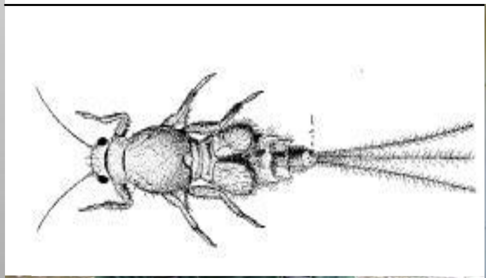
State of Ohio
Environmental Protection Agency

Division of Surface Water

Biological and Water Quality Study of Swan Creek and Selected Tributaries 2006

Watershed Assessment Units 04100009 070, and 04100009 080.

Fulton and Lucas Counties



OHIO EPA Technical Report EAS/2008-12-11

March 20, 2009

Ted Strickland, Governor, State of Ohio
Chris Korleski, Director

Biological and Water Quality Study of the Swan Creek Watershed 2006

Lucas and Fulton
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NOTICE TO USERS

Ohio EPA incorporated biological criteria into the Ohio Water Quality Standards (WQS; Ohio Administrative Code 3745-1) regulations in February 1990 (effective May 1990). These criteria consist of numeric values for the Index of Biotic Integrity (IBI) and Modified Index of Well-Being (MIwb), both of which are based on fish assemblage data, and the Invertebrate Community Index (ICI), which is based on macroinvertebrate assemblage data. Criteria for each index are specified for each of Ohio's five ecoregions (as described by Omernik 1987), and are further organized by organism group, index, site type, and aquatic life use designation. These criteria, along with the existing chemical and whole effluent toxicity evaluation methods and criteria, figure prominently in the monitoring and assessment of Ohio's surface water resources.

The following documents support the use of biological criteria by outlining the rationale for using biological information, the methods by which the biocriteria were derived and calculated, the field methods by which sampling must be conducted, and the process for evaluating results:

Ohio Environmental Protection Agency. 1987a. Biological criteria for the protection of aquatic life: Volume I. The role of biological data in water quality assessment. Div. Water Qual. Monit. & Assess., Surface Water Section, Columbus, Ohio.

Ohio Environmental Protection Agency. 1987b. Biological criteria for the protection of aquatic life: Volume II. Users manual for biological field assessment of Ohio surface waters. Div. Water Qual. Monit. & Assess., Surface Water Section, Columbus, Ohio.

Ohio Environmental Protection Agency. 1989a. Addendum to Biological criteria for the protection of aquatic life: Volume II. Users manual for biological field assessment of Ohio surface waters. Div. Water Qual. Plan. & Assess., Ecol. Assess. Sect., Columbus, Ohio.

Ohio Environmental Protection Agency. 1989b. Biological criteria for the protection of aquatic life: Volume III. Standardized biological field sampling and laboratory methods for assessing fish and macroinvertebrate communities. Div. Water Quality Plan. & Assess., Ecol. Assess. Sect., Columbus, Ohio.

Ohio Environmental Protection Agency. 1990. The use of biological criteria in the Ohio EPA surface water monitoring and assessment program. Div. Water Qual. Plan. & Assess., Ecol. Assess. Sect., Columbus, Ohio.

Rankin, E.T. 1989. The qualitative habitat evaluation index (QHEI): rationale, methods, and application. Div. Water Qual. Plan. & Assess., Ecol. Assess. Sect., Columbus, Ohio.

Since the publication of the preceding guidance documents, the following new publications by the Ohio EPA have become available. These publications should also be consulted as they represent the latest information and analyses used by the Ohio EPA to implement the biological criteria.

DeShon, J.D. 1995. Development and application of the invertebrate community index (ICI), pp. 217-243. in W.S. Davis and T. Simon (eds.). Biological Assessment and Criteria: Tools for Risk-based Planning and Decision Making. Lewis Publishers, Boca Raton, FL.

Ohio Environmental Protection Agency. 2008a. 2008 Updates to Biological criteria for the protection of aquatic life: Volume II and Volume II Addendum. Users manual for biological field assessment of Ohio surface waters. Div. of Surface Water, Ecol. Assess. Sect., Groveport, Ohio.

Ohio Environmental Protection Agency. 2008b. 2008 Updates to Biological criteria for the protection of aquatic life: Volume III. Standardized biological field sampling and laboratory methods for assessing fish and macroinvertebrate communities. Div. of Surface Water, Ecol. Assess. Sect., Groveport, Ohio.

Ohio Environmental Protection Agency. 2006a. Methods for assessing habitat in flowing waters: Using the Qualitative Habitat Evaluation Index (QHEI). Ohio EPA Tech. Bull. EAS/2006-06-1. Revised by the Midwest Biodiversity Institute for Div. of Surface Water, Ecol. Assess. Sect., Groveport, Ohio.

Rankin, E. T. 1995. The use of habitat assessments in water resource management programs, pp. 181-208. in W. Davis and T. Simon (eds.). Biological Assessment and Criteria: Tools for Water Resource Planning and Decision Making. Lewis Publishers, Boca Raton, FL.

Yoder, C.O. and E.T. Rankin. 1995. Biological criteria program development and implementation in Ohio, pp. 109-144. in W. Davis and T. Simon (eds.). Biological Assessment and Criteria: Tools for Water Resource Planning and Decision Making. Lewis Publishers, Boca Raton, FL.

Yoder, C.O. and E.T. Rankin. 1995. Biological response signatures and the area of degradation value: new tools for interpreting multimetric data, pp. 263-286. in W. Davis and T. Simon (eds.). Biological Assessment and Criteria: Tools for Water Resource Planning and Decision Making. Lewis Publishers, Boca Raton, FL.

Yoder, C.O. 1995. Policy issues and management applications for biological criteria, pp. 327-344. in W. Davis and T. Simon (eds.). Biological Assessment and Criteria: Tools for Water Resource Planning and Decision Making. Lewis Publishers, Boca Raton, FL.

Yoder, C.O. and E.T. Rankin. 1995. The role of biological criteria in water quality monitoring, assessment, and regulation. Environmental Regulation in Ohio: How to Cope With the Regulatory Jungle. Inst. of Business Law, Santa Monica, CA. 54 pp.

These documents and this report may be obtained by writing to:

Ohio EPA, Division of Surface Water
Ecological Assessment Section
4675 Homer Ohio Lane
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(614) 836-8772

Acknowledgments

The following Ohio EPA staff members are acknowledged for their contribution to this report:

Study Area Description – Cherie Blair
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Copies of this report are located on the Ohio EPA internet web page (www.epa.state.oh.us/dsw/document_index/psdindx.html) or may be available on CD from:

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FOREWORD

What is a Biological and Water Quality Survey?

A biological and water quality survey, or "biosurvey", is an interdisciplinary monitoring effort coordinated on a waterbody specific or watershed scale. This effort may involve a relatively simple setting focusing on one or two small streams, one or two principal stressors, and a handful of sampling sites or a much more complex effort including entire drainage basins, multiple and overlapping stressors, and tens of sites. Each year Ohio EPA conducts biosurveys in 4-5 study areas with an aggregate total of 350-400 sampling sites.

The Ohio EPA employs biological, chemical, and physical monitoring and assessment techniques in biosurveys in order to meet three major objectives: 1) determine the extent to which use designations assigned in the Ohio Water Quality Standards (WQS) are either attained or not attained; 2) determine if use designations assigned to a given water body are appropriate and attainable; and 3) determine if any changes in key ambient biological, chemical, or physical indicators have taken place over time, particularly before and after the implementation of point source pollution controls or best management practices. The data gathered by a biosurvey is processed, evaluated, and synthesized in a biological and water quality report. Each biological and water quality study contains a summary of major findings and recommendations for revisions to WQS, future monitoring needs, or other actions which may be needed to resolve existing impairment of designated uses. While the principal focus of a biosurvey is on the status of aquatic life uses, the status of other uses such as recreation and water supply, as well as human health concerns, are also addressed.

The findings and conclusions of a biological and water quality study may factor into regulatory actions taken by Ohio EPA (*e.g.*, NPDES permits, Director's Orders, the Ohio Water Quality Standards [OAC 3745-1], Water Quality Permit Support Documents [WQPSDs]), and are eventually incorporated into State Water Quality Management Plans, the Ohio Nonpoint Source Assessment, and the biennial Integrated Water Quality Monitoring and Assessment Report (305[b] and 303[d]).

Hierarchy of Indicators

A carefully conceived ambient monitoring approach, using cost-effective indicators consisting of ecological, chemical, and toxicological measures, can ensure that all relevant pollution sources are judged objectively on the basis of environmental results. Ohio EPA relies on a tiered approach in attempting to link the results of administrative activities with true environmental measures. This integrated approach includes a hierarchical continuum from administrative to true environmental indicators (Fig. 1). The six "levels" of indicators include: 1) actions taken by regulatory agencies (permitting, enforcement, grants); 2) responses by the regulated community (treatment works, pollution prevention); 3) changes in discharged quantities (pollutant loadings); 4) changes in ambient conditions (water quality, habitat); 5) changes in uptake and/or

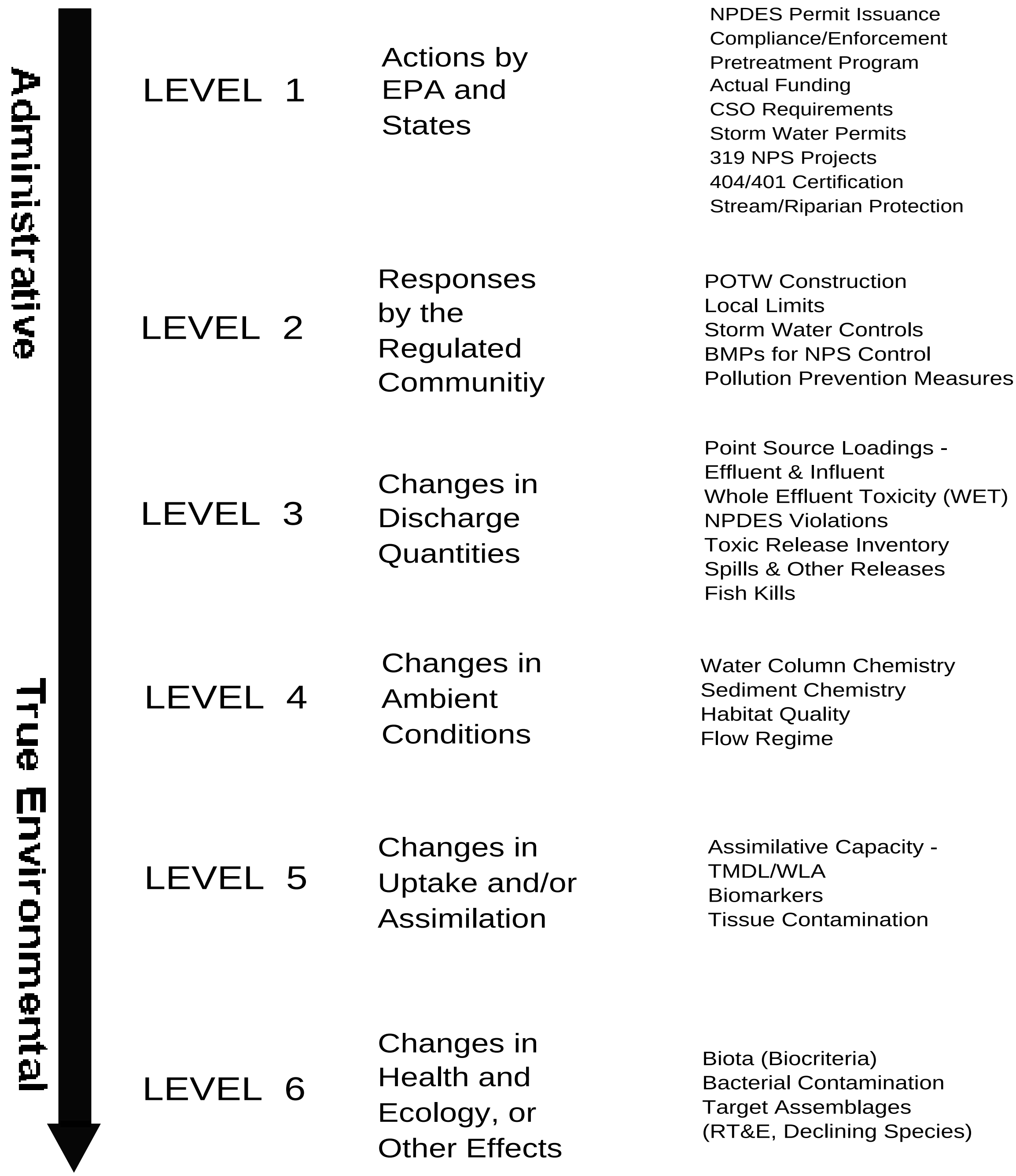

Figure 1. . Hierarchy of administrative and environmental indicators which can be used for water quality management activities such as monitoring and assessment, reporting, and the evaluation of overall program effectiveness. This is patterned after a model developed by the U.S. EPA.

assimilation (tissue contamination, biomarkers, wasteload allocation); and, 6) changes in health, ecology, or other effects (ecological condition, pathogens). In this process the results of administrative activities (levels 1 and 2) can be linked to efforts to improve water quality (levels 3, 4, and 5) which should translate into the environmental "results" (level 6). Thus, the aggregate effect of billions of dollars spent on water pollution control since the early 1970s can now be determined with quantifiable measures of environmental condition. Superimposed on this hierarchy is the concept of stressor, exposure, and response indicators. *Stressor* indicators generally include activities which have the potential to degrade the aquatic environment such as pollutant discharges (permitted and unpermitted), land use effects, and habitat modifications. *Exposure* indicators are those which measure the effects of stressors and can include whole effluent toxicity tests, tissue residues, and biomarkers, each of which provides evidence of biological exposure to a stressor or bioaccumulative agent. *Response* indicators are generally composite measures of the cumulative effects of stress and exposure and include the more direct measures of community and population response that are represented here by the biological indices which comprise Ohio's biological criteria. Other response indicators could include target assemblages, *i.e.,* rare, threatened, endangered, special status, and declining species or bacterial levels which serve as surrogates for the recreation uses. These indicators represent the essential technical elements for watershed-based management approaches. The key, however, is to use the different indicators *within* the roles which are most appropriate for each.

Describing the causes and sources associated with observed impairments revealed by the biological criteria and linking this with pollution sources involves an interpretation of multiple lines of evidence including water chemistry data, sediment data, habitat data, effluent data, biomonitoring results, land use data, and biological response signatures within the biological data itself. Thus the assignment of principal causes and sources of impairment represents the association of impairments (defined by response indicators) with stressor and exposure indicators. The principal reporting venue for this process on a watershed or subbasin scale is a biological and water quality report. These reports then provide the foundation for aggregated assessments such as the Integrated Water Quality Monitoring and Assessment Report (305[b] and 303[d]), the Ohio Nonpoint Source Assessment, and other technical bulletins.

Ohio Water Quality Standards: Designated Aquatic Life Use

The Ohio Water Quality Standards (WQS; Ohio Administrative Code 3745-1) consist of designated uses and chemical, physical, and biological criteria designed to represent measurable properties of the environment that are consistent with the goals specified by each use designation. Use designations consist of two broad groups, aquatic life and non-aquatic life uses. In applications of the Ohio WQS to the management of water resource issues in Ohio's rivers and streams, the aquatic life use criteria frequently result in the most stringent protection and restoration requirements, hence their emphasis in biological and water quality reports. Also, an emphasis on protecting for aquatic life generally results in water quality suitable for all uses. The five different aquatic life uses currently defined in the Ohio WQS are described as follows:

1) *Warmwater Habitat (WWH)* - this use designation defines the "typical" warmwater assemblage of aquatic organisms for Ohio rivers and streams; *this use represents the principal restoration target for the majority of water resource management efforts in Ohio.*

2) *Exceptional Warmwater Habitat (EWH)* - this use designation is reserved for waters which support "unusual and exceptional" assemblages of aquatic organisms which are characterized by a high diversity of species, particularly those which are highly intolerant and/or rare, threatened, endangered, or special status (*i.e.*, declining species); *this designation represents a protection goal for water resource management efforts dealing with Ohio's best water resources.*

3) *Coldwater Habitat (CWH)* - this use is intended for waters which support assemblages of cold water organisms and/or those which are stocked with salmonids with the intent of providing a put-and-take fishery on a year round basis which is further sanctioned by the Ohio DNR, Division of Wildlife; this use should not be confused with the Seasonal Salmonid Habitat (SSH) use which applies to the Lake Erie tributaries which support periodic "runs" of salmonids during the spring, summer, and/or fall.

4) *Modified Warmwater Habitat (MWH)* - this use applies to streams and rivers which have been subjected to extensive, maintained, and essentially permanent hydromodifications such that the biocriteria for the WWH use are not attainable *and where the activities have been sanctioned by state or federal law;* the representative aquatic assemblages are generally composed of species which are tolerant to low dissolved oxygen, silt, nutrient enrichment, and poor quality habitat.

5) *Limited Resource Water (LRW)* - this use applies to small streams (usually <3 mi^2 drainage area) and other water courses which have been irretrievably altered to the extent that no appreciable assemblage of aquatic life can be supported; such waterways generally include small streams in extensively urbanized areas, those which lie in watersheds with extensive drainage modifications, those which completely lack water on a recurring annual basis (*i.e.*, true ephemeral streams), or other irretrievably altered waterways.

Chemical, physical, and/or biological criteria are generally assigned to each use designation in accordance with the broad goals defined by each. As such the system of use designations employed in the Ohio WQS constitutes a "tiered" approach in that varying and graduated levels of protection are provided by each. This hierarchy is especially apparent for parameters such as dissolved oxygen, ammonia-nitrogen, temperature, and the biological criteria. For other parameters such as heavy metals, the technology to construct an equally graduated set of criteria has been lacking, thus the same water quality criteria may apply to two or three different use designations.

Ohio Water Quality Standards: Non-Aquatic Life Uses

In addition to assessing the appropriateness and status of aquatic life uses, each biological and water quality survey also addresses non-aquatic life uses such as recreation, water supply, and human health concerns as appropriate. The recreation uses most applicable to rivers and streams are the Primary Contact Recreation (PCR) and Secondary Contact Recreation (SCR) uses. The criterion for designating the PCR use can be having a water depth of at least one meter over an area of at least 100 square feet or, lacking this, where frequent human contact is a reasonable expectation. If a water body does not meet either criterion, the SCR use applies. The attainment status of PCR and SCR is determined using bacterial indicators (*e.g.*, fecal coliform, *E. coli)* and the criteria for each are specified in the Ohio WQS.

Attainment of recreation uses are evaluated based on monitored bacteria levels. The Ohio Water Quality Standards state that all waters should be free from any public health nuisance associated with raw or poorly treated sewage (Administrative Code 3745-1-04, Part F). Additional criteria (Administrative Code 3745-1-07) apply to waters that are designated as suitable for full body contact such as swimming (PCR- primary contact recreation) or for partial body contact such as wading (SCR- secondary contact recreation). These standards were developed to protect human health, because even though fecal coliform bacteria are relatively harmless in most cases, their presence indicates that the water has been contaminated with fecal matter.

Water supply uses include Public Water Supply (PWS), Agricultural Water Supply (AWS), and Industrial Water Supply (IWS). Public Water Supplies are simply defined as segments within 500 yards of a potable water supply or food processing industry intake. The AWS and IWS use designations generally apply to all waters unless it can be clearly shown that they are not applicable. An example of this would be an urban area where livestock watering or pasturing does not take place, thus the AWS use would not apply. Chemical criteria are specified in the Ohio WQS for each use and attainment status is based primarily on chemical-specific indicators. Human health concerns are additionally addressed with fish tissue data, but any consumption advisories are issued by the Ohio Department of Health.

INTRODUCTION

As part of the Total Maximum Daily Load (TMDL) effort and the five year basin approach to monitoring, assessment, and the issuance of National Pollution Discharge Elimination System (NPDES) permits, ambient biological, water column chemical, sediment, and fish tissue sampling was conducted in the Swan Creek watershed from June through October, 2006. The entire 40 miles of Swan Creek and every major tributary were included in the study area. Sample site locations and details are listed in Table 1.

Objectives of the study were to:

1) Monitor and assess the chemical, physical and biological integrity of water bodies within the Swan Creek Watershed,

2) Evaluate the physical conditions in streams listed in the study plan to identify their potential to support aquatic biological communities,

3) Characterize the amount of aquatic resource degradation attributable to various land uses including agricultural practices, suburban community development, and urban expansion,

4) Evaluate the biological potential to support the WWH use designation, and

5) Determine any aquatic impacts from known point sources including wastewater treatment plants (WWTPs), and from unsewered communities.

The findings of this evaluation may factor into regulatory actions taken by the Ohio EPA (e.g., NPDES permits, Director's Orders, or the Ohio Water Quality Standards (OAC 3745-1)), and may eventually be incorporated into State Water Quality Management Plans, the Ohio Nonpoint Source Assessment, and the biennial Integrated Water Quality Monitoring and Assessment Report (305[b] and 303[d] report).

Table 1. Sample sites for the Swan Creek basin and lower Maumee River tributaries, 2006.

