTSD.pdf or call the Ohio EPA Division of Surface Water at (614) 644-2001.

sources. Even the sites with good habitat were affected due to low flow conditions and sedimentation. The sites between 50 $mi.^2$ and 225 $mi.^2$ were more predictable in terms of habitat condition positively affecting the fish community. This was likely due to increased flow which provided increased pool depths and improved the functioning of various cover types to support a greater diversity of fish species.

The information presented in Figure 10 is instructive as to where restoration activities might best be directed. First, funds do not need to be spent to improve conditions in areas where the drainage area exceeds 225 $mi.^2$. These sites are largely already meeting ecoregion expectations for aquatic life and should continue to do so unless new impacts (*i.e*., additional WWTP loadings, drainage improvements) are introduced. Preservation of existing riparian areas would be beneficial in maintaining healthy biological communities.

A second conclusion is that the efforts to improve habitat in stream segments with drainage areas between 50 $mi.^2$ and 225 $mi.^2$ should result in better fish communities. A benchmark would be to restore the stream habitat so that a QHEI score of at least 60 is achieved. Nutrient sources should also be addressed where it has been noted in the assessment unit summaries to benefit both biological communities and recreational use concerns.

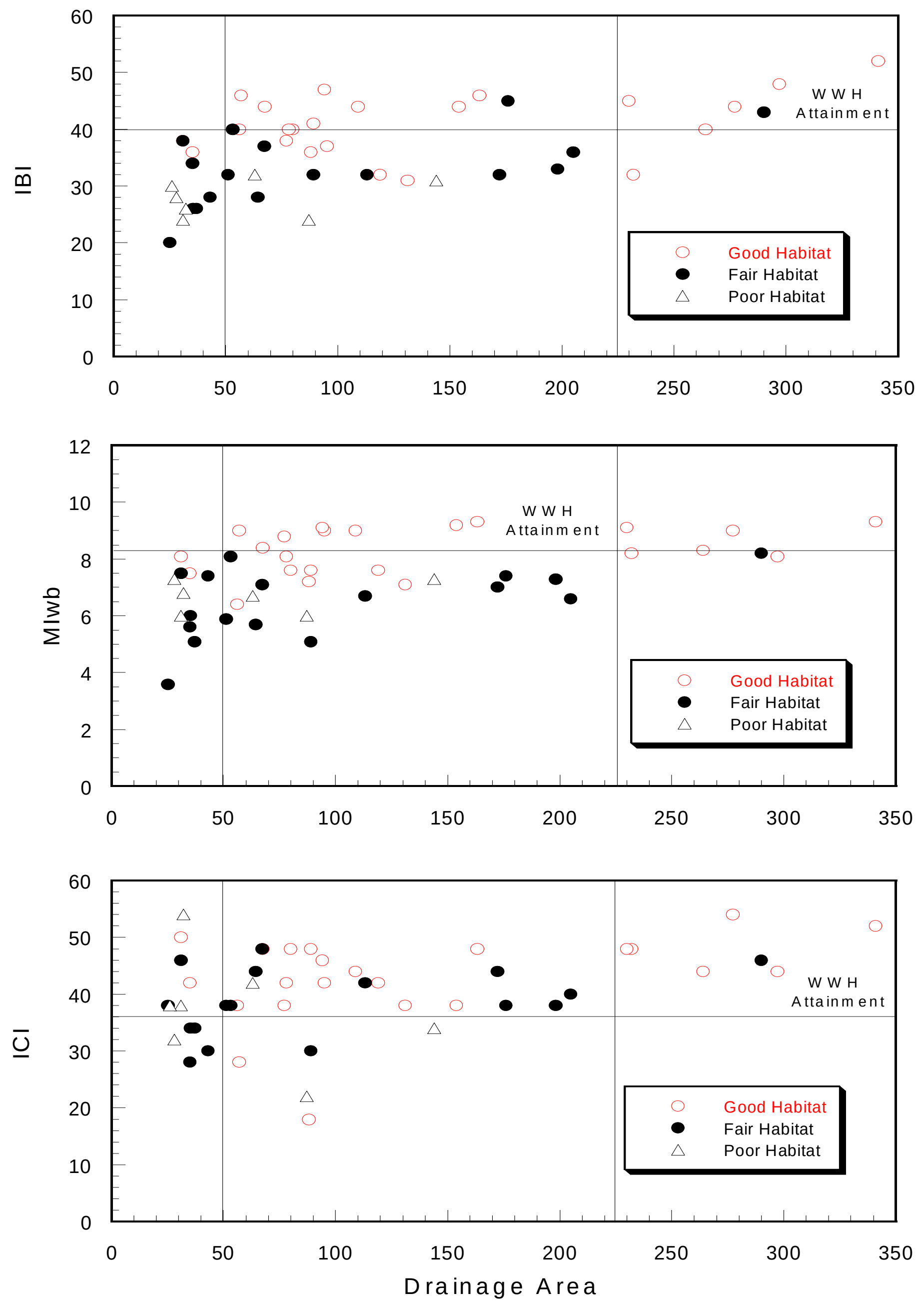


Figure 10 Biological index scores of 20mi^2 to 500mi^2 drainage area sites in the 2001 Sandusky River study area as related to habitat quality. Corresponding ICI scores are used where narrative evaluations were made based on qualitative sampling results.

2.2.1.2 Assessment Unit Scores

Assessment unit scores are used to grade aquatic life use status within an 11 digit HUC. Scores are determined using a combination of spatial and linear analysis. A score of 100 is possible if all monitored sites meet designated aquatic life uses. Data is grouped according to the watershed size at the point of sampling: sites with drainage areas ≤5 mi.^{2}; sites with drainage areas >5 mi.^{2} and ≤20 mi.^{2}; sites with drainage areas >20 mi.^{2} and ≤50 mi.^{2}; and sites with drainage areas >50 mi.^{2}. Within each assessment unit a "linear" attainment score is calculated for the stream segments with drainage areas >50 mi.^{2} in the fashion described above for large rivers. A separate "spatial" attainment score is calculated for each assessment unit using information about the fraction or proportion of sites within data groups that demonstrated full aquatic life use attainment. To correct a bias in biosurvey design that generates a larger number of data points from small watersheds the following formula was used to give more weight in the final spatial score to results from larger streams.

Data Group 1		Data Group 2		Data Group 3		
≤5 mi.^{2}		>5 mi.^{2} to ≤20 mi.^{2}		>20 mi.^{2} to ≤50 mi.^{2}		Spatial Score
[(a/b	+	a/b)/2	+	(a/b)]/2 x 100	=	c

where

a= number of sites in full attainment
b= number of sites in data group
c= spatial attainment score for assessment unit

Assessment unit scores 80-99 generally indicate a localized water quality issue and are considered medium priority for TMDL development, since a targeted fix might address the problem better than a complete watershed effort. Assessment unit scores 40-79 indicate a problem of such a scale that make them good candidates for a traditional TMDL and make them a high priority. Assessment unit scores 0-39 indicate severe basin wide problems that may require significant time and resources and make them a low priority. Education about how land use affects water quality and encouraging stewardship in these areas may be more effective than a traditional TMDL. Scores for the assessment units sampled in 2001 are presented in Appendix B.

Ohio has developed a point system to prioritize waters identified as impaired and requiring a TMDL. The method is described in the *2004 Integrated Water Quality Monitoring and Assessment Report*[3] (Ohio EPA, 2004). A total of 13 points can be

[3] 2004 Integrated Water Quality Monitoring and Assessment Report at; http://www.epa.state.oh.us/dsw/tmdl/2004IntReport/final_2004IR_main_text.pdf or call the Ohio EPA Division of Surface Water at (614) 644-2001.

assigned to an assessment unit. Impairment of the recreation use is more heavily weighted (7 points) compared to the aquatic life use (4 points) and fish consumption advisories (2 points).

2.2.2 Recreation Use Attainment

The method used by Ohio EPA to evaluate attainment of recreation uses is currently under development. For this report, all the fecal coliform data from an assessment unit was pooled to calculate the geometric mean and 90th percentile values. An assessment unit was considered impaired if the geometric mean value exceeded the primary contact recreation (PCR) minimum criterion (1000 CFU/100 ml) or the 90th percentile value exceeded the PCR average criterion (2000 CFU/100 ml). A summary of the fecal coliform results is presented in Table 8. Results that are presented in bold type exceeded the target values. Based on this type of evaluation, the Bucyrus, Upper Sandusky, Upper Tymochtee, and Tiffin assessment units are considered impaired. The sources of impairment vary, but include CSOs, septic systems, and livestock.

Table 8. Summary of 2001 fecal coliform data

HUC 11 Assessment Unit	Geometric Mean	90th Percentile
Bucyrus 04100011-020	711	**3200**
Broken Sword Creek 04100011-030	423	1125
Upper Sandusky 04100011-040	**1151**	**10000**
Upper Tymochtee 04100011-050	570	**2357**
Lower Tymochtee 04100011-060	344	1266
Mexico 04100011-070	306	1129
Honey Creek 04100011-080	506	1859
Tiffin 04100011-090	830	**4163**
Large River 04100011-001	247	1428

2.3 Causes 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 following paragraphs are provided to present the varied causes of impairment that were encountered during the 2001 study. While the various perturbations are presented under separate headings, it is important to remember that they are often interrelated and cumulative in terms of the detrimental impact that can result.

2.3.1 Habitat and Flow Alterations

Habitat and flow alterations result from the manipulation of drainage. Common practices in agricultural areas include channelization, installation of subsurface tile systems, and removal of riparian vegetation. Channelized streams are constructed to increase capacity, flow rate, and efficiency of tiles. Tiles lower the water table to facilitate the cultivation of fields and the removal of vegetation facilitates long term maintenance. Habitat lost directly impacts biological communities by limiting the complexity of living spaces available to aquatic organisms. Consequently, communities are not as diverse. Drainage systems keep water from ponding and slowly filtering through the soil, thus recharging groundwater and augmenting the stream at a lower volume and more sustained rate. The end result is flows that are flashy and streams that frequently become intermittent or dry.

There are other consequences that result from the loss of riparian vegetation. It eliminates an important source of coarse organic matter essential for a balanced ecosystem. In addition, an intact tree canopy limits the energy input from the sun and moderates temperature and evaporation.

Increased amounts of sediment are likely to enter streams altered for drainage by either overland transport or increased bank erosion. The removal of wooded riparian areas furthers the erosional process. Deep trapezoidal channels keep all but the highest flow events confined within the artificially high banks. As a result, areas that were formerly flood plains and allowed for the removal of sediment from the primary stream channel no longer serve this function. Drainage practices that reduce or eliminate water movement and sources of turbulence (riffles, snags, and meanders) can exacerbate organic enrichment impacts by limiting reaeration.

2.3.2 Sedimentation

Whenever the natural flow regime is altered to facilitate drainage, increased amounts of sediment are likely to enter streams either by overland transport or increased bank erosion. The removal of wooded riparian areas furthers the erosional process. Channelization keeps all but the highest flow events confined within the artificially high banks. As a result, areas that were formerly flood plains and allowed for the removal of sediment from the primary stream channel no longer serve this function. As water levels fall following a rain event, interstitial spaces between larger rocks fill with sand and silt and the diversity of available habitat to support fish and macroinvertebrates is reduced. Silt also can clog the gills of both fish and macroinvertebrates, reduce visibility thereby excluding site feeding fish species, and smother the nests of lithophilic fishes. Lithophilic spawning fish require clean substrates with interstitial voids in which to deposit eggs. Conversely, pioneering species benefit. They are generalists and best suited for exploiting disturbed and less heterogeneous habitats. The net result is a lower diversity of aquatic species compared with a typical warmwater stream with natural habitats.

Sediment also impacts water quality, recreation, and drinking water. Nutrients absorbed to soil particles remain trapped in the watercourse. Likewise, bacteria, pathogens, and pesticides which also attach to suspended or bedload sediments become concentrated in waterways where the channel is functionally isolated from the landscape. Community drinking water systems address these issues with more costly advanced treatment technologies.

2.3.3 Phosphorus

The form of phosphorus that can be readily used by plants is inorganic orthophosphate. It is an essential nutrient for plant growth and is often the limiting factor, so sudden inputs can stimulate nuisance algae blooms. The amount of phosphorus tied up in the nucleic acids of food and waste is actually quite low. Even so, it is eventually converted to orthophosphate by bacteria. The amount of orthophosphate contained in synthetic detergents, on the other hand, is a great concern. It was for this reason that the General Assembly of the State of Ohio enacted a law in 1990 to limit phosphorus content in household laundry detergents sold in the Lake Erie drainage basin to 0.5 % by weight.

2.3.4 Organic Enrichment and Low Dissolved Oxygen

The two main sources of oxygen in water are diffusion from the atmosphere and plant photosynthesis. Since the amount that dissolves from air depends on its partial pressure and solubility, this portion is quite low (air only contains 21% oxygen). The amount that dissolves is also affected by barometric pressure, temperature, and surface turbulence. Less oxygen is soluble as temperature increases, while turbulence promotes diffusion because it increases area and breaks surface tension. This is why drainage practices like channelization and removal of riparian vegetation are so detrimental, they eliminate shade that keeps water cool and reduce turbulence produced by riffles, meanders, and debris snags. Since light provides the energy for photosynthesis, this process only produces oxygen by day. At night, plants consume oxygen by the reverse process of respiration. Oxygen is also consumed by bacteria that decay organic matter, so it can be easily depleted unless it is replenished from the air.

2.3.5 Ammonia

In aquatic ecosystems, ammonia shifts from a gaseous state to undissociated ammonium hydroxide to dissociated ammonium ion. Under normal conditions almost no ammonia is present as gas, a very small amount is present as ammonium hydroxide, and the rest is ammonium ion. This is important because while the ammonium ion is almost harmless to aquatic life, the compound ammonium hydroxide is very toxic. It can reduce growth and reproduction or even cause mortality. Alkaline pH shifts, like those caused by severe algae blooms, favor the production of gaseous ammonia, so the amount of ammonium hydroxide increases.

2.3.6 Nitrate

Nitrate is the most common form of inorganic nitrogen in streams. It is an essential nutrient for plant growth and can be a limiting factor. The ion moves easily through soil and is rapidly lost from the land. Although elevated nitrate is sometimes responsible for enrichment impacts, the greatest concern is for quality of drinking water supplies. Babies are at risk because sometimes bacteria present in the gut reduce nitrate to nitrite, which forms methemoglobin. This compound reduces the oxygen carrying capacity of blood, causing respiratory problems (“blue babies”). In severe cases it can be fatal.

There are five stream segments in the study area designated as public water supplies, three on the Sandusky River (Bucyrus, Upper Sandusky, and Tiffin) and one each on Honey Creek (Attica) and Alum Ditch (New Washington). Chapter 4.0 provides more details about the nitrate concentrations in the Sandusky River watershed.

2.3.7 Pathogens

Bacteria levels in streams are a concern because they are a human health issue and affect attainment of recreation uses. People can be exposed to organisms while wading, swimming, and fishing. In the upper Sandusky River watershed, fecal coliform was used as the indicator organism to evaluate risk of exposure to pathogens. Fecal coliform bacteria are relatively harmless in most cases, but their presence indicates that the water has been contaminated with feces from a warm-blooded animal. Although intestinal organisms eventually die off outside the body, some will remain virulent for a period of time and may be dangerous sources of infection. This is especially a problem if the feces contained pathogens or disease producing bacteria and viruses. Reactions to exposure can range from an isolated illness such as skin rash, sore throat, or ear infection to a more serious wide spread epidemic. Some types of bacteria that are a concern include *Escherichia*, which cause diarrhea and urinary tract infections, *Salmonella*, which cause typhoid fever and gastroenteritis (food poisoning), and *Shigella*, which cause severe gastroenteritis or bacterial dysentery. Some types of viruses that are a concern include polio, hepatitis A, and encephalitis. Disease causing microorganisms such as cryptosporidium and giardia are also a concern.

Since fecal coliform bacteria are associated with warm-blooded animals, there are both human and animal sources. Human sources, including effluent from sewage treatment plants or discharges by septic systems, are a more continuous problem. Contamination from combined sewer overflows are associated with wet weather events. Animal sources are usually more intermittent and are also associated with rainfall, except when domestic livestock have access to the water. Large livestock farms store manure in holding lagoons and this creates the potential for an accidental spill. Liquid manure applied as fertilizer is a runoff problem if not managed properly and it sometimes seeps into field tiles.

2.3.8 Contaminated Sediment

The chemical quality of sediment is important because it can affect attainment of aquatic life, recreation, and water supply uses and edibility of sport fish. The pollutants of greatest interest are those that bind strongly to soil, persist for long periods of time in the environment, and bioaccumulate in the food chain. Contaminated sediment was discovered in the Sandusky River around Bucyrus, especially downstream from CSOs and the WWTP discharge. The pollutants of greatest concern are mercury and polycyclic aromatic hydrocarbons (PAHs). The highest level of mercury documented was just downstream from the Bucyrus WWTP at 0.701 mg/kg. This exceeds the Ohio reference value of 0.12 mg/kg and threshold effect concentration defined by MacDonald (2000) of 0.18 mg/kg, indicating a potential for aquatic life toxicity. Extreme levels of PAHs in sediment are justification for issuing contact advisories and at lower levels they can be toxic to aquatic life. PAHs are the byproducts of fossil fuel combustion and contained in creosote and coal tar. Some have been documented to cause skin cancer in lab animals and are strongly suspected human carcinogens. The highest level of

PAHs was downstream from the Bucyrus CSOs at 24.05 mg/kg. This exceeds the probable effect concentration defined by MacDonald of 22.8 mg/kg, indicating that aquatic life toxicity is likely.

Due to the persistent nature of mercury and PAHs in the environment and the risk to human health, a serious commitment needs to be made to eliminate the sources of these pollutants. It might also be necessary to further delineate the extent of contamination and consider the possibility of remediation activities.

2.3.9 Sport Fish Consumption Advisories

Ohio does not include fish consumption among the codified beneficial uses, so no criteria exist and attainment status cannot be assessed. However, the Ohio Department of Health issues a sport fish consumption advisory in cooperation with the Ohio EPA and Ohio Department of Natural Resources[4].

A statewide/nationwide advisory for mercury has been issued since 1997 to protect women of child bearing age and children under the age of six. These sensitive populations are advised not to eat more than one meal per week of any species of fish caught from any body of water in Ohio. An advisory specific to the Sandusky River issued in 2003 recommends that channel catfish and largemouth bass meals be limited to one per month. This advisory applies to the entire population and is issued because of mercury and PCB contamination documented in tissue samples collected in 1997.

Mercury is a human health concern because extended exposure can damage the brain, kidneys, and developing fetus. Elemental mercury forms inorganic salts when it enters the aquatic environment, but bacteria convert these to methyl-mercury. It is this organic form of mercury that bioaccumulates in the aquatic food chain.

Elevated levels of mercury are present in water, sediment, and fish tissue samples collected from the Sandusky River around the Bucyrus area. A sediment hot spot was discovered in a ½ mile segment of the river in the vicinity of the Bucyrus WWTP discharge and overflows from several CSOs. Levels remained above reference conditions for approximately 5 ½ miles, indicating that the material is re-suspended and transported downstream. Nearly 21 miles downstream from the sediment hot spot mercury exceeding human health and wildlife criteria was detected in a water sample. These criteria are established to protect drinking water supplies and edibility of sport fish. The 2003 Ohio sport fish consumption advisory recommends limiting meals of channel catfish and largemouth bass caught in the Sandusky River to one per month because of high mercury levels.

[4]*Ohio Sport Fish Consumption Advisory* at http://www.epa.state.oh.us/dsw/fishadvisory/index.html or call the Ohio EPA Public Interest Center at (614) 644-2160.

2.4 Sources of Impairment

Sources of pollution are usually classified as either point or non-point. The location of point sources is easy to identify at the end of a pipe and most are regulated by a permit to control quality of effluent. The location of non-point sources is difficult to identify because they come from all land uses. They are difficult to control and not often regulated, but have a major impact on water quality. Section 319 of the CWA was ratified in 1987 to require states to develop non-point source management programs.

2.4.1 Point Sources

Point sources include municipal and industrial types. The wastewater they discharge can contain a wide variety of pollutants, but of particular concern are organic matter and nutrients. Organic enrichment contributes to dissolved oxygen sags and is usually measured with the BOD test. Nutrient enrichment can stimulate plants and algae to grow to the point where they are a nuisance and detrimental to the environment. The compounds ammonia, nitrate, and phosphorus are measured to evaluate the extent of enrichment.

Sewage treatment plants are designed to provide conditions suitable for microbes to convert organic compounds into stable inorganic compounds. Two components that are important for a system to operate efficiently are a long retention time and oxygen. These conditions stimulate bacterial respiration, which converts organic carbon to carbon dioxide and water. Another important process performed by bacteria involves the nitrogen cycle, which converts organic nitrogen and ammonia to ammonium, then nitrite, and finally nitrate. The treatment of phosphorus usually requires the addition of chemicals to encourage particles to adsorb to their surface and coagulate in masses heavy enough to precipitate out of the wastewater. This is why most phosphorus ends up in sludge, making it an attractive fertilizer.