RIVER_CODE	RIVER	RM	LOCATION	DRAINAGE_Area	LATITUDE_D	LONGITUDE_	USGS_QUAD	SAMPLING
04-003-000	Swan Creek	40.68	Fulton Co. Rd. 6-1	7.5	41.6061	-83.9828	Swanton	F, Mq, C, P
04-003-000	Swan Creek	34.41	Fulton Co. Rd. 3	14.6	41.5615	-83.9213	Swanton	F, Mq, C, P
04-003-000	Swan Creek	32.82	TWP Rd 2.	25.7	41.5546	-83.9019	Swanton	F, M, C, OC, S, P
04-003-000	Swan Creek	30.90	Upst. St. Rt. 64 (drive into facility)	28.2	41.5679	-83.8748	Swanton	F, M, C, P
04-003-000	Swan Creek	25.99	@ ST. RT. 295	88.0	41.5381	-83.825	Whitehouse	C, P
04-003-000	Swan Creek	24.70	@Spencer Rd	89.0	41.5336	-83.8069	Whitehouse	F, M, C, P
04-003-000	Swan Creek	21.60	NE of Whitehouse @ Stitt R	140.0	41.5372	-83.7678	Whitehouse	F, M, C, P, FT
04-003-000	Swan Creek	18.50	Monclova @ Albon	146.0	41.5581	-83.7367	Maumee	F, M, C, P
04-003-000	Swan Creek	15.30	Upst. Salsibury Rd.	160.0	41.5833	-83.7028	Maumee	F, M, C, P, FT
04-003-000	Swan Creek	10.84	St Rt 20/ Reynolds Rd	192.0	41.6114	-83.6647	Maumee	F, M, C, P
04-003-000	Swan Creek	6.00	Adj. Arlington Ave	199.0	41.6228	-83.5365	Rossford	C, OC, S, P
04-003-000	Swan Creek	4.40	Upst. South Ave	200.0	41.6297	-83.5883	Toledo	F, M
04-003-000	Swan Creek	4.20	Dst. South Avenue	200.0	41.6306	-83.5875	Toledo	F, M, C, OC, S, P
04-003-000	Swan Creek	1.58	@ City Park Avenue	203.0	41.6414	-83.5575	Toledo	F, M, C, OC, S, P
04-003-000	Swan Creek	1.0	Adj. Erie St. Market	203.5	41.64194	-83.54694	Toledo	FT
04-003-000	Swan Creek	0.19	OC Bridge	204.0	41.6464	-83.5365	Toledo	OC, S, P
04-098-000	Heilman Ditch	1.76	St Rt 20/Conant Rd	10.8	41.5782	-83.6624	Maumee	C, Mq. P
04-003-002	Blystone Ditch	0.54	Monclova Rd.	6.5	41.5590	-83.7248	Maumee	F, Mq, C, P
04-003-003	Fewless Creek	1.80	Fulton County Rd. 4 (Utah)	5.9	41.5500	-83.9407	Swanton	F, Mq, C, P
04-004-000	Wolf Creek	4.06	Albon Rd.	7.9	41.6064	-83.7375	Maumee	F, Mq, C, P
04-004-000	Wolf Creek	1.96	Perrysburg-Holland Rd.	12.9	41.6106	-83.7034	Maumee	F, Mq, C, P
04-004-000	Wolf Creek	0.48	Holland-Sylvania Rd.	26.1	41.6094	-83.6842	Maumee	F, M, C, OC, S, P
04-005-000	Cairl Creek	1.32	Pilliad Rd.	10.6	41.6072	-83.6995	Maumee	F, Mq, C, P
04-006-000	Blue Creek	9.97	Fulton Co. Rd. 3	7.4	41.4928	-83.9026	Colton	Mq, C, P
04-006-000	Blue Creek	7.80	Manore Rd.	12.9	41.4953	-83.8557	Grand Rapids	F, Mq, C, P
04-006-000	Blue Creek	5.57	St. Rt. 295	27.0	41.4947	-83.8266	Grand Rapids	F, M, C, P
04-006-000	Blue Creek	0.73	Finzel Rd.	44.5	41.5269	-83.7810	Whitehouse	F, M, C, OC, S, P
04-008-000	Harris Ditch	1.55	St. Rt. 295	7.7	41.4786	-83.8263	Grand Rapids	F, Mq, C, P
04-010-000	Ai Creek	10.44	Co. Rd. L (in town of Ai)	6.8	41.6284	-83.9365	Assumption	F, Mq, C, P
04-010-000	Ai Creek	8.29	Co. Rd. L (east of town of Ai)	12.5	41.6284	-83.9253	Assumption	F, Mq, C, P
04-010-000	Ai Creek	3.50	Swanton WWTP effluent	17.5	41.5910	-83.9022	Swanton	C, OC, P, E

Table 1.
Continued

RIVER_CODE	RIVER	RM	LOCATION	DRAINAGE_Area	LATITUDE_D	LONGITUDE_	USGS_QUAD	SAMPLING
04-010-000	Ai Creek	2.10	Scott Rd.	19.5	41.5877	-83.8633	Whitehouse	F, Mq, C, P
04-010-000	Ai Creek	1.66	St. Rt. 2	49.3	41.5826	-83.8611	Whitehouse	F, M, C, OC, S, P

Table Key

Sites

Grey=Historical Site

White=Geometric Site

Sampling Methods

M	Macroinvertebrate quantitative
Mq	Macroinvertebrate qualitative
C	Water Chemistry
OC	Water Chemistry Organics
E	WWTP effluent chemistry
S	Sediment chemistry
P	Pathogen
FT	Fish Tissue

Summary

The Swan Creek Watershed is a valuable natural resource that provides a wide variety of uses. It serves as a drinking water resource in the town of Swanton. Swan Creek is ecologically important throughout its drainage and has special ecological importance within the reaches buffered by metro parks such as Oak Openings, having rare and endangered plant species. Fishing and other recreational opportunities occur mostly in the lower portions of the watershed.

Study Sites and Aquatic Life Use Attainment

The 2006 watershed study consisted of 33 sites sampled from 9 streams in the Swan Creek basin. Ambient biology, physical habitat quality, water column chemistry, bacteriological, and fish tissue data were collected (Table 1). Twenty six sites were sampled for water chemistry, pathogens, physical habitat, and both fish and macroinvertebrate community health. Twenty seven percent (7 sites) of those study sites did not attain their designated or recommended aquatic life uses. Fifty eight percent (15 sites) partially attained designated or recommended aquatic life uses. Only four study sites (15%) fully met their designated WWH aquatic life uses (Table 3, pg. 10). Water chemistry and pathogen sampling was conducted at 32 total sites. Results from this sampling yielded E. coli exceedances at every stream site in the watershed.

Pollution Issues

In this historically forested and wetland buffered low gradient watershed the development of residential communities, industry, agriculture, hydromodifications, and other anthropogenic alterations have had severe impacts to the water quality. Unsafe E.coli levels throughout the watershed were detected which are attributed to failing septic systems, CSO's, and poorly treated WWTP effluent. In the upper portion of the watershed tiled fields and ditches exported silt, sediment and nutrients downstream by torrent flows from rain events (ordinary rain events washing downstream at extraordinary velocities in the absence of buffers and the amplified addition of tiled fields and straightened ditches). Torrent flows were further amplified in the middle and lower reaches of the watershed by the additional impervious surfaces and storm water drainages associated with urbanization which had scoured the stream channel and created deeply incised banks. As Swan Creek flowed beyond the South Avenue dam (RM 4.4) it received effluent from Toledo CSO's and additional storm water drainage before flowing into the Maumee River.

Improvements

Large improvements in water quality were made between the mid to late 1980's with tighter restrictions placed on point source effluent limits in the Swan Creek watershed. In the past 16 years water quality has been steadily improving; however, the overall quality of the Swan Creek watershed is still poor. Careful planning to limit environmental impacts from future development in the watershed is critical in maintaining the current conditions of the watershed. Riparian habitat, sewage treatment, and storm water improvements need to be made in order to restore good water quality.

Recommendations

Once a watershed's condition has been studied and any impairments identified, it is useful to examine ways to correct the problems. In this section, some general recommendations for the Swan Creek watershed are discussed. More specific, quantified recommendations may result from the Total Maximum Daily Load project.

Recommendations are not limited to this chapter. Recommendations for changes at specific locations that would benefit stream resource quality (for example, riparian and streamside buffer practices and landuse changes) are interspersed throughout this document. Another type of recommendation, pertaining specifically to revisions to stream use designations, are contained in the stream use designation section, pg. 7.

Manage Storm Water

The Swan Creek watershed and the overall water quality downstream to the Maumee River is directly affected by storm water drainage and the ways the watershed is buffered from precipitation events. Reduction of sediment, nutrients, fertilizers/chemicals, erosion, and hydrologic modifications can be accomplished through proper storm water management. Agricultural drainage was responsible for storm water pollution in the upper portion of the watershed and impervious surfaces (urbanization) were responsible in the middle and lower portions of the watershed.

Not only is the Swan Creek watershed affected by improper storm water management, but the Maumee River and Lake Erie also receive the influx of pollutants as well. Sediment, nutrients and algae blooms are problematic in the western basin of Lake Erie. Coincidentally the watershed in the western basin was historically forests and wetlands. Currently the western basin is principally drained by tiled fields and ditches exporting sediments and nutrients into the lake. Eliminating agriculture and residences in this area, obviously, is not the answer, nor is it a reasonable idea. Re-establishing natural riparian buffers (wetland and treed riparian corridors) in the watershed to help slow storm water and filter pollutants before they reach the surface waters is the correct action in reducing storm water pollution.

In addition to restoring riparian buffers an effort should be made to take advantage of the streams natural assimilative capacities. Natural development of stream channels provide an array of beneficial services: settling fine sediments into adjacent floodplains, processing of nutrients into productive biomass instead of nuisance algae, improved water quality, creation of natural instream habitats to increase carrying capacity of biomass, and ultimately – and most importantly for adjacent landowners – evolution into a stable channel and the slowing of erosion.

Nutrient Enrichment and Bacteria

Nutrient enrichment was one of the biggest problems in the Swan Creek watershed detected in this study. Methodologies describing ways to reduce nutrient influx from the general landscape (agricultural drainage/ urban storm water) were described above. A variety of sources that contributed to nutrient enrichment were: failing home septic systems, CSO's (combined sewer overflows), WWTP's (waste water treatment plants) over application of fertilizer, and inadequate riparian buffers. The sources for these pollutants in each subwatershed were different and the resolutions to these problems will be tailored to benefit each issue.

High levels of fecal coliform and E. coli bacteria were found throughout the Swan Creek watershed and are a danger to human health. People can be exposed to contaminated water while wading, swimming, and fishing. Fecal coliform and E. coli 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, especially a problem if the feces contained pathogens or disease-producing bacteria and viruses. Reactions to exposure can range from a skin rash, sore throat or ear infection to more serious flu-like symptoms.

Through implementing the use of municipal WWTP's in communities having problematic septic systems and updating the capacity and technology of current WWTP's within the Swan Creek watershed many of the areas polluted by bacteria/E. coli can be remedied.

Improve Habitat Quality

Many headwater streams (>20 Mi.^{2} in drainage area) of the Swan Creek watershed have been physically altered. Some small water courses have been legally petitioned under the provisions of the County Ditch Law to facilitate drainage. They will be maintained in this condition in perpetuity or until their petitions are revoked. Other streams were altered by individual landowners or under provisions of older ditch laws. Regardless, channelization has lowered habitat quality in portions of the Swan Creek watershed.

In an effort to remedy these problems an effort should be made to restore these modified streams to their natural morphological state. Natural stream channels have a greater capacity to assimilate nutrients and fine sediments by flushing them into adjacent floodplains, processing nutrients into productive biomass rather than nuisance algae, improving water quality, creating diverse instream habitats, and ultimately – and most important for adjacent landowners – evolution into a stable channel. Many of the current causes and sources of stress within the watershed can be eliminated by allowing riparian land, water and vegetation to naturally evolve. Wherever possible, previous physical modifications should be undone (i.e., remove remaining dams, restore cutoff channels, restore wetlands, and move dikes and levees away from stream banks).

Use Designations

Aquatic life use designations for the Swan Creek watershed were evaluated during the 2006 field season as either Warm Water Habitat (WWH) or Limited Resource Water (LRW). Only three sample sites on Swan Creek and one on Blue Creek fully attained designated aquatic life uses. Four streams in the study area were previously undesignated (Blystone Ditch, Harris Ditch, Ai Creek, and Fewless Creek) and are recommended to be designated WWH. The biology in these four streams has the potential to meet WWH aquatic life use community standards. If partial and non-attainment pollution issues within these streams are remedied WWH standards may be attained (Table 3). WWH aquatic life uses were verified at four historically designated streams in the watershed (Swan Creek, Wolf Creek, Cairl Creek, and Blue Creek). A LRW aquatic life use was verified at Heilman Ditch (Table 2).

All waters within the study area are impaired entirely or for most of their length (Figure 2). A Primary Contact Recreation PCR use designation was historically assigned to Swan Creek, Wolf Creek, Cairl Creek, and Blue Creek and has been recommended for Blystone Ditch, Harris Ditch, Ai Creek, and Fewless Creek. Due to E.coli levels that exceeded the maximum threshold for human health in all of these stream segments these waters are unsafe for PCR (see chemistry section for further explanation).

Table 2. Stream use designations for water bodies in the Swan Creek watershed based on sampling conducted during 2006.

Use designations based on Ohio EPA biological field assessments appear as a plus sign (+). Use designations based on the 1978 and 1985 standards is displayed by an asterisk (*). Use designations based upon results other than Ohio EPA biological data are marked with a circle (o). The delta symbol (Δ) indicates a new use designation based upon the findings of this report.

Water Body Segment	Use Designations													Comments
		Aquatic Life Habitat						Water Supply			Recreation			
	SRW	WWH	EWH	MWH	SSH	CWH	LRW	PWS	AWS	IWS	BW	PCR	SCR	
Swan creek - at RM 30.84		+						o/+	*/+	*/+		*/+		PWS intake - Swanton
- all other segments		+							*/+	*/+		*/+		
Heilman ditch							+		+	+			+	Small drainageway maintenance
Blystone Ditch		Δ							Δ	Δ		Δ		Previously undesignated
Wolf creek		+							*/+	*/+		*/+		

Water Body Segment	**Use Designations**													**Comments**
		Aquatic Life Habitat						**Water Supply**			**Recreation**			
	SRW	**WWH**	**EWH**	**MWH**	**SSH**	**CWH**	**LRW**	**PWS**	**AWS**	**IWS**	**BW**	**PCR**	**SCR**	
Cairl creek (formerly Dry creek)		*							*/+	*/+		*/+		
Blue creek		+							*/+	*/+		*/+		
Mosquito Creek		*							*	*		*		
Harris Ditch (formerly South Swan Creek)		*/+							*/+	*/+		*/+		
Ai Creek		Δ							Δ	Δ		Δ		Previously undesignated
Fewless Creek		Δ							Δ	Δ		Δ		Previously undesignated

SRW = state resource water; WWH = warmwater habitat; EWH = exceptional warmwater habitat; MWH = modified warmwater habitat; SSH = seasonal salmonid habitat; CWH = coldwater habitat; LRW = limited resource water; PWS = public water supply; AWS = agricultural water supply; IWS = industrial water supply; BW = bathing water; PCR = primary contact recreation; SCR = secondary contact recreation.

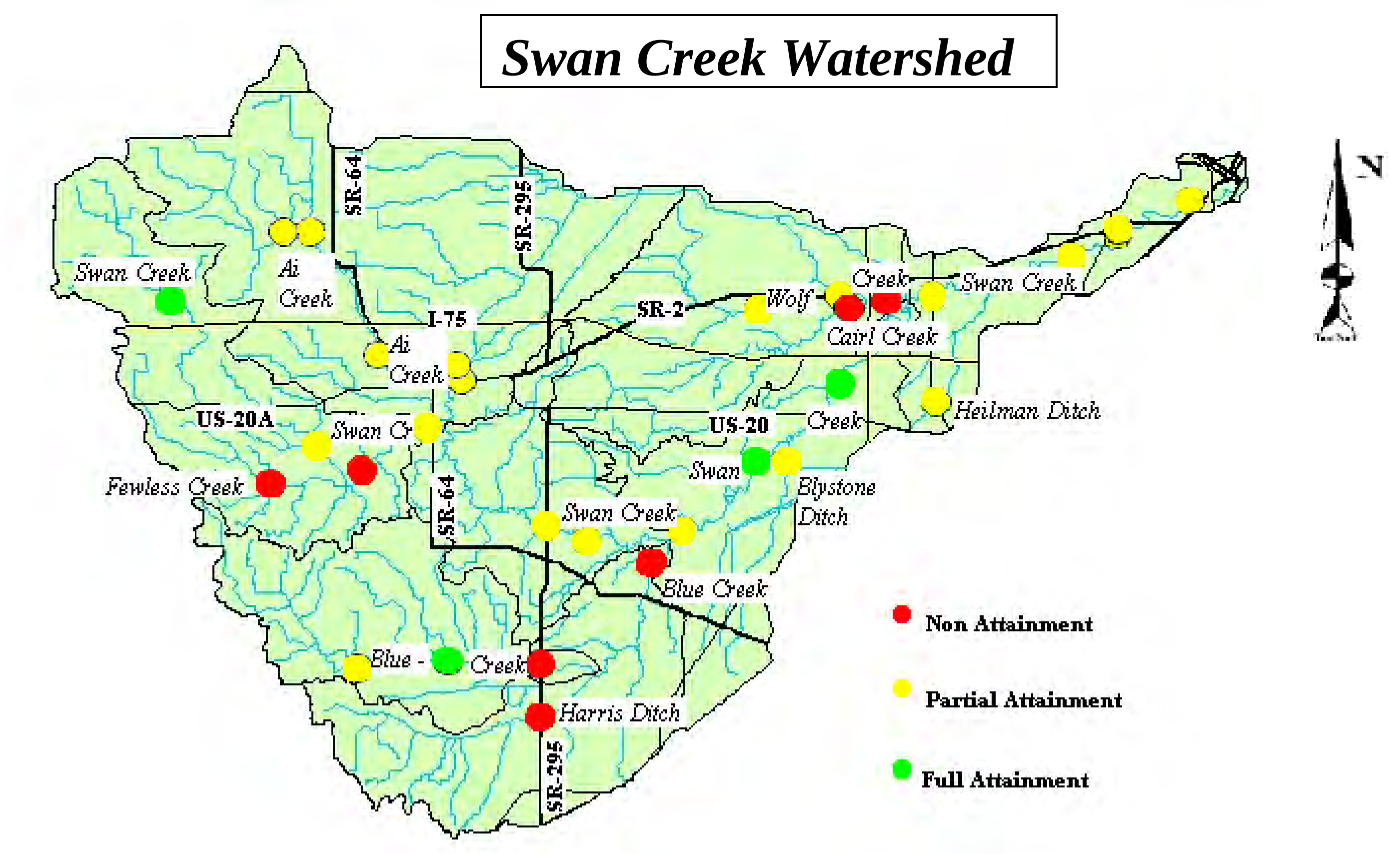

Figure 2. Aquatic life use attainment map for the 2006 Swan Creek watershed study, HUC's (04100009 070 and 04100009 080).

Aquatic Life Use Attainment Status and Trends

The overall aquatic life use attainment score for the upper Swan Creek watershed (HUC 04100009 070) was 4.1 and the middle and lower sections (HUC 04100009 080) scored 14.4. An overall attainment score of 0 would reflect 0 sites meeting designated or recommended aquatic life uses while a score of 100 would reflect all sites meeting designated or recommended aquatic life uses. This attainment score was calculated according to the protocol and procedures established in the 2008 Integrated Water Quality Monitoring and Assessment Report, which can be accessed at:
http://www.epa.state.oh.us/dsw/tmdl/2008IntReport/2008OhioIntegratedReport.html.

Twenty five percent (7 sites) of the study sites sampled did not attain their designated or recommended aquatic life uses (Table 3). Five of the seven sites in non attainment were a result of poor fish and macroinvertebrate community scores. Two of the sites not attaining their designated or recommended aquatic life uses resulted from very poor fish community scores. Fifty four percent (15 sites) of the study sites sampled partially attained designated or recommended aquatic life uses. Of these partially attaining sites, three resulted from poor fish community scores, eleven partially attained from poor macroinvertebrate community scores, and one site fell into partial attainment status due to both poor fish (low MIwb) and macroinvertebrate community scores. Four study sites (14%) fully met their respective designated or recommended aquatic life uses.

Table 3. Aquatic life use attainment status for stations sampled in the Swan Creek based on data collected June-October 2006. The Index of Biotic Integrity (IBI), Modified Index of well being (MIwb), and Invertebrate Community Index (ICI) are scores based on the performance of the biotic community. The Qualitative Habitat Evaluation Index (QHEI) is a measure of the ability of the physical habitat to support a biotic community.

River Mile Fish/Invertebate	IBI	MIwb	ICI	QHEI	Attainment Status	Causes	Sources
Swan Creek - (04003) HELP Ecoregion – WWH Existing							
40.7^{H}/40.6	28	NA	MG^{ns}	48	Full		
34.4^{H}	34	H	F*	44.5	Partial	Sedimentation/siltation, direct habitat alterations, nitrate/nitrite, bacteria-E. coli	Crop production with subsurface drainage, channelization, on site treatment systems
32.9^{W}	31^{ns}	5.2*	36	44.5	**NON**	Sedimentation/siltation, direct habitat alterations, nitrate/nitrite,	Crop production with subsurface drainage, onsite treatment systems

River Mile Fish/Invertebate	***IBI***	***MIwb***	***ICI***	***QHEI***	***Attainment Status***	***Causes***	***Sources***
						bacteria-E. coli	
30.9 W/31.0	36	5.9*	32 ns	43.5	Partial	Sedimentation/siltation, direct habitat alterations, nitrate/nitrite, bacteria-E. coli , lime sludge	Crop production with subsurface drainage, lime sludge discharge from Swanton WTP, on site treatment systems
24.7 W/24.6	35	6.4*	22*	40	Partial	Sedimentation/siltation, direct habitat alterations, bacteria-E. coli, nitrate/nitrite	Crop production, on site treatment systems
21.6 W/21.7	36	6.5*	36	41	Partial	Sedimentation/siltation, direct habitat alterations, nitrate/nitrite, bacteria-E. coli	Crop production with subsurface drainage, sewage discharges in unsewered areas, SSO's
18.5 W	41	6.4*	38	66.5	Partial	Nitrate/nitrite, bacteria-E. coli	Crop production with subsurface drainage, sewage discharges in unsewered areas
15.3 W	42	7.5	38	38	Full		
10.8 W/10.9	40	7.5	36	63	Full		
4.4 B	31 ns	8.7	16*	43.5	Partial	Direct habitat alterations, sedimentation/siltation	Impoundment, urban runoff/storm sewers
4.2 W/4.1	42	8.2	22*	74.5	Partial	Nitrate/nitrite, bacteria-E. coli, dieldrin, sedimentation/siltation	Urban runoff/storm sewers, upstream impoundment
1.4 B/1.6	45	8.5*	16*	34	Partial	Sedimentation/siltation, direct habitat alterations, nitrate/nitrite, bacteria-E.coli, copper, lead, zinc, cadmium, and mercury in sediment	Channelization, urban runoff/storm sewers, CSO's,
Fewless Creek - (04097) HELP Ecoregion - Undesignated / WWH Recommended							
1.8 H	20*	H	P*	24	**NON**	Sedimentation/siltation, direct habitat alterations, nitrate/nitrite, **bacteria-E. coli**	Crop production with subsurface drainage, channelization, **on-site treatment systems**
Ai Creek - (04010) HELP Ecoregion – Undesignated / WWH Recommended							
10.5 H/10.4	24 ns	H	F*	26.5	Partial	Direct habitat alterations, nitrate/nitrite, total phosphorus, sedimentation/siltation, **bacteria-E. coli**	Channelization, crop production with subsurface drainage, **on-site treatment systems**
8.3 H	26 ns	H	F*	49	Partial	Direct habitat alterations,	Channelization, crop production with

River Mile Fish/Invertebate	***IBI***	***MIwb***	***ICI***	***QHEI***	***Attainment Status***	***Causes***	***Sources***
						nitrate/nitrite, sedimentation/siltation, **bacteria-E. coli**	subsurface drainage, **on-site treatment systems**
2.1^{H}	28	H	F*	30	Partial	Direct habitat alterations, nitrate/nitrite, total phosphorus, sedimentation/siltation, bacteria-E. coli	Channelization, crop production with subsurface drainage, Swanton WWTP
1.7^{W}1.6	33	6.9^{ns}	28*	26.5	Partial	Sedimentation/siltation, Direct habitat alterations, total phosphorus, nitrate-nitrite, bacteria-E. coli	Swanton WWTP, golf course upst., channelization, sewage discharges in unsewered areas
Blue Creek - (04006) HELP Ecoregion – WWH Existing							
- / 10.0	-	H	F*	29.5	**-**	Direct habitat alterations, sedimentation/siltation, bacteria-E.coli,	Channelization, crop production with subsurface drainage, on site sewage discharge
7.8^{H}	30	H	MG^{ns}	37.5	Full		
5.5^{W}	<u>22</u>*	<u>5.6</u>*	46	24	**NON**	Direct habitat alterations, sedimentation/siltation, nitrate/nitrite, bacteria-E. coli	Channelization, crop production with subsurface drainage, sewage discharges in unsewered areas
0.8^{W}/0.7	32	<u>4.8</u>*	30^{ns}	29	**NON**	Sedimentation/siltation, direct habitat alterations, nitrate/nitrite, **bacteria-E.coli**, chromium, copper, and mercury in sediment	Channelization, crop production with subsurface drainage, **on-site treatment systems,** urban runoff/storm sewers
Harris Ditch (Formerly named South Swan Creek) - (04008) HELP Ecoregion – WWH							
1.6^{H}	<u>12</u>*	H	F*	28.5	**NON**	Sedimentation/siltation, direct habitat alterations, nitrate/nitrite, aluminum, **bacteria-**E.coli	Channelization, crop production with subsurface drainage, sewage discharges in unsewered areas
Blystone Ditch - (04081) HELP Ecoregion – Undesignated / WWH Recommended							
0.6^{H}	34	H	F*	46	Partial	Sedimentation/siltation, direct habitat alterations	Crop production with subsurface drainage, channelization
Wolf Creek - (04004) HELP Ecoregion – WWH Existing							
4.1^{H}/4.2	28	H	F*	45	Partial	Sedimentation/siltation, direct	Crop production, channelization, sewage

River Mile Fish/Invertebate	IBI	MIwb	ICI	QHEI	Attainment Status	Causes	Sources
						habitat alterations, bacteria-E. coli	discharges in unsewered areas, sand quarry upstream
2.0 [H]	28	H	F*	40	Partial	Sedimentation/siltation, direct habitat alterations, bacteria-E. coli, aluminum	Channelization, impervious surface/parking lot runoff, urban runoff/storm sewers
0.5 [W]	33	5.5*	34	43.5	**NON**	Sedimentation/siltation, direct habitat alterations, bacteria-E.coli, aluminum, benzo[a]pyrene	Channelization, urban runoff/storm sewers
Cairl Creek - (04005) HELP Ecoregion – WWH Existing							
1.3 [H]	24[ns]	H	P*	35.5	**NON**	Sedimentation/siltation, direct habitat alterations, nitrate/nitrite, bacteria-E. coli	Dam or impoundment, urban runoff/storm sewers
Heilman Ditch (04-098) HELP Ecoregion – Limited Resource Water Existing							
- /3.0	-	H	VP*	_	-	Strontium, ammonia (total), phosphorus (total), nitrate/nitrite, bacteria-E. coli	Urban and industrial runoff (Anderson & stone quarry), channelization, culverted channel

Ecoregion Biocriteria for Huron Erie Lake Plain

	IBI			MIwb			ICI		
Site Type	WWH	EWH	MWH	WWH	EWH	MWH	WWH	EWH	MWH
Headwaters	28	50	20	H	H	H	34	46	22
Wading	32	50	22	7.3	9.4	5.6	34	46	22
Boat	34	48	20	8.6	9.6	5.7	34	46	22
Lacustuary	42	50	NA	8.6	9.5	NA	42	52	NA

H - Headwater site, MIwb is not applicable.

W - Wading site.

B - Boat site.

a - MIwb is not applicable to headwater streams with drainage areas $\leq$ 20 mi^2.

b - A narrative evaluation of the qualitative sample based on attributes such as EPT taxa richness, number of sensitive taxa, and community composition was used when quantitative data was not available or considered unreliable due to current velocities less than 0.3 fps flowing over the artificial substrates. VP=Very Poor, P=Poor, LF=Low Fair, F=Fair, MG=Marginally Good, G=Good, VG=Very Good, E=Exceptional

c - Attainment status is given for the existing or if a change is proposed then the proposed use designations.

NA - Not applicable

ns - Nonsignificant departure from biocriteria ($\leq$4 IBI or ICI units, or $\leq$0.5 MIwb units).

* - Indicates significant departure from applicable biocriteria (>4 IBI or ICI units, or >0.5 MIwb units). Underlined scores are in the Poor or Very Poor range.

The macroinvertebrate data from the 1992 Swan Creek survey is most comparable to the current study, approximating the five downstream stations. Number of qualitative EPT taxa, ICI scores and number of qualitative sensitive taxa for the 1992 and 2006 surveys (Figure 31, pg. 81) illustrate some noticeable differences. Based on the ICI scoring and the narrative evaluation from RM 21.7 to 10.9, the macroinvertebrate communities in 2006 were performing better than in 1992. There was also a slight increase in the number of EPT taxa at comparable stations. However, the lower three downstream stations (RMs 4.4, 4.1, and 1.6) were not demonstrating any improvement with ICI scores well below the WWH ecoregional biocriterion (ICI = 34) and, for the most downstream site at RM 1.6, the interim biocriterion established for Lake Erie impounded backwaters (ICI = 22). The lack of noticeable improvement over the 1992 ICI scores illustrates that urban runoff, CSOs, contaminated sediments, lack of suitable stream morphology and habitat continue to stress the macroinvertebrate community.

The largest improvements in IBI scores occurred in the lower reaches of Swan Creek at St. Rt. 20, Reynolds Rd., (RM 10.8) between the 2006 (IBI = 40) and 1986 (IBI = 25) scores (Fig 33, pg. 85). Significant improvements among the 1986 and 2006 fish communities continued down to the mouth. The most recent historical data from 1993 showed only negligible improvements in the middle reaches of Swan Creek. One reason for the dramatic improvements since the 1986 sampling year may be attributed to federal funds issued to municipalities used for WWTP improvements during the mid 1980's.

Physical habitat is a critical factor in supporting healthy fish and macroinvertebrate community structure in the watershed. All the macroinvertebrate communities that scored well on the ICI were situated where the riparian zone is intact. While fish communities scored better with increased drainage areas diluting NPS pollutants. The predominant riparian vegetative width varied between 30 and 100 feet and was comprised of large trees. Most stations exhibited natural channel morphology, fair riffle quality and slight bank erosion. These desirable physical characteristics are paramount in assimilating, sequestering, deflecting and reducing sunlight through shading (factor in algal production) of excess nutrient inputs into the ecosystem.

Swan creek is slowly recovering from the damages of channelization and poor riparian habitat in the upstream stations. The marginally good and fair evaluated stations are showing signs of recovery from channelization and the riparian zones are regenerating with young hardwoods. Recovery could be enhanced by restricting further streambed channelization and encouraging the establishment and protection of hardwood plantings in the riparian zone. Since the gradient is low, the recovery process will take a long time. The downstream stations are still plagued by contaminated runoff, CSO's, contaminated sediments and poor habitat. Improving current WWTP facilities and controlling further inputs would help improve the aquatic biota and overall water quality.

Fish Tissue

The state of Ohio has a general limit of no more than one meal per week of any sport fish due to mercury contamination. Fish tissue was examined in Swan Creek sport fish within the reach from Stitt Road, northeast of Whitehouse (RM 21.6), down to the Erie Street Market area (RM 1.0) (Table 4). Yellow bullhead, *Ameiurus natalis*, tissue contained mercury levels in the advisory range to warrant a consumption advisory of two meals per week. Brown bullhead, *Ameiurus nebulosus*, common carp, *Cyprinus carpio*, largemouth bass, *Micropterus salmoides*, rainbow trout, *Oncorhynchus mykiss*, rock bass, *Ambloplites rupestris*, and white bass, *Morone chrysops*, have mercury levels in the advisory range of one meal per week. Freshwater drum, *Aplodinotus grunniens*, and northern pike, *Esox lucius*, have mercury levels in the advisory range of one meal per month. PCBs found in common carp, largemouth bass, rainbow trout, and white bass resulted in a one meal per week advisory for these species. PCBs detected in freshwater drum warranted a one meal per month advisory.

Table 4. Lengths and weights of fish tissue specimens sampled from Swan Creek during the 2006 field season, (June – Oct.).

Collection #	Site Name	RM	Species	Sample Type	# Fish	Length 1	Weight 1
268	Swan Creek at Stitt Rd.	21.6	NORTHERN PIKE	SOF	1	635	380
267	Swan Creek at Stitt Rd.	21.6	ROCK BASS	SOFC	5	203	190
269	Swan Creek at Stitt Rd.	21.6	YELLOW BULLHEAD	SFFC	6	203	110
49	Swan Creek adj. Swan creek Metro Park Glendale	9.8	RAINBOW TROUT	SOF	1	501	1040
52	Swan Creek - Metro Park by Library Highland Park	4.4	COMMON CARP	SOF	1	590	3350
53	Swan Creek - Metro Park by Library Highland Park	4.4	FRESHWATER DRUM	SFF	1	540	2000
55	Swan Creek - Metro Park by Library Highland Park	4.4	WHITE BASS	SFFC	2	295	200
54	Swan Creek - Metro Park by Library Highland Park	4.4	YELLOW BULLHEAD	SOF	1	258	330
57	Swan Creek adj. Erie St. market	1	BROWN BULLHEAD	SFF	1	235	2009
58	Swan Creek adj. Erie St. market	1	COMMON CARP	SFF	1	406	1000
59	Swan Creek adj. Erie St. market	1	LARGEMOUTH BASS	SOF	1	390	1000
50	Swan Creek upst. Salisbury Rd.	0	COMMON CARP	SFF	1	505	2500
51	Swan Creek upst. Salisbury Rd.	0	ROCK BASS	SOFC	10	175	142

Collection #	Length 2	Weight 2	Length 3	Weight 3	Length 4	Weight 4	Length 5	Weight 5	Length 6	Weight 6	Length 7	Weight 7
267	260	325	228	200	241	250	215	160	0	0	0	0
269	222	150	215	100	165	75	222	123	200	75	0	0
55	235	170	0	0	0	0	0	0	0	0	0	0
51	183	150	180	140	196	195	175	150	190	170	185	150

Collection #	Length 8	Weight 8	Length 9	Weight 9	Length 10	Weight 10
Cont. 51	185	180	194	177	180	142

Sample Types: Skin On Fillet (SOF), Skin On Fillet Composite (SOFC), Skin Off Fillet Composite (SFFC), and Skin Off Fillet (SFF).

For additional information related to the Fish Consumption Advisory, please see the 2008 Ohio Sport Fish Consumption Advisory homepage at: http://www.epa.state.oh.us/dsw/fishadvisory/index.html

Study Area Description

General

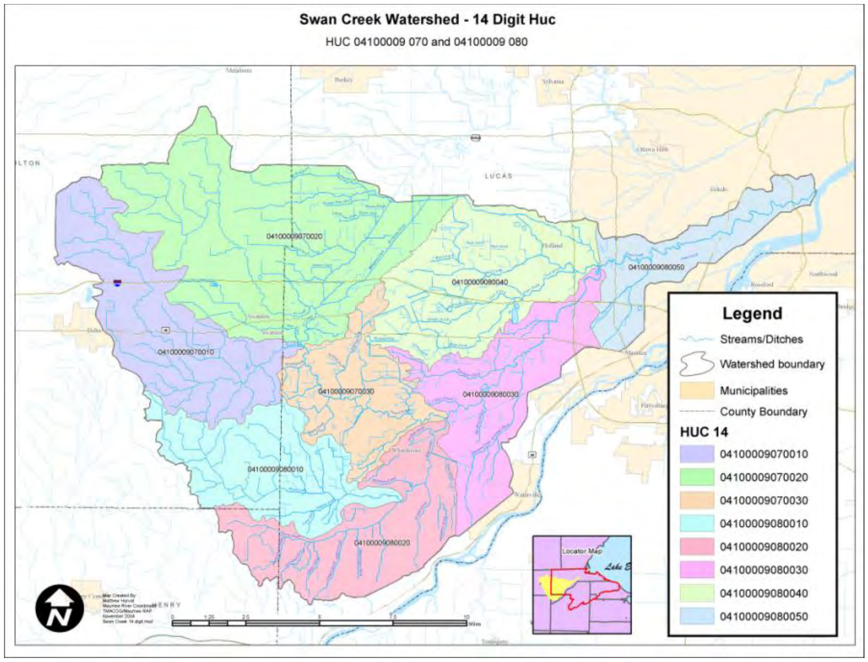

Figure 3. Map of the eight 14 digit hydrologic units that make the Swan Creek Watershed.

The Swan Creek Watershed is comprised of 12 11-digit and 8 14-digit Hydrologic Units (Fig. 3). The drainage area of Swan Creek is 204 square miles. Its headwaters rise in Henry, Fulton and western Lucas counties. Over 200 miles of creeks and ditches drain this watershed. Swan Creek itself is about 40 miles long.[1] The gradient is similar to that of the Maumee River with a drop of 2.1 feet per mile. The major streams that feed Swan Creek are Ai Creek, Blue Creek, and Blystone Ditch.

The Swan Creek watershed can be divided into three major reaches based on the dominant stream characteristics within each reach. In the upstream reach from the headwaters to Stitt Road (RM 21.6), northeast of Whitehouse, the channel substrates are unstable consisting predominately of sand and silt. This reach drains primarily agricultural land. The upper reach of Swan Creek has an important aesthetic value as it flows through the Oak Openings Preserve Metropark in western Lucas County.

The middle reach extends from RM 18.5 to 6.0, where the creek is actively eroding its channel. The banks are high (35 to 45 feet or more), unstable, and are intermixed with detached floodplains. Bedrock in the channel at Albon Road (RM 18.5) prevents the extension of the erosion upstream. The land use in the middle reach is primarily residential and is one of the fastest developing areas in northwest Ohio. Land areas

[1] *Swan Creek Watershed Plan of Action*, Maumee RAP/TMACOG, April 2001.

included are Monclova and Springfield townships in Lucas County and the western edge of the City of Toledo. Tributaries to Swan Creek that have extensive floodplains include Wolf Creek, Blystone Ditch, Stone Ditch, Cairl Creek, Drennan Ditch and Heilman Ditch.

The lower reach, from River Mile 6 to the mouth in downtown Toledo, is actively silting in its channel. The banks are as high as 35 to 45 feet and are intermixed with floodplain areas. This lower reach is affected by seiche fluctuations in the Maumee River and Lake Erie. The level of Lake Erie prevents the lower reach from naturally deepening itself. Major stressors to this lower reach include hydromodification, urban development and extremely poor water quality, due to storm water runoff.

The lower reach is highly urbanized with little vacant land. The land use is mixed residential, commercial, and industrial. Within this reach are two major open space areas. The first is Highland Park between South Avenue and Swan Creek (RM 4.0), with the second being Sterling Field. This playing field is within an oxbow in the creek and lies between two major streets, Collingwood and Hawley (RMs 2.5-1.5).

Ecoregion/Soils/Topography

The study area is located entirely in the Huron-Erie Lake Plains (HELP) ecoregion, and more specifically the Oak Openings. The HELP ecoregion is a broad, fertile, nearly flat plain that takes its name from being formed by retreating glacial lakes. US EPA describes this ecoregion as "fine, poorly-drained, water-worked glacial till and lacustrine sediment; also coarser end moraine and beach ridge deposits." Several areas of the HELP Ecoregion have special ecological importance, such as the Oak Openings region, which helps to buffer the Swan Creek watershed (Fig. 4).

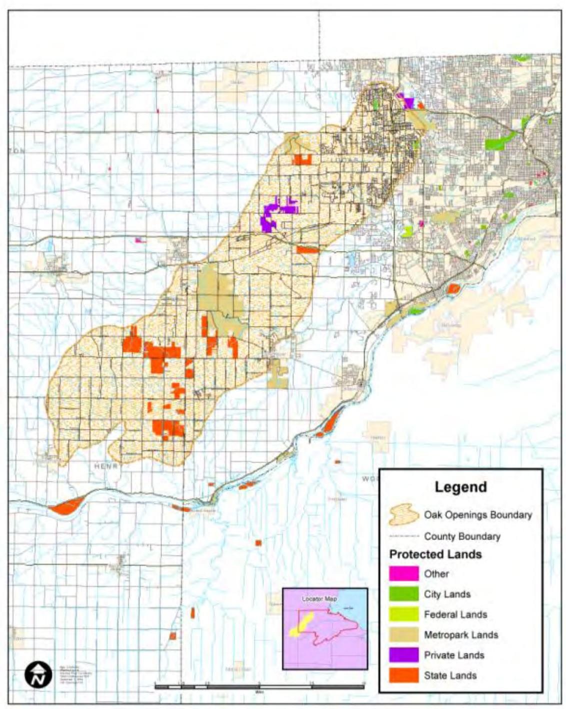

Figure 4. Oak Openings regional map.

When the Great Black Swamp was drained in the late 1800s, settlers in northwest Ohio discovered very fertile soils under the deciduous swamp forests. Today most of the area has been cleared and artificially drained for agricultural crop production. Stream habitat and water quality have been degraded by channelization and agricultural drainage activities.

The soils of the project area are level to gently sloping and are very poorly to somewhat poorly drained. Lucas County soils formed in clayey and loamy lake-laid sediment and water-reworked glacial till on broad flats of an old glacial lake.[2]

Oak Openings

One of northwest Ohio's most important natural habitat areas is the Oak Openings region, which borders the former Great Black Swamp. The Oak Openings Region, located within portions of the Swan Creek watershed, is a 130 square mile area supporting globally rare oak savanna and wet prairie habitats. It is home to more rare species of plants and animals than any other area of Ohio. Its trees, plants, sandy soils, wet prairies, and floodplains benefit the region by acting as natural filters for our air and water.

Natural floodplain corridors occur between the Oak Openings Region and Lake Erie along the Maumee River and Swan Creek. Preserved natural floodplains in these areas help to balance the effects of development and the resulting downstream effects of increased urban runoff. Floodwater is slowed within the broad forested areas of the floodplain allowing for groundwater replacement and evaporation to take place.

The number of rare plants and animals is higher in northwest Ohio than any other place in Ohio primarily because the Oak Openings Region. This area is home to approximately 180 rare plant and animal species whose survival depends upon the region's unique combination of wet and dry, sand and clay, forest and prairie.[3]

Land Use

In 2003 land use classifications produced by The University of Toledo for the Swan Creek watershed showed 57 percent of the land used by mixed juvenile vegetation. This vegetation type can be row crops in an early stage of growth, tracts of open space or yards. Forest and grassland accounted for 18 percent and 9 percent respectively, and 6 percent was in cultivated fields. Approximately 8 percent of the watershed has been developed for residential use, 2 percent for urban uses, and less than 1 percent for commercial/industrial uses (Fig. 5).

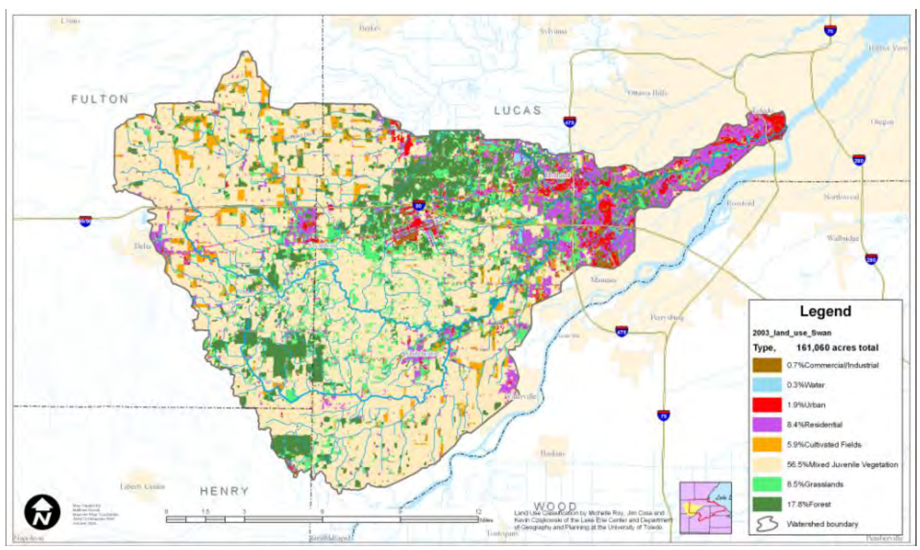

Figure 5. Local land use map for the Swan Creek Watershed.

[2] *Soil Survey of Lucas County*, USDA Soil Conservation Service, June 1980.
[3] Green Ribbon Initiative Brochure: www.oakopen.com.

The Swan Creek Preserve Metropark is located in the middle reach within the western boundaries of the City of Toledo. This is a developed urban area that is still experiencing some residential and commercial growth. Swan Creek flows through this park and is its primary natural feature. The park is an important resource for the area not only because of its location, but also because it is probably the best example of preserved flood plain habitat in the region.