2.4.2 Combined Sewer Overflows

These types of sewer systems carry both sanitary waste and stormwater runoff. They are not a problem during dry weather, because treatment plants are designed to handle these flows. It is during wet weather that CSOs and bypasses become a concern, because they activate to prevent flooding of the system. Since this wastewater is not treated it contains a high amount of organic matter, nutrients, and pathogens. It can also contain a high amount of metals and oily waste.

CSOs and bypasses in Bucyrus are the suspected origin of mercury contamination in the Sandusky River. The collection system consists of 60% combined and 40% separate sewers and there are 16 CSOs. The Bucyrus WWTP also has a raw bypass when flows exceed the hydraulic capacity of 6.0 MGD. Flows between the design capacity of 3.4 MGD and the hydraulic capacity receive primary treatment and disinfection. A manufacturer of fluorescent light bulbs, an industrial source of mercury waste, has reported disposing of mercury contaminated wastewater into the Bucyrus sewer system at a sewer trunk identified in the Bucyrus NPDES permit as numbers 23 and 24 (before it reaches the head of the WWTP). The manufacturer has installed a treatment system that reduced discharge loads of mercury. Ohio EPA will continue to work with this facility to further reduce mercury contributions.

2.4.3 Agriculture

Agriculture is the number one industry in Ohio and it is the predominant land use in the upper Sandusky River watershed. The major commodities produced include field, fruit, and vegetable crops and a variety of livestock. Pollution problems that arise include the introduction of sediment, organic matter, nutrients, pathogens, and pesticides.

The cultivation of land for crop production makes it susceptible to water and wind erosion and this increases the amount of sediment in streams. It also increases the amount of nutrients, especially phosphorus, and pesticides that are applied to crops to increase yield. Although nitrate passes easily thorough soil it still contributes to pollution problems because it enters through field tiles installed to improve drainage.

A major concern with livestock production is the management of manure. Confined feeding areas usually require the collection and storage of manure and this creates the potential for spills. Pasture land contributes to pollution too, especially if the livestock have unrestricted access to the stream.

2.4.4 Septic Systems

Septic systems are used to treat sanitary sewage in areas where no municipal facilities exist. These systems usually employ a settling tank followed by either a leaching field or sand filters. They have a finite life span and require routine maintenance to operate properly. When poorly designed or neglected they contribute loads of organic matter, nutrients, and pathogens. Another problem that occurs in small towns is cross connecting failed systems to storm sewers. This solves the problem of sewage backing up in yards and basements, but severely harms the environment.

2.4.5 Stormwater

Stormwater runoff can be a significant source of impairment. Runoff from lands modified by human activities can harm surface water resources in several ways, including the changing of natural habitat and hydrologic patterns and elevating pollutant concentrations and loadings. Storm water runoff may contain or mobilize high levels of contaminants, such as sediment, nutrients, heavy metals, pathogens, toxins, oxygen-demanding substances, and floatables.

The origin of stormwater includes discharges from Phase II MS4s and both Phase I and II Industrial and Construction activities. An MS4 is any public entity (city, village, transportation department, university, military base, etc.) that owns or operates a separate storm sewer system. The Ohio EPA anticipates designating the cities of Bucyrus and Tiffin as Phase II MS4 in early 2004.

2.4.6 Hydromodification

Hydromodification includes activities like channelization, removal of riparian vegetation, and dam construction. Channelization redefines the natural structure and form of a stream to make it straight, wide, and deep. This is done to increase capacity and flow rate and improve the operation of internal drainage systems. The removal of riparian vegetation is often conducted as a part of channelization projects. This practice reduces friction, allows farming closer to the channel, and facilitates maintenance activities. Most dams were constructed for flood control, but some were intended to enhance navigation, recreation, and water supplies.

3.0 PROBLEM STATEMENT

The goal of the TMDL process is full attainment of the Water Quality Standards established for aquatic life and recreation uses summarized in Table 7. Both of these beneficial uses are impaired to some degree in the upper Sandusky River watershed. The major causes of non-attainment for aquatic life uses are organic enrichment, excessive nutrients, sedimentation, habitat degradation, and flow alteration. Organic enrichment usually causes dissolved oxygen WQS violations due to the oxygen demand exerted by algal respiration and decomposition of the organic matter. The specific nutrients are mentioned below. The major cause of non-attainment for recreation uses are elevated fecal coliform counts.

Nutrients, except under unusual circumstances, rarely approach concentrations in the ambient environment that are toxic to aquatic life. *Quality criteria for Water* concluded that "levels of nitrate nitrogen at or below 90 mg/l would not have [direct] adverse effects on warmwater fish" U.S. EPA (1976). 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 daily 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 (specifically total phosphorus and nitrate-nitrogen) and sediment loads in the Sandusky River watershed are the highest among 7 major Ohio watersheds that are monitored for those parameters, based on 1997-98 data (Baker et al., 2001, Table 8.5).

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 intermittence), 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 Sandusky River watershed was excellent at most mainstem sites, but tended to be below target in the tributaries, as drainage area decreased. Appendices C through F show subwatershed maps illustrating the spatial distribution of aquatic life use attainment, and quality of habitat and various other habitat-related indicators. Most of the habitat problems are related to agricultural activities, since more than 80% of the watershed is devoted to agriculture.

The parameters selected for Total Maximum Daily Load development are total phosphorus, sediment, bacteria, and dissolved oxygen. Instead of trying to develop sediment mass loadings, the Qualitative Habitat Evaluation Index (QHEI) will be used as a surrogate. Specifically, the substrate scores can be used to indicate siltation problems. Dissolved oxygen modeling was performed for the headwaters of the Sandusky River (within assessment unit 04100011-020), and more details are given in chapter 4 and Appendix J. Ohio EPA also performed fecal coliform bacteria modeling for several tributaries suspected of being impaired, although the assessment is based on limited data. More details about the bacteria modeling are available in Chapter 4 and Appendix G.

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.

3.1.1 Nutrients

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 9. 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 9. Total Phosphorus Target Values

Statewide Criteria	**TP (mg/l)**	
Watershed Size	WWH	MWH
Headwaters (H)- drainage area < 20 mi^2	0.08	0.34
Wadeable (W)- drainage area 20-200 mi^2	0.10	0.28
Small Rivers (SR)- drainage area 200-1000 mi^2	0.17	0.25

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.

Figure 11 shows the phosphorus concentrations measured in the upper Sandusky River watershed during the summer 2001 Ohio EPA surveys. The results are for samples collected in the Sandusky River mainstem within the Bucyrus assessment unit. The graph shows that most results were well above the target value.

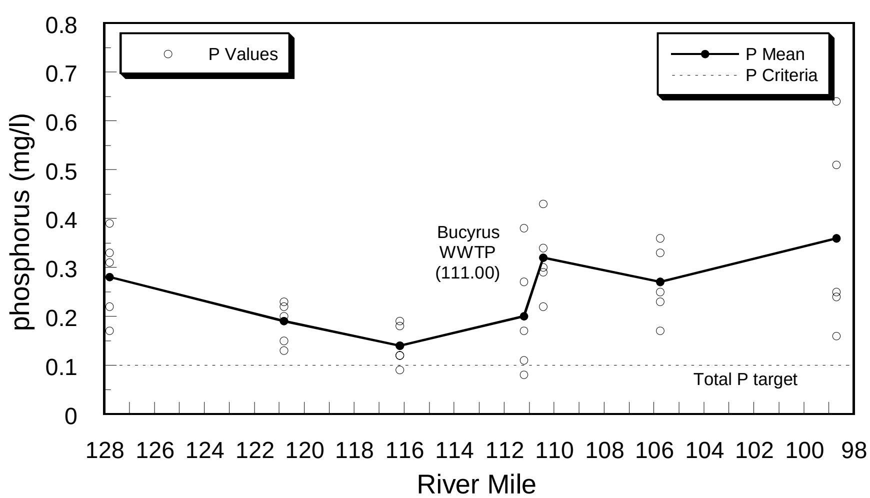


Figure 11. Total P Concentrations in Sandusky River mainstem samples collected by Ohio EPA during 2001.

3.1.2 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.

Figure 12 shows an example of the D.O. sags observed in the mainstem Sandusky River, within the Sandusky-Bucyrus Assessment Unit (04100011-020) during a July 2001 survey. The dissolved oxygen sag near river miles 116 and 110 of the Sandusky river is caused by a combination of low summer flows, CSO loads from Crestline and Bucyrus, and relatively high load of nutrients from these and other smaller dischargers. The sag near river mile 83 was not as pronounced and is not impairing the stream. Dissolved oxygen modeling was performed for the Sandusky river from headwaters to river mile 95. More details are available in chapter 4 and appendix A.

Figure 13 shows violations of the minimum D.O. WQS measured in Broken Sword Ck on 3 separate dates. The data shows signs of excessive benthic algal growth. Field observations indicate that lack of riparian shade allow high levels of solar radiation to reach the stream resulting in high algal productivity and high water temperatures, which combine with low summer flows to hinder biological performance. The stream improves downstream from this site as riparian shade and additional flows increase.

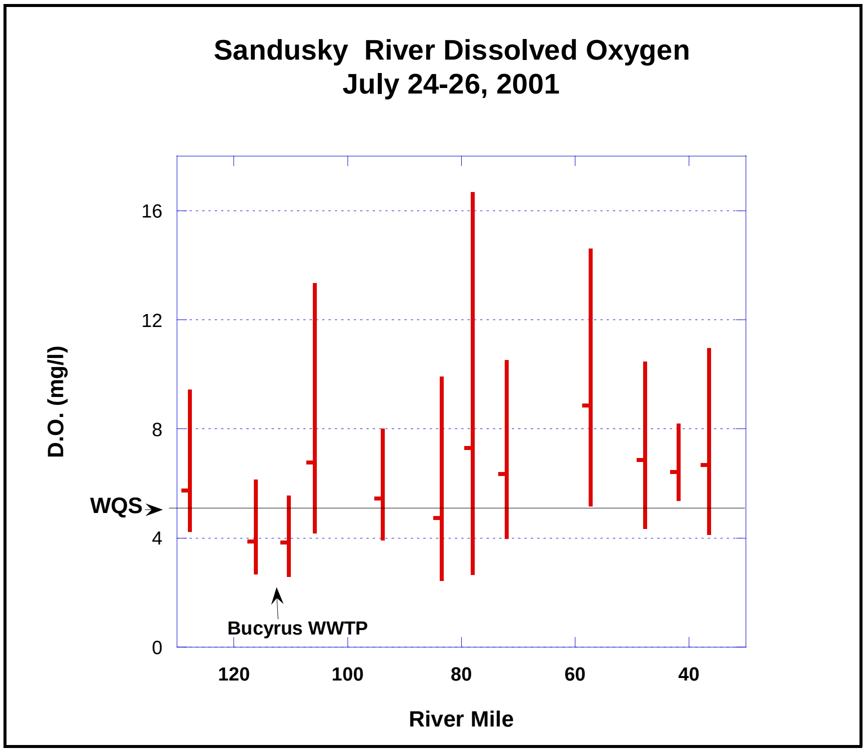


Figure 12. Dissolved oxygen profile in the Sandusky River during July 24-26, 2001 survey

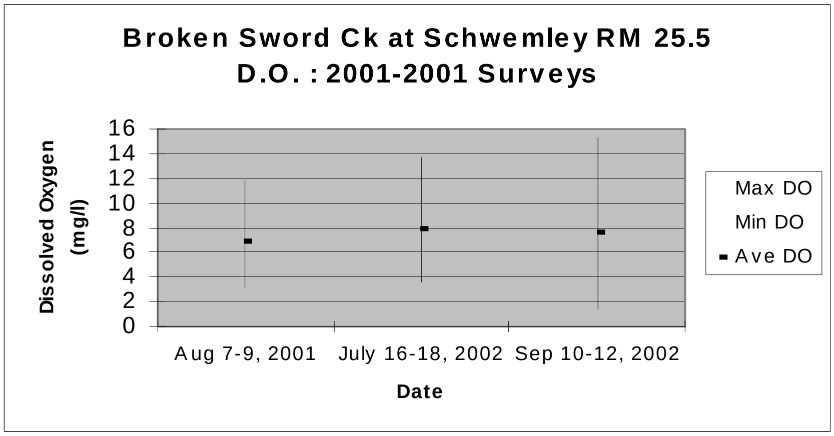


Figure 13. Violation of minimum D.O. WQS in Broken Sword Ck at Schwemley Road

3.1.3 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. Although total suspended solids (TSS) were measured at most sites, Ohio currently has no statewide numeric criteria that can be used to assess the observed TSS concentrations. For that reason, Ohio EPA's QHEI (Qualitative Habitat Evaluation Index) scores determined for the 2001 upper Sandusky River watershed sites can be used as surrogates. The QHEI is a quantitative index that combines the scores given to six physical stream/riparian variables, thus yielding a numeric value for a stream's habitat. The variables included in the index are: substrate, instream cover, riparian characteristics, channel characteristics, pool/riffle quality, and gradient/drainage area. It can be used to assess a stream's habitat and determine which of the six variables needs to be improved to reach the QHEI target score. The substrate variable includes an assessment of sediment quality and quantity, thus providing a numeric target for sedimentation. The substrate score is available for each site that received a QHEI evaluation. A target score of 12 to 13 (of a maximum score of 20) is recommended for Warmwater Habitat (WWH) sites, and 10 for Modified Warmwater Habitat (MWH) and Limited Warmwater (LWH) sites. The riparian characteristics variable evaluates information on riparian width, flood plain quality and bank erosion. This variable also provides a numeric value that can be used to track improvements resulting from implementation of management practices. The QHEI target is $\geq$60 for the WWH use designation, $\geq$45 for the MWH use designation, and $\geq$30 for the LWH use designation. Since habitat is usually strongly correlated with the IBI (Index of Biotic Integrity, a fish index), the QHEI provides a quantitative way to evaluate how habitat issues affect the attainment of the aquatic use designations. The target is compared against the median QHEI score from data collected in each assessment unit. Figure 14 compares the 50^{th} percentile of the habitat scores for each assessment unit against the WWH and MWH targets, providing a quick assessment of the overall habitat condition of each major subwatershed. Additional details about the Habitat (QHEI) scores for tributaries within each assessment unit is available in Appendix D.

3.1.4 Biocriteria

The biocriteria are the definitive measure 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 status of biocriteria in the upper Sandusky River watershed is listed in appendix C, and are also mapped by assessment unit. Applicable criteria are available in OAC Chapter 3745-1.

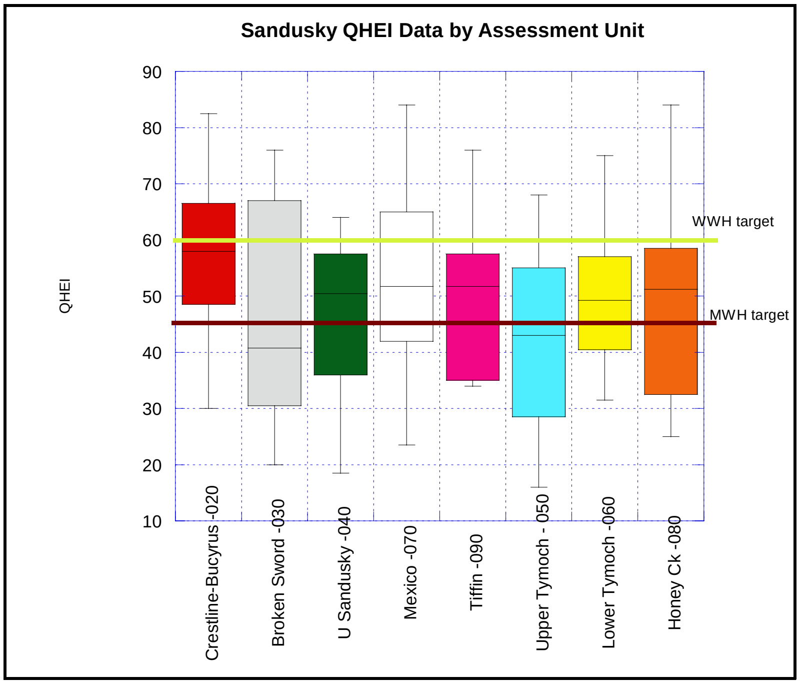


Figure 14. Habitat targets versus observed values in Sandusky watershed assessment units

3.1.5 Bacteria

Bacteria samples were collected at 117 sites on 37 streams during the summer of 2001. The statewide numerical and narrative criteria for primary contact recreational use designation requires that for each designation at least one of the two bacteria standards (fecal coliform or E. coli) must be met. These criteria apply outside the mixing zone and for fecal coliform state; the geometric mean content (either MPN or MF), based on not less than five samples within a thirty-day period, shall not exceed 1,000 per 100 ml and shall not exceed 2,000 per 100 ml in more than 10 percent of the samples taken during any thirty-day period. Since fewer than 5 samples were taken at each site, the data results could not be used to determine if a site was violating the WQS. Section 2.2.2 in chapter 2 explained how the available data was pooled by assessment unit to evaluate which of them were considered impaired due to bacteria. In addition to examining the bacteria data from impaired assessment units, sample results were scrutinized based on the geometric mean values and proximity to potential sources of bacteria. From that assessment, individual sites were picked as likely to exceed WQS and bacteria modeling was performed only for those. The target selected for use in the bacteria modeling is the WQS used to compare to the geometric mean of the sample values, **1000 counts (or MPN)/100 ml.** It is expected that meeting the 1000 counts/100 ml standard will also result in meeting the other half of the standard (not to exceed 2000 counts/100 ml in more than 10% of the samples).

3.2 Current Deviation from Target

3.2.1 Nutrients (Total P)

As described in the preceding section, target values for total phosphorus vary with the drainage area of a given stream segment. Table 10 illustrates the median concentrations compared to the target values for total phosphorus arranged by assessment unit (HUC) and drainage area size. The phosphorus TMDLs are based on the “% deviation from target “data for Headwaters shown below.

Table 10. Comparison of total phosphorus concentrations to target values in Sandusky River Assessment Units by drainage area

HUC 11 Assessment Unit	Watershed Size	TP Target (mg/l)	TP Median (mg/l)	Deviation from Target (%)
Bucyrus 04100011-020	Headwater	0.08	0.12	49
	Wadeable	0.10	0.22	123
Broken Sword Creek 04100011-030	Headwater	0.08	0.08	0
	Wadeable	0.10	0.10	0
Upper Sandusky 04100011-040	Headwater	0.08	0.11	34
	Wadeable	0.10	0.14	43
	Small River	0.17	0.16	0
Upper Tymochtee Ck 04100011-050	Headwater	0.08	0.10	19
	Wadeable	0.10	0.10	0
Lower Tymochtee Creek 04100011-060	Headwater	0.08	0.13 *	62
	Wadeable	0.10	0.08	0
	Small River	0.17	0.07	0
Mexico 04100011-070	Headwater	0.08	0.07	0
	Wadeable	0.10	0.07	0
	Small River	0.17	0.10	0
Honey Creek 04100011-080	Headwater	0.08	0.13	65
	Wadeable	0.10	0.10	0
Tiffin 04100011-090	Headwater	0.08	0.10	21
	Wadeable	0.10	0.05	0
Mainstem 04100011-001	Small River	0.17	0.08	0

*Average

Since the headwater streams (those with drainage area <20 mi^2) are the most impaired in the Sandusky watershed, the recommended load reduction for each assessment unit was based on the percent deviation from the target for each assessment unit's headwater streams. This percent reduction number was applied to existing point source loads to determine the recommended load reductions. For nonpoint source loads, a 25 percent load reduction is recommended. The justification for selecting this percentage is explained in Section 4.4.2.

3.2.2 Dissolved Oxygen

Dissolved oxygen data were collected under various flow and loading conditions in 2001 and 2002. The stream flows were particularly low during August 2002, and the Sandusky River was at critical low flows during that survey. Figure 15 shows the deviation from the average D.O. WQS during several surveys conducted during 2001 and 2002. All the surveys point to the Bucyrus area as having a consistent dissolved oxygen sag that frequently violates the average WQS.

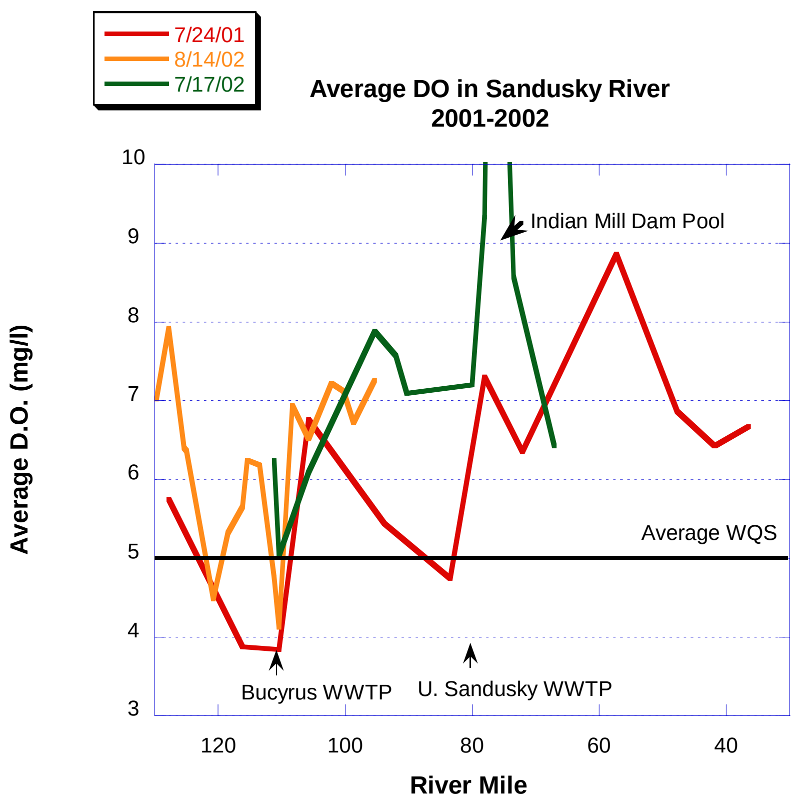


Figure 15. Average D.O. in Sandusky River during 2001-02 Datasonde deployments

3.2.3 Ammonia-N

Ohio EPA data indicates that ammonia nitrogen is not a cause of impairment at the Assessment Unit Level. A few violations of NH3-N WQS were recorded in smaller tributaries, and more details about those specific areas are given in the Technical Support Document (Ohio EPA, 2002).