The Metroparks of the Toledo Area administers over 8,000 acres of natural, historical, and cultural parklands in Lucas County. Eleven parks and two recreational trails provide access and interpretation in northwest Ohio's premier natural areas: the Oak Openings Region; the Great Black Swamp; and Maumee River, Ottawa River, and Swan Creek Corridors.[4]

The Toledo Metroparks are creating and preserving a system of natural area parks to be held in public ownership and maintained in essentially an undeveloped form for the use and enjoyment of this and future generations. They are also acquiring and preserving historic areas in the region. Recreational facilities are provided including picnic areas, playgrounds, and playfields. Nature trails for hiking, bird watching, jogging, bicycling, and winter skiing are also provided on Metropark lands.

The Ohio Department of Natural Resource also manages the Maumee State Forest (3,068 acres) and several nature preserves in the western portion of Lucas County including Irwin Prairie (223 acres) and the Louis W. Campbell Mesic Sand Prairie (169 acres). The Kitty Todd Preserve is a 672 acre nature preserve that is managed by The Nature Conservancy.[5]

The City of Toledo has established walking paths along Swan Creek from the Erie Street Market (RM 0.9) to Summit St. (RM 0.2). A variety of native plant materials have been placed along the Walk to help prevent bank erosion and beautify the area. The Maumee RAP helped to fund the plantings and interpretive signage to describe the project. The City of Toledo also built a dock along the Riverwalk at the Erie Street Market for canoe and pontoon boat access to Swan Creek.

Figure 6. The Maumee RAP merged with the nonprofit, Partners for Clean Streams, in 2007.

Watershed Groups

Over the last twenty years there have been several local watershed groups interested and involved in the Swan Creek watershed, including ClearWater and the

[4] Metroparks of the Toledo Area website: http://metroparkstoledo.com.

[5] Ohio Dept of Natural Resources Division of Natural Areas and Preserves web site: http://www.dnr.state.oh.us/dnap/preservelistnopermit.htm and http://www.dnr.state.oh.us/dnap/permitonly.htm.

Maumee RAP (remedial action plan). They have partnered with many local, state, and federal agencies and encouraged restoration and protection efforts. After nearly twenty years of working under the umbrella of the Toledo Metropolitan Area Council of Governments (TMACOG), in early 2007 the Maumee RAP voted to merge with a new nonprofit organization, Partners for Clean Streams (PCS), (Fig. 6). In late 2007, ClearWater dissolved itself as an organization and put its support behind Partners for Clean Streams. Most local community watershed efforts for the Lower Maumee River watershed are now being led or are in partnership with the Partners for Clean Streams.[6]

A watershed action plan has been developed for the Swan Creek watershed along with four other subwatersheds of the Lower Maumee River/Lake Erie Basin. The effort was led by Ohio EPA's Maumee RAP Coordinator, with collaboration from many local agencies and Maumee RAP partners. A draft plan was submitted in January 2006 for State endorsement by ODNR and Ohio EPA. The *Maumee AOC Stage 2 Watershed Restoration Plan (Stage 2 Restoration Plan)* received "Full Endorsement Pending" status from the State of Ohio's watershed plan program and will be fully endorsed with the completion of a Coastal Nonpoint Source Pollution Management Measures section. The *Stage 2 Plan* was also reviewed by Ohio EPA as an official Maumee RAP Stage 2 Report, and requires additional prioritization of implementation activities before it is submitted to U.S.EPA for review.

With the Maumee RAP Committee completing its merger into PCS's organization in January 2008, they have become the Maumee RAP Advisory Committee (RAC) and intend to spend much of 2008 making the changes requested by Ohio EPA and ODNR for completing the *Stage 2 Restoration Plan* for full state endorsement and Stage 2 approval.

Watershed Restoration Efforts

Partners for Clean Streams has two projects underway that will be completed in late 2008 – early 2009 that will benefit the Swan Creek watershed. These projects are being funded through a grant from the Joyce Foundation. The *Highland Park Dam Decommissioning and Riparian Enhancement Project for Swan Creek* directly supports improving conditions that were identified as problematic in this report. This lowhead dam at Highland Park prevents migrating fish from spawning upstream, traps sediments, and degrades water quality, but cannot be cheaply removed due to a sewer line being encased in the dam. This project will demonstrate a dam mitigation technique that will decrease its impact by building structures into and raising the streambed to restore natural water movement, allowing spawning fish to swim upstream past the dam, thus creating a more natural environment.

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[6] Partners for Clean Streams and Maumee RAP websites: www.PartnersForCleanStreams.org and www.MaumeeRAP.org.

The second project, *Wetland and Riparian Inventory and Restoration Plans for Swan Creek & Ottawa River*, involves planning for future improvements in the watershed. This project is currently identifying and prioritizing up to fifteen potential wetland and/or riparian mitigation sites in both the Swan Creek and Ottawa River watersheds. These lists will be used to capture mitigation or penalty funds that become available. Data collected for this report is being used to identify and prioritize the sites for these plans.

The Blue Creek Wetland Research Project was accomplished through a grant from USEPA-GLNPO awarded to TMACOG in 1993 for reconstruction of a wetland to research the effects of agricultural runoff on water quality. With other funds from Ohio EPA, ODNR and local match, the project totaled nearly $50,000 and was completed by the end of 1993. Ohio State University provided design consultation services for the project area. Ongoing research at the Blue Creek Wetland is being conducted by Bowling Green State University and the University of Toledo. The Blue Creek Project is the first recreated wetland of its kind in the Swan Creek watershed providing wildlife habitat, assimilation of NPS pollutants, flood control, research, and educational opportunities (TMACOG, 1993).

There have not been any previous Section 319 grants for implementation projects in this watershed. However, Lucas SWCD is preparing a FY09 proposal for the *Mosquito Creek Stream Restoration Project.* This project will be located on Metropark property in the Blue Creek Conservation Area (BCCA). Mosquito Creek is a tributary to Blue Creek at the confluence with the wetland constructed in 1993. The site includes the Toledo Area Metroparks' native plant nursery which is home to rare and endangered species. The project would restore approximately 2000 linear feet of the stream using natural channel design techniques in and along the stream channel. The floodplain areas will be used for propagating native plants that require more water. Other areas around the creek are also used to propagate native warm season grasses and forbs for use in naturalizing other Metropark land. The site will be a demonstration project visible to the public and partners of the BCCA. (Lucas SWCD, 2007)

Nonpoint Sources and Unsewered Areas
Agricultural nonpoint sources of impairment include sedimentation, nutrient enrichment, channelization, and habitat alteration. Bacteria and organic enrichment impairments were primarily caused by unsewered villages and failing home sewage systems in rural areas. Currently the villages of Ai and Neapolis do not have centralized wastewater treatment facilities, and may be adversely affecting tributaries to Swan Creek. Critical areas for sewer extensions and septic system replacements are identified in the Maumee AOC Stage 2 Restoration Plan.

Storm Water
The city of Toledo is a Phase 1 Municipal Separate Storm Sewer System (MS4), and has been permitted since 1997. The city has sampling data for seasonal ambient stations and at least 2 wet weather outfalls in this watershed. In 2006 they requested to change from multiple wet weather stream sampling events to annual watershed specific monitoring. In

2006 they analyzed quarterly samples from Swan Creek at four separate outfall locations in the Phase 1 watershed area.

Other permits have been issued to the following operators of Phase 2 –MS4 storm water facilities including: ODOT, Ohio Turnpike, Lucas County, portions of Monclova, Spencer, Springfield and Waterville Townships, and the cities of Holland, Maumee and Waterville.

Balanced Growth Initiative

In 2004, a Balanced Growth Blue Ribbon Task Force of experts and stakeholders advised the Ohio Lake Erie Commission to "develop strategies that will balance the protection of Lake Erie with continued economic growth" in response to the Lake Erie Protection & Restoration Plan (2000). Their recommendations called for a voluntary, incentive-driven program for the state to encourage planned, orderly growth and change at the local level. The Swan Creek watershed is one of three areas in Ohio that received funding for a pilot project.

A model for development that includes Priority Conservation Areas (PCA) and Priority Development Areas (PDA) is being put together by the Swan Creek Pilot Project Technical Committee. These Priority Areas will need to be endorsed by at least 75% of the jurisdictions in the watershed before the State can approve the plan. The main concept of the Priority Plan is that the location of development and conservation is critical to the impact on a watershed. PCAs and PDAs can allow for growth and economic development as well as protect the environment and water quality.

It is hoped that through scientific and planning projects such as the TMDL and Balanced Growth Initiative, the recommendations put forth in the Lake Erie Protection & Restoration Plan and the Remedial Action Plan can be implemented efficiently and effectively, and provide further incentive for proper land use and stewardship (TMACOG, 2007).

METHODS

All physical, chemical, and biological field, laboratory, data processing, and data analysis methodologies and procedures adhere to those specified in the Manual of Ohio EPA Surveillance Methods and Quality Assurance Practices (Ohio Environmental Protection Agency 2006b) and Biological Criteria for the Protection of Aquatic Life, Volumes I-III (Ohio Environmental Protection Agency 1987a, 1987b, 1989a, 1989b, 2008a, 2008b), The Qualitative Habitat Evaluation Index (QHEI): Rationale, Methods, and Application (Rankin 1989, 1995, 2006a) for aquatic habitat assessment, and the Ohio EPA Sediment Sampling Guide and Methodologies (Ohio EPA 2001). Sampling locations are listed in Table 1.

Determining Use Attainment Status

Use attainment status is a term describing the degree to which environmental indicators are either above or below criteria specified by the Ohio Water Quality Standards (WQS; Ohio Administrative Code 3745-1). Assessing aquatic use attainment status involves a primary reliance on the Ohio EPA biological criteria (OAC 3745-1-07; Table 7-15). These are confined to ambient assessments and apply to rivers and streams outside of mixing zones. Numerical biological criteria are based on multimetric biological indices including the Index of Biotic Integrity (IBI) and Modified Index of well being (MIwb), indices measuring the response of the fish community, and the ICI, which indicates the response of the macroinvertebrate community.

Three attainment status results are possible at each sampling location - full, partial, or non-attainment. Full attainment means that all of the applicable indices meet the biocriteria. Partial attainment means that one or more of the applicable indices fails to meet the biocriteria. Non-attainment means that none of the applicable indices meet the biocriteria or one of the organism groups reflects poor or very poor performance. An aquatic life use attainment table (Table 3) is constructed based on the sampling results and is arranged from upstream to downstream and includes the sampling locations indicated by River Mile, the applicable biological indices, the use attainment status (*i.e.*, full, partial, or non-attainment), the Qualitative Habitat Evaluation Index (QHEI), and a sampling location description.

Habitat Assessment

Physical habitat was evaluated using the 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 the QHEI score which generally ranges from 20 to less than 100. The QHEI is used to evaluate the characteristics of a stream segment, as opposed to the characteristics of a single sampling site. As such, individual sites may have poorer physical habitat due to a localized disturbance yet still support aquatic communities closely resembling those sampled at adjacent sites with better habitat, provided water quality conditions are similar. QHEI scores from hundreds of segments around the state have indicated that mean values greater than 60 are *generally* conducive to the existence of warmwater faunas whereas mean segment scores less than 45 generally cannot support a warmwater assemblage consistent with the WWH biological criteria. Mean segment scores greater than 75 frequently reflect habitat conditions which have the ability to support exceptional warmwater faunas.

Sediment and Surface Water Assessment

Nitrile gloves were worn in handling decontaminated stainless steel scoops to collect fine grain sediment samples in the upper 4 inches of the bottom material at each location. Decontamination of sediment sampling equipment followed the procedures outlined in the Ohio EPA sediment sampling guidance manual (Ohio EPA 2001). Sediment grab samples were homogenized in stainless steel pans (material for VOC analysis was not homogenized), transferred into glass jars with teflon® lined lids, placed on ice (to maintain 4^{o}C) in a cooler, and shipped to an Ohio EPA contract lab. Sediment data is reported on a dry weight basis. Surface water samples were collected, preserved and delivered in appropriate containers to either an Ohio EPA contract lab or the Ohio EPA Division of Environmental Services. Surface water samples were evaluated using comparisons to Ohio Water Quality Standards criteria, reference conditions, or published literature. Sediment evaluations were conducted using guidelines established in MacDonald *et al.* (2000) and Ohio Specific Reference Values (2003).

Recreational Use Assessment

Recreation use attainment was assessed by using *E. coli* bacteria indicator organisms. Their presence indicates that the water has been contaminated with feces from warm blooded animals. Counts are reported in colony forming units (CFU)/100 ml. To determine if criteria codified in OAC 3745-1-07 are met, a minimum of five samples must be collected within any 30-day period during the recreation season (May 1-October 15). Rules for the PCR use state that the fecal coliform geometric mean shall not exceed 1000 and not more than 10% of the samples shall exceed 2000 and that the *Escherichia coli* geometric mean shall not exceed 126 and not more than 10% of the samples shall exceed 298.

Macroinvertebrate Community Assessment

Macroinvertebrates were collected from artificial substrates and from natural habitats. The artificial substrate collection provided quantitative data and consisted of a composite sample of five modified Hester-Dendy multiple-plate samplers colonized for six weeks. At the time of the artificial substrate collection, a qualitative multihabitat composite sample was also collected. This sampling effort consisted of an inventory of all observed macroinvertebrate taxa from the natural habitats at each site with no attempt to quantify populations other than notations on the predominance of specific taxa or taxa groups within major macrohabitat types (e.g., riffle, run, pool, margin). Stations with insufficient flow to place artificial substrates or where the artificial substrates were missing were only sampled qualitatively from the natural substrates. These stations were evaluated and assigned a narrative evaluation based on community attributes such as EPT (Ephemeroptera – mayfly, Plecoptera – stonefly, and Trichoptera – caddisfly) diversity and predominance, sensitive taxa diversity and predominance, and tolerant taxa predominance. Detailed discussion of macroinvertebrate field and laboratory procedures is contained in Biological Criteria for the Protection of Aquatic Life, Volume III (Ohio EPA 1989b).

Fish Community Assessment
Fish were sampled using pulsed DC electrofishing methods. Field processing of fish sampled included identifying each individual to species, counting, weighing, and recording any external abnormalities. Discussion of the fish community assessment methodology used in this report is contained in Biological Criteria for the Protection of Aquatic Life, Volume III, (Ohio EPA 1989b).

Fish Tissue Assessment
All field, laboratory, data processing, and data analysis methodologies and procedures adhere to those specified in the Manual of Ohio EPA Surveillance Methods and Quality Assurance Practices (Ohio Environmental Protection Agency 2006b), and State of Ohio Cooperative Fish Tissue Monitoring Program Fish Tissue Guidance Manual (OhioEPA 2004). Fish tissue sampling locations are listed in Table 1. Fish tissue sample specifications (species, lengths/weights, type of sample, etc.) are provided in Table 4. Summarized results are presented in the fish tissue results section, pg. 16.

Fish were collected using a variety of pulsed DC electrofishing equipment, with collections occurring between June–October, 2006. Fish tissue samples were placed on either dry or wet ice in the field and transported back to the Ecological Assessment Section Laboratory at 4675 Homer Ohio Lane, Groveport, Ohio 43125 and placed in a chest freezer prior to being delivered to the Ohio EPA Division of Environmental Services Laboratory for analysis.

Causal Associations
Using the results, conclusions, and recommendations of this report requires an understanding of the methodology used to determine the use attainment status and assigning probable causes and sources of impairment. The identification of impairment in rivers and streams is straightforward. The numerical biological criteria are used to judge aquatic life use attainment and impairment (partial and non-attainment). Rationale for using the biological criteria, within a weight of evidence framework, has been extensively discussed elsewhere (Karr *et al.* 1986; Karr 1991; Ohio EPA 1987a,b; Yoder 1989; Miner and Borton 1991; Yoder 1991; Yoder 1995). Describing the causes and sources associated with observed impairments relies on an interpretation of multiple lines of evidence including water chemistry data, sediment data, habitat data, effluent data, land use data, and biological results (Yoder and Rankin 1995). Thus the assignment of principal causes and sources of impairment in this report represent the association of

impairments (based on response indicators) with stressor and exposure indicators. The reliability of the identification of probable causes and sources is increased where many such prior associations have been identified, or have been experimentally or statistically linked together. The ultimate measure of success in water resource management is the restoration of lost or damaged ecosystem attributes including aquatic community structure and function. While there have been criticisms of misapplying the metaphor of ecosystem "health" compared to human patient "health" (Suter 1993), in this document we are referring to the process for evaluating biological integrity and causes or sources associated with observed impairments, not whether human health and ecosystem health are analogous concepts.

SUMMARY OF FINDINGS

Spills and Fish Kills

In the Swan Creek watershed there have been eight spills and two fish kills dating from July 30, 1987 to April 30, 2006 (Table 5). In Lucas County on July 30, 1987 a sewage spill in Swan Creek killed 2,227 fish and on June 10, 2005 low dissolved oxygen in Old Swanton Reservoir (Ai Creek) resulted in a fish kill of 300 as a consequence of natural drought conditions. As shown in Table 2, spills in the Swan Creek watershed are not a common source of pollution. Many of the pollutants found in the watershed are associated with non-point sources and poorly operating WWTP's. These pollution sources and non-point sources are discussed in further detail throughout the report.

Table 5. Spills and Fish Kills in the Swan Creek Watershed from July 30, 1987 to April 30, 2006

River	County	Date	River Mile	Miles Affected	# Fish Killed	Operation	Pollutant	Source
Swan Creek	Lucas	30-Jul-87	-	-	2227	-	sewage	-
Swan Creek	Lucas	10-Aug-99	15	0.43	0	golf course	pesticides, fungicides	Brandywine Golf Course
Swan Creek	Lucas	21-Jan-06	8.2	0.25	0	chemical Ind.	chemicals used to make air fresheners	D&J manufacturing
Zaleski Ditch (Trib. to Cairl Creek)	Lucas	02-Apr-03	2.2	2.15	0	airport	de-icing chemicals	Toledo Express Airport
Zaleski Ditch (Trib. to Cairl Creek)	Lucas	09-Jan-05	2.2	2.15	0	airport	de-icing chemicals	Toledo Express Airport
Zaleski Ditch (Trib. to Cairl Creek)	Lucas	04-Sep-04	2.2	2.15	0	airport	de-icing chemicals	Toledo Express Airport
Old Swanton Reservoir (Ai Creek)	Fulton	10-Jun-05	4.1	0.01	300	natural	natural	natural
Heilman Ditch	Lucas	26-Apr-04	2.3	2.3	0	quarry	heating oil	Stoneco, Inc.
Heilman Ditch	Lucas	30-Apr-06	2.3	0.5	0	quarry	heating oil	Stoneco, Inc.

Chemical Water Quality

Chemical and physical water quality was assessed at 28 locations throughout the Swan Creek watershed. Surface water grab samples were analyzed for organic, and inorganic parameters, metals and nutrients. Dissolved oxygen levels, pH and temperatures were recorded in the field at each sampling location. At the majority of sites, six sampling runs were conducted on two-week intervals. Grab water organic chemical samples were only collected twice at selected sites. *Escherichia coli* (E. coli) bacteria samples were collected 8 times at most sites during the survey. Chemical water quality values which exceeded established criteria or target values but did not necessarily represent violations of the Ohio Water Quality Standards (WQS) are presented in Table 6. However, exceedances do indicate potential for aquatic life and recreation use impairments.

Swan Creek

Water quality samples were collected at 13 locations from the Swan Creek main stem. One site was located within the lacustuary (Lake Erie seiche affected) zone. The remaining sites were located in free flowing segments. Sample results that exceeded the Ohio WQS numerical criteria or target values are presented in Table 6. E. coli sample results exceeded the primary contact recreational use geometric mean criteria of 126/100 ml. at all Swan Creek sites (Fig. 7). The E. coli geometric mean criterion is based on not less than five samples collected in a thirty-day period. E.coli exceedances were attributed to faulty septic systems in rural communities within the upper portion of the Swan Creek watershed and CSO's in the urbanized lower reaches of the watershed. The median phosphorus concentrations in the lower segments of Swan Creek were at or above the target value of 0.10 mg/l (Fig. 8). The median nitrate+nitrite concentrations exceeded the target nutrient value of 1.0 mg/l in Swan Creek (Figure 9). Elevated nutrients found in the watershed resulted from NPS agricultural runoff in the upper portion of the watershed, urbanization and agricultural runoff in the middle portion, and stormwater runoff in the lower portion of the watershed. No dissolved oxygen, pH or temperature exceedances were recorded.

Upstream from the Village of Swanton the following three sampling locations were assessed: Fulton County Road 6-1 (RM 40.68), Fulton County Road 3 (RM 34.41) and Township Road 2 (RM 32.82). Nitrate+nitrite concentration in 38 % of the samples collected from these sites exceeded the Outside Mixing Zone Average (OMZA) Human Health/Drinking criterion of 10 mg/l and 94 % exceeded the ecoregion target value of 1.0 mg/l. Agriculture was the dominant land use upstream from the Village of Swanton. Excess nitrate+nitrite from land applied farm fertilizers appear to be running off into Swan Creek. Such excess fertilizers enter streams through tile drainages and/or a lack of vegetative riparian buffers. All E. coli results exceeded the maximum primary contact criterion of 298 per 100 ml. and the site specific geometric mean value indicating poorly treated sewage was entering Swan Creek due to outdated or faulty septic systems. Phosphorus concentrations slightly exceeded the target value of 0.1 mg/l in one of six samples collected at Township Road 2.

One sample location was assessed just upstream of the Village of Swanton's municipal water treatment facility intake at (RM 30.90) located just upstream of State Route 64. Nitrate+nitrite concentrations in one of six samples collected exceeded the Outside Mixing Zone Average (OMZA) Human Health/Drinking criterion of 10 mg/l and all sample results exceeded the target value of 1.0 mg/l.

Downstream at State Route 295 (RM 25.99) one round of inorganic chemistry and two rounds of bacteria samples were collected prior to this site being eliminated from the study. Phosphorus and nitrate-nitrite concentrations both exceeded their respective target values. E.coli levels exceeded the site specific maximum of 298 colonies per 100 milliliters.

At Spencer Road (RM 24.70) just north of the Village of Whitehouse six of six water quality grab samples exceeded the target value of 0.01 mg/l for phosphorus. All nitrate+nitrite concentrations exceeded the target value of 1.0 mg/l and one sample result exceeded the Human Health OMZA criterion of 10.0 mg/l. Downstream at Stitt Road (RM 21.60) all sample concentrations exceeded their respective nutrient target values (Table 6). Nitrate+nitrite concentrations in samples collected at Albon Road (RM 18.50), Salsibury Road (RM 15.30) and State Route 20 (RM 10.84) exceeded the target value in five of six grabs. Phosphorus levels exceeded the target value in five out of six samples collected at RM 18.50 and four out of six samples collected at RM 15.30. Cool groundwater and shade helped keep water temperatures low and reduce impacts typically associated with elevated nutrient levels at RM 15.30, which was in full biological attainment. Swan Creek at RM 18.50 partially attained its designated WWH criteria, table 3, specific causes of impairment at this site are further discussed in the biological sections of this report.

At South Avenue, immediately downstream from the South Avenue dam (RM 4.20), phosphorus concentrations exceeded the target value in five of six samples collected and nitrate+nitrite levels exceeded the target value in six of six samples. Dieldrin was detected in one of two organic samples at a concentration of 0.0045 µg/l which exceeds the Tier I Human Health standard of 0.0000065 µg/l. Dieldrin is a break down product of the insecticide aldrin which was a widely used pesticide for corn crops from 1950 until 1970. Aldrin was banned in 1974, except to control termites. In 1978, all uses in the U.S. were banned.

Swan Creek is confined to its channel in the lower reaches due to steeply leveed banks making it nearly impossible to naturally deposit silts and other pollutants along its flood plane. At City Park Avenue (RM 1.60) phosphorus concentrations exceeded the target value in four out of six samples collected and levels of nitrate+nitrite were elevated above the target value in all six samples. Just upstream of the confluence of the Maumee River at the Owns-Corning Bridge (RM 0.19) four of six phosphorus samples exceeded the target value and one of six nitrate+nitrite samples exceeded the target. Aluminum was detected in one sample at a concentration of 1080 µg/l which is above the Tier II Human Health Standard. Dieldrin was detected in one of two organic samples at a concentration of 0.0057µg/l. The Tier I Human Health standard for dieldrin is 0.0000065 µg/l. While many phosphorus exceedances were mentioned, it was not found to be a pollutant in Swan Creek. The elevated phosphorus samples collected throughout Swan Creek were negligibly over their respective target values and were not extraordinary for a highly precipitous sampling season (Table 6 and Fig. 8). Evidence of nutrient enrichment from phosphorus pollution was not found at any of the main stem Swan Creek sample locations. For further explanation on evaluating phosphorus pollution please see nutrient enrichment under the mechanisms for water quality impairment section (Appendix F).

Ai Creek

Four sites were sampled on Ai Creek. E. coli results from all samples collected exceeded the maximum recreation primary contact criterion of 298/100 ml. and the site specific geometric mean of 126/100 ml. This was attributed to faulty or outdated on site septic systems throughout and adjacent to the unsewered community of Ai. At County Road L (RM 10.44) in the Village of Ai one phosphorus concentration exceeded the target value. Nitrate+nitrite concentrations exceeded the respective target value in all samples collected and the Human Health OMZA criterion of 10.0 mg/l on one occasion. Copper was detected in one sample at a concentration of 106µg/l which exceeded the Aquatic Life OMZA and IMZM WQS criteria. Downstream at County Road L (RM 8.29) one phosphorus concentration exceeded the target value on one occasion. Nitrate+nitrite concentrations exceeded the respective target value in five of six samples collected and the Human Health OMZA criterion of 10.0 mg/l on one occasion. At Scott Road (RM 2.10) and State Route 2 (RM 1.66) on the downstream side of the Village of Swanton phosphorus concentrations exceeded the target value in all samples collected. Nitrate+nitrite concentration exceeded the respective target value in all samples and the Human Health OMZA criterion of 10.0 mg/l on one occasion at each site. Median phosphorus concentrations in the upper segments of Ai Creek were near the target value. In the lower portions of the creek median phosphorus levels were elevated above the target value (Figure 10). Median nitrate+nitrite concentrations were elevated well above the target value of 1.0 mg/l (Figure 11). Continuous monitoring equipment deployed in AI Creek at Scott Road (RM 2.10) revealed diurnal dissolved oxygen sags below the Outside Mixing Zone Minimum (OMZM) criterion on several occasions. Monitoring equipment was deployed August 29 to September 1, September 14 – 19 and again on September 20 -22, 2006. Dissolved oxygen graphs of data retrieved during these events are displayed in Figures 12, 13 & 14.

Fewless Creek

One sampling location was selected on Fewless Creek at Fulton County Road 4 (RM 1.80). All E. coli results exceeded the maximum primary contact criterion of 298/100 ml. and the primary contact recreational use geometric mean criterion of 126/100 ml. Faulty or outdated septic treatment systems upstream of the site were the reason for the dangerous E. coli levels. Phosphorus concentrations exceeded the target value of 0.1 mg/l in two of six samples collected. All nitrate+nitrite concentrations exceeded the target value of 1.0 mg/l and two of six sample results exceeded the Human Health OMZA criterion of 10.0 mg/l. Unbuffered chemical fertilizers draining from upstream farm fields into Fewless Creek had most likely caused the elevated phosphorus and nitrate+nitrite levels.

Blue Creek

Four locations were sampled on Blue Creek. All E. coli results from samples collected from Blue Creek exceeded the maximum primary contact criterion of 298/100 ml. and the primary contact recreational use geometric mean criterion of 126/100 ml. These E. coli exceedances most likely resulted from faulty on site septic systems. At Fulton County Road 3 (RM 9.97) in the uppermost segment of the creek phosphorus concentrations in one of six samples was slightly elevated above the target value of 0.10 mg/l. Arsenic was detected at a concentration of 10.8 µg/l in one sample which exceeds the Human Health Outside Mixing Zone Average criterion of 10.0 µg/l. At Manore Road (7.80 RM) one phosphorus value exceeded the respective nutrient target value. Nitrate+nitrite concentrations exceeded the target value in five of six samples collected. Downstream at State Route 295 (RM 5.57) phosphorus concentrations in two of six samples collected exceeded the target value and nitrate+nitrite concentrations were elevated above the target value in five of six samples. Upstream of the confluence with Swan Creek at Finzel Road (RM 0.73) nitrate+nitrite concentrations exceeded the target value in five of six samples collected. Median phosphorus concentrations were below the target value of 0.1 mg/l as presented in Figure 15. Median nitrate+nitrite levels were elevated above the target value of 1.0 mg/l (Figure 16). Elevated phosphorus and nitrate+nitrite concentrations can be attributed to fertilizer runoff from farm fields draining into Blue Creek.

Harris Ditch (Formerly named South Swan Creek)

Harris Ditch which is a small tributary to Blue Creek was sampled at State Route 295 (RM 1.55). As a result from poorly treated waste water from home septic systems, all E. coli results exceeded the maximum primary contact criterion of 298/100 ml. and the primary contact recreational use geometric mean criterion of 126/100 ml. Fertilizer runoff from farm fields has led to elevated levels of phosphorus and nitrate+nitrite levels in Harris Ditch. Phosphorus concentrations exceeded the target value of 0.1 mg/l in two of six samples collected. Nitrate+nitrite concentrations exceeded the target value of 1.0 mg/l in five of six samples. Aluminum was detected at a concentration 2910 µg/l in one sample. The Tier II Human Health criterion for aluminum is 970µg/l.

Blystone Ditch

Blystone Ditch is a small tributary of Swan Creek at RM 17.59. One sample site was assessed on this tributary at Monclova Road (RM 0.54). All E. coli results exceeded the maximum primary contact criterion of 298/100 ml. and the primary contact recreational use geometric mean criterion of 126/100 ml. Phosphorus concentrations exceeded the target value of 0.1 mg/l in two of six samples collected. Nitrate+nitrite concentrations exceeded the target value of 0.10 mg/l in three of six samples. These elevated levels of phosphorus and nitrate+nitrite resulted from fertilizer runoff through tiled farm field drainages.

Wolf Creek

Three sample sites were selected for the water quality assessment of Wolf Creek. Runoff pollutants found in Wolf Creek resulted from rural drainage (tiled field drains) in the upstream section and urban runoff (impervious surfaces/storm drains) in the lower section. All E. coli results from samples collected from Wolf Creek exceeded the maximum primary contact criterion of 298/100 ml. and the primary contact recreational use geometric mean criterion of 126/100 ml. At Albon Road (RM 4.06) nitrate+nitrite concentrations exceeded the target value of 1.0 mg/l in one of six samples collected. Downstream at Perrysburg-Holland Road (RM 1.96) phosphorus concentrations exceeded the target value of 0.10 mg/l in one of six samples. Nitrate+nitrite concentrations exceeded the target value in three of six samples. Aluminum was detected in one sample at a concentration of 1050 µg/l which exceeds the WQS. The Tier II Human Health WQS is 970 µg/l. At Holland-Sylvania Road (RM 0.48) phosphorus concentrations exceeded the target value of in one of six samples. Nitrate+nitrite concentrations exceeded the target value in five of six samples. Aluminum concentrations exceeded the Tier II Human Health WQS in two of six samples. Benzo[a]pyrene concentrations exceeded the Tier SV Aquatic Life and Tier II Human Health WQS in one of two samples collected. Median phosphorus concentrations were below the target value of 0.1 mg/l as presented in Figure 17. Median nitrate-nitrite levels were elevated above the target value of 1.0 mg/l (Figure 18).

Cairl Creek

Water quality samples were collected at Pilliad road (RM 1.32) on Cairl Creek. E. coli results exceeded the maximum primary contact criterion of 298/100 ml. and the primary contact recreational use geometric mean criterion of 126/100 ml. Phosphorus concentrations exceeded the target value of 0.10 mg/l in one of six samples. Nitrate+nitrite concentrations exceeded the target value of 1.0 mg/l in all samples collected. The downstream low head dam compounded this issue by dramatically slowing the creek's flow in this section. There was a noticeable build up of debris and sediments throughout this reach upstream of the dam.

Heilman Ditch

Heilman Ditch was assessed at State Route 20/Conant Road (RM 1.76). E. coli results exceeded the maximum secondary contact criterion of 576/100 ml in four of five samples. Phosphorus and nitrate+nitrite concentrations exceeded their respective target values in all samples collected. Ammonia levels exceeded the Statewide-Protection of Aquatic Life criterion of 10.7 mg/l in one sample. Dissolved solids concentrations were elevated above the Statewide-Protection of Aquatic Life criterion of 1500 mg/l in four of six samples. Strontium concentrations exceeded the Tier I Aquatic Life OMZA criterion of 5300 µg/l in five of the six samples and exceeded the Tier I Human Health criterion of 180000 µg/l in three of six samples. Urban and industrial runoff were suspected to have caused the elevated chemical levels found in Heilman Ditch.

Table 6. Exceedances of Ohio Water Quality Standards (Ohio Administrative Code 3745-1) or nutrient target values documented within the Swan Creek Basin study area during 2006. Aquatic Life Use Designations within the Swan Creek Basin include: Warmwater Habitat; (WWH); Limited Water Resource (LWR); Agricultural Water Supply (AWS); Industrial Water Supply (IWS); Recreational Use Designations include Primary Contact (PCR) & Secondary Contact (SCR)

Stream **(Use Designations)**	**River Mile**	**Use**	**Parameter (Target or WQS)**	**Water Quality Degradation (Result / Unit)**
Swan Creek (WWH, PCR, AWS, IWS)	40.68	WWH	nitrate-nitrite (1.00 mg/l) (10.0 mg/l)	5 of 6 grabs & median above target
				3 of 6 grabs above Human Health OMZA
				(13.20, 19.60, 10.05, 10.00, 6.00 / mg/l)
		PCR	E.Coli (126/100ml/5 samples/30days) (298/100ml/<10%/30days)	violated site specific geometric mean
				(2266/100 ml)
				violated site specific maximum
				(1900, 7000, 730, 1400, 4400 / 100 ml)
	34.41	WWH	nitrate-nitrite (1.00 mg/l) (10.0 mg/l)	6 of 6 grabs & median above target
				3 of 6 grabs above Human Health OMZA
				(1.06, 9.26, 6.58,12.20, 24.50, 12.40 / mg/l)
		PCR	E.Coli (126/100ml/5 samples/30days) (298/100ml/<10%/30days)	violated site specific geometric mean
				(1493/100 ml)
				violated site specific maximum
				(700, 1000, 1200, 3400, 2600 / 100 ml)
	32.82	WWH	phosphorus (0.10 mg/l)	1 of 6 grabs above target
				(0.112 / mg/l)
			nitrate-nitrite (1.00 mg/l) (10.0 mg/l)	6 of 6 grabs & median above target
				1 of 6 grabs above Human Health OMZA
				(6.08, 8.52, 8.83, 13.9, 9.82, 4.43 / mg/l)
		PCR	E.Coli (126/100ml/5 samples/30days) (298/100ml/<10%/30days)	violated site specific geometric mean
				(1178/100 ml)
				violated site specific maximum
				(490, 890, 1800, 4600, 630 / 100 ml)

Stream (Use Designations)	River Mile	Use	Parameter (Target or WQS)	Water Quality Degradation (Result / Unit)
Swan Creek WWH, PCR, AWS, IWS	30.90	WWH	nitrate-nitrite (1.0 mg/l) (10.0 mg/l)	6 of 6 grabs & median above target
				1 of 6 grabs above Human Health OMZA
				(6.27, 8.25, 8.60, 14.00, 9.25, 1.71 / mg/l)
		PCR	E.Coli (126/100ml/5 samples/30days) (298/100ml/<10%/30days)	violated site specific geometric mean
				(863/100 ml)
				violated site specific maximum
				(350, 470, 1000, 400, 730 / 100 ml)
	25.99	WWH	phosphorus (0.10 mg/l)	1 of 1 grabs above target
				(0.201 mg/l)
			nitrate-nitrite (1.0 mg/l)	1 of 1 grabs above target
				(5.82 mg/l)
		PCR	E.Coli (298/100ml/<10%/30days)	violated site specific maximum
				(310, 1200 / 100 ml)
	24.70	WWH	phosphorus (0.10 mg/l)	6 of 6 grabs & median above target
				(0.153, 0.169, 0.176, 0.162, 0.190, 0.211 / mg/l)
			nitrate-nitrite (1.0 mg/l) (10.0 mg/l)	6 of 6 grabs & median above target
				1 of 6 grabs above Human Health OMZA
				(3.06, 4.75, 6.02, 10.5, 5.37, 1.21 / mg/l)
		PCR	E.Coli (126/100ml/5 samples/30days) (298/100ml/<10%/30days)	violated site specific geometric mean
				(689/100 ml)
				violated site specific maximum
				(380, 710, 790, 6100, 120 / 100 ml)
	21.60	WWH	phosphorus (0.10 mg/l)	6 of 6 grabs & median above target
				(0.114, 0.132, 0.190, 0.146, 0.135, 0.235 / mg/l)
			nitrate-nitrite (1.0 mg/l)	6 of 6 grabs & median above target
				(4.19, 2.36, 5.15, 9.65, 5.40, 1.46 / mg/l)
		PCR	E.Coli (126/100ml/5 samples/30days) (298/100ml/<10%/30days)	violated site specific geometric mean
				(2658/100 ml)
				violated site specific maximum
				(410, >10000, 13000, 4700, 530 / 100 ml)

Stream **(Use Designations)**	**River Mile**	**Use**	**Parameter (Target or WQS)**	**Water Quality Degradation (Result / Unit)**
Swan Creek WWH, PCR, AWS, IWS	18.50	WWH	phosphorus (0.10 mg/l)	5 of 6 grabs & median above target
				(0.112, 0.101, 0.109, 0.112, 0.178 / mg/l)
			nitrate-nitrite (1.0 mg/l)	5 of 6 grabs & median above target
				(2.55, 4.21, 5.94, 9.82, 5.30 / mg/l)
		PCR	E.Coli (126/100ml/5 samples/30days) (298/100ml/<10%/30days)	violated site specific geometric mean
				(584/100 ml)
				violated site specific maximum
				(210, 310, 530, 5800, 340 / 100 ml)
	15.30	WWH	phosphorus (0.10 mg/l)	4 of 6 grabs & median above target
				(0.112, 0.129, 0.104, 0.133 / mg/l)
			nitrate-nitrite (1.0 mg/l)	5 of 6 grabs & median above target
				(2.29, 4.11, 5.30, 9.88, 5.00 / mg/l)
		PCR	E.Coli (126/100ml/5 samples/30days) (298/100ml/<10%/30days)	violated site specific geometric mean
				(497/100 ml)
				violated site specific maximum
				(210, 350, 610, 1700, 400 / 100 ml)
	10.84	WWH	nitrate-nitrite (1.0 mg/l)	5 of 6 grabs & median above target
				(1.92, 3.32, 9.56, 7.94, 4.30 / mg/l)
		PCR	E.Coli (126/100ml/5 samples/30days) (298/100ml/<10%/30days)	violated site specific geometric mean
				(617/100 ml)
				violated site specific maximum
				(440, 920, 420, 1600, 330 / 100 ml)
	4.20	WWH	phosphorus (0.10 mg/l)	5 of 6 grabs & median above target
				(0.193, 0.500, 0.118, 0.119, 0.146 / mg/l)
			nitrate-nitrite (1.0 mg/l)	6 of 6 grabs & median above target
				(2.70, 3.29, 5.53, 8.09, 3.93, 1.16 / mg/l)
			dieldrin (0.0000065 µg/l)	1 of 2 grabs above Tier I Human Health value
				(0.0045 µg/l)
		PCR	E.Coli (126/100ml/5 samples/30days) (298/100ml/<10%/30days)	violated site specific geometric mean
				(551/100 ml)
				violated site specific maximum
				(340, 900, 520, 1400, 230 / 100 ml)

Stream **(Use Designations)**	**River Mile**	**Use**	**Parameter (Target or WQS)**	**Water Quality Degradation (Result / Unit)**
Swan Creek WWH, PCR, AWS, IWS	1.60	WWH	phosphorus (0.10 mg/l)	4 of 6 grabs & median above target
				(0.111, 0.111, 0.128, 0.222 / mg/l)
			nitrate-nitrite (1.0 mg/l)	6 of 6 grabs above median & target
				(4.09, 5.78, 3.36, 8.94, 2.33, 1.43 / mg/l)
		PCR	E.Coli (126/100ml/5 samples/30days) (298/100ml/<10%/30days)	violated site specific geometric mean
				(921/100 ml)
				violated site specific maximum
				(490, 310, 910, 200, 2400 / 100 ml)
	0.19	WWH	phosphorus (0.10 mg/l)	3 of 6 grabs above median & target
				(0.129, 0.148, 0.257 / mg/l)
			nitrate-nitrite (1.0 mg/l)	5 of 6 grabs above median & target
				(1.51, 3.09, 3.64, 8.46, 7.24 / mg/l)
			aluminum (970 µg/l)	1 of 6 grabs above Tier II Human Health
				(1080 µg/l)
			dieldrin (0.0000065 µg/l)	1 of 2 grabs above Tier I Human Health value
				(0.0057 µg/l)
		PCR	E.Coli (126/100ml/5 samples/30days) (298/100ml/<10%/30days)	violated site specific geometric mean
				(244/100 ml)
				violated site specific maximum
				(29, 110, 670, 1500, 270 / 100 ml)
Ai Creek WWH, PCR, AWS, IWS	10.44	WWH	phosphorus (0.10 mg/l)	4 of 6 grabs above median & target
				(0.232, 0.216, 0.119, 0.118 / mg/l)
			nitrate-nitrite (1.0 mg/l) (10.0 mg/l)	6 of 6 grabs above median & target
				1 of 6 grabs above Human Health OMZA
				(2.65, 9.85, 15.2, 8.37, 6.93, 2.50 / mg/l)
			copper (OMZM 32.7 µg/l) (IMZM 65.1 µg/l)	1 of 6 grabs violated Aquatic Life OMZM & IMZM
				(106 µg/l)
		PCR	E.Coli (126/100ml/5 samples/30days) (298/100ml/<10%/30days)	violated site specific geometric mean
				(4477/100 ml)
				violated site specific maximum
				(10000, >10000, 2000, 1800, 5000 / 100 ml)

Stream **(Use Designations)**	**River Mile**	**Use**	**Parameter (Target or WQS)**	**Water Quality Degradation (Result / Unit)**
Ai Creek WWH, PCR, AWS, IWS	8.29	WWH	phosphorus (0.10 mg/l)	1 of 6 grabs above target
				(0.160 mg/l)
			nitrate-nitrite (1.0 mg/l) (10.0 mg/l)	5 of 6 grabs above median & target
				1 of 6 grabs above Human Health OMZA
				(9.92, 16.0, 9.03, 7.62, 2.68 / mg/l)
		PCR	E.Coli (126/100ml/5 samples/30days) (298/100ml/<10%/30days)	violated site specific geometric mean
				(2134/100 ml)
				violated site specific maximum
				(1200, 3000, 4000, 2200, 1400 / 100 ml)
	2.10	WWH	phosphorus (0.10 mg/l)	6 of 6 grabs above median & target
				(1.21, 0.332, 0.652, 0.546, 0.208, 0.829 / mg/l)
			nitrate-nitrite (1.0 mg/l) (10.0 mg/l)	6 of 6 grabs above median & target
				1 of 6 grabs above Human Health OMZA
				(4.44, 7.19, 3.76, 8.65, 13.7, 9.18 / mg/l)
		PCR	E.Coli (126/100ml/5 samples/30days) (298/100ml/<10%/30days)	violated site specific geometric mean
				(3272/100 ml)
				violated site specific maximum
				(900, 8600, 2200, 6300, 3500 / 100 ml)
	1.66	WWH	phosphorus (0.10 mg/l)	6 of 6 grabs above median & target
				(0.968, 0.268, 0.413, 0.361, 0.237, 0.551 / mg/l)
			nitrate-nitrite (1.0 mg/l) (10.0 mg/l)	6 of 6 grabs above median & target
				1 of 6 grabs above Human Health OMZA
				(4.57, 5.76, 3.17, 8.12, 11.10, 8.46 / mg/l)
		PCR	E.Coli (126/100ml/5 samples/30days) (298/100ml/<10%/30days)	violated site specific geometric mean
				(2200/100 ml)
				violated site specific maximum
				(830, 7400, 1400, 5000, 1200 / 100 ml)