3.2.4 Sedimentation, Habitat, & Biocriteria

The biological criteria scores for each monitoring site have already been shown in Appendix C. A comparison of the median habitat and substrate scores for each assessment unit to the recommended target, are shown in Tables 11 and 12. The deviation from the target is the "TMDL" or improvement needed to reach the target. As mentioned earlier, the QHEI target is $\geq$60 for the WWH use designation, $\geq$45 for the MWH use designation, and $\geq$30 for the LWH use designation.

Table 11. Comparison of habitat scores (QHEI) to recommended target values by use designation.

HUC 11 Assessment Unit	Use Designation[1]	# of sites	Observed QHEI (50th %ile)	Target QHEI	Deviation from Target (%)
Bucyrus 04100011-020	WWH	23	58	60	3
	MWH	3	21.5	45	52
Broken Sword Creek 04100011-030	WWH	6	66	60	meets
	MWH	4	30.5	45	32
	LRW	1	37.5	30	meets
Upper Sandusky 04100011-040	WWH	9	57	60	5
	MWH	2	25	45	44
Upper Tymochtee Creek 04100011-050	WWH	11	50	60	17
	MWH	4	21	45	53
	LRW	1	32	30	meets
Lower Tymochtee Creek 04100011-060	WWH	12	49	60	18
Mexico 04100011-070	WWH	11	51.5	60	14
	MWH	5	55	45	meets
Honey Creek 04100011-080	WWH	13	55.5	60	8
	MWH	7	32.5	45	28

Table 11. Comparison of habitat scores (QHEI) to recommended target values by use designation.

HUC 11 Assessment Unit	Use Designation[1]	# of sites	Observed QHEI (50th %ile)	Target QHEI	Deviation from Target (%)
Tiffin 04100011-090	WWH	6	54.8	60	9
	MWH	2	34.5	45	23

1 Aquatic Life Use Designations are based on the proposed/recommended use designations as determined by the 2001 survey.

Table 12. Comparison of substrate scores to recommended target values by use designation.

HUC 11 Assessment Unit	Use Designation[1]	# of sites	Observed Substrate (50th %ile)	Target Substrate	Deviation from Target (%)
Bucyrus 04100011-020	WWH	23	14	12.5	meets
	MWH	3	5	10	50
Broken Sword Creek 04100011-030	WWH	6	13.8	12.5	meets
	MWH	4	5	10	50
	LRW	1	10	8	meets
Upper Sandusky 04100011-040	WWH	9	9	12.5	28
	MWH	2	0.8	10	93
Upper Tymochtee Creek 04100011-050	WWH	11	9.5	12.5	24
	MWH	4	0.5	10	95
	LRW	1	5	8	38
Lower Tymochtee Creek 04100011-060	WWH	12	10	12.5	20
Mexico 04100011-070	WWH	11	10	12.5	20
	MWH	5	15	10	meets
Honey Creek 04100011-080	WWH	13	14.5	12.5	meets
	MWH	7	8	10	20
Tiffin 04100011-090	WWH	6	11.8	12.5	6
	MWH	2	10.8	10	meets

1 Aquatic Life Use Designations are based on the proposed/recommended use designations as determined by the 2001 survey.

3.2.5 Bacteria

The geometric mean from samples collected by Ohio EPA were compared to the WQS as described in section 3.1.5. From the 117 sites sampled, 13 sites were chosen as likely to exceed WQS and selected for modeling. Those sites are spread over six assessment units.

To determine the deviation from target, the target load was subtracted from the geometric mean load of the site samples. The bacteria load was calculated by multiplying the geometric mean site concentration by the average of the site flows taken on the sample dates. The target was calculated by multiplying the WQS, (1000 counts/100 ml) by the site flow. Refer to table 13 for a list of the selected sites, the deviation from target, and the percent reduction needed to achieve the target.

Table 13. Bacteria Target Deviation (* based on 1000 counts/100 ml WQS)

Stream	Assessment Unit Number 04100011-	RM at site	site flow (ml/hr)	geometric mean load from field samples (counts/hr)	target fecal coliform load * (counts/hr)	deviation from geometric mean target (counts/hr)	% reduction needed
Paramour Creek	020	6.31	2.34E+07	4.20E+08	2.34E+08	1.86E+08	56
Unnamed trib. to Paramour Creek @ Hook Rd.	020	0.18	2.40E+07	6.29E+08	2.40E+08	3.89E+08	38
Westerly Creek	020	2.41	3.98E+07	4.71E+08	3.98E+08	7.28E+07	85
Westerly Creek	020	0.13	5.30E+07	7.79E+08	5.30E+08	2.49E+08	68
Indian Run	030	0.94	5.30E+07	7.11E+08	5.30E+08	1.81E+08	75
Little Sandusky River	040	6.52	1.16E+08	6.14E+09	1.16E+09	4.98E+09	19
Honey Run	040	0.52	6.73E+07	6.73E+09	6.73E+08	6.06E+09	10
Negro Run	040	0.52	1.02E+08	3.68E+09	1.02E+09	2.66E+09	28
Prairie Run (2001data only)	050	1.02	2.24E+07	5.01E+08	2.24E+08	2.77E+08	45
Warpole Creek	050	2.53	2.14E+07	2.67E+08	2.14E+08	5.33E+07	80
“Lower” Little Tymochtee Creek	060	0.9	8.97E+07	8.97E+09	8.97E+08	8.07E+09	10
Unnamed tributary to Sycamore Creek	060	0.36	1.12E+07	1.34E+08	1.12E+08	2.24E+07	83
Morrison Creek	090	2.36	8.05E+07	2.33E+09	8.05E+08	1.53E+09	35

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. Figure 16 shows the total phosphorus loads reported by major dischargers in the watershed for the summer season (1998-2000). The data is arranged by assessment units, and illustrates the relatively higher loads of phosphorus being discharged in the upper reaches of the watershed, where lower streamflow is available to assimilate the wastewater during the summer months. Figure 17 shows the magnitude of the $CBOD_5$ loads being discharged to various subwatersheds in the study area (excludes CSO loads). Those plants that have CSOs periodically discharge concentrated slugs of nutrients (CBOD, ammonia, phosphorus) into the receiving streams. The proportion of this load is small compared to what originates from nonpoint sources, but tends to cause dissolved oxygen sags in the vicinity of the outfalls (as observed downstream of some of the Bucyrus CSOs). Discharges from CSOs during summer storms are of particular concern, due to the persistent oxygen demand caused by solids that settle downstream of the outfalls, and the nuisance algal growth stimulated by the added nutrient loads. Figure 18 shows the CSO loads of suspended solids and CBOD from the major dischargers to the Sandusky River in Assessment Units 020 and 040. Due to the smaller drainage area (lower streamflow), those portions of the Sandusky River basin are more prone to point source impacts.

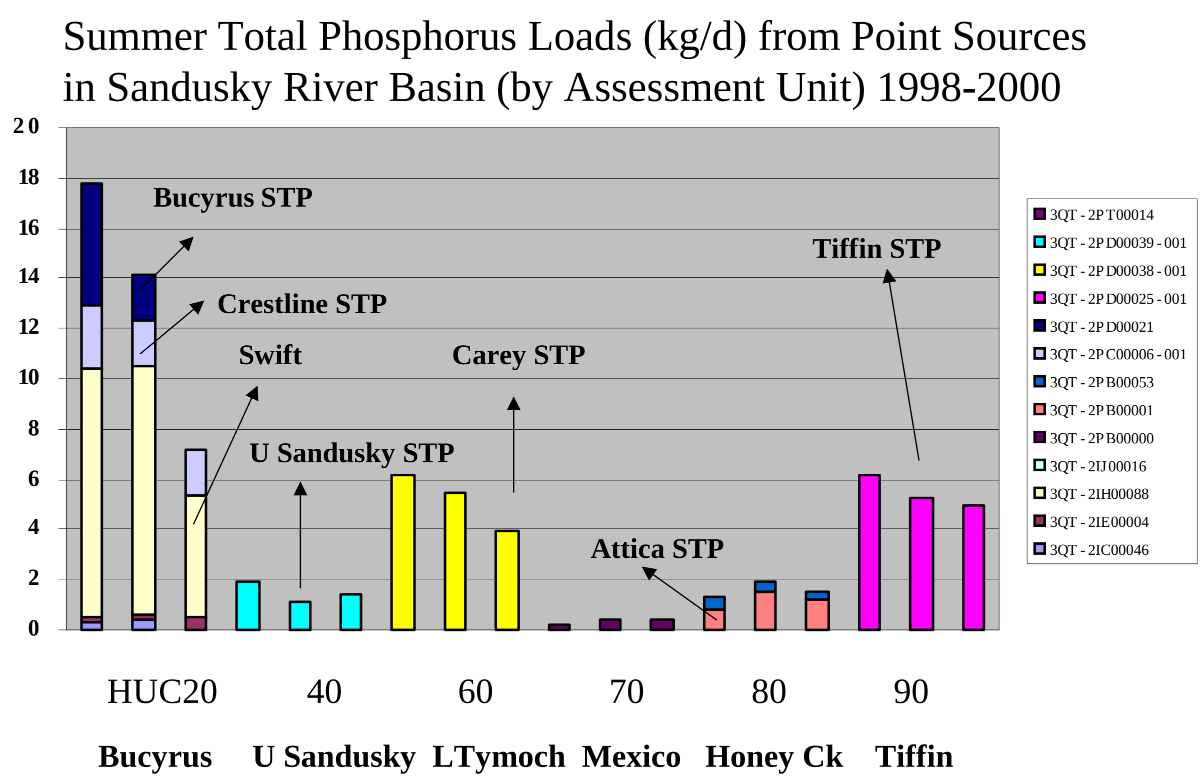


Figure 16. Summer Loads of Phosphorus from Point Sources in Sandusky Watershed

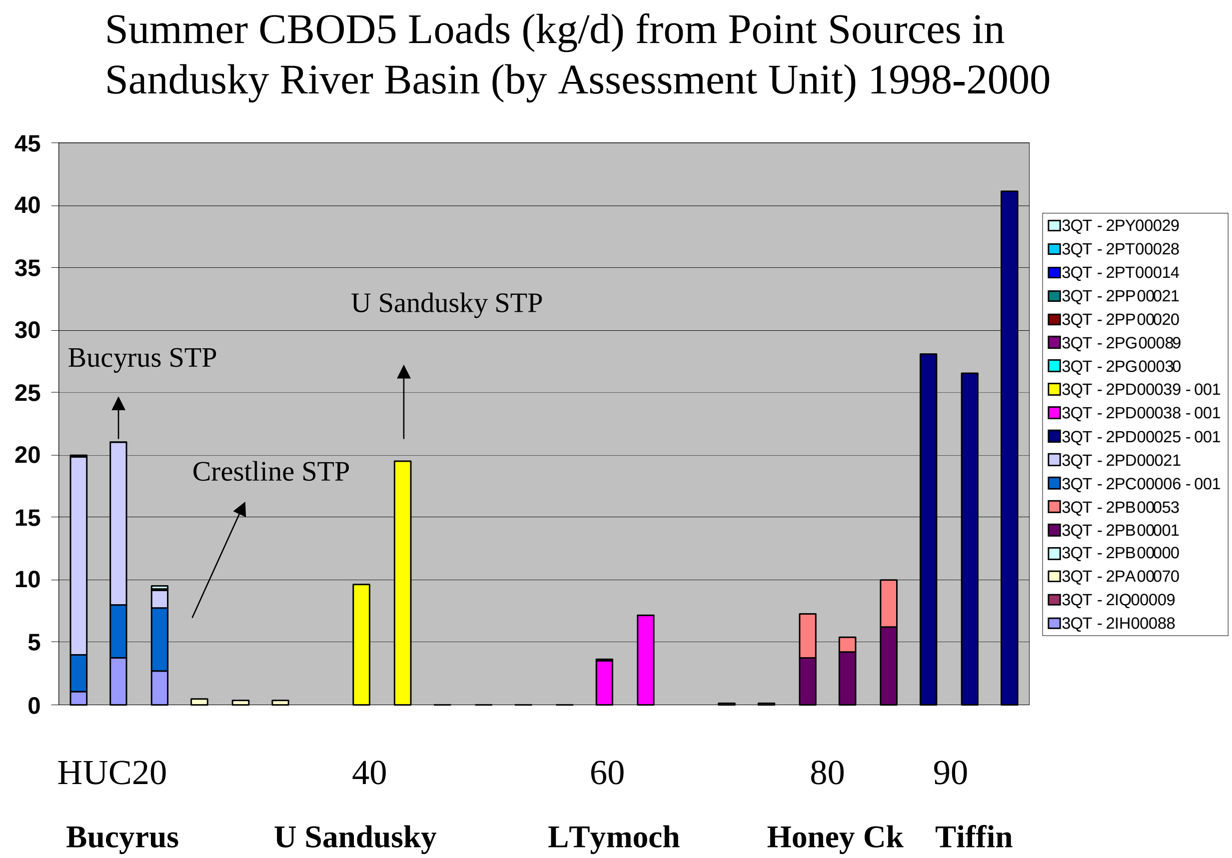
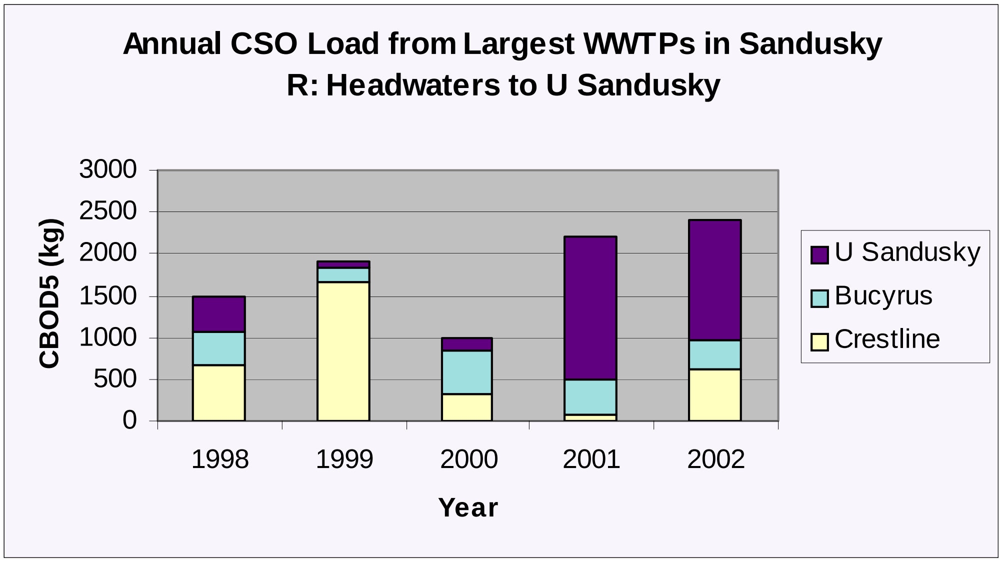


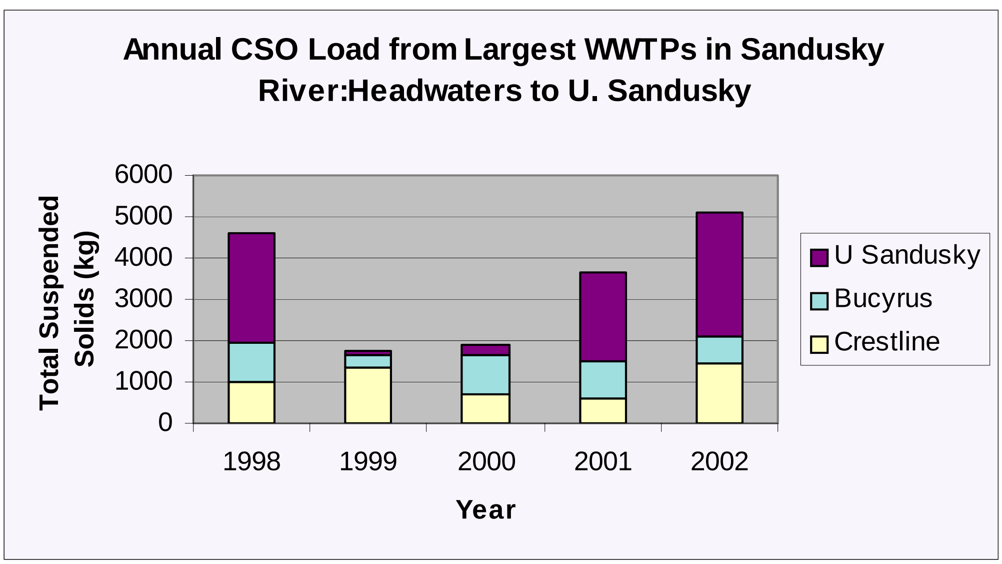
Figure 17. Summer $CBOD_5$ Loads from Point Sources in the Sandusky Watershed

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.

Failing home sewage treatment systems (HSTS) are the identified source of bacteria impairment in various subwatersheds in the Upper Sandusky River study area. Source identification is covered in more detail in Chapter 2. Allocation of loads follows in Chapter 4.

Figure 18. Annual CSO Loads of $CBOD_5$ and Suspended Solids From Crestline, Bucyrus and Upper Sandusky WWTPs (1998-2002).





4.0 TOTAL MAXIMUM DAILY LOADS

A TMDL provides a mechanism to recommend controls required to meet water quality standards. The TMDL is the sum of the wasteload allocations for the point sources and the load allocations for natural background and nonpoint sources in a watershed. Also included in TMDL calculations is a margin of safety (implicit or explicit) to account for any uncertainty regarding the relationship between pollutant load and water quality. Attainment of water quality standards (WQS) will require a combination of pollutant load reductions and improvement of other conditions (such as instream and riparian habitat, cropland and livestock management practices, stormwater management, etc.) if they have been identified as causes of impairment.

For the upper Sandusky River watershed, some of the major causes of impairment are linked to habitat modifications that are (directly and indirectly) related to the predominant land use (agriculture). For example, the widespread installation of drainage tiles designed to quickly drain agricultural lands has the undesirable effect of desiccating the headwaters during periods of low precipitation. This lack of flow makes most of the headwater streams in the watershed more susceptible to nutrient enrichment from fairly small pollutant sources.

The attainment of WQS in Ohio requires meeting criteria based on the health of the aquatic biological community (biocriteria). Chemical water quality criteria are established as a surrogate for direct measurement of the aquatic biological community to allow a determination if a particular pollutant is present in amounts that are projected to cause impairment in an aquatic biological community. In the Sandusky River watershed, total phosphorus has been targeted for load reductions because it is found at concentrations exceeding Ohio EPA guidelines (as seen in Section 3.2). Although nitrate concentrations are also high in this watershed, total phosphorus is typically considered the limiting factor among nutrients, and is also more cost effective to control than nitrate (which is mostly in dissolved form and cannot be filtered or settled out). When this watershed is re-assessed (after implementation of total phosphorus load reduction practices), the significance of nitrogen loads regarding biological community health will be examined if the biological criteria have not been met. Although a nitrate TMDL was not done, information about nitrogen (and other nutrients) loads in the assessment units is provided in Section 4.2. That information will be useful for counties and citizens in the watershed that are concerned about reducing the concentration of nitrate in their water supply.

As mentioned in Section 3.0, the major causes of non-attainment of the aquatic life use are organic enrichment, excessive nutrients, sedimentation, habitat degradation and flow alteration. Bacteria are impairing the recreational use in several tributaries. Various approaches are followed for TMDL development for each of them, and are described in Section 4.1.

4.1 Method of Calculation

Due to time and staff constraints, a complex model that could integrate several of the impairment causes was not pursued. The requirements of this project are met by the use of the modeling approaches that are summarized in Table 14.

Additional modeling of the Sandusky watershed is being conducted by University of Florida staff, using the SWAT model. Although the model won't be fully calibrated in time for this report, it may be useful for the stakeholders that need to implement load reductions in the Sandusky watershed.

The Sandusky River has a high capacity to assimilate nutrients, as shown by decay rate studies and biological results indicating that most of the mainstem is in full attainment of the aquatic life use designation. Despite its high assimilative capacity, the unit area export rates of total phosphorus, suspended solids and nitrate nitrogen measured in the Sandusky River at Fremont are among the highest compared to several other major streams in Ohio, according to data from Heidelberg College Water Quality Laboratory shown in Table 15 (Baker, 2002). Due to the variety of conditions that are affecting the streams, several approaches were used to determine the TMDLs for this report.