Stream (Use Designations)	**River Mile**	**Use**	**Parameter (Target or WQS)**	**Water Quality Degradation (Result / Unit)**
Blystone Ditch	0.54	WWH	phosphorus (0.10 mg/l)	2 of 6 grabs above target
				(0.516, 0.626 / mg/l)
			nitrate-nitrite (1.0 mg/l)	3 of 6 grabs above target
				(1.50, 6.12, 1.15 / mg/l)
		PCR	E.Coli (126/100ml/5 samples/30days) (298/100ml/<10%/30days)	violated site specific geometric mean
				(2688/100 ml)
				violated site specific maximum
				(2600, 10000, 1200, 1500, 3000 / 100 ml)
Fewless Creek WWH, PCR, AWS, IWS	1.80	WWH	phosphorus (0.10 mg/l)	2 of 6 grabs above target
				(0.164, 0.187 / mg/l)
			nitrate-nitrite (1.0 mg/l) (10.0 mg/l)	6 of 6 grabs above median & target
				2 of 6 grabs above Human Health OMZA
				(3.15, 8,97, 6.66, 8.61, 21.2, 12.3 / mg/l)
		PCR	E.Coli (126/100ml/5 samples/30days) (298/100ml/<10%/30days)	violated site specific geometric mean
				(7174/100 ml)
				violated site specific maximum
				(1200, 10000, 5500, 1200, 24000 / 100 ml)
Blue Creek WWH, PCR, AWS, IWS	9.97	WWH	phosphorus (0.10 mg/l)	1 of 6 grabs above target
				(0.104 mg/l)
			arsenic (10.0 µg/l)	1 of 6 grabs above Human Health OMZA
				(10.8 µg/l)
		PCR	E.Coli (126/100ml/5 samples/30days) (298/100ml/<10%/30days)	violated site specific geometric mean
				(630/100 ml)
				violated site specific maximum
				(760, 420, 480, 590,1100 / 100 ml)
	7.80	WWH	phosphorus (0.10 mg/l)	1 of 6 grabs above target
				(0.182 mg/l)
			nitrate-nitrite (1.0 mg/l)	5 of 6 grabs above median & target
				(1.61, 2.08, 1.83, 4.77, 2.92 / mg/l)
		PCR	E.Coli (126/100ml/5 samples/30days) (298/100ml/<10%/30days)	violated site specific geometric mean
				(1580/100 ml)
				violated site specific maximum
				(1300, 6400, 530, 1400, 1600 / 100 ml)

Stream (Use Designations)	**River Mile**	**Use**	**Parameter (Target or WQS)**	**Water Quality Degradation (Result / Unit)**
Blue Creek WWH, PCR, AWS, IWS	5.57	WWH	phosphorus (0.10 mg/l)	2 of 6 grabs above target
				(0.112, 0.202 / mg/l)
			nitrate-nitrite (1.0 mg/l)	5 of 6 grabs above median & target
				(1.41, 2.08, 2.26, 5.06, 2.12 / mg/l)
		PCR	E.Coli (126/100ml/5 samples/30days) (298/100ml/<10%/30days)	violated site specific geometric mean
				(1622/100 ml)
				violated site specific maximum
				(1200, 1300, 800, 1800, 5000 / 100 ml)
	0.73	WWH	nitrate-nitrite (1.0 mg/l)	5 of 6 grabs above median & target
				(1.31, 2.21, 2.74, 7.76, 5.67 / 100 ml)
		PCR	E.Coli (126/100ml/5 samples/30days) (298/100ml/<10%/30days)	violated site specific geometric mean
				(1983/100 ml)
				violated site specific maximum
				(370, >10000, 650, 2900, 4400 / 100 ml)
Harris Ditch (formerly named South Swan Creek)	1.55	WWH	phosphorus (0.10 mg/l)	2 of 6 grabs above target
				(0.178, 0.248 / mg/l)
			nitrate-nitrite (1.0 mg/l)	5 of 6 grabs above median & target
				(3.42, 8.14, 1.95, 6.92 / mg/l)
			aluminum (970 µg/l)	1 of 6 grabs above Tier II Human Health
				(2910 µg/l)
		PCR	E.Coli (126/100ml/5 samples/30days) (298/100ml/<10%/30days)	violated site specific geometric mean
				(852/100 ml)
				violated site specific maximum
				(550, 690, 530, 1600, 1400 / ml)

Stream (Use Designations)	**River Mile**	**Use**	**Parameter (Target or WQS)**	**Water Quality Degradation (Result / Unit)**
Wolf Creek WWH, PCR, AWS, IWS	4.06	WWH	nitrate-nitrite (1.0 mg/l)	1of 6 grab above target
				(1.54 mg/l)
		PCR	E.Coli (126/100ml/5 samples/30days) (298/100ml/<10%/30days)	violated site specific geometric mean
				(593/100 ml)
				violated site specific maximum
				(2600, 650, 1400, 1200, 26 / 100 ml)
	1.96	WWH	phosphorus (0.10 mg/l)	1 of 6 grabs above target
				(0.123 mg/l)
			nitrate-nitrite (1.0 mg/l)	3 of 6 grab above target
				(1.11, 1.02, 1.49 / mg/l)
			aluminum (970 µg/l)	1 of 6 grabs above Tier II Human Health
				(1050 µg/l)
			E.Coli (126/100ml/5 samples/30days) (298/100ml/<10%/30days)	violated site specific geometric mean
				(1017/100 ml)
				violated site specific maximum
				(2300, 1200, 880, 1000, 450 / 100 ml)
	0.48	WWH	phosphorus (0.10 mg/l)	1 of 6 grabs above target
				(0.267 mg/l)
			nitrate-nitrite (1.0 mg/l)	5 of 6 grabs above median & target
				(1.50, 1.80, 2.12, 1.70, 1.30 / mg/l)
			aluminum (970 µg/l)	2 of 6 grabs above Tier II Human Health
				(1160, 1010 / µg/l)
			benzo[a]pyrene (1.1 µg/l IMZM) (0.54 µg/l OMZM) (0.060 µg/l OMZA) (0.00002 µg/l drink/nondrink)	1 of 2 grabs above Tier SV Aquatic Life & Tier II Human Health
				(1.32 µg/l)
		PCR	E.Coli (126/100ml/5 samples/30days) (298/100ml/<10%/30days)	violated site specific geometric mean
				(1009/100 ml)
				violated site specific maximum
				(1700, 1000, 610, 100, ND / 100 ml)

Stream **(Use Designations)**	**River Mile**	**Use**	**Parameter (Target or WQS)**	**Water Quality Degradation (Result / Unit)**
Cairl Creek	1.32	WWH	phosphorus (0.10 mg/l)	1 of 6 grabs above target
				(0.139 mg/l)
			nitrate-nitrite (1.0 mg/l)	6 of 6 grabs above median & target
				(3.03, 3.70, 2.87, 3.38, 5.64, 2.21 / mg/l)
		PCR	E.Coli (126/100ml/5 samples/30days) (298/100ml/<10%/30days)	violated site specific geometric mean
				(901/100 ml)
				violated site specific maximum
				(1400, 730, 700, 1300, 640 / 100 ml)
Heilman Ditch LWR, SCR, AWS, IWS	1.76	LWR	ammonia (10.7 mg/l)	Statewide-Protection of Aquatic Life
				(19.1 mg/l)
			phosphorus (0.10 mg/l)	6 of 6 grabs above target & median
				(2.11, 1.57, 0.78 / mg/l)
			nitrate-nitrite (1.0 mg/l) (10.0 mg/l)	6 of 6 grabs above median & target
				2 of 6 grabs above Human Health OMZA
				(16.4, 6.05, 6.80, 3.31, 10.3, 3.89 / mg/l)
			dissolved solids (1500 mgl)	Statewide-Protection of Aquatic Life
				(1840, 1760, 1890, 1820 / mg/l)
			strontium (5300 µg/l OMZA) (18000 µg/l drink)	5 of 6 grabs above Tier I Aquatic Life
				(14800, 19900, 18200, 17900, 18700 / µg/l)
				3 of 6 grabs above Tier I Human Health
				(19900, 18200, 18700 / µg/l)
		SCR	E.Coli (576/100ml/<10%/30days)	violated site specific maximum
				(170, >10000, 650, 2200, 12000 / mg/l)

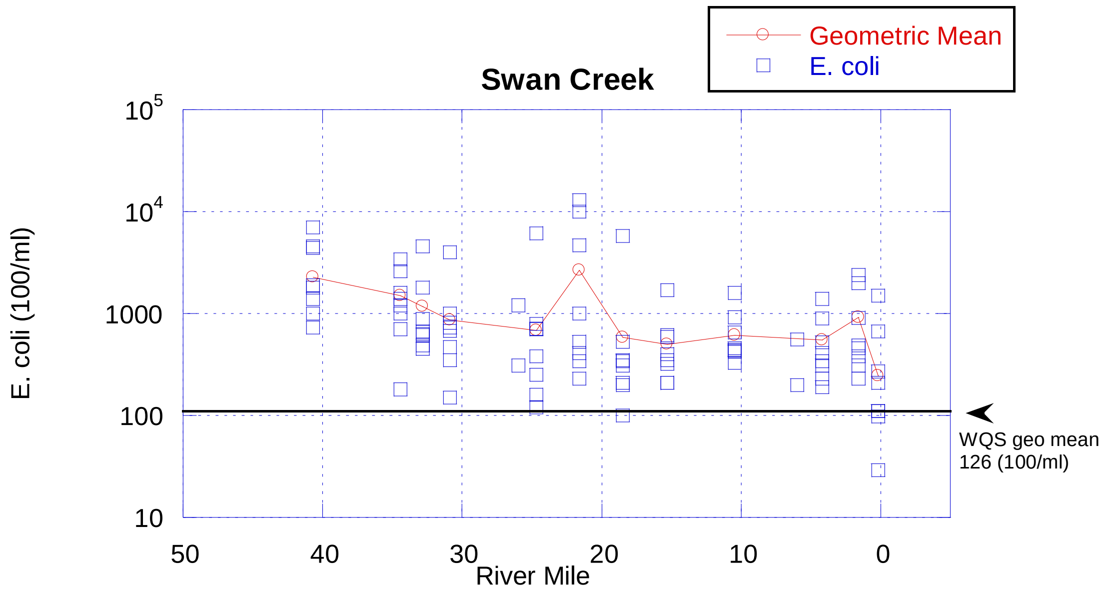

Figure 7. Geometric mean calculated from E. coli results from water quality samples collected during the 2006 Swan Creek Survey.

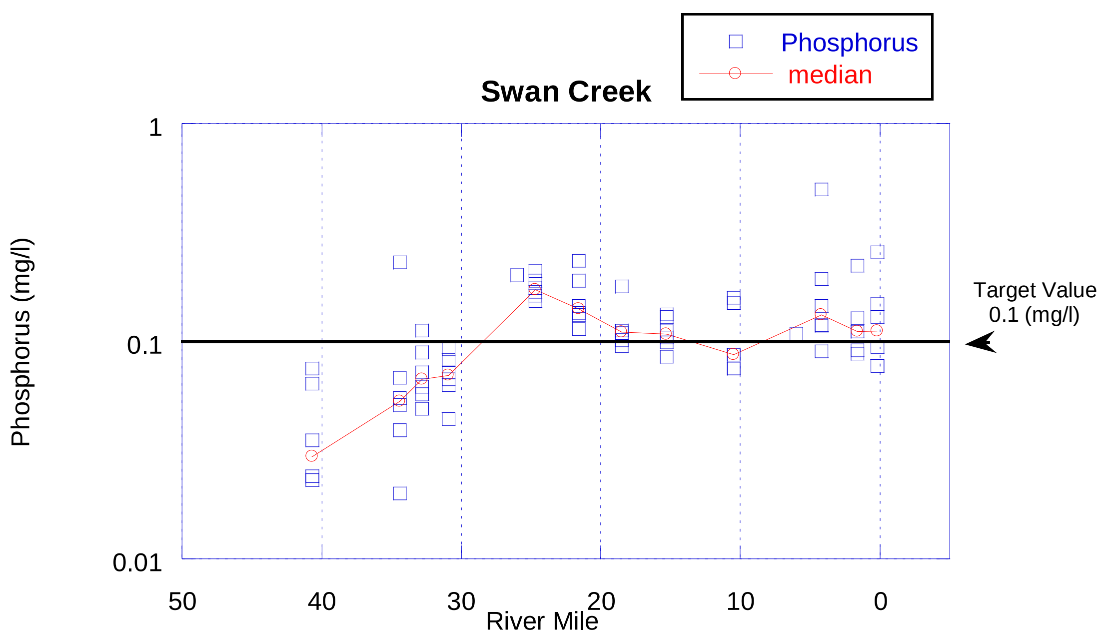

Figure 8. Total phosphorus & median concentrations from water quality samples collected during the 2006 Swan Creek Survey.

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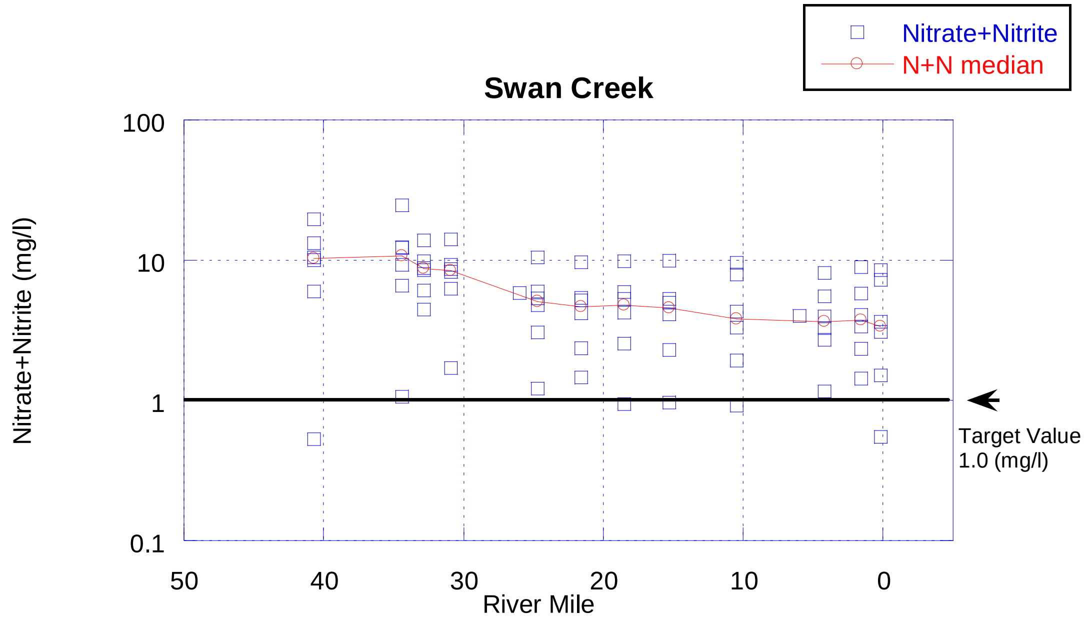

Figure 9. Nitrate-nitrite & median concentrations from water quality samples collected during the 2006 Swan Creek Survey.

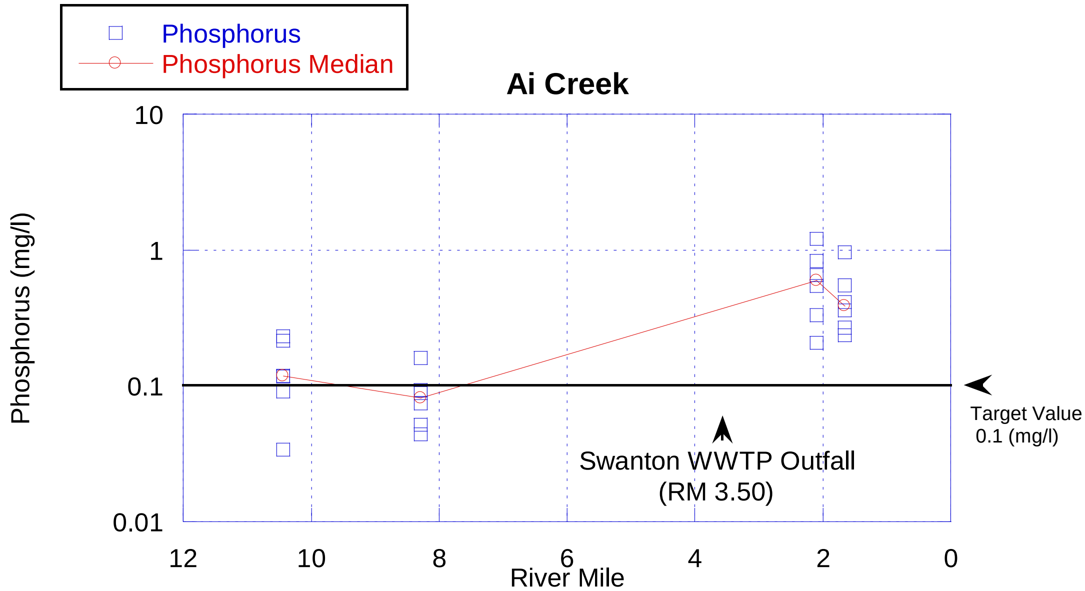

Figure 10. Total phosphorus & median concentrations from water quality samples collected from Ai Creek during the 2006 Swan Creek Survey.

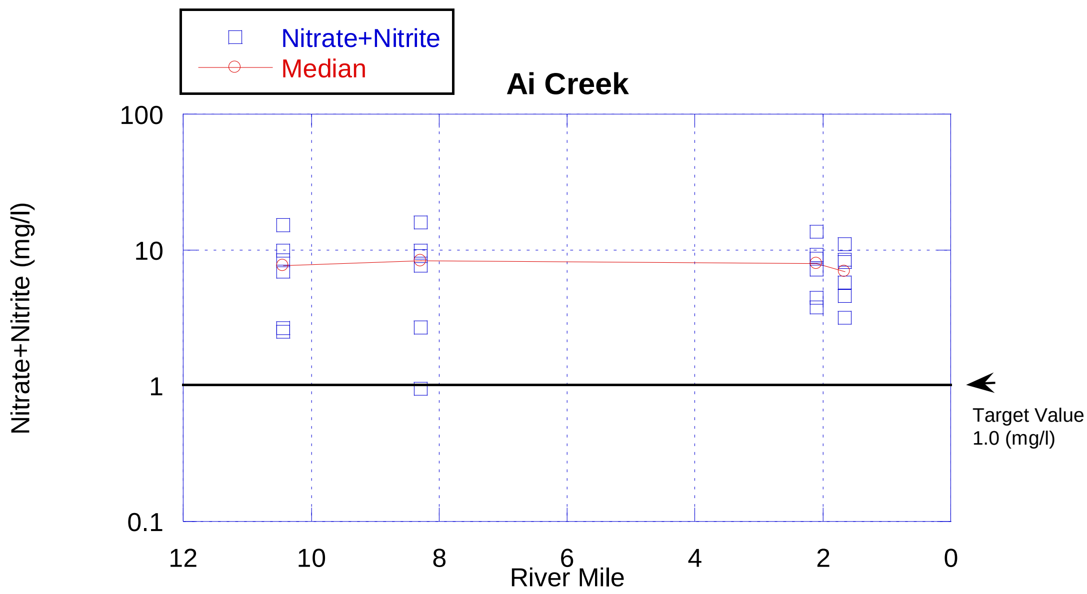

Figure 11. Nitrate-nitrite & median concentrations from water quality samples collected from Ai Creek during the 2006 Swan Creek Survey.