1. 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 mainly used for dissolved oxygen, to address the impact of organic enrichment from oxygen-demanding parameters (mainly CBOD and ammonia).

2. Determine the nonpoint and point source loading contributions to the stream network. This method determined the annual phosphorus load to the stream. Information of seasonal variations is also provided. Total phosphorus is used as the indicator for excessive nutrients.

3. Establish current habitat and substrate conditions and quantify desired habitat and substrate goals. This method quantifies sedimentation and habitat degradation.

4. Estimate bacteria loads for those assessment units that were found to be impaired by bacteria. Due to the small number of bacteria samples collected in the watershed, the calibration of the model used for get these estimates is not as robust as desired, but is provided as a first step for the benefit of the Sandusky Watershed Coalition and other stakeholders.

Table 14. Modeling Approach Summary

Model or Method	**Parameters Analyzed**	**Goals**	**How was it used?**
Load Duration Curves and Stream Gage Monitoring Data	• Phosphorus • TSS • Nitrogen (not included as a TMDL)	Quantify the total nutrient load in the Sandusky River and major tributaries. Evaluate and compare nutrient loadings between sub-watersheds and between point and nonpoint sources	• Quantify the existing loads from both point and nonpoint sources. • Establish percent load reduction goals based on meeting nutrient targets that are linked to biological index attainment.
Bacterial Indicator Tool	• Fecal Coliforms	Quantify bacteria loads in impaired tributaries	• Quantify the existing loads and recommend percent load reductions using targets based on the fecal coliform WQS.
Multi SMP Water Quality Model	• Dissolved Oxygen • CBOD • Ammonia	Evaluate the <u>instream</u> water quality under steady 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. • The cumulative impact of settleable nutrients from CSOs and other sources are simulated through sediment oxygen demand, and algal productivity and respiration
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 Sandusky River 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.

Table 15. Comparison of unit area export rates[A] for various area rivers for the 1997-2000 water years, as measured by Heidelberg College Water Quality Laboratory

Watershed	Suspended Solids	Total Phosphorus	Soluble Reactive Phosphorus	Nitrate-nitrogen	Chloride
Maumee (OH)	494	1.13	0.184	16.9	74.0
Sandusky (OH)	494	1.07	0.138	17.2	69.3
Cuyahoga (OH)	670	0.89	0.142	6.9	508.0
Grand (OH)	457	0.48	0.035	2.1	118.0
Scioto (OH)	333	0.92	0.298	11.9	110.8
Great Miami (OH)	253	0.99	0.404	13.4	131.1
River Raisin (MI)	256	0.50	0.068	1.4	84.4

[A] All export rates in lbs/acre/yr.

4.1.1 Response in the Stream

As mentioned above, the headwaters are most susceptible to pollutant loads during low streamflow periods, due to lack of dilution flow. In the Sandusky River mainstem, the Multi SMP (a simplified Dissolved Oxygen) model was used to simulate the instream dissolved oxygen regime from the headwaters (in Paramour Creek, downstream of Crestline) to river mile 95 (downstream of the city of Bucyrus). The use of a simple dissolved oxygen (D.O.) model is applicable in cases where more than 50% of the streamflow is due to wastewater plant effluent. Such is the case for this reach, which is located in Assessment Unit 0400011-020. During critical low flow periods (summer), the streamflow is almost 100% effluent from the cities of Crestline and Bucyrus, as well as a few other small dischargers.

The model was calibrated using a combination of data collected by Ohio EPA during several surveys conducted under low flow conditions in 1979, 1985 and 2002. Refer to Appendix A for more details on the Multi SMP modeling.

Figure 19 shows the results of the dissolved oxygen calibration performed for the Sandusky River downstream of Crestline and Bucyrus. The D.O. data was collected under 7Q10 conditions. Although a validation survey was not performed, D.O. data collected with submersible monitors (Datasondes) during July of the same year reflected the same trends. The average D.O. measured during the July and August Datasonde

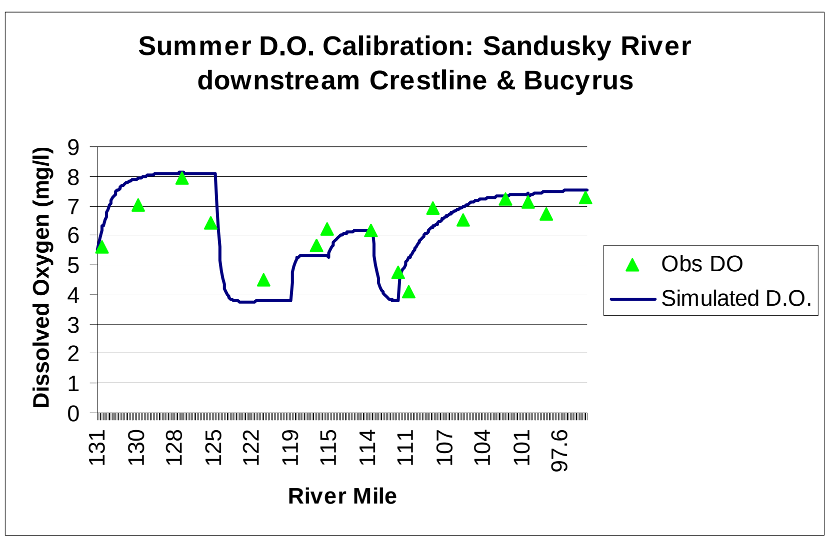


Figure 19. Dissolved Oxygen Calibration for the Sandusky River near Bucyrus

surveys is shown in Figure 20, and confirms the location of the D.O. sags shown in Chapter 3 (Figure 12) in the Bucyrus area. Sensitivity analysis was performed to determine which input parameters are more critical in the simulation, and showed that the model was most sensitive to sediment oxygen demand and the reaeration coefficient. Refer to appendix A for more details on the D.O. modeling.

The calibrated Multi-SMP model for the Upper Sandusky River was used to simulate water quality under summer 7Q10 design conditions. Upstream flows and discharger water quality for these design conditions are specified in Table 16. These effluent limits coupled with drastic reduction in CSO nutrient loads are expected to eliminate the D.O. violations.

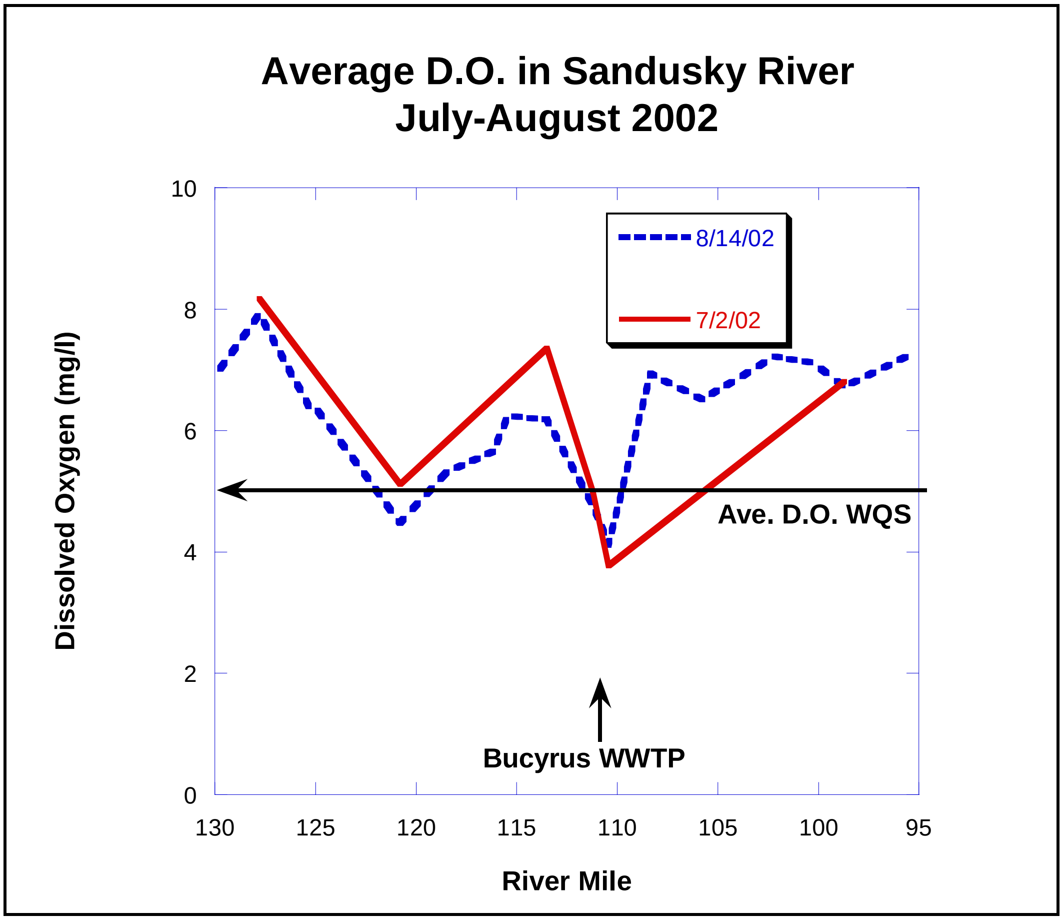


Figure 20. Average dissolved oxygen in Sandusky River near Bucyrus (2002)

Table 16. Upstream Flow and Discharger Effluent Quality Used in Summer D.O. Simulations of the Sandusky River near Bucyrus

Source	Flow (cfs)	$CBOD_5$ (mg/l)	NH_3-N (mg/l)	D.O. (mg/l)
Upstream Flow	0.36	3.7	0.07	5.5
Crestline WWTP	1.47	10.	0.8	6.0
Timken	0.62	10.	1.0	6.0
Bucyrus WWTP	5.26	10.	2.0	6.0
Swift	0.25	10.	2.0	6.0

The effluent concentrations in Table 16 include a 50% reduction in ammonia effluent limits for the Crestline WWTP. The Bucyrus WWTP winter limits (not shown) for ammonia will also be reduced in the next permit issuance cycle. See Chapter 6 for more details.

The predicted instream D.O. in the Upper Sandusky River under summer 7Q10 design conditions is shown in Figure 21. As can be seen from the figure, violations of the average D.O. water quality standard were predicted under summer 7Q10 design conditions. This D.O. deficit is believed to be due to a combination of several factors: large CSO nutrient loads that settle in the pooled areas; very low summer flow due to impact of agricultural drainage tiles and water withdrawals, and low reaeration coefficient in parts of the stream due to the low stream slope.

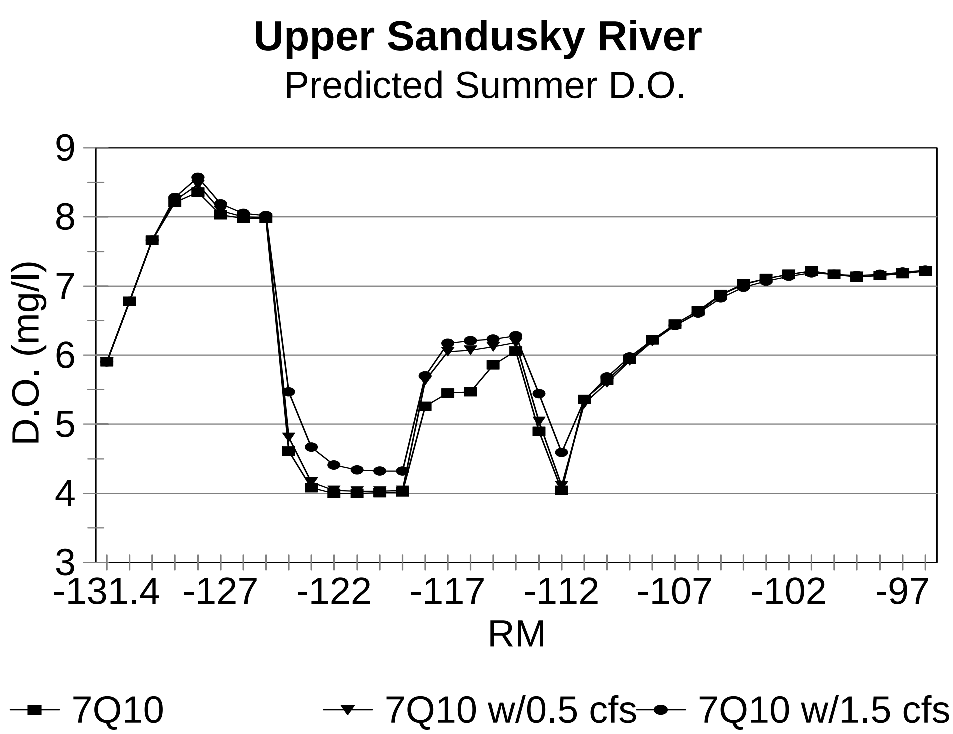


Figure 21. Summer D.O. Simulation of the Upper Sandusky River under 7Q10 and Flow Augmentation Scenarios

4.1.2 Loads to the Stream

The Sandusky River basin is privileged to have three USGS gages (1 in the mainstem and 2 at tributaries) that have been monitored on a daily basis for more than 25 years. The water samples are collected and analyzed by staff from Heidelberg College's Water Quality Laboratory. Table 17 shows the name, location, drainage area, and proportion of mainstem drainage area (up to Fremont) represented by the gages. It also shows the total phosphorus targets that were used to develop the phosphorus loading curves. Continued monitoring at these gages is essential to assess the effectiveness of any point and nonpoint source management practices implemented in this watershed. The high frequency of sampling at these gages provides a very reliable measure of the instream pollutant loads.

Table 17. USGS Gages in the Sandusky Watershed used in developing the Load Duration Curves, and Total Phosphorus Targets Applied to each gage

Location	Drainage Area (mi^2)	% Area	Total P Target (mg/l)
Sandusky River near Fremont	1251	100%	0.17
Honey Creek at Melmore	149	11.9%	0.10
Rock Creek at Tiffin	34.6	2.7%	0.10

The wealth of water quality data available at these 3 gages made it possible to develop flow & load duration curves in the Sandusky River basin. The information collected at these and other Ohio EPA gages was used to determine the percent load reductions needed for Total Phosphorus. "Flow duration analysis looks at the cumulative frequency of historic flow data over a specified period. The duration analysis results in a curve, which relates flow values to the percent of time those values have been met or exceeded. Thus, the full range of stream flows is considered. Low flows are exceeded a majority of the time, whereas floods are exceeded infrequently. Duration curve analysis identifies intervals, which can be used as a general indicator of hydrologic condition (i.e. wet versus dry and to what degree). This indicator, when combined with other basic elements of watershed planning, can help point problem solution discussions towards relevant watershed processes, important contributing areas, and key delivery mechanisms. These are all major considerations when identifying those controls that might be most appropriate and under what conditions. Duration curves also give a context for evaluating both monitoring data and modeling information." (Cleland, 2003).

The first step of the load duration curve method is to calculate and develop a flow duration curve using continuous flow data at the gage site of interest. Figure 22 shows a flow duration curve using data from a gage in one of the Sandusky River tributaries, Honey Creek at Melmore. The curve compares the flow duration interval (FDI) - the percent of time a particular flow value is met or exceeded, to that flow value. A FDI is also referred to as a flow recurrence interval. The right side of the curve ("drought side") drops quickly toward zero, and indicates the effect that drainage tiles have in the

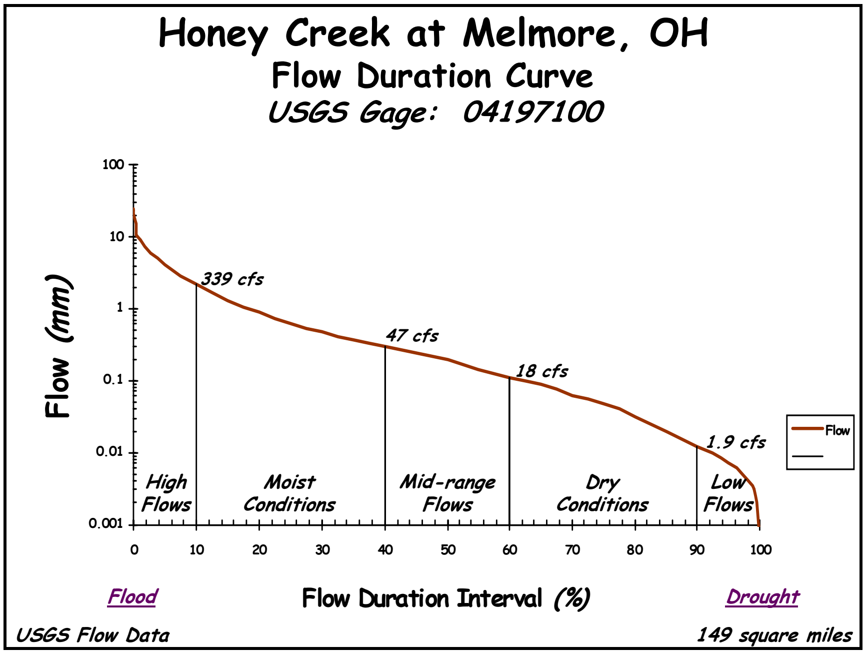


Figure 22. Flow Duration Curve for Honey Creek at Melmore

flow regime of most tributaries in this watershed.

Extremely high flows are rarely exceeded and have low FDI values; very low flows are often exceeded and have high FDI values. The flow duration curve includes all flows observed at the gage for the applicable period of record.

A load duration curve is created by multiplying the flow duration curve flow values by the applicable water quality criterion or target (shown in Table 17) and a conversion factor. The independent x-axis remains as the FDI, and the dependent y-axis depicts the load at that point in the watershed. The curve represents the allowable load (or the TMDL) at each flow condition. Depicting flows as intervals ranging from drought to flood may be easier to understand by citizens in the watershed. By comparing the load duration curve to the loads from samples collected over a wide range of flow conditions, it is possible to estimate the percent load reductions needed to meet the TMDL target under each flow interval, and determine which conditions are more critical at this location. The points above the LDC (Load Duration Curve) show values that exceed the target load, and points on or below the curve indicate when the target is being met. This is evident in Figure 23. The graph shows that the total phosphorus TMDL is being met under the Low Flow, Dry Conditions and Mid-Range flow intervals on the graph, but is exceeded under Moist Conditions and High Flows. Several data sources were used in the assessment, as discussed below. The most complete water quality data sets were provided by the Water Quality Laboratory at Heidelberg College in Tiffin, Ohio for the three gages mentioned in Table 17. These samples were typically collected daily, or more frequently during periods of high streamflow. Data from 1985 through 2002 was analyzed for this TMDL report. The existing nutrient loads (for each assessment unit) were determined based on the data from those three USGS gages, point source effluent data, and other estimates from other sources.

Since the Sandusky River watershed is dominated by agricultural land use, the Honey Creek gage at Melmore is deemed to be representative of a typical subwatershed in the study area. Honey Creek's land use is 85% agricultural, compared to 84% for the Sandusky watershed. Also, its drainage area of 149 mi^2 is similar to the area of most of the assessment units being discussed, and it is moderately influenced by a few small point sources.

Flow duration curves were developed using the full period of record (1976 to 2002 for Honey Ck at Melmore). Although there is water quality data for this gage dating back to 1985, the period from 1994 to 2001 was selected as being more representative of existing conditions, and the recommended percent load reductions were based on this period.

Figure 23 displays individual total phosphorus data points superimposed over the line that indicates the desired target or TMDL for total phosphorus. This plot shows fewer data points than were used for the analyses, in order to avoid obscuring the TMDL line on the chart. Note that at this gage, the phosphorus load target is being met under the low flow through mid-range flow conditions. Based on recommendations from a technical advisor and stakeholder, a "concentration duration curve" was prepared for Honey Creek at Melmore, to assess how frequently the target concentration of total P was being exceeded (Baker, 2003). Figure 24 shows the concentration duration curve for total phosphorus data collected at the Honey Creek-Melmore gage from January 1995 to March 2002. A regression line over the data points indicates that the target concentration of Total P (0.1 mg/l) is usually met under the low flow through mid-range flow conditions at this gage. This is similar to the trend observed in the load duration curve (Figure 23).