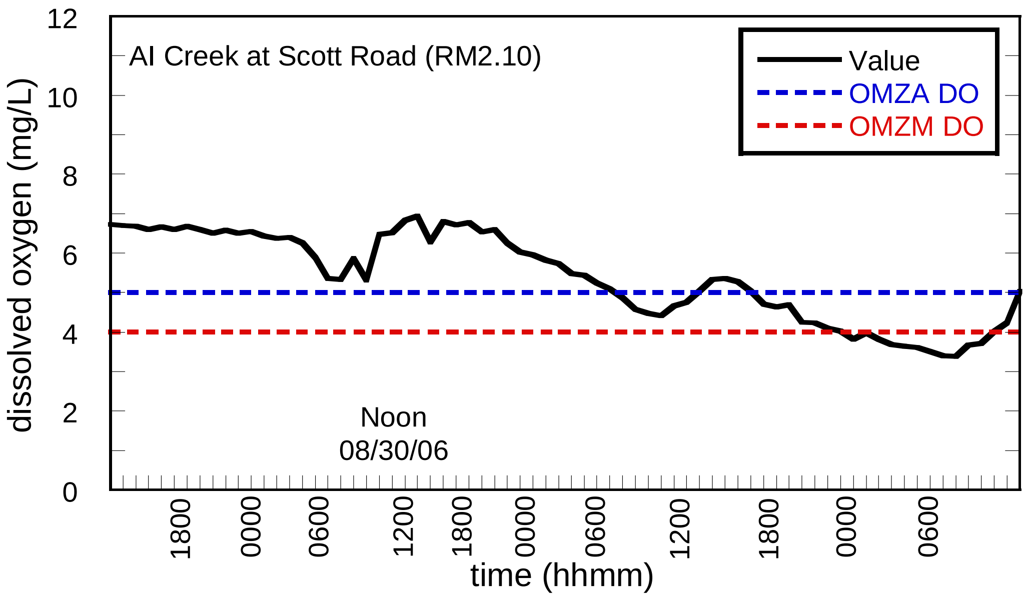

Figure 12. Dissolved oxygen values from AI Creek at Scott Road (RM 2.10) recorded using continues monitors deployed August 29- September 1, 2006

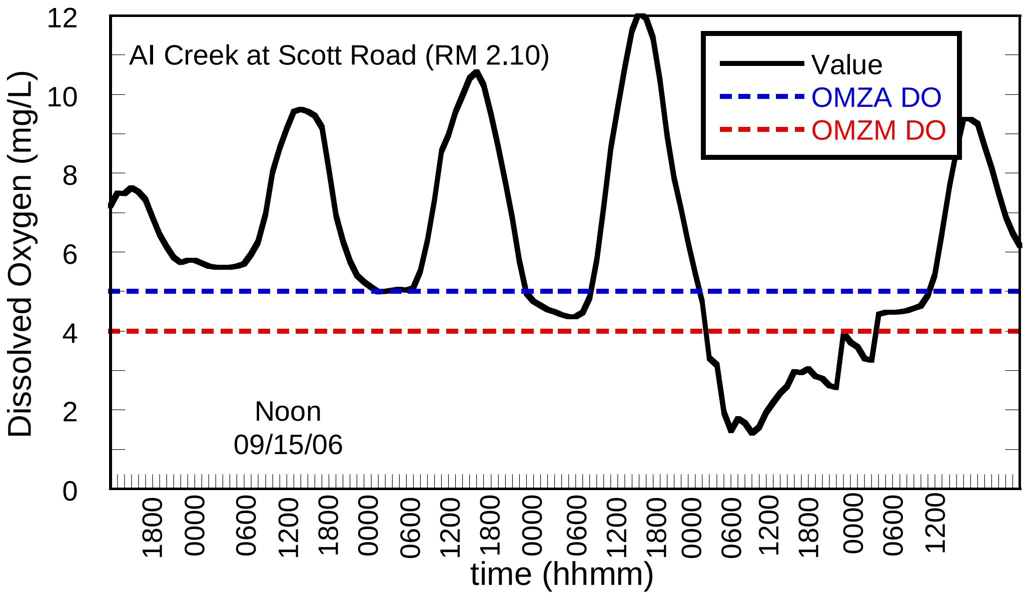

Figure 13. Dissolved oxygen values from AI Creek at Scott Road (RM 2.10) recorded using continuous monitors deployed September 14-19, 2006

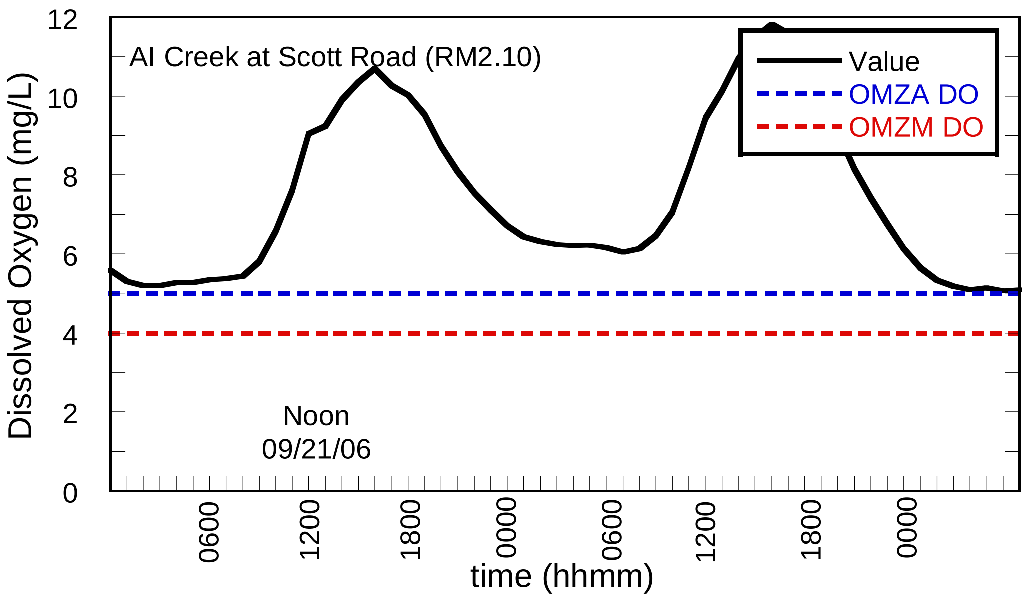

Figure 14. Dissolved oxygen values from AI Creek at Scott Road (RM 2.10) recorded using continuous monitors deployed September 20-22, 2006

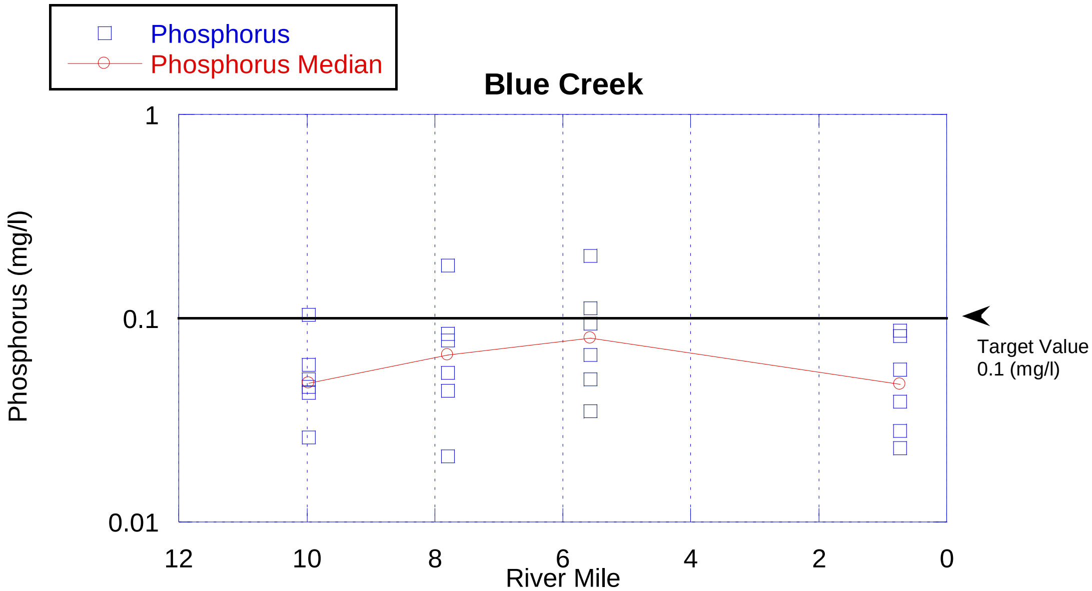

Figure 2. Total phosphorus & median concentrations from water quality samples collected from Blue Creek during the 2006 Swan Creek Survey.

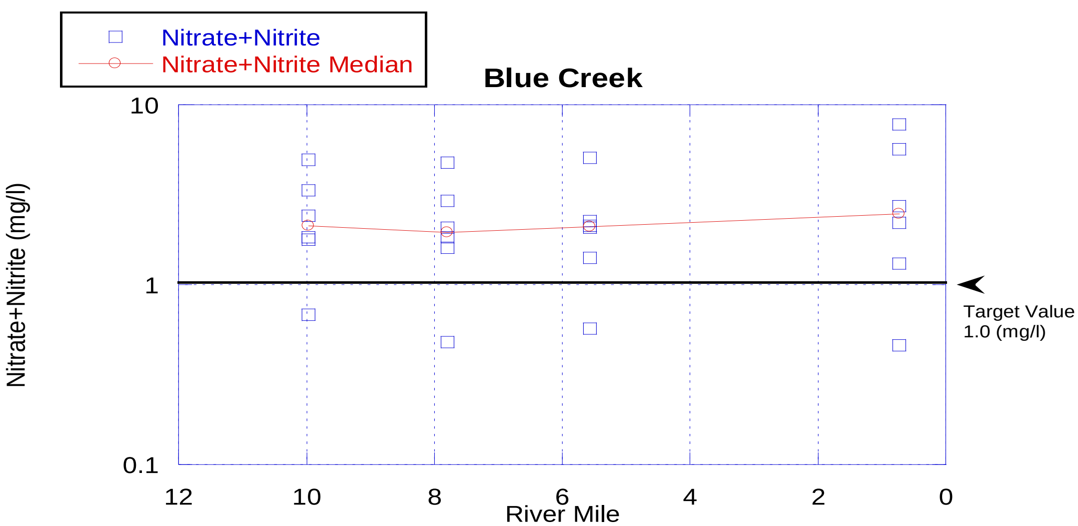

Figure 16. Nitrate-nitrite & median concentrations from water quality samples collected from Blue Creek during the 2006 Swan Creek Survey

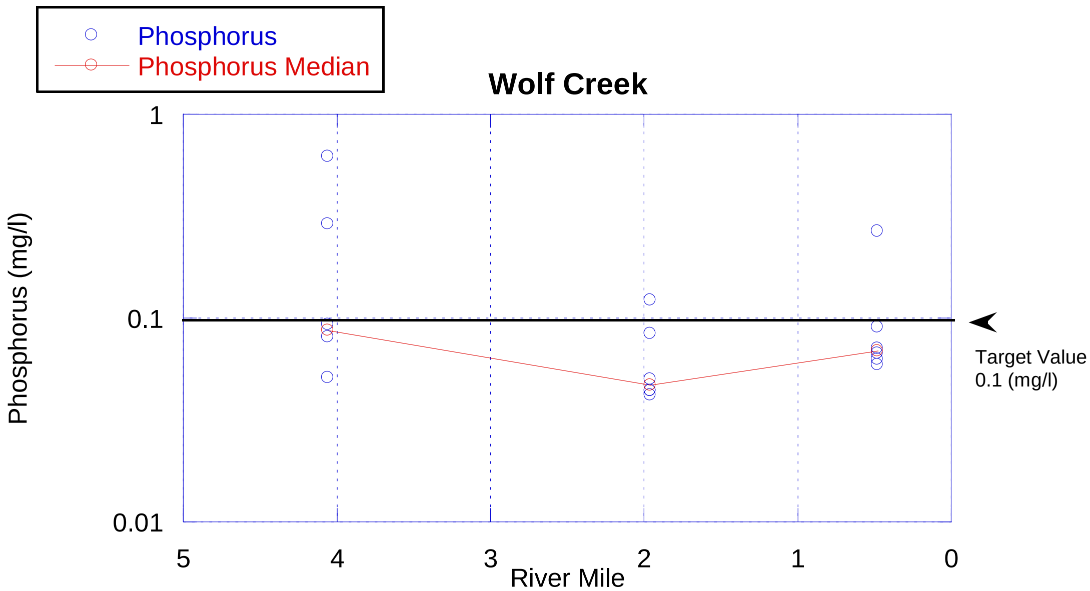

Figure 17. Total phosphorus & median concentrations from water quality samples collected from Wolf Creek during the 2006 Swan Creek Survey.

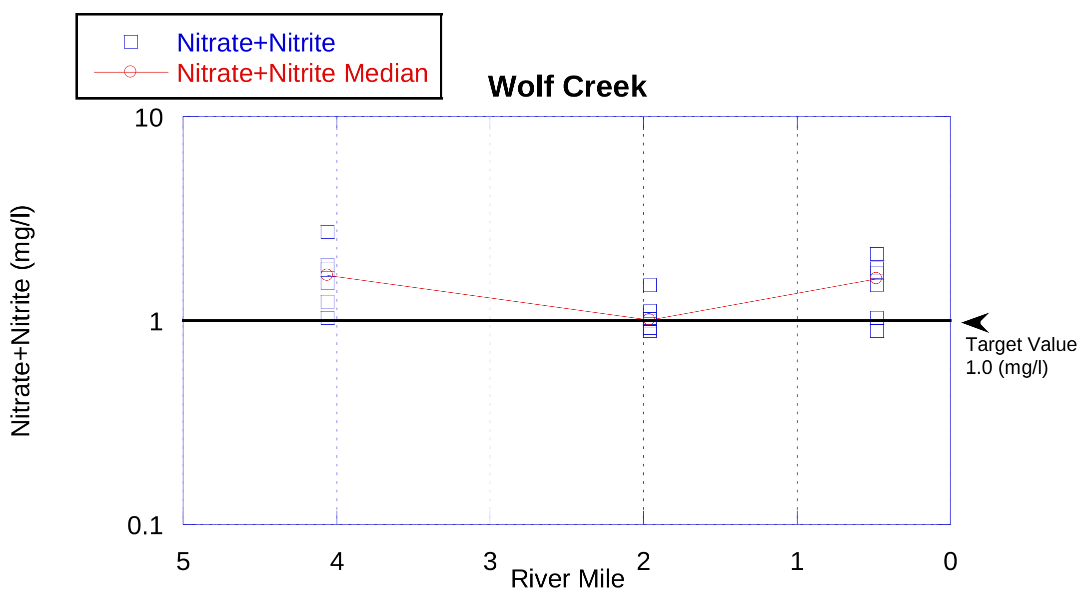

Figure 18. Nitrate-nitrite & median concentrations from water quality samples collected from Wolf Creek during the 2006 Swan Creek Survey.

Pollutant Loadings

Facilities which are authorized to discharge pollutants under a National Pollutant Discharge Elimination System (NPDES) into the Swan Creek watershed are listed in table 7. Facilities which hold NPDES permits within the watershed consist of the municipal owned Swanton Waste Water Treatment Plant (WWTP), the municipal owned Swanton Water Treatment Plant (WTP), a privately owned stone quarry and several small package plants which service mobile home parks.

The Swanton WWTP was constructed in 1977 and upgraded in 2001. The treatment system has an average design flow of 0.92 million gallons a day (MGD) and consists of a primary sedimentation unit, trickling filters, secondary clarification, chlorination, sand filters and dechlorination. The final outfall from the Swanton WWTP is located on AI Creek at RM 3.50. Annual loadings (kg/day) of total phosphorus and nitrate+nitrite were evaluated using the Liquid Effluent Analysis Processing System (LEAPS) (Figure 19 & 20). This system is a database that stores monthly self-monitoring data which is submitted to the Ohio EPA. The sanitary sewer collection system that services the Village of Swanton consists of 40 % separated sewers. The remaining 60 % of the collection system is combined sewers that collect both storm water and sanitary wastewater. During wet weather when flows of storm water and sanitary wastewater exceed the capacity of the WWTP, overflows may bypass the treatment plant and discharge to the receiving stream. Permitted overflows and locations are presented in Table 8.

Additional overflows exist in the lower segments of the Swan Creek watershed that originate from the City of Toledo WWTP and are also listed in Table 8. The primary final outfall for the City of Toledo WWTP discharges to the Maumee River and was included in the Swan Creek study area.

Table 7. Facilities regulated by National Pollutant Discharge Elimination System in the Swan Creek watershed.

Facility Name	Ohio EPA Permit No.	Receiving Stream	River Mile	Type of Treatment
Country Court MHP	2PY00060	Swan Creek	37.6	Extended aeration/sandfilter/Cl
Swanton WTP	2IW00252	Swan Creek	30.84	Sandfilter backwash/clarifier sludge blowoff/settling ponds
Arrowhead Lake MHP	2PY00067	Wiregrass Ditch		Extended aeration/sandfilter/Cl/deCl
Stoneco, Inc. Maumee Quarry	2IJ00048	Heilman Ditch via storm sewer		Sedimentation settling
Forest MHP	2PY00019	Trib. to Fewless Creek	0.03	Extended aeration/sandfilter/Cl
Peaceful Acres MHP	2PY00064	Blue Creek	7.9	Topco system/settling/skimmer
Swanton Meadows MHP	2PY00022	AI Creek	10.75	Package plant w/Cl/ Settling pond
Village of Swanton	2PB00025	AI Creek	3.5	Digester/tricking filter/clarifier/sandfilters

Table 8. Sewer system overflows authorized by National Pollutant Discharge Elimination System during wet weather in the Swan Creek watershed.

Facility Name	Ohio EPA Permit No.	Receiving Stream	Location
Swanton WWTP	2PB00025008	AI Creek	Main St. Bridge
	2PB00025013	AI Creek	Dodge St. RR Bridge
	2PB00025016	AI Creek	High School Foot Bridge
	2PB00025018	AI Creek	Fulton St.
	2PB00025019	AI Creek	Main St. (apple orchard)
	2PB00025020	AI Creek	E. Garfield (Street Dept.)
	2PB00025024	Mary Wander Ditch	Brookside @ Crestwood
	2PB00025027	Mary Wander Ditch	Church St.
	2PB00025028	Mary Wander Ditch	Hallett @ Broadway
Toledo WWTP	2PF00000042	Swan Creek	Erie St. south of Hamilton
	2PF00000043	Swan Creek	Hamilton &Anthony Wayne Trail
	2PF00000045	Swan Creek	Ewing & Hamilton
	2PF00000046	Swan Creek	Hawley St. south of bridge
	2PF00000047	Swan Creek	Pere West, east of Gibbons St.
	2PF00000048	Swan Creek	Hillside & Chester St.
	2PF00000050	Swan Creek	Fearing St. in Highland Park

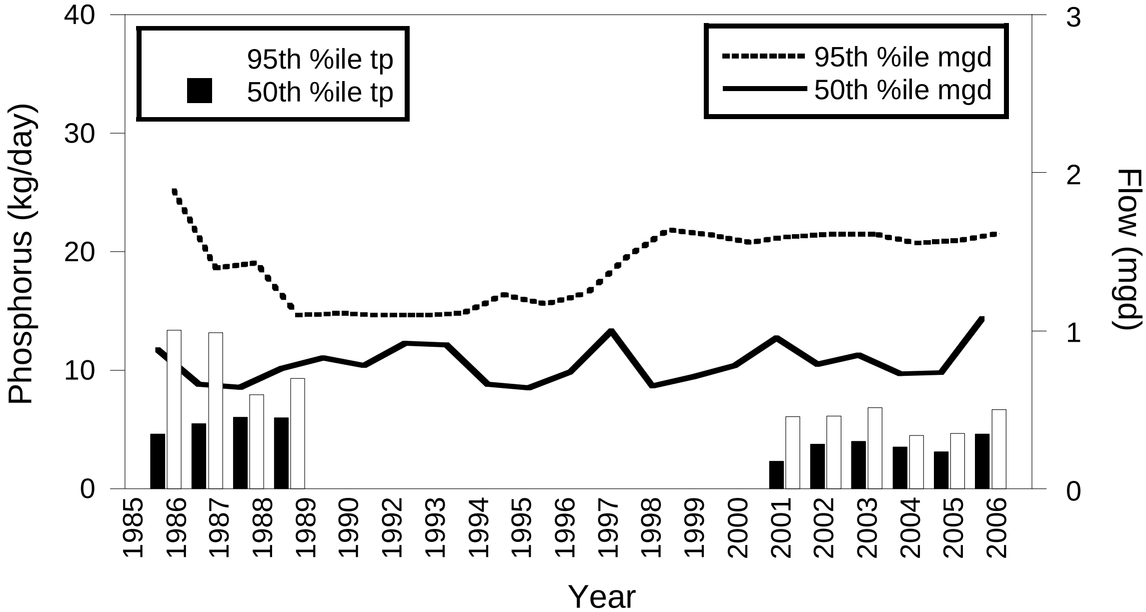

Figure 19. Annual total phosphorus loadings (kg/day) and flow from the Swanton WWTP, 1986 to 2006.

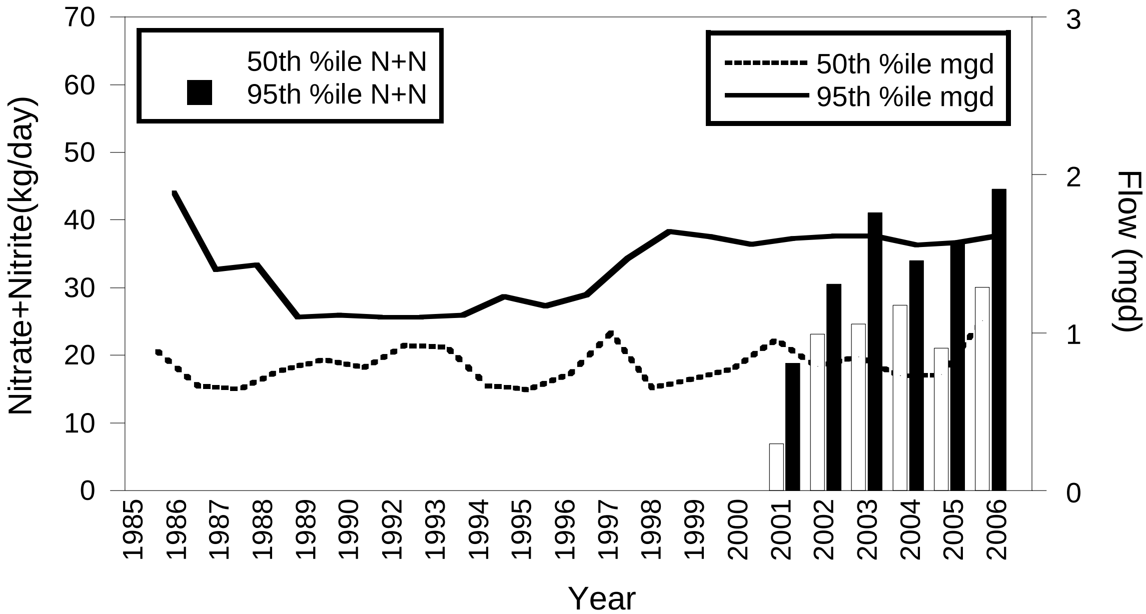

Figure 20. Annual total nitrate+nitrite loadings (kg/day) and flow from the Swanton WWTP. Nitrate+nitrite values only available from 2001 to 2006.

Swanton Reservoir

The monitoring and assessment of “lakes”, including natural lakes and man made impoundments and upground reservoirs, is an important compliment to the study of stream ecosystems. Lakes act as watershed sinks for the upstream loadings of sediment, nutrients, and pesticides. Thus, their assessment can be an important indicator of the combined effects that both point and non point pollution sources have on surface water quality.

Swanton Reservoir is a 25 acre upground reservoir that was built in 1937 to store drinking water and provide a source of recreation. The lake is open to public fishing and boating and a small launch ramp is provided. All watercraft are restricted to either hand power or electric motors. Fish management activities include fall stocking of rainbow trout. This is considered a “put and take” fishery and not a viable year round population. A survey done by Ohio DNR in 2005 indicated that the lake contains mostly a stunted population of panfish (i.e., bluegill, green sunfish). Swimming is not allowed at any time.

Source water for the reservoir is obtained from Swan Creek via pumps located at River Mile 30.85. There is also a ground water well for back up during periods of drought. The reservoir storage capacity is about 100 million gallons. Pumping is suspended during runoff events. Pump is conducted when stream water quality is best. The lake does provide some preliminary treatment by permitting the settling of suspended materials and biological assimilation of nutrients. Lake water that is pumped into the Swanton WTP is treated by lime soda softening and sand filtration. Sludge from the clarifiers and filter backwash is piped to one of three settling lagoons. Supernatant from the lagoons is discharged to Swan Creek at River Mile 30.84 and regulated under NPDES permit # 2IW00252. It was noted that these lagoons were functioning very poorly because they were so full of sludge that not enough retention time was allowed to fully treat the wastewater.

Swanton is classified as a community public water system by the Ohio EPA Division of Drinking and Ground Waters (DDAGW). Standards and monitoring requirements that apply are defined in the Federal Safe Drinking Water Act and Ohio Public Drinking Water Standards. All community public water systems are required to prepare and distribute an annual Consumer Confidence Report that summarizes finished water quality. The only problem documented in the 2005 report was a violation for total trihalomethane. These compounds are suspected human carcinogens and form when chlorine combines with organic matter during the disinfection process.