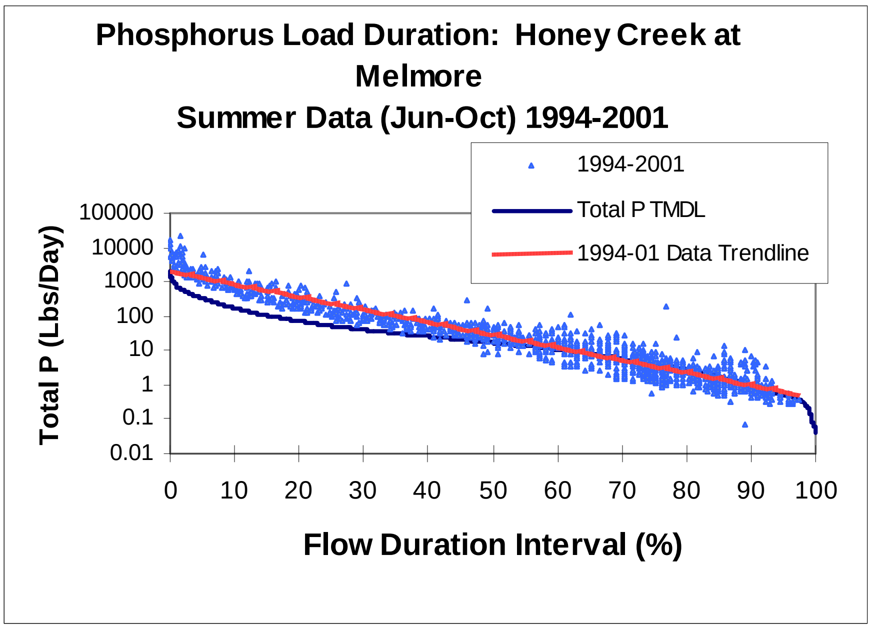


Figure 23. Load Duration Curve for Honey Creek at Melmore

Figure 25 shows a plot of total phosphorus loads measured at the Honey Creek-Melmore gage that were associated with storm events. The data is limited to the period 1997-2001, and includes those water quality samples associated with storm flows (SF) greater than half of the total flow (SF>50%). The chart identifies these data points as red diamonds superimposed on the load duration curve, illustrating that storm flows contribute a large portion of the phosphorus loads. Since phosphorus is usually attached to soil particles, it is logical to expect total suspended solids to behave in a similar fashion. Thus, the largest portion of the phosphorus and sediment load reductions are needed under the "high flow" and moist flow" conditions shown in the chart.

Data collected at the USGS stations was supplemented with samples collected at 10 temporary gaging stations installed by Ohio EPA throughout the watershed. Figure 26 shows the location of the 10 Ohio EPA sites where a stage vs. streamflow correlation was established, to estimate the flows during sampling events. The location of the 3 USGS gages in the watershed is also depicted. These gages played a major role in prioritizing which subwatersheds are contributing the largest pollutant loads, because they allow comparison of pollutant loads from similar drainage areas that were monitored (for streamflow and water quality) during 2001 and 2002. The instantaneous loads were calculated for each sampling date, and the load was divided by the drainage area at each site, to compare pollutant "flux" (as kg/mi^2/day) among the sites. Most of the data was collected between low flow to mid-range flow conditions. Load duration curves were prepared for each of the Ohio EPA gaging sites and are available in Appendix B. The site description for each station is also included there.

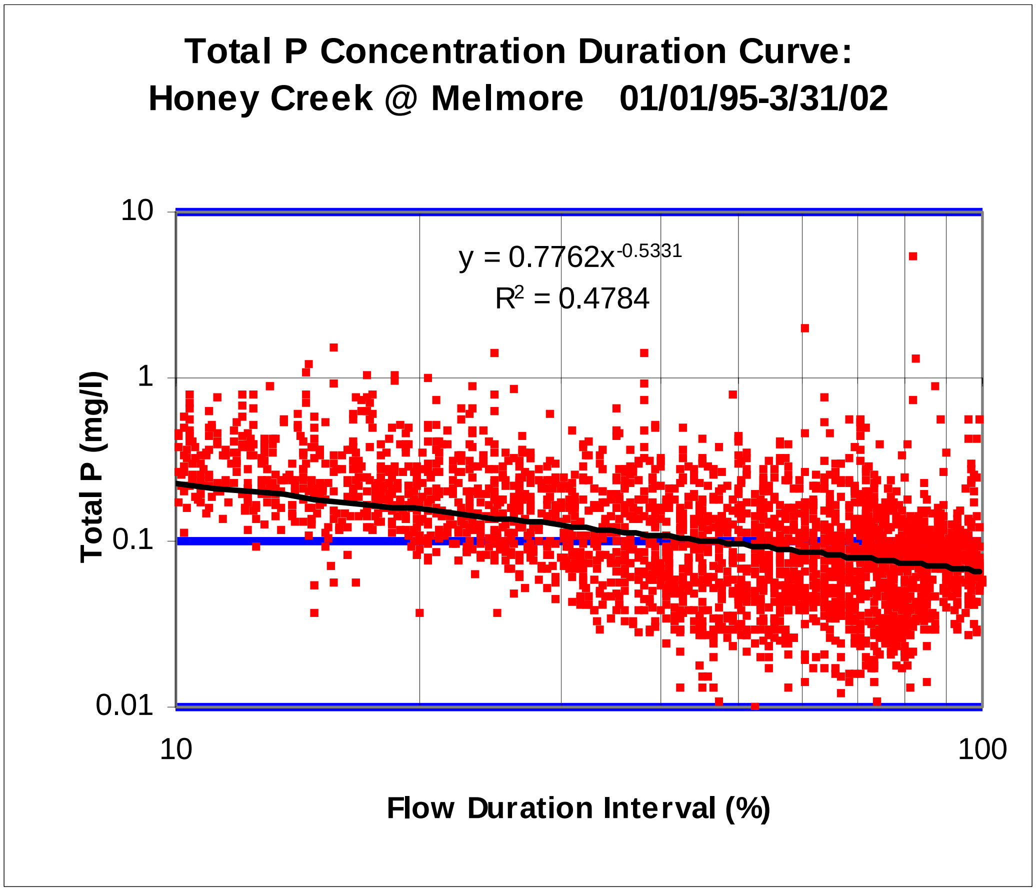


Figure 24. Concentration Duration Curve for Honey Ck - Melmore

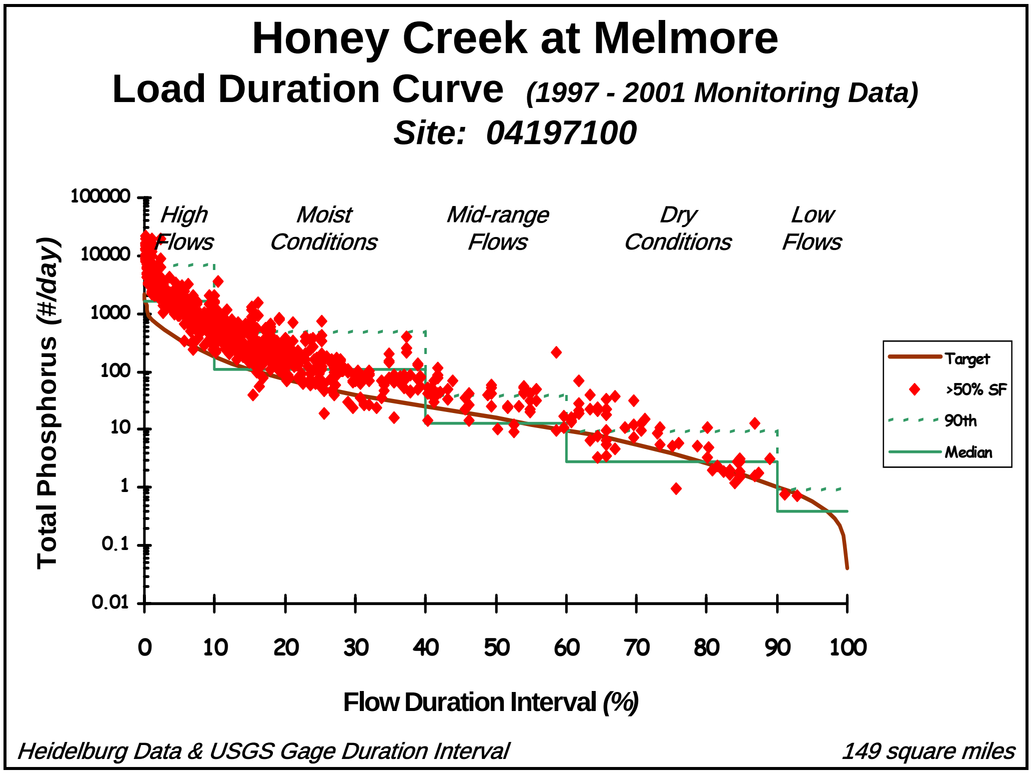


Figure 25. Total P loads associated with storm events at Honey Creek gage

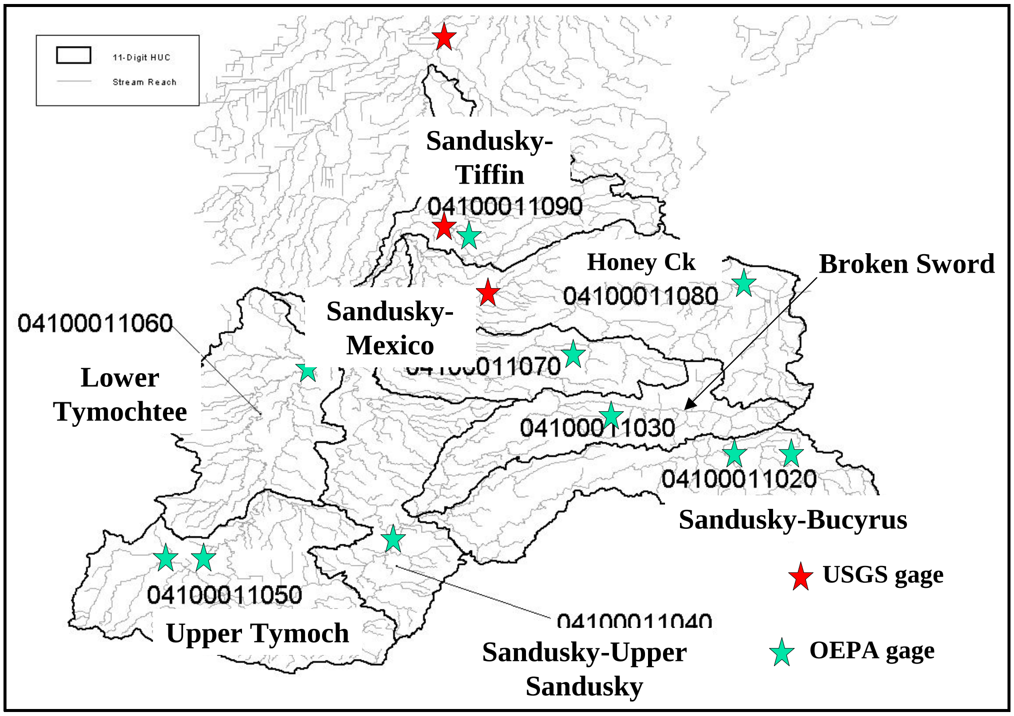


Figure 26. Location of Sandusky watershed assessment units and USGS/ Ohio EPA stream gaging stations

4.1.3 Habitat and Sediment 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. For this reason, the Habitat scores are presented using a few different approaches.

To decide if a subwatershed was meeting its target Habitat score, all the scores were evaluated by grouping them by subwatershed and use designation. The 50th percentile of the observed data was compared to the appropriate habitat (QHEI) target: 60 for Warmwater habitat, 45 for Modified warmwater and 30 for Limited warmwater habitat streams. Clustering the data in this fashion is believed to be more reflective of subwatershed conditions, instead of assessing habitat on a station by station basis. That information was shown in Chapter 3 (Table 10). In addition, the habitat data was mapped and also plotted by river mile for various subwatersheds, to provide the stakeholders with more details regarding the spatial distribution of the impaired sites. This is particularly relevant in those assessment units where most of the warmwater habitat sites are meeting the habitat targets, but a few sites show poor habitat. Some of the sub-scores of the QHEI index were also assessed.

The substrate sub-score is an indicator of siltation, therefore can be used as a surrogate for sediments. **Recommended substrate targets are used to develop sediment “TMDLs” in this report.** The Substrate scores were shown in Chapter 3 (Table 11). The QHEI and other subscore plots are available in Appendices D through F.

4.1.4 Linkages among Biological Scores, Sedimentation and Agricultural Conservation Activities in the Sandusky River Watershed

The biological scores in the Sandusky River mainstem have increased significantly since 1979, as shown in Figure 27 (Ohio EPA, 2001). The areas showing least improvement are closer to the headwaters and suffer from point source, Combined Sewer Overflow, and hydrologic modification impacts. There have been major changes in farming practices in the watershed during the same period. The information reported in Chapter 10 of the Sandusky River Watershed Resource Inventory & Management plan (2002) indicates that the percent of acres under conservation tillage had increased from essentially zero in 1976 to over 30% for corn crops and over 70% for soybeans (up to the year 2000).

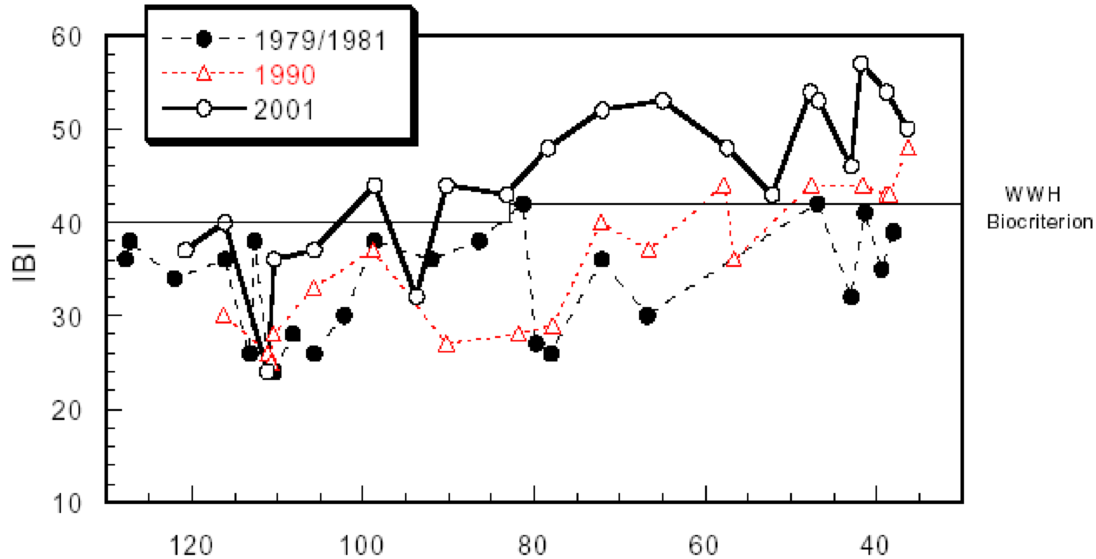


Figure 27. Longitudinal trend of the Index of Biotic Integrity (IBI) in the Sandusky River between 1979 and 2001.

Figures 28 and 29 illustrate the trends for these two crops, which accounted for 71% of the cultivated farmland in the 4 county area that includes the Sandusky River watershed. There was a sharp drop in conservation tillage acres in 1989, which may partly explain the drop in IBI scores measured at a few sites during the 1990 Ohio EPA survey. The drop in scores during that year between RM 92 and 81 was attributed to sedimentation and embeddedness. In addition to the increase in acreage under conservation tillage, about 98% of the farmland classified as “highly erodible” was receiving some kind of conservation treatment by 1995. Analyses of trends in water quality measured in the Sandusky River from 1975 to 1995 showed that total phosphorus and Total Suspended Solids concentration dropped by 46.3% and 27.2%, respectively. (Richards & Baker, 2002). These observed reductions are more impressive considering that the number of acres harvested for soybeans, corn and wheat (combined) increased from 698,200 to 808,500 acres between 1976 and 2000. Point Sources only represent about 6% of the total P load in the watershed, and septic systems less than 1 %, therefore load reductions in those sources won’t have a significant impact in the overall load (although they may be dictated due to local impact in water quality, as documented in the Crestline and Bucyrus area).

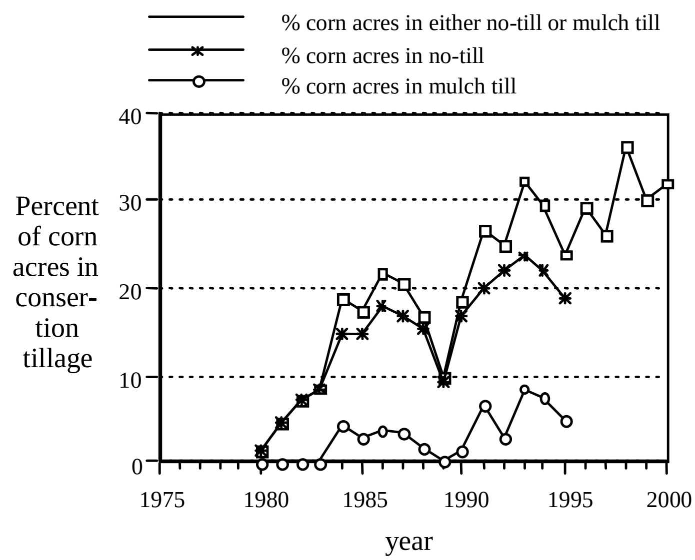


Figure 28. Percent of total corn acres in no-till or mulch till production for Crawford, Sandusky, Seneca, and Wyandot counties through 1995.

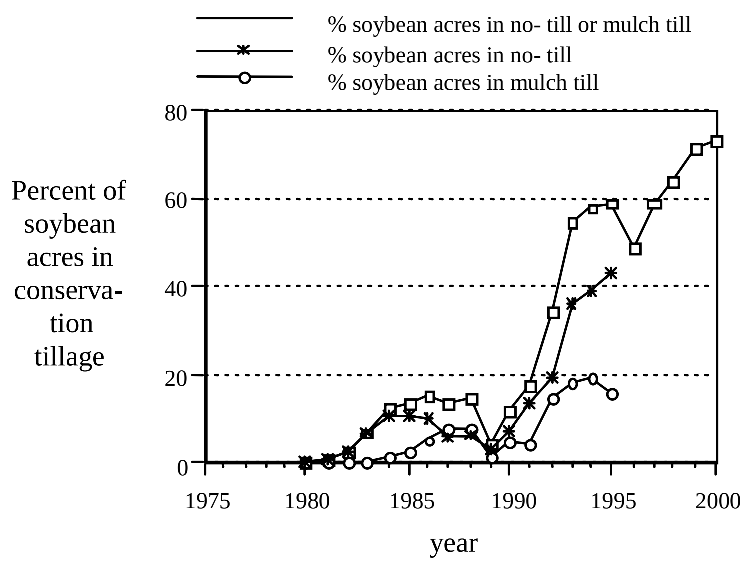


Figure 29. Percent of total soybean acres in no-till or mulch till production for Crawford, Sandusky, and Wyandot counties through 1995.

4.1.5 Bacteria Assessment

Fecal coliform bacteria were found likely to exceed the primary contact recreational use designation in twelve tributaries (spread over 6 assessment units) within the Upper Sandusky River watershed. A bacteria sampling run throughout the basin done in the summer of 2001, an assessment of the data from OEPA's toxicity expert and discussion with district personnel familiar with the area helped to pinpoint a number of areas that could potentially exceed the bacteria primary contact public recreation water quality standard (WQS).

The bacteria was simulated using United States Environmental Protection Agency's (USEPA's) Bacterial Indicator Tool. It is a spreadsheet that estimates the bacteria contribution from multiple sources. It is setup currently for fecal coliform, the modeled parameter in this study. The tool was designed to use the output as input to WinHSPF and the Hydrological Simulation Program Fortran (HSPF) water quality model in BASINS. However, for the purposes of this report due to the small areas in the problem subbasins it was used as a stand alone model. The tool estimates the monthly accumulation rate of fecal coliform bacteria on four land uses (cropland, forested, built-up, and pastureland), as well as the asymptotic limit for the accumulation should no washoff occur. The tool also estimates the direct input of fecal coliform bacteria to streams from grazing agricultural animals and failing septic systems (USEPA, 2000). Failing septic systems and grazing livestock are considered to be the main bacteria sources in the impaired areas. Refer to Appendix G for more details about the bacteria modeling.

4.2 Critical Conditions and Seasonality

Nutrient sources in the Sandusky River watershed are mainly related to the dominant land use (agriculture). Streamflow and water quality data collected at the three USGS gaging sites were examined to look for seasonal patterns and critical conditions. Water quality samples were collected at the Ohio EPA gaging sites during all seasons, to provide finer resolution for smaller tributaries (down to the 30 mi^2 drainage area level). The critical condition for dissolved oxygen and nutrient instream concentrations was confirmed to be the summer low-flow period, using submersible dissolved oxygen monitors and performing an intensive Dissolved Oxygen/Time of Travel study. Although point sources provide a much smaller proportion of nutrients than nonpoint sources, the summer low flow and high stream temperatures make the streams more susceptible to nutrient enrichment during that season. Seasonality is addressed in this TMDL report by examining the load and flow duration curves generated at three USGS gaging stations located within the watershed, and the monthly and seasonal nutrient concentrations observed at all gaged sites.

Figure 30 depicts the strong seasonal streamflow variation, with higher flows during December through May, and much lower flows during the summer. The Sandusky-Fremont and Rock Creek-Tiffin USGS gages exhibit similar seasonal variation. The streamflow is shown as millimeters of water over the drainage area of the watershed. The magnitude of the higher flows (shown as those exceeded only 5% of the time) compared to lower flows (exceeded 25% of the time) is typical of agricultural watersheds in northwest Ohio that have been modified by widespread installation of drainage tiles. The tiles intercept water as it infiltrates through the soil and send it out to drainage ditches and creeks. The tiles are considered indispensable to make the poorly drained soils in northwest Ohio suitable for farming.

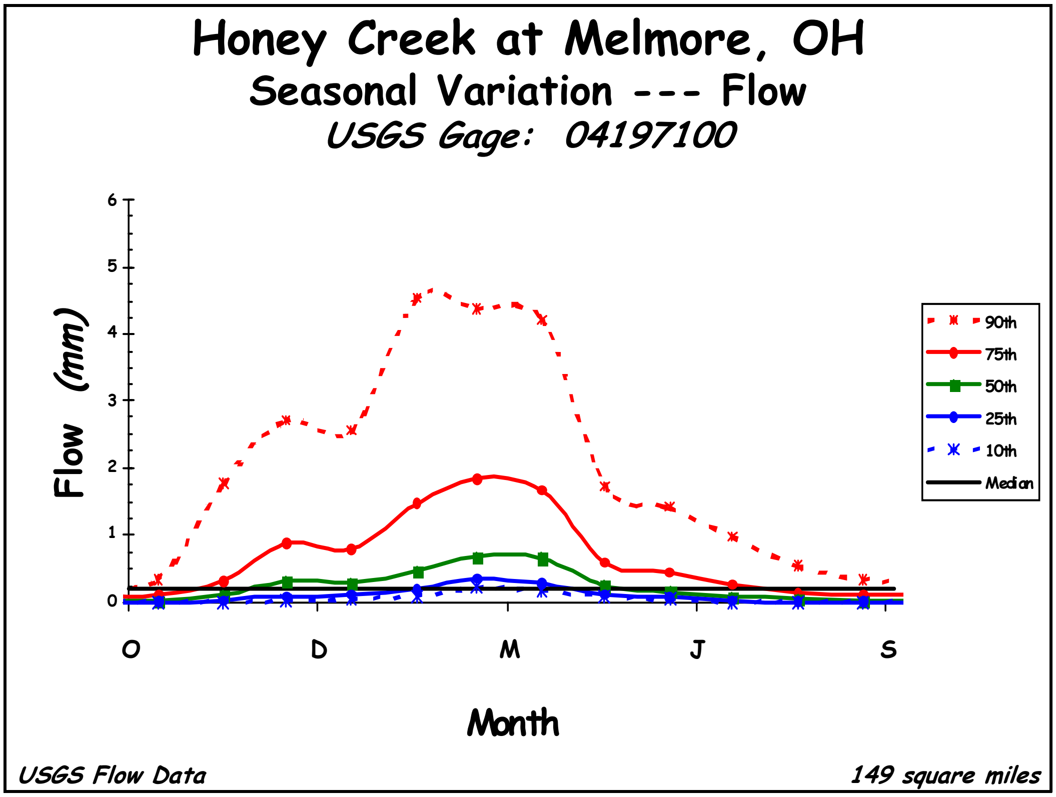


Figure 30. Seasonal Flow variations: Honey Creek at Melmore

Figures 31 through 33 show the monthly variation in the concentrations of total phosphorus, total suspended solids and nitrate + nitrite measured at the Sandusky-Fremont, Honey Creek-Melmore, and Rock Creek-Tiffin USGS gages. The values are based on daily (or more frequent) measurements collected between 1985 and 2001. The data indicates that phosphorus and suspended solids concentrations are usually highest during June and July. Since the Total Phosphorus targets proposed by Ohio EPA are concentration-based, any point source controls would be particularly effective if implemented during the summer (June-September), for those subwatersheds that are effluent dominated.

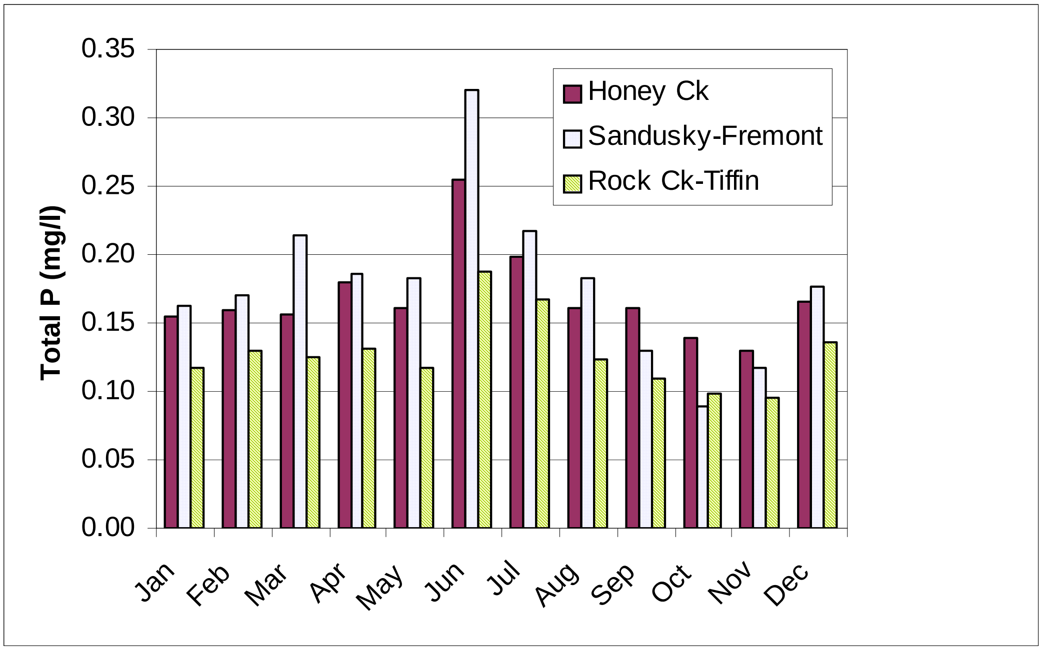


Figure 31. Average monthly total phosphorus concentration at three USGS gages in the Sandusky watershed (1985-2001)

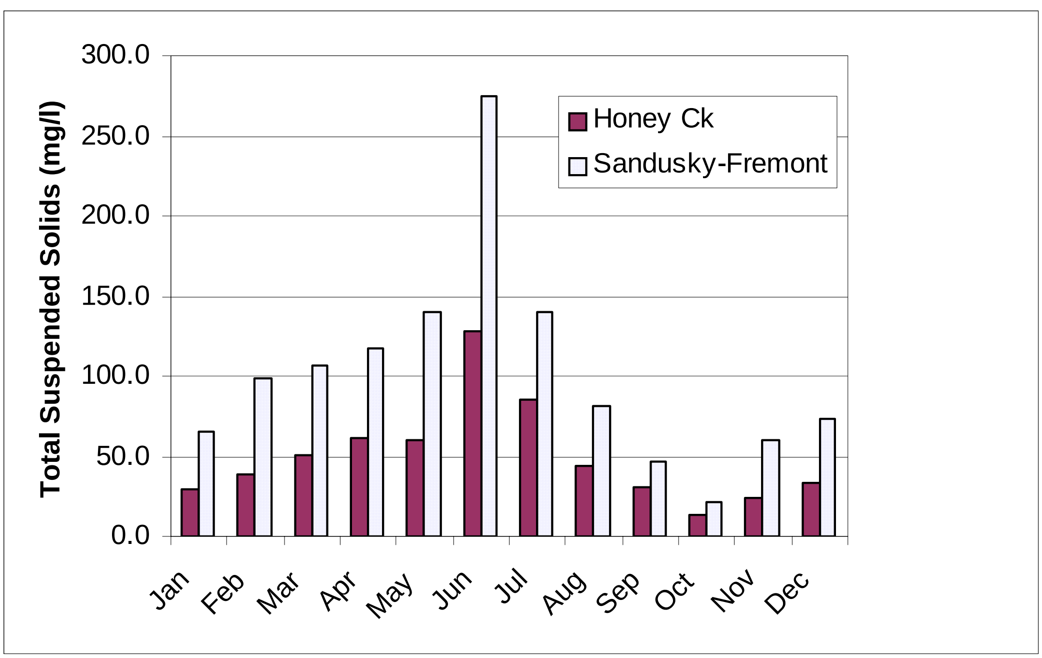


Figure 32. Average monthly TSS concentration at two USGS gages in the Sandusky watershed (1985-2001)

Figure 33 indicates that Nitrate + Nitrite follows a different seasonal pattern, with concentrations between 5 and 6 mg/l from December through May, a peak of 7 to 8 mg/l in June, and considerably lower concentrations during the summer and fall. Drainage tiles are assumed to be the main delivery mechanism to the stream for NO_3+NO_2 (as well as for ammonia and other soluble nitrogen compounds), because these inorganic forms of nitrogen don't readily adsorb to soil particles. Also notice that concentrations of all parameters increase from smallest (Rock Ck) to largest (Sandusky-Fremont), in spite of nutrient assimilation.

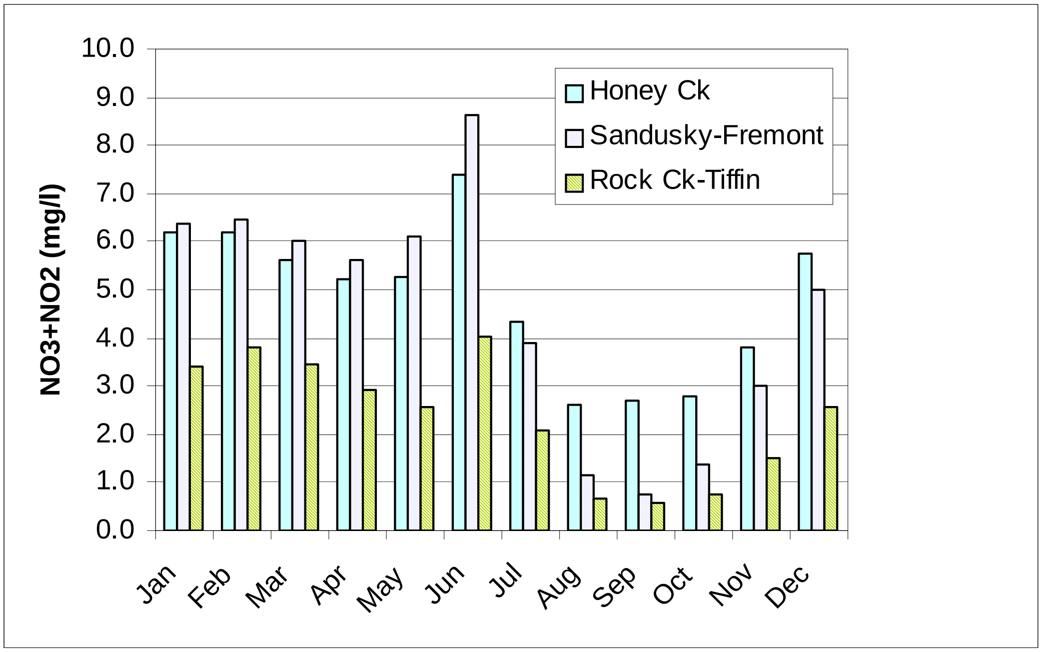


Figure 33. Average monthly concentration of NO_3 + NO_2 at three USGS gages in the Sandusky watershed (1985-2001)

Figure 34 supports the assumption that phosphorus attaches to soil particles, showing a high correlation between Total Suspended Solids and Total Phosphorus concentrations. The data comprises thousands of data points collected at the Sandusky-Fremont USGS gage from 1985 to 2001. It also indicates that sediment reduction management practices will likely result in total phosphorus reductions.

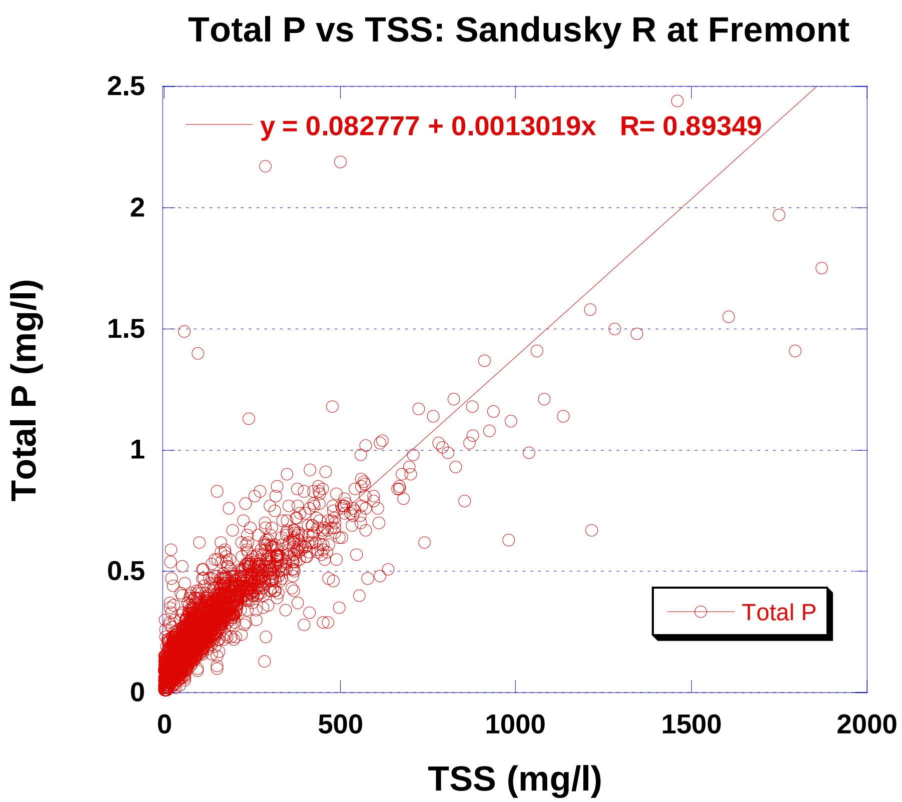


Figure 34. TSS vs Total P Correlation at Fremont gage

4.2.2 Allocation Methods

The upper Sandusky watershed offers particular challenges because there is a disproportionate amount of nutrient and sediment load coming from non point sources. In addition, there are seasonal streamflow patterns that tend to penalize point sources located near headwaters, due to the low volume of streamflow available for wastewater assimilation during the summer. Thus, the TMDLs must take into account the impact of high phosphorus concentrations observed in headwater streams under low flows, as well as high sediment/phosphorus loads transported during high flows. The categories of sources for this TMDL include:

- Nonpoint sources based on runoff over land
- Groundwater
- Point sources
- Combined sewer overflows
- Septic systems

Each of these sources receives an allocated portion of the total allowable load. Another allocated category includes margin of safety to account for uncertainty in the analysis. No reserve for future growth was allocated because census data indicates negative population growth during the last few decades for most of the counties in the study area. The method to determine the appropriate allocation for each of these sources and categories varied and is discussed more fully below.

<u>Nonpoint sources</u>
The upper Sandusky watershed was assessed based on 8 subwatersheds, corresponding to 11-digit HUC (Hydrologic Unit Code) assessment units. The drainage area and land cover information for each of the assessment units are shown in Chapter 2 (Table 3). The sub-watershed boundaries are also shown in Figure 26. Nutrient loading to the Sandusky River watershed was determined from data collected at three USGS gages. The Honey Creek gage was selected as being representative of most of the subwatersheds in the Sandusky River basin, based on land use similarities, hydrology (affected by tile drainage), and drainage area size. The drainage area at the Honey Creek gage is 149 mi^2, and the drainage areas of the assessment units range from 95 to 180 mi^2. The average total phosphorus export rate for the Honey Creek watershed (based on data collected by Heidelberg College at the USGS gage in Melmore) averaged 1.1 lbs/acre/year for the period 1997 through 2000. This export rate is very close to the export rate reported for the Sandusky River at Fremont (1.07 lbs/acre/yr) in Table 15 for the same period. Therefore an export rate of 1.1 lbs/acre/day was multiplied by the drainage area of each assessment unit to estimate the "Nonpoint Source" load of total phosphorus. Since the export rate is based on data collected under all flow conditions, it includes the influence of runoff over land, septic systems, groundwater, and air deposition.

<u>Groundwater</u>
The groundwater contribution of total phosphorus was estimated as follows:

- The streamflow for the year 2000 was separated into baseflow and surface runoff using a USGS baseflow separation program called HYSEP (Sloto & Crouse, 1996).

- The baseflow for that year was multiplied by the 25th percentile of the total phosphorus concentration measured by Ohio EPA at the Honey Creek assessment unit (HUC -080) during 2001-02. That value was 0.055 mg/l, from 49 samples collected at sites draining from 20 to 200 mi^2.
- For comparison, the same percentile was determined for the data collected at the Honey Creek-Melmore gaging station between January 2000 and March 2002. The result was 0.051 mg/l. The annual "groundwater P load" was compared against the total P measured at the Honey Creek gage during 2000, and found to be 4.0% of the measured load. Used the same % of groundwater P load to NPS load (4.0%) for other assessment units.

Point Sources

Point source loads of total phosphorus and other nutrients were determined using dischargers' monitoring data. Total phosphorus load data from 1998 through 2001 was examined for the permitted dischargers, and the year 2001 was selected as representative of that period, for purposes of estimating the total phosphorus load for each assessment unit. For those dischargers that don't monitor total phosphorus (because the discharge is very small or not expected to contain phosphorus) their flow information was used to estimate the annual phosphorus load by assuming an effluent concentration of 1 mg/l for wastewater treatment plants and 0.025 mg/l for other dischargers such as quarries. Appendix H shows the existing and recommended total phosphorus loads for the most significant dischargers in the study area.

Combined Sewer Overflows

For CSOs, there was no information regarding the total P concentration in CSO discharge. The following procedure was used to estimate the phosphorus concentration. The data collected by Heidelberg College from Jan 1985 to Mar 31, 2002 at the Sandusky River-Fremont gage was analyzed to determine which streamflows exceeded 75th pctl of all flows in the gage history. This value equals 5000 cfs, based on a flow duration curve developed for that gage. A total of 278 values exceeding 5000 cfs were measured during that period. The 50th percentile of the total phosphorus concentrations associated with those high flows was assumed to be representative of CSO concentration of total P. That value was 0.52 mg/l, and was multiplied by the CSO discharge volume reported by various dischargers throughout the watershed to estimated the total P CSO loads. There is some margin of error in these estimates because some dischargers do not report every instance an overflow occurs.

The city of Tiffin reported 446 CSO events between 1998 and 2002 (about 89 events per year), while others reported much lower frequency of CSO discharge events. Table 18 shows the estimated number of CSO discharges and loads for the major cities or villages with CSOs in the upper Sandusky watershed. The CBOD5 and TSS loads are based on data reported by the facilities.

To estimate how many storm events could have triggered CSO discharges, a baseflow separation program (HYSEP) was used to estimate the number of high-flow days during the year 2000, using streamflow data. The results showed that the streamflow consisted of > 50% stormflow during 91 days, and > 75% stormflow during 46 days in the year

2000 at the Honey Creek-Melmore gage. It was assumed that most of those instances would have produced CSO events. This matches well with the Tiffin WWTP monitoring data, which indicates 95 CSO events during 2000. See Chapter 6 for more details about the long term CSO control plans required from several dischargers in this watershed.

Septic Systems

Used estimates from Seneca and Crawford county health departments to determine that 472 and 343 people from each respective county are contributing total P to the Honey Creek subwatershed through defective home sewage treatment systems (HSTS). As a worst case scenario, assumed that 100% of the total P generated (1.3 grams/person/ day after plant uptake) is delivered to the stream. In that case, the total daily total P load from failing septic systems would be 2.4 lbs/day for the Honey Creek assessment unit. This load was 0.7 % of the nonpoint source load estimated for Honey Creek using the phosphorus export rate. The same percent was multiplied by the nonpoint source load of the other assessment units to estimate their septic system phosphorus load. The septic system phosphorus concentrations were based on values recommended by Haith(1996). These estimates are considered adequate because the population density of the study area is low, and the phosphorus load from defective septic systems is small compared to the total nonpoint source load.

Table 18. Combined Sewer Overflow Load Data (kg/year) for Major Dischargers in the Upper Sandusky Watershed based on data from 1998 -2002.

Discharger	**CSO events/yr**	**Flow per event (MGD)**	**Annual TSS load**	**Annual CBOD5 load**	**Estimated Annual Total P load**
Crestline WWTP [A]	10	0.25	1022	675	3.1
Bucyrus WWTP [B]	10 (est)	0.55	3774	1845	10.9
U. Sandusky [C] WWTP	7	0.41	1664	756	8.3
Tiffin WWTP [A]	89	0.52	23575	10439	141

[A] Data from April 1999 to May 2003
[B] Load Data from 1997 to 2002; flow estimates from long term control plan (Nov 2000)
[C] Data from January 1998 to December 2002

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.

An explicit margin of safety of 5% is included for the Sandusky watershed phosphorus TMDLs. The abundance of phosphorus load data allows for a reliable quantification of existing loads, therefore a 5% MOS is adequate. In addition, there are several areas where an implicit margin of safety is incorporated including the 303(d) listing process and the target development process. 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 that there is 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, delisting 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 the 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 effects 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.

Another conservative assumption implicit in the target used is that the phosphorus targets for WWH streams were applied for all the tributaries, even though some of the streams are recommended for Modified Warmwater Habitat or Limited Warmwater Habitat (which have less restrictive targets). If the targets recommended for the MWH segments had been used, the recommended percent phosphorus reduction under low flows would likely have been smaller.

The habitat targets and the specific aspects of the habitat (riparian and substrate) that are degraded as shown in appendices D through F add another layer of potential protection to achieving the WQS by providing additional guidance on alternate means to reduce the nutrient load to the stream and directly improve stream conditions so that an increase in assimilative capacity is possible due to improved 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.

4.4 TMDL Calculations

4.4.1 Load-based Calculations: Total Phosphorus Point Source Allocations

The recommended phosphorus reductions were determined after examination of load duration curves (LDCs) for sites covering subwatersheds in the range of 30 to 150 square miles, and for a mainstem site draining 1251 square miles. The LDCs helped select locations where the target phosphorus load was being exceeded. Under lower flows, the recommended load reductions were determined based on water quality data collected at each subwatershed (mainly under low flow conditions), and vary according to drainage area (headwater, wadeable or small river) and the deviation from the phosphorus target concentration observed at each assessment unit. **Since the headwater streams (those with drainage area <20 mi^2) are the most impaired in this watershed, the recommended load reduction for each assessment unit was based on the percent deviation from the target for each unit's headwater streams. These low-flow load reductions were applied to point sources.** The median of the total phosphorus concentrations measured in each assessment unit during 2001-02 was compared to the appropriate target to determine the percentage load reduction. Table 10 in Chapter 3 showed the phosphorus targets, median concentrations observed, and percent deviation from target for each assessment unit.

The load duration curve analyses performed for the Honey Creek and Sandusky River gages indicates that the total phosphorus target loads are being met most of the time, being exceeded only during high flows (streamflows exceeded 5 percent of the time) in the mainstem. Similar results were observed for the Honey Creek gage, except that the phosphorus target loads were also exceeded for flows in the 25th percentile. Other temporary gaging sites (shown in appendix B) show excessive phosphorus loads during low flow periods, and support the need for measures to control CSOs, septic systems, and point source nutrient loads. That information was used to support implementation of point source and CSO controls, as well as septic system improvements. **The recommended point source load percent reductions are based on the data collected in each assessment unit and are summarized in Table 19.**

4.4.2 Total Phosphorus Allocation for Nonpoint Sources

Export rates for total phosphorus in the Sandusky watershed rank high compared to other Ohio watersheds (as shown in Table 15 of the report). However, the largest portion of this load is transported during less frequent extreme flows, based on load duration curves at the USGS gaging sites (see Figures 23-25). The WWH use designation is being fully met at the 3 USGS gages that were assessed. The high-flow nutrient loads don't seem to be affecting aquatic life at these sites, although the impacts on Lake Erie are not fully understood.

A feasible goal of 25% total P load reduction for <u>nonpoint sources</u> is recommended for the Sandusky watershed due to the following reasons:

1. It will bring the unit area pollutant export rate for the Sandusky River closer to those of other Ohio streams. The existing export rate for the Sandusky River and Honey Creek is around 1.1 lb/acre/yr, while the Scioto and Cuyahoga range from 0.89 to 0.92 lbs/acre/yr. For comparison, a watershed with higher percentage of forest land cover (Grand River) has an export rate of 0.48 (which is not representative of an agricultural watershed). A smaller load reduction wouldn't lower the export rate sufficiently, while a larger reduction is not sufficiently justified at this time (from the aquatic life use perspective).

2. A larger load reduction is not recommended because it may deflect resources needed to address other causes of impairment (habitat and streamflow) that are believed to have a larger impact on use attainability.

3. Given the phosphorus reductions observed during the past 20 years, it is very reasonable to expect that an additional 25% reduction is achievable and will accompany the attainment of aquatic life water quality standards, when combined with habitat and flow improvements.

4. This feasible load reduction will obtain broader (and essential) support from farmers and other stakeholders. Recommendation of a larger load reduction may lead to excessive time invested in defending the benefits of a larger load reduction versus the cost of implementation, delaying the onset of stream and watershed restoration activities.

5. The 25% load reduction can be achieved through a combination of management practices that allow maximum flexibility for the entities responsible for implementation. For example, flow augmentation and habitat improvements will increase the stream's assimilative capacity, thus lowering the phosphorus load downstream. Nutrient management and tillage practices would reduce sediment and nutrient loads. The practices can be tailored to the specific watershed based on feasibility and stakeholder acceptance, making them more likely to happen.

6. Year to year load variability is so high that a target of 25% nonpoint source load reduction will suffice to trigger implementation of best management practices to reduce the phosphorus loads. In addition, it is the phosphorus concentrations

under low flow conditions that are impairing the use designation, while the high flow loads are quickly transported downstream. There is ongoing research to determine if the phosphorus loads are contributing to Lake Erie's anoxia problem and what additional reductions may be required (Matisoff, 2002b).

The recommendations for the Sandusky River watershed are based on the interaction of habitat, hydrology, agricultural trends, relative influence of point sources and their effect on aquatic life as measured by Ohio EPA surveys. They are also tempered by the level of stakeholder participation in the watershed and the opportunity for successful implementation. These recommendations cannot necessarily be applied to other watersheds without consideration of watershed-specific characteristics.

Table 19 shows the recommended phosphorus TMDLs for the Sandusky watershed (by assessment unit). All segments in the study area are included in one of these 8 assessment units. Unlisted and attaining stream segments are also included because they are sources of load whether they are locally impaired or not. The table lists the existing point source and nonpoint source loads, the needed reduction, and the allocations for total phosphorus for each assessment unit. The existing NPS category covers agricultural, groundwater/natural background inputs, septic systems and storm runoff. 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.

In most assessment units, point source loads represent a small fraction of the existing total phosphorus load, hence any significant load reductions require nonpoint source controls. However, the point sources frequently have a greater impact on aquatic life use attainment in several Sandusky subwatersheds during summer low flow periods. The lack of streamflow to sustain a viable biological community severely limits the streams' ability to assimilate nutrients. Small discharges such as failing septic systems have a short term impact in water quality (both bacteria and nutrients) under low flow conditions and should be corrected.

The allocations for Sandusky-Upper Sandusky (-040) and Upper Tymochtee (-050) are being modified. Please see draft Addendum for more information.

Table 19. TMDLs and Total Phosphorus Allocations for the Sandusky River watershed

Assessment Unit (04100011-0xx)	Existing Conditions			Percent Reduction		TMDL	Margin of Safety	TMDL Allocations		
	NPS	PS	Total	NPS	PS			Natural	WLA	LA
Total Phosphorus (kg/day)										
Sandusky-Bucyrus (-020)	120	22	142	25	50	101	5	4	11	81
Broken Sword Creek (-030)	83	0.3	83.3	25	25	63	3.2	2.7	0.2	57
Sandusky-Upper Sandusky (-040)	106	7.9	114	25	34	85	4.2	3.5	5.4	72
Upper Tymochtee (-050)	150	0.015	150	25	20	112	5.6	4.9	0.012	102
Lower Tymochtee (-060)	114	5.5	120	25	60	89	4.4	3.8	3.4	77
Sandusky-Mexico (-070)	106	0.3	106.3	25	0	80	4	3.5	0.3	72
Honey Creek (-080)	157	4.1	161	25	65	119	6	5.2	1.4	106
Sandusky-Tiffin (-090)	102	15.1	117	25	0*	92	4.6	3.4	15.1	69

* The % point source reduction applies to phosphorus load from main outfall, not to CSO discharges.

Table 20. Estimated Annual Loads (kg/yr) of Total Phosphorus by Source for each Sandusky Watershed Assessment Unit[A]

Source	Bucyrus 04100011-020	Broken Sword 04100011-030	Upper Sandusky 04100011-040	Upper Tymochtee 04100011-050	Lower Tymochtee 04100011-060	Sandusky-Mexico 04100011-070	Honey Creek 4100011-080	Sandusky-Tiffin 04100011-090
Point Sources	7921	110	2884	5.5	2008	110	1497	5512
CSOs	14	NA	8	NA	NA	NA	NA	141
Unregulated Runoff	41518	28702	36589	51925	39434	36844	54559	35270
Stormwater	438	302	386	547	415	388	574	372
Septic Systems	306	212	270	383	291	272	398	260
Background/ groundwater	1444	997	1274	1805	1370	1281	1900	1227
Air Deposition	44	3	77	37	11	35	14	39

[A] The magnitude of nonpoint source loads fluctuates widely every year depending on precipitation amount and intensity, fertilizer application rates, crop rotations, etc. This table is based on average conditions and is meant to illustrate relative loads from each source. The point source loads represent the maximum allowable under existing permits, prior to TMDL load reductions.

4.4.2 Habitat Calculations for Aquatic Life

Table 21 shows the Habitat "TMDLs." This table indicates how far each assesment unit is from meeting a recommended habitat score. The table shows the percent improvement in habitat score required to reach the recommended habitat score for each assessment unit. Within each assessment unit, the sites were subdivided based on their proposed use designation, which influences the recommended target. This table is useful for the stakeholders to prioritize which assesssment units need habitat improvements.

A table showing the habitat (QHEI) scores and subscores for other components of the QHEI index is included in Appendix D, which also includes graphics showing the deviation of the QHEI score from the target for tributaries in each assessment unit. That appendix provides more detail for assessment units which may have good overall scores, but have a few sites with poor habitat. Some examples of longitudinal Habitat score plots are shown below.

Table 21. Deviation of Existing Habitat Scores (QHEI) from "TMDL" Target Values in Sandusky River Assessment Units (by Use Designation)

Assessment Unit Name and Number	Use Designation[1]	# of sites	Observed QHEI 50th pctl	Habitat target value	Deviation from target (%)
Sandusky-Bucyrus (04100011-020)	WWH	23	58	60	3
	MWH	3	21.5	45	52
Broken Sword Ck (04100011-030)	WWH	6	66	60	Meets
	MWH	4	30.5	45	32
	LWH	1	37.5	30	Meets
Sandusky-Upper Sandusky (04100011-040)	WWH	9	57	60	5
	MWH	2	25	45	44
Tymochtee-Headwaters (04100011-050)	WWH	9	50	60	17
	MWH	4	21	45	53
	LWH	1	32	30	Meets
Tymochtee-Lower (4100011-060)	WWH	12	49	60	18
Sandusky-Mexico (04100011-070)	WWH	11	51.5	60	14
	MWH	5	55	45	Meets
Honey Creek (04100011-080)	WWH	13	55.5	60	8
	MWH	7	32.5	45	28
Sandusky-Tiffin (04100011-090)	WWH	6	54.8	60	9
	MWH	2	34.5	45	23

[1] Aquatic Life Use Designations are based on the proposed/recommended use designations as determined by the 2001 biological and water quality survey of the Sandusky River and tributaries.

Figure 35 shows the QHEI scores per river mile for the Sandusky River mainstem. Except for three sites (river mile 52.3 near the Walnut Grove campground, and river miles 120 and 111, in the Bucyrus area) all the assessed sites were above or very close to the target. The other biological indices (for fish and macroinvertebrates) were also lower at those sites, stressing the importance of good habitat to maintain a healthy biological community. The lower QHEI target of 45 at river mile 43 is due to its classification as Modified Warmwater habitat caused by the influence of the Ella Street dam in Tiffin. Appendix C details the biological index scores and use attainment status for each monitored site in the Upper Sandusky study area.

Figure 36 illustrates a common occurrence in small streams in the study area. The headwaters show very poor habitat due to channelization, lack of riparian vegetation, siltation, impact from tile drainage, etc. Broken Sword Creek's improved habitat scores are helped by increased riparian shading and a constant supply of water from a quarry downstream of river mile 15. This is an example of the benefits of flow augmentation.

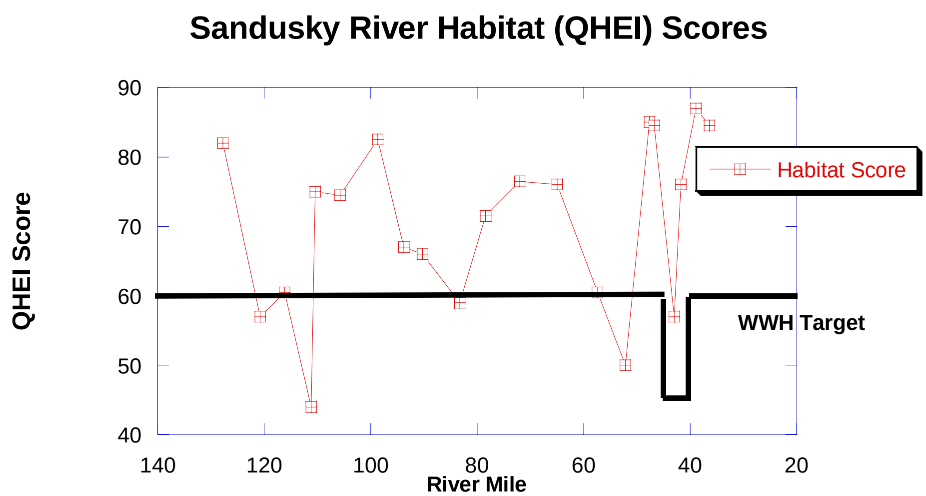


Figure 35. Habitat Scores by River Mile for the Sandusky River mainstem

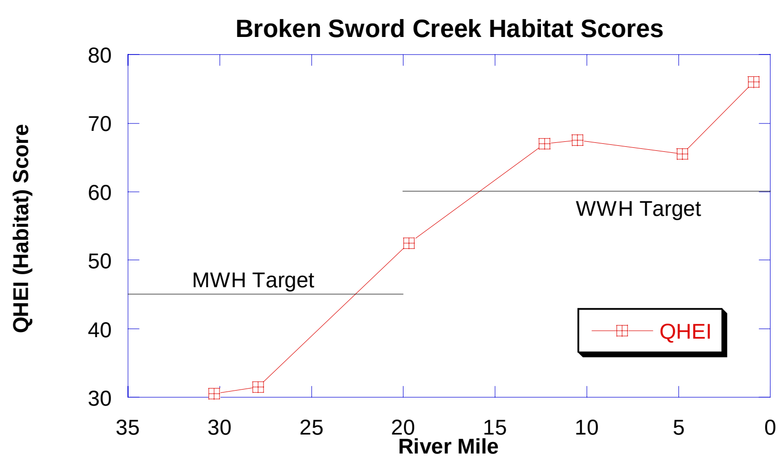


Figure 36. Habitat Scores by River Mile for Broken Sword Creek (Assessment Unit -030)

4.4.3 Substrate/Sediment "TMDLs"

The substrate subscores from the Habitat (QHEI) asessment are being used as a surrogate for sediments. Table 22 shows the Substrate/Sediment "TMDL"s. Similar to Table 21, it indicates the percent deviation from a recommended substrate score for each assesment unit and use designation. Following implementation of best management practices designed to reduce agricultural sediment loads and bank erosion, the substrate scores should improve over time. The numerical targets provide a framework for tracking improvements in the stream in response to sediment load reductions. This table should be used in conjunction with the phosphorus and habitat TMDL tables to prioritize the assessment units that have the greatest need for restoration/intervention.

Table 22. Deviation of Existing Substrate Scores from "TMDL" Target Values in Sandusky River Assessment Units (by Use Designation)

Assessment Unit Name and Number	Use Designation[1]	# of sites	Observed Substrate 50th pctl	Substrate target value	Deviation from target (%)
Sandusky-Bucyrus (04100011-020)	WWH	23	14	12.5	Meets
	MWH	3	5	10	50
Broken Sword Ck (04100011-030)	WWH	6	13.8	12.5	Meets
	MWH	4	5	10	50
	LWH	1	10	8	Meets
Sandusky-Upper Sandusky (04100011-040)	WWH	9	9	12.5	28
	MWH	2	0.8	10	93
Tymochtee-Headwaters (04100011-050)	WWH	11	9.5	12.5	24
	MWH	4	0.5	10	95
	LWH	1	5	8	38
Tymochtee-Lower (04100011-060)	WWH	12	10	12.5	20
Sandusky-Mexico (04100011-070)	WWH	11	10	12.5	20
	MWH	5	15	10	Meets
Honey Creek (04100011-080)	WWH	13	14.5	12.5	Meets
	MWH	7	8	10	20
Sandusky-Tiffin (04100011-090)	WWH	6	11.8	12.5	6
	MWH	2	10.8	10	Meets

1 Aquatic Life Use Designations are based on the proposed/recommended use designations as determined by the 2001 biological and water quality survey of the Sandusky River and tributaries.

4.4.4 Bacteria Assessment

As mentioned in Chapters 2 and 3, the bacteria assessment was performed based on a limited data set, but the statistical analysis of the pooled data indicated that the streams shown below are likely to exceed bacteria WQS.

The results of bacteria modeling performed for those sites is shown in Table 23. The recommended % reduction represent the fecal coliform load reduction needed to meet the fecal coliform water quality standard. It is recommended that the information provided below be used to prioritize the sites for which bacteria load abatement may be most urgently needed, in case grants are available for septic system upgrades. Any additional data that may be available to local health departments (but not always accessible to Ohio EPA) should be used to verify the recommendations shown below. Failing septic systems and grazing livestock are considered to be the main bacteria sources. Appendix G contains more details about the bacteria modeling performed for these sites.

Table 23. Bacteria Load Reductions

Stream	Assessment Unit Number, 04100011-	RM at site	% reduction needed
Paramour Creek	020	6.31	56
Unnamed trib. to Paramour Creek @ Hook Rd.	020	0.18	38
Westerly Creek	020	2.41	85
Westerly Creek	020	0.13	68
Indian Run	030	0.94	75
Little Sandusky River	040	6.52	19
Honey Run	040	0.52	10
Negro Run	040	0.52	28
Prairie Run (2001data only)	050	1.02	45
Warpole Creek	050	2.53	80
“Lower” Little Tymochtee Creek	060	0.9	10
Unnamed tributary to Sycamore Creek	060	0.36	83
Morrison Creek	090	2.36	35

5.0 PUBLIC PARTICIPATION

The Ohio EPA convened an external advisory group (EAG) in 1998 to assist the Agency with the development of the TMDL program in Ohio. The EAG met multiple times over eighteen months and in July 2000 issued a report to the Director of Ohio EPA on their findings and recommendations. This TMDL was developed using a process endorsed by the the EAG.

Ohio EPA involved the partners and public stakeholders in the upper Sandusky River TMDL project by soliciting input and recommendations for action from the Sandusky River Watershed Coalition (SRWC), an established local watershed group. This group formed in 1997 and began its planning efforts with a 319 mini-grant of $15,000. The funds were used to develop a watershed inventory in 1999. The group then applied for and received a 319 Watershed Coordinator grant in 2000. The grant, jointly administered by Ohio EPA and Ohio DNR, provides funding with local match over 6 years to employ a local watershed coordinator. The Coalition hired the first coordinator and continued work on the comprehensive watershed action plan. The first Sandusky River Watershed Resource Inventory and Management Plan was completed in June 2001, with additions in November 2001. During this action planning phase, the coordinator and SRWC also participated in the study planning for the TMDL assessment phase. The coordinator assisted with organizing the public planning meetings in May 2001 and coordinating a public involvement event with the SRWC membership in July 2001. She also organized her own media coverage and assisted Ohio EPA Public Information Center with the same during the sampling season.

The public outreach activities included at least three formal presentations by Ohio EPA to the full membership of the SRWC during 2002 and 2003 as the water quality and biological data was compiled and interpreted. The coordinator and two members of the coalition participated in preparing the Technical Support Document and the TMDL report.

Consistent with Ohio's current Continuous Planning Process (CPP), the draft TMDL report was public noticed from March 5 through April 9, 2004. The document was posted on Ohio EPA's web page (www.epa.state.oh.us/dsw/tmdl/index.html); the SRWC also posted the draft report on the web page (www.riverwatershed.org). In addition, copies of the report will be distributed to local libraries. A summary of the comments received and the associated responses are included in this final report in Appendix O.

The SRWC is in the process of updating their Watershed Action Plan so it can receive state endorsement. This document will incorporate the TMDL recommendations and provide a schedule and detailed action plan for restoring impaired subwatersheds. It will thus serve as the Implementation Plan for this TMDL.

Public involvement is pivotal 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 to Ohio EPA. Ohio EPA is reluctant to rely solely on regulatory actions and strongly upholds the need for voluntary actions facilitated by the SRWC and partners to bring this section of the Sandusky River watershed into attainment.

Table 24. Sandusky River Watershed Coalition and public involvement

Date	Time	Subject(s)
4/6/01	10:00 - 12:00 AM	Upper Sandusky TMDL Kick-off meeting at Ohio EPA-NWDO. Attended by partner agencies and Sandusky River Watershed Coalition (SRWC) staff and members.
April, 2001	-	Fact sheet developed by Ohio EPA for distribution at public TMDL assessment planning meetings.
4/25/01	-	Invitation letter from Wyandot SWCD to attend public planning meeting at Gottfried Nature Center in Upper Sandusky on May 15-16, 2003
5/15/01	9:00 -3:00 PM	Upper Sandusky TMDL assessment planning meeting with local agencies and public officials - Part I
5/16/01	9:00 -11:00 AM	Upper Sandusky TMDL assessment planning meeting with local agencies and public officials - Part II
6/20/01	-	Study Plan draft sent to SRWC partners for comment.
June 2001	-	Notification letters sent to landowners by Wyandot SWCD if their property was a sampling location.
6/29/01	11:00AM	Phone conference with EPA, Green Mountain Institute and SRWC coordinator to plan the July 30th SRWC public involvement event.
7/30/01	4:00-8:00 PM	Sandusky River Watershed Coalition hosts an informative and interactive public event at Stepping Stones Park in Upper Sandusky, Ohio. A TMDL monitoring demonstration was conducted by Ohio EPA Ecological Assessment staff.
January 2002	6:30PM	Ohio EPA presentation at SRWC meeting on attainment status of fish communities during the 2001 summer sampling.
10/24/02	6:30PM	Ohio EPA presentation at Annual SRWC Meeting. Sampling work for the NPS model continued throughout spring and summer of 2003 and some causes and sources have emerged.
4/22/03	10-2:30PM 8:30-10AM	TMDL Team meeting (agency) to discuss and assemble the Upper Sandusky Technical Support Document(TSD). Conference call 4/25 to complete the TSD discussion included the SRWC coordinator.
4/24/03	6:30PM	SRWC quarterly meeting of full membership. EPA provided coordinator with handouts of attainment status and narrative by subwatershed assessment units.
5/21/03	-	TSD published and distributed to SRWC Steering Committee.
8/27/03	9:30-3:00 PM	TMDL team meeting with representatives from SRWC to discuss drafting the TMDL report and schedule for public comment.

Table 24. Sandusky River Watershed Coalition and public involvement

Date	Time	Subject(s)
Aug-Sep 2003	-	Transition to new Sandusky River Watershed Coalition Coordinator
10/2/03	9:30-1:30 PM	NPS Area Assistance Team and SRWC Plan Development Committee meet to discuss the TMDL and revisions to the Watershed Action Plan.
October, 2003	-	Draft Upper Sandusky TMDL report for team and agency review
10/22/03	-	TMDL pamphlet for upper Sandusky River Watershed ready for SRWC Annual meeting
10/23/03	7:00-9:00	SRWC annual meeting and presentation of TMDL recommendations. Comment period announced for November, 2003.
03/05/04-04/09/04	-	Public notice of the Upper Sandusky River TMDL Report
Ongoing Activity	-	The Sandusky River Watershed Coalition meets monthly as a steering committee on the first Monday, and quarterly as a full Coalition in January, April, July, and October. Seven subcommittees meet as needed to work on projects or grants.

Table 25. News media coverage and publicity events

Date	Topic
5/6/01	Tiffin Advertiser Tribune Article previewing summer events on Sandusky River including the TMDL assessment sampling by Ohio EPA
5/21/01	Toledo Blade article on public meetings to plan TMDL sampling
5/22/01	Tiffin Advertiser-Tribune article on same public meetings.
June-July 2001	Newspaper staffs from Bucyrus, Upper Sandusky, Tiffin and Toledo shadowed the field staff and featured photos and articles on the sampling activities and TMDL process.
July 30, 2001	News agencies covered the SRWC public involvement event at park in Upper Sandusky, Ohio
May 2002	Publication of The Science of TMDLs by American Soybean Association and National Corn Growers Association. Sandusky River TMDL process is highlighted in the four page fact sheet.

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 Sandusky River are organic enrichment, nutrients, habitat alteration, flow alteration, sedimentation, and pathogens. 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.

Potential restoration strategies used to achieve the TMDL restoration targets might include:

- Public education for awareness of watersheds and water quality
- Riparian buffer initiatives
- Corridor protection ordinances
- Dam evaluation and removal
- Flood plain management
- Flow augmentation
- Sediment and erosion control practices
- Conservation farming practices
- Comprehensive nutrient management plans
- Livestock waste management plans
- County wide home sewage treatment system plans
- Storm water management plans
- Enforcement of storm water Phase I and II regulations
- Limit and reuse point source discharge water
- Eliminate point source discharges
- NPDES program - permit limitations and compliance schedules
- Elimination/control of combined sewer overflows (CSOs)
- Municipal pretreatment program
- Centralized treatment for unsewered communities
- Sediment remediation

The Sandusky River Watershed Coalition began developing a comprehensive resource inventory and watershed action plan in 1998 by focusing on water resource issues. They formed five subcommittees; agriculture, wastewater, water supply, stream flow and habitat, and education/special events. A sixth subcommittee for grass roots development was formed in 2002. Each subcommittee's action plan in the 2001 document identified a problem statement, goals, resources needed, funding sources, success indicators, and a time frame. The Sandusky River Coalition's watershed action plan is in an update and revision phase at the time of this report. The plan will describe primarily voluntary nonpoint source BMPs and restoration actions to reach the TMDL load reduction targets and should also contain reasonable assurances the implementation activities will occur. The Coalition is seeking endorsement of their plan from Ohio EPA and ODNR. The involvement of the Coalition and partners will be critical to the implementation of nonpoint source restoration actions.

Point source reductions will be achieved through effluent limitations, compliance schedules, and special conditions in existing dischargers' NPDES permits. Permits should be issued for all discharges from currently unpermitted facilities in the watershed. A schedule will be developed for issuance of NPDES permits consistent with implementing the TMDL recommendations.

6.1 Reasonable Assurances

As part of an implementation plan, reasonable assurances provide a level of confidence that the waste load allocations and load allocations in TMDLs will be implemented by Federal, State, or local authorities and/or by voluntary action. The Sandusky River Watershed Resource Inventory and Management Plan contains a list of the non-enforceable management practices and actions necessary to achieve the restoration targets. Reasonable assurances for planned point source controls, such as wastewater treatment plant upgrades, combined sewer overflow control and changes to NPDES permits will be compliance schedules included in planned NPDES permit actions or other enforceable mechanisms. 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.

6.1.1 Minimum Elements of an Implementation Plan

Whether an implementation plan is for one TMDL or a group of TMDLs, it should include at a minimum the following eight elements:

- Implementation actions/management measures
- Time line
- Reasonable assurances
- Legal or regulatory controls
- Time required to attain water quality standards
- Monitoring plan
- Milestones for attaining water quality standards
- TMDL revision procedures

6.1.2 Reasonable Assurances Summary

This is a summary of the regulatory, non-regulatory and incentive based actions applicable to or recommended for the Sandusky River watershed. Many of these activities deal specifically with the point source discharge regulatory actions. Nonpoint source no-regulatory and incentive programs are discussed in more detail in the

Sandusky River Watershed Action Plan.

Regulatory:

- NPDES permit limits for phosphorus
- NPDES permit limits for ammonia nitrogen, dissolved oxygen, and CBOD
- Controlled discharge or flow augmentation for discharges on small receiving streams
- Pretreatment programs
- Implementation of Phase I and II storm water requirements for Bucyrus and Tiffin.
- NPDES permit schedules for CSO elimination or Long Term Control Plans for Bucyrus, Tiffin, Upper Sandusky and Crestline
- DFFOs for wastewater treatment facilities in unsewered areas (Morral, Meeker, Marseilles, Harpster and nearby unincorporated area of Little Sandusky, and McCutcheonville)

Non-regulatory:

- Remediation of mercury contaminated sediment downstream from Bucyrus
- Dam removal
- Flow augmentation in headwater streams or near point source discharges
- 319 grant agreement with local watershed group for a full time watershed coordinator

Endorsement of the SRWC Watershed Action Plan which includes:

- Watershed awareness education activities
- Source protection of ground and surface drinking water supplies (SWAP)
- Storm water management
- Septic system improvements through implementation of home sewage treatment system (HSTS) plans in 5 counties
- Agricultural conservation practices
- Riparian buffer initiatives
- Manure nutrient management plans
- SRWC and partners working to promote and implement the watershed action plan and other activities contributing to the goals of the TMDL project
- Periodic stream monitoring to measure progress
- Conduct chemical and biological sampling in the watershed, following the agency monitoring schedule
- Develop criteria for ditch maintenance program
- Restore access to flood plains and oxbows

Incentive-based:

- 319-funded projects for the entire Sandusky River watershed which support the goals of this TMDL (see appendix L)
- 319-funded (in part) watershed coordinator to promote watershed improvement activities
- USDA Farm Bill programs for agricultural BMPs
- Lake Erie CREP for buffer practices throughout the Lake Erie watersheds

- Clean Ohio Grant Fund opportunities for natural resource protection and improvement and farmland BMPs (see Appendix M)
- Various loan opportunities for WWTP improvements (see Appendix N)
- WPCLF Linked Deposit funding at a reduced interest rate for agricultural BMPs and home sewage treatment system replacements in the watershed
- Loan opportunities through WRRSP program for riparian/habitat improvements
- FmHA grants and WPCLF loan opportunities for centralized wastewater treatment in small communities

6.1.3 Implementation Actions, Time Line, and Reasonable Assurances

6.1.3.1 Point Source Controls

Implementation of the TMDL for the Upper Sandusky River watershed NPDES permit holders will consist of special conditions in the NPDES permits. The four major POTWs in the study area - Crestline, Bucyrus, Upper Sandusky, and Tiffin - currently have monthly and weekly concentration and loading limits for phosphorus in their NPDES permits. These limits are shown in Table 26.

The data presented in Table 27 show that each of these plants discharges phosphorus loads that are lower than those required to meet the TMDL. The NPDES permit for each of the major POTWs will include the following special condition that requires them to meet the TMDL phosphorus load as well as their final effluent limits for phosphorus (example written for Crestline):

> <u>Upper Sandusky TMDL Phosphorus Load Compliance</u>
> The permittee shall achieve the final effluent limits for total phosphorus in Part I. A. of this permit and an allowable total phosphorus load of 2.4 kg/day.
>
> The allowable total phosphorus load may be expressed as:
>
> 2.4 kg/day total phosphorus = med Qeff x med Peff x F
>
> where:
> *med Qeff* = 5-year median daily effluent flow rate (MGD). This flow value shall be the median of the daily flows at station number 2PC00006001 for the previous 5 consecutive calendar years.
> *med Peff* = median daily effluent total phosphorus concentration during January - December (mg/l)
> *F* = conversion factor

The following NPDES permit holders discharge phosphorus at levels that are greater than their TMDL loads (see Table 28): Swift Eckrich, Inc., Village of Carey, Village of Attica, and Village of Bloomville. The current NPDES permits for these dischargers do not include final effluent limits for phosphorus. Table 29 presents the final effluent limits for total phosphorus that will be included in the NPDES permits for these facilities to bring them into compliance with their TMDL loads.

Because these dischargers currently are not able to comply with the proposed phosphorus limits, a compliance schedule similar to the one that follows will be included in each of their NPDES permits (example written for Carey):

<u>Upper Sandusky TMDL Phosphorus Reduction Implementation Schedule</u>
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 for total phosphorus in Part I. A. of this permit, and an allowable total phosphorus load of 3.4 kg/day.

The allowable total phosphorus load may be expressed as:

3.4 kg/day total phosphorus = (med Qeff x med Peff x F)

where:
med Qeff = 5-year median daily effluent flow rate (MGD). This flow value shall be the median of the daily flows at station number 2PD00038001 for the previous 5 consecutive calendar years.
med Peff = median daily effluent total phosphorus concentration during January - December (mg/l).
F = conversion factor

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 this 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 (monthly average) and the allowable total phosphorus load of 3.4 kg/day. Permits To Install shall be obtained if necessary.

3. If the final effluent limit of 1.0 mg/l total phosphorus (monthly average) and the allowable total phosphorus load of 3.4 kg/day is not achieved by implementing measures identified in the evaluation, not later than 18 months from the effective date of this permit, the permittee shall submit a general plan to the Ohio EPA Northwest District Office to achieve the final effluent limit and the allowable total phosphorus load. [Event Code 1299]

The general plan for achieving the final effluent limit and allowable total phosphorus load shall address, at a minimum, the following:

a. The treatment technology required to achieve the final effluent limit and allowable load.
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 and allowable load for phosphorus. At 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 Northwest District Office within 14 days of attaining operational level; and achieving the final effluent limit and allowable load for phosphorus not later than 36 months from the effective date of this 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 (monthly average) and the allowable total phosphorus load of 3.4 kg/day not later than 36 months from the effective date of this permit. (Event Code 5699)

Table 26. Phosphorus Limits for Major POTWs

Facility	Parameter	Season	Concentration (mg/l)		Load (kg/d)	
			Monthly	Weekly	Monthly	Weekly
Crestline Permit No. 2PC00006	Total Phosphorus	Annual	1.0	1.5	3.6	5.4
Bucyrus Permit No. 2PC00006	Total Phosphorus	Annual	1.0	1.5	13	19.5
Upper Sandusky Permit No. 2PD00039	Total Phosphorus	Annual	1.0	1.5	7.6	11.4
Tiffin Permit No. 2PD00025	Total Phosphorus	Annual	1.0	1.5	15	23

Table 27. Phosphorus Discharges for Major POTWs

Facility TMDL Load	**Crestline 2.4 kg/day**		**Bucyrus 6.4 kg/day**		**U. Sandusky 5.3 kg/day**		**Tiffin 15.1 kg/day**	
Year	P_{eff}	Load	P_{eff}	Load	P_{eff}	Load	P_{eff}	Load
1998	0.89	2.4	0.62	5.1	0.41	1.9	0.50	5.6
1999	0.62	1.6	0.30	2.5	0.31	1.5	0.42	4.7
2000	0.59	1.5	0.74	6.1	0.31	1.5	0.40	4.5
2001	0.75	2.0	0.63	5.2	0.24	1.1	0.67	7.6
2002	0.59	1.5	0.52	4.3	0.45	2.1	0.49	5.5

Load (kg/day) = P_{eff} x Q_{eff} x F
P_{eff} = median daily effluent phosphorus concentration (mg/l)
Q_{eff} = 5 year median daily effluent flow rate, 1998 - 2002 (MGD)
F = conversion factor

Table 28. Phosphorus Discharges for Minor Facilities

Facility TMDL Load	Swift Eckrich 2.4 kg/day		Carey 3.4 kg/day		Attica 0.8 kg/day		Bloomville 0.45 kg/day	
Year	P_{eff}	Load	P_{eff}	Load	P_{eff}	Load	P_{eff}	Load
1998	40.4	11.4	3.8	6.8	1.5	1.0	2.8	0.6
1999	21.9	6.2	3.1	5.5	1.6	1.1	2.5	0.5
2000	16.7	4.7	2.7	4.8	1.5	1.0	2.3	0.5
2001	13.0	3.7	3.0	5.4	1.8	1.2	2.7	0.6
2002	12.5	3.5	4.9	8.7	2.8	1.9	3.2	0.7

Load (kg/day) = P_{eff} x Q_{eff} x F
P_{eff} = median daily effluent phosphorus concentration (mg/l)
Q_{eff} = 5 year median daily effluent flow rate, 1998 - 2002 (MGD)
F = conversion factor

Table 29. Phosphorus Limits for Minor Dischargers

Facility	Parameter	Season	Concentration (mg/l)		Load (kg/d)		Basis[1]
			Monthly	Weekly	Monthly	Weekly	
Swift Ekrich, Inc. Permit No. 2IH00088	Total Phosphorus	Annual	4.0	6.0[2]	2.4	3.6[2]	TMDL
Village of Carey Permit No. 2PD00038	Total Phosphorus	Annual	1.0	1.5	3.4	5.2	TMDL
Village of Attica Permit No. 2PB00001	Total Phosphorus	Annual	1.0	1.5	0.8	1.1	TMDL
Village of Bloomville Permit No. 2PB00053	Total Phosphorus	Annual	1.2	1.8	0.45	0.7	TMDL

[1] TMDL = Total Maximum Daily Load for the Upper Sandusky River
[2] These quantities are daily maximum values, not 7-day averages.

Combined sewer overflows (CSOs) have been identified as sources of impairment in several assessment units. Beyond the findings of this TMDL study, the control of CSOs is required by the *Wet Weather Water Quality Act of 2000*, and the components of an acceptable CSO control program are included in the national *Combined Sewer Overflow Control Policy* (U.S. EPA., April 1994).

Crestline

The Village of Crestline has one CSO. The Villages current NPDES permit requires it to implement the nine minimum control measures for CSOs that are required by the national *CSO Control Policy*. Upon renewal, the Village's NPDES permit will include a compliance schedule to develop and submit a long-term CSO control plan (LTCP). The LTCP will include an implementation schedule. When the LTCP is approved by the Director, implementation will be required either through the NPDES permit or some other enforceable mechanism.

Bucyrus

Bucyrus has 22 CSOs. The City's current NPDES permit requires it to implement the nine minimum control measures for CSOs that are required by the national *CSO Control Policy*. In November 2000, the City submitted an LTCP, which Ohio EPA determined to be inadequate. The Agency currently is considering options for requiring the City to revise and resubmit an approvable long-term CSO control plan. When an LTCP is approved by the Director, implementation will be required either through the NPDES permit or some other enforceable mechanism.

Upper Sandusky

Upper Sandusky has 4 CSOs. The City's current NPDES permit requires it to implement the nine minimum control measures for CSOs that are required by the national *CSO Control Policy*. The City received a $588,000 loan through the Water Pollution Control Loan Fund for various sanitary sewer projects, including a combined sewer separation project. When it is renewed, the City's NPDES permit will include a compliance schedule to develop and submit a long-term CSO control plan (LTCP). The LTCP will include an implementation schedule. When the LTCP is approved by the Director, implementation will be required either through the NPDES permit or some other enforceable mechanism.

Tiffin

Tiffin has 30 CSOs. The City's current NPDES permit requires it to implement the nine minimum control measures for CSOs that are required by the national *CSO Control Policy*. In January 2002, the Tiffin City Council approved a phased plan for separating its combined sewers. When it is renewed, the City's NPDES permit will include a compliance schedule to develop and submit a long-term CSO control plan (LTCP). The LTCP will include an implementation schedule. When the LTCP is approved by the Director, implementation will be required either through the NPDES permit or some other enforceable mechanism.

6.1.3.2 Agriculture

The Sandusky 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 non-point sources of pollution significantly, and efforts in this direction continue. However, non-point contributions of sediment and nutrients from agriculture are high. Livestock production has been a source of manure spills, and livestock access to streams is a source of stream bank erosion in several subwatersheds. 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. A current 319 grant was awarded for FY02 and has made excellent progress in delivering cost share for agricultural BMPs in the upper Sandusky watershed. Livestock Environmental Assurance Program, CREP, and other 2002 Farm Bill programs.

6.1.3.3 Habitat Alteration and Hydromodification

A lack of instream and streamside habitat and low water levels in small headwater streams has caused multiple impairments in the Sandusky River and tributary streams. Unlike sediment and nutrient reductions from crop land, the solutions for these problems will not be simple BMPs that currently have incentive programs. Improved habitat will rely on long term changes and social acceptance of new trends in agricultural drainage practices. Implementation actions could include:

- Adopt changes to the Ohio Drainage Laws that restrict streams being put on permanent maintenance programs
- Promote one sided ditch maintenance and filter strips to reduce the frequency of maintenance on petition ditches
- Limit on water withdrawals below prescribed base stream flows
- Promote wetlands to provide storage of floodwater and groundwater recharge
- Adoption of riparian protection ordinances that prevent flood plain encroachment and riparian removal
- Ordinances to protect and extend the Ohio Scenic River designation
- Removal of St. John’s dam (completed November 2003) and evaluation of other dams
- Flow augmentation.

6.1.3.4 Home Sewage Treatment System Management

Septic systems impact water quality in the upper Sandusky River watershed through both point and nonpoint discharges from failed, faulty, or discharging systems. Implementation actions to address these sources of pollution would include, identification and replacement of faulty septic systems, elimination of on-site septic systems through extension of municipal sanitary sewers, and public education on septic system maintenance. HSTS plans have been developed for five counties in the watershed. A Section 319 grant proposal was submitted for FY04 funding to address replacement of septic systems in seven critical areas in the watershed. A recommendation to fund this grant is awaiting approval of the Director of Ohio EPA and U.S. EPA.

6.1.3.5 Storm Water Management

In the upper Sandusky watershed, sources of stream impairment may include discharges from Phase II MS4s and storm water dischargers from both Phase I and II Industrial and Construction activities. An MS4 is any public entity (village, township, ODOT, turnpike, college, park district, military base, etc.) that owns or operates a separate storm sewer system. Implementation actions could include drafting ordinances for storm water and sediment and erosion control, and expanding existing programs (i.e. Soil and Water Conservation Districts (SWCDs) to include storm water monitoring. Public education, such as developing an adult education program about storm water pollution, would be an important and necessary part of the implementation plan.

6.1.3.6 Public Education

The SRWC has had an education and special events subcommittee since April 2000. This subcommittee should be expanded to focus on general NPS/watershed related education programs to increase public awareness about the resource. This Committee would continue to inform the public to help them understand the importance of water resources in their watershed, and what we know about the current condition and problems in the watershed. They can develop programs and information that will help local landowners and public officials understand why people should care, and what they can do to help reduce the impairments and restore the Sandusky River. The primary focus would be building public awareness about the value of a healthy watershed and the importance of reducing/eliminating these sources of pollution.

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 in-stream water quality chemical monitoring. This sampling will be done at a minimum by certain 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 Sandusky River Watershed Coalition 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 SRWC work with the Ohio EPA to develop a plan and locate resources for establishing and maintaining a volunteer monitoring program in the watershed. Ohio EPA should support efforts by the Coalition and partners such as Heidelberg to compete for funding of a water quality monitoring program to support their watershed action plan.

A biological and water quality study of the upper Sandusky River, similar to that conducted by the Ohio EPA in 2001 will be scheduled when 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 SRWC or other appropriate parties would be needed to keep the implementation activities on schedule. Once the majority of 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.

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