Swanton Reservoir was assessed by the Ohio EPA during the 2006 field season. All testing was done at the deepest part of the lake in a creek channel not far from the outlet structure. Swan Creek was straightened and the channel relocated when the reservoir was built. During each of three sampling events profiles for temperature, dissolved oxygen, pH, and conductivity were recorded at 0.5 meter intervals and the secchi transparency depth was measured. Samples for lab analysis were collected from the water column at 0.5 meter below the surface and 0.5 meter above the bottom. An additional surface sample was field filtered to determine the chlorophyll a concentration and a vertical tow net was used to collect phytoplankton and zooplankton specimens. A sediment sample was also collected during one of the sampling events.

A variety of parameters were tested in the water column samples, including physical attributes, biochemical oxygen demand, nutrients, metals, and organic compounds. Results were compared to Ohio Water Quality Standards and Drinking Water Standards, although the latter only apply to the finished product distributed for consumption. Statewide Water Quality Criteria (3745-1-07) are established for the protection of aquatic life and Lake Erie Basin Criteria (3745-1-33) are established for the protection of human health and wildlife. Primary Drinking Water Standards (OAC 3745-81) are set for pollutants with serious human health implications and are usually expressed as maximum contaminant levels (MCLs). Some of these pollutants include metals, nitrate, pesticides, and organic disinfection byproducts. Secondary Contaminant Standards (OAC 3745-82) are set for pollutants associated with aesthetic constituents like taste, odor, and color. Some of these pollutants include dissolved solids, iron, and manganese.

Conditions in the Swanton Reservoir were poor at times based on results from the three sampling events. No herbicides, insecticides, or other organic compounds were detected in any of the samples. Most problems were documented in the bottom layer of water (i.e., hypolimnion) during periods of thermal stratification. This layer is essentially isolated from the surface layer (i.e., epilimnion) by a middle layer that creates a density barrier (i.e., metalimnion). The thermocline is the depth at which temperature falls 1°C or more for each 1 m of depth. The thermocline was at a depth of about 3 m on May 23. Dissolved oxygen in the hypolimnion was below statewide criteria established for warmwater habitat and was as low as 0.2 mg/L in the bottom sample. The manganese concentration was 723 µg/L in the bottom sample and this exceeds the secondary drinking water standard of 50 µg/L. The thermocline was at a depth of about 4 m on August 8 and the hypolimnion was anoxic (Figure 21). The water had a strong rotten egg odor (H_2S) and was light black in color. This indicated that anaerobic decomposition was taking place. The ammonia concentration was 13.3 mg/L in the bottom sample and this exceeded the statewide maximum aquatic life criterion. It is doubtful that any higher aquatic life can survive in this zone under these conditions. Manganese was again above the secondary drinking water standard in the bottom sample at a concentration of 1,610 µg/L. Turnover had taken place by the September 19 sampling event and there were no dissolved oxygen or ammonia problems. Turnover occurs when temperatures in the epilimnion cool enough to break the thermocline and allow the water column to mix. Manganese in the surface sample was above the secondary drinking water standard at a concentration of 56 µg/L.

Sediment is important to evaluate in lakes because it has an impact on storage capacity, recreation, water quality, and aquatic life communities. Loss of water storage capacity due to sedimentation can reduce the useful life of a lake and lead to costly dredging. Loss of capacity was not quantitatively measured in Swanton Reservoir. However, little loss was evident based on contour maps and field sonar measurements. It is still possible to distinguish the old creek channel, indicating that it has not filled in nearly 70 years after construction. Sedimentation from bank erosion is controlled by limestone riprap placed along the insides of the dikes to protect them from wind and wave action.

A sediment sample for lab analysis was collected by dredge and emptied into a mixing bowl. A portion of the sample was immediately placed in a container for volatile organic compound analysis. The remainder was homogenized and split into containers to measure physical attributes, nutrients, metals, semi-volatile organic compounds, chlorinated insecticides, and polychlorinated biphenyls (PCBs). The sample consisted of 21.9 % solids and 5.8 % organic carbon. Particle size distribution was 41.4% sand, 7.3% medium/coarse silt, 36.6% very fine/fine silt, 9.7% medium/coarse clay, and 5.0% fine clay.

The quantity and quality of sediment can affect recreation and human health. Too much sediment can cause excessive turbidity and damage lake aesthetics. Direct contact with sediment is a concern because certain chemicals cause skin cancer, such as polynuclear aromatic hydrocarbons (PAHs). No PAHs or other organic compounds were detected in the sample, so this problem should not be an issue. Other chemicals in sediment can bioaccumulate in the aquatic food chain and can trigger sport fish consumption advisories. No fish tissue was collected from Swanton Reservoir during the study. There is a statewide advisory that recommends not eating more than one meal a week of any species caught in Ohio because of mercury concentrations. Women of childbearing age and children 15 and under are most sensitive because high levels of mercury can damage the developing brains, kidneys, and developing fetuses.

Some compounds in sediment are toxic to benthic organisms at elevated levels. Sediment data were evaluated using guidelines established in "*Development and Evaluation of Consensus-Based Sediment Quality Guidelines for Freshwater Ecosystems"* (MacDonald *et al*. 2000). The consensus-based sediment guidelines define two levels of ecotoxic effects. A *Threshold Effect Concentration* (TEC) is a level of sediment chemical quality below which harmful effects are unlikely to be observed. A *Probable Effect Concentration* (PEC) indicates a level above which harmful effects are likely to be observed. In addition, the Ohio Sediment Reference Values represent ecoregion background conditions based on data collected at Ohio reference sites.

Copper was found to be extremely elevated in Swanton Reservoir and was measured at 1,610 mg/kg. This concentration is considerably higher than the PEC of 149 mg/kg. The practice of applying copper sulfate to control algae blooms in the reservoir is likely the source. The WTP operator indicated that this management practice is no longer used (Mike Fields, Village of Swanton, personal communication).

The trophic state index (Carlson, 1977) is a means of classifying lakes by predicting algal biomass. The index can be calculated using either secchi depth, chlorophyll a, or phosphorus measurements. Table 9 summarizes trophic state index (TSI) values calculated for Swanton Reservoir. Since the parameters in the calculations are used to predict algal biomass, chlorophyll a is the best predictor. When secchi depth over predicts biomass, it is likely that water transparency is affected by small particles suspended in the water column such as silt and clay. When phosphorus concentrations under predicts biomass, it is likely the limiting growth nutrient.

Lakes with values ≤ 37 are considered oligotrophic, 38-47 mesotrophic, 48-66 eutrophic, and ≥ 67 hypereutrophic. This information is useful when making management decisions because lakes that fall within a particular trophic state exhibit certain characteristics. For example, at TSI values <30 the water is very clear, the hypolimnion has oxygen throughout the year, and coldwater fisheries dominate (i.e., Salmonid). However, at TSI values > 60 the water is turbid, the hypolimnion becomes anoxic, blue greens dominate the algal community and cause taste and odor problems, and warmwater fisheries dominate (i.e., black-bass). A method used by Ohio EPA to determine the final TSI of a lake averages summer chlorophyll a, secchi depth, and spring phosphorus values. Swanton Reservoir is considered eutrophic with a final TSI of 64.5 using this formula ([63.4+72.1+58.1] ÷ 3).

Table 9. TSI values for Swanton Reservoir, 2006.

Date	TSI chlorophyll a	TSI secchi depth	TSI phosphorus
May 23	70.3	71.5	58.1
Aug. 8	63.4	60.7	27.4
Sept. 19	72.1	64.1	52.2

It is apparent that nutrients from Swan Creek and those released from sediment are stimulating algae blooms in the lake. Nutrient criteria for streams in Ohio are currently under development. In the interim, target values presented in "*Association between Nutrients, Habitat, and the Aquatic Biota in Ohio Rivers and Streams"* (Ohio EPA, 1999) are used as guidelines. Statewide values for wadeable streams (20 mi^2 ≥ drainage area < 200 mi^2) were applied to data obtained from stream samples collected during the study and include a value of 1.00 mg/L for nitrate-nitrite and 0.10 mg/L for phosphorus. Results from six sets of grab samples collected at the intake location June-August show that nitrate-nitrite values are considerably above target. Concentrations ranged from 1.17-14.0 mg/L with a median value of 8.42 mg/L. In contrast, phosphorus never exceeded target values and ranged from 0.044-0.092 mg/L.

Nutrient criteria for lakes in Ohio are also currently under development. Currently, federal ambient water quality criteria recommendations based on the 75th percentile calculated from regional reference sites are available (U.S. EPA, 2000). Table 10 presents the recommended federal criteria for aggregate ecoregion VI, which includes the Huron Erie Lake Plain, and summarizes nutrient based values from surface samples collected in Swanton Reservoir.

Table 10. Recommended federal criteria for aggregate ecoregion VI.

	T-phosphorus (µg/L)	T-nitrogen (mg/L)	chlorophyll a (µg/L)	secchi depth (m)
Reference	37.5	0.78	8.59	1.356
May 23	42	7.47	57.14	0.45
Aug. 8	5	3.16	28.20	0.95
Sept. 19	28	1.60	69.06	0.75

A value equal to one half the lab reporting limit was used in instances where the analytical result was less than the reporting limit. The total nitrogen value is equal to the sum of total nitrogen and nitrate-nitrite nitrogen. The chlorophyll a value is the arithmetic mean of the three replicate samples. Values that are shaded in the table exceeded the recommended federal nutrient criteria. Results show that surface samples exceeded recommended criteria in all instances except summer phosphorus.

Reducing nutrients in runoff from the watershed would be of great benefit to the lake ecosystem, improve the quality of drinking water, and likely reduce the cost of treatment. Row crop agriculture is by far the dominant land use in the source water protection area (74.3%). It will be imperative to implement best management practices to reduce the nutrient load from these areas. There is also a significant portion of land used for livestock production (13.1%). Home sewage treatment systems also contribute to the load and the Village of Brailey is an area not served by central collection and treatment facilities. Other sources include two mobile home parks served by package plants and a combined sewer overflow (CSO) at the Jackson Street lift station in the Village of Delta.

A reduction in nutrients would minimize the impact from nuisance algae blooms. These blooms are likely the cause of anoxic conditions in the hypolimnion during the summer because as algal cells die and sink to the bottom their decomposition depletes oxygen. Algae blooms also affect pH, contribute to taste and odor problems, and are probably the source of organic matter in the formation of trihalomethane compounds during the disinfection process. Another concern regarding algae is the potential for species that produce toxins.

Besides implementing management practices in the source water protection area, it might be necessary to manage nutrients within the lake. Dredging sediment would be one way of removing nutrients from the system. Another possibility would be chemical treatment to precipitate phosphorus from the water column and bind it in sediment. The introduction of herbivorous fish species might be a way to reduce the amount of algae in the water and reduce internal nutrient cycling.

It was surprising that such a strong thermocline developed in a lake as shallow as Swanton Reservoir. Apparently, the lake is protected enough that wind and wave action do not keep the water column mixed. Another management technique that would improve water quality would be to aerate the hypolimnion to increase dissolved oxygen levels. This would eliminate hypoxia and the subsequent release of nutrients (ammonia and phosphorus) and minerals (iron and manganese) from the sediment.

Nutrients in sediment are a concern because they are released into the water column under certain conditions. Ammonia can be directly toxic to aquatic life if levels are elevated in pore water. In addition, bacteria convert ammonia into nitrate under aerobic conditions. Besides being a plant nutrient, nitrate in drinking water is a major concern because it can cause oxygen starvation in tissues if it is fed to pregnant women or babies and can result in a potentially fatal condition known as methemoglobinemia (blue babies). The ammonia concentration in Swanton Reservoir sediment was 270 mg/kg. This is considered slightly elevated when compared to a dataset of results from statewide lake samples collected by Ohio EPA 1993-1995 (n=32). The phosphorus concentration in Swanton Reservoir sediment was 760 mg/kg. This level is considered non elevated when compared to a dataset of results from statewide lake samples collected by NRCS 1988-1989 and Ohio EPA 1993-1995 (n=104).

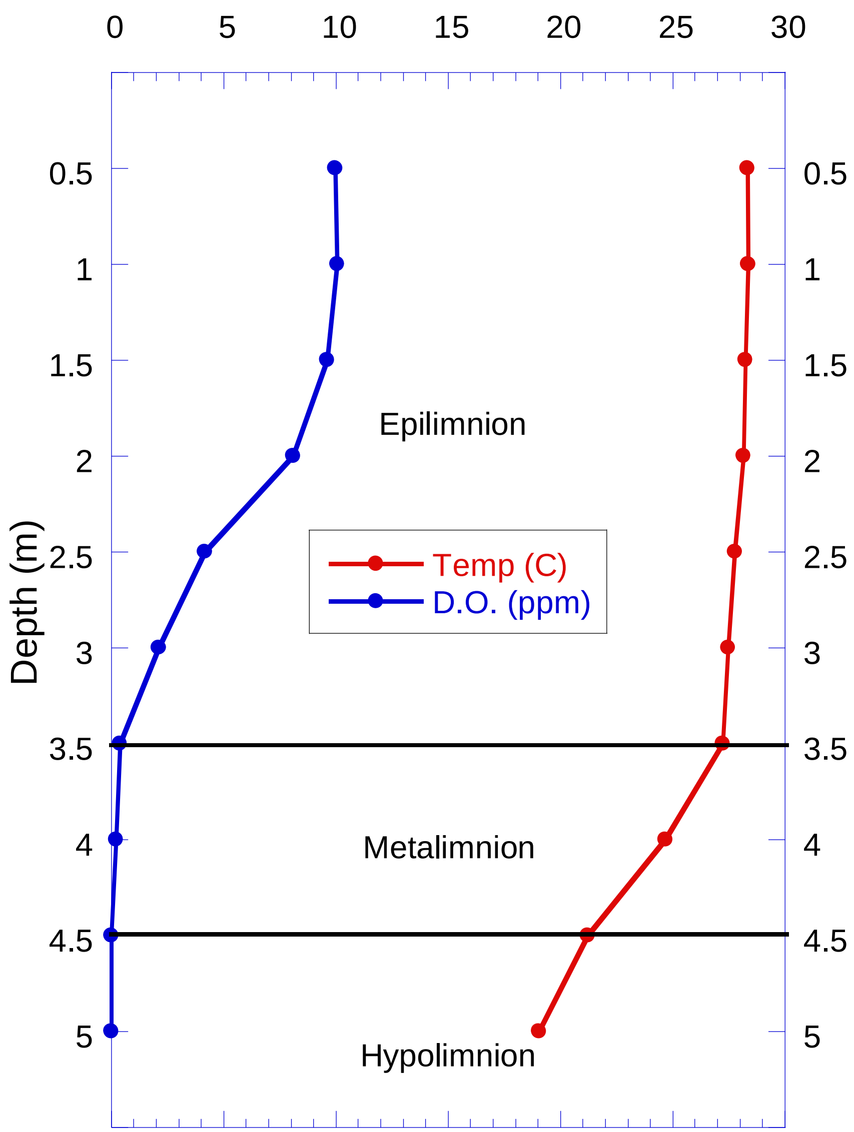

Figure 21. Temperature and dissolved oxygen profile in Swanton Reservoir on August 8, 2006.

Sediment Quality

Sediment data were evaluated using guidelines established in *Development and Evaluation of Consensus-Based Sediment Quality Guidelines for Freshwater Ecosystems* (MacDonald *et al*. 2000). The consensus-based sediment guidelines define two levels of ecotoxic effects. A *Threshold Effect Concentration* (TEC) is a level of sediment chemical quality below which harmful effects are unlikely to be observed. A *Probable Effect Concentration* (PEC) indicates a level above which harmful effects are likely to be observed. In addition, the Ohio Sediment Reference Values represent ecoregion background conditions based on data collected at Ohio reference sites.

The chemical sediment quality was assessed at five locations throughout the Swan Creek basin. Several additional sites were not sampled due to the lack of fine grain sediments. Sediments selected for sampling consisted mainly of fine silts and clays, which are generally associated with persistent environmental contaminants. Chemical quality of sediment is a concern because many pollutants bind strongly to soil particles, are persistent in the environment, and accumulate in the food chain.

Sediment grab samples were analyzed for inorganic metals, semi-volatile organics, polychlorinated biphenyls (PCBs), and pesticides. Sediments with chemical concentrations reported above the Consensus-Based Probable Effect Concentration (PEC) and/or the Ohio Sediment Reference Value may result in negative environmental impacts and warrant further evaluation. Results of sediment samples are summarized in Table 11 & 12**.** Organic parameters were only reported if detected above the analytical method detection limits

Table 11 Metal concentrations (mg/kg) in sediments collected from the Swan Creek Basin in 2006. Values proceeded by a < were below the reporting limit. Those proceeded by; (*) exceeded the threshold effect concentration, (**) exceed the probable effect concentration described by MacDonald et al (2000). Values proceeded by (+) exceeded Ohio-specific Sediment Reference Values (SRVs).

Site	Al	Ba	Ca	Cr	Cu	Fe	Pb	Mg	Mn	Ni	K	Na	Sr	Zn	Hg	As	Cd	Se
Swan Creek RM 32.82	4420J	46.2	15300	<20	16.8	9140	<27	5060	286	<27	<1330	3340	47	68	0.031+	4.92	0.323	<1.33
Swan Creek RM 4.40	4440	40.4	22100	<15	12.2	8690	<20	6350	219	<20	<1010	<2530	56	102	0.029+	3.31	0.356	<1.01
Swan Creek RM 1.60	10000	109	33900	25	263+**	19500	138+**	11900	450	<31	<1540	<3840	87	264+*	0.231+*	8.38	1.43+*	<1.54
Swan Creek RM 0.19	15200	124	41500	27	39.3*	25000	48+*	13000	577	<33	2600	<4100	140	172*	0.096+	6.98	0.91	<1.64
Blue Creek RM 0.73	8480J	112	30500	67+	59.1+*	13200	<32	11600	502	<32	<1610	<4020	572+	98.6	0.229+*	4.34	0.602	<1.61

Table 12. Detected organic chemicals & concentrations (µg/kg) in sediments collected from the Swan Creek Basin in 2006. Values proceeded by; (*) exceeded the threshold effect concentration, (**) exceed the probable effect concentration described by MacDonald et al (2000).

Site	Aldrin	d-BHC	DDD	DDE	Chlordane	Total PCB's	bis(2-Ethylhexyl)phthalate	Total PAH's
Swan Creek RM 32.82	Non detect	Non detect	Non detect	Non detect	Non detect	Non detect	Non detect	Non detect
Swan Creek RM 4.40	Non detect	Non detect	9.1*	8.6*	Non detect	55.9	Non detect	15.57
Swan Creek RM 1.60	12.1	Non detect	24.2*	35.9*	82.1**	1045.4**	Non detect	328.7
Swan Creek RM 0.19	Non detect	Non detect	Non detect	13.8*	Non detect	249*	Non detect	17.61
Blue Creek RM 0.73	Non detect	10.0**	Non detect	9.0*	8.01	Non detect	Non detect	1.11

Physical Habitat

During the 2006 sampling season 12 sites on the mainstem and 14 sites on the tributaries of Swan Creek were assessed for physical habitat quality. The average QHEI was good ($\bar{x}$ = 48.42) for mainstem sites with a range from 74.5 (RM 4.2) to 34 (RM 1.4). Tributary sites scored poor on average ($\bar{x}$ = 34.64) and ranged from 49 (Ai Creek RM 8.3) to 24 (Fewless Creek RM 1.8 and Blue Creek RM 5.5) (Table 1).

Swan Creek

The most upstream sample site on Swan Creek at Fulton County Road 6-1 (RM 40.7) was channelized having a sparse wooded riparian buffer with silt and sand as the predominant substrates. Land use surrounding this sample site was agricultural with row crops planted up to the top of the leveed stream bank along river right. Despite full biological performance at this site, the QHEI score was only a fair 48 (Fig. 22). Many habitat improvements could be made with the adjacent land use and riparian zone which would result in better water quality in the headwaters of Swan Creek.

The only one of the twelve Swan Creek sites that scored in the very good range (RM 4.2) was downstream of the South Avenue Dam (Fig. 22). A QHEI score of 74.5 was recorded at this site, which was partially attributed to the South Avenue Dam trapping sediment in its dampool. The silt settling properties of the dam did not have a lasting effect on the habitat. The downstream end of the site consisted of more moderate amounts of silt as a result of the swift flow in the tailwater exporting fine sediments to the first outside bend. Due to the lack of extensive embeddedness throughout the site, River Mile 4.2 also scored well in the substrate category having five high quality substrate types and eight types overall (Appendix A, QHEI attributes).

Two sites scored within the good range, (RM 10.8) State Route 20 at Reynolds Road and (RM 18.5) Monclova Road (Fig. 22). The Reynolds Road site at RM 10.8 was characteristic of an urban stream habitat. While the site exhibited a moderate amount of instream cover including rootwads, undercut banks, rootmats, logs and other woody debris, it also displayed many impacts from urbanization. The stream bed is scoured from flashy storm events largely due to urban storm water runoff from city streets, parking lots, and other impervious surfaces within the watershed. Both the right and left banks throughout this stretch exhibited moderate to heavy erosion despite the 10-50 m wide wooded riparian zone along both banks. The riffle and run substrates were unstable consisting predominately of fine gravel, sand, and silt. The deeply incised stream channel has limited the ability of this section of Swan Creek to deposit instream sediments along the floodplain. In this case the stream is confined to its narrow channel and the sediment as well.

Swan Creek in Monclova at Albon Road (RM 18.5) had the best quality substrates of any of the sampling locations. The predominant substrate was bedrock, although boulder slabs, boulders, cobble, and gravel were also present. The land use surrounding this stream reach consisted of one large residential lot (river right), local fire department (river left), and a moderate to narrow wooded riparian which was mostly upstream of Monclova Road and persisted beyond the site upstream as well. River Mile 18.5 was the only locality within the study area where Water Willow, *Dianthera americana L.*, was found. This emergent rooted aquatic is indicative of streams with clean substrates and considerable flows.

Six of the Swan Creek QHEI scores were in the fair range and one bordered the poor range (Fig. 22). The habitat at all seven sites suffered from moderate to heavy amounts of silt extensively embedding the substrates. The two most upstream sites RM 40.7 and 34.41 (Fulton county road 3), both showed signs of recovery from channelization. There was no riparian corridor at RM 40.7 and a narrow riparian zone of only 5-10 m at RM 34.41. Rowcrop agriculture was the predominant land use surrounding both sites.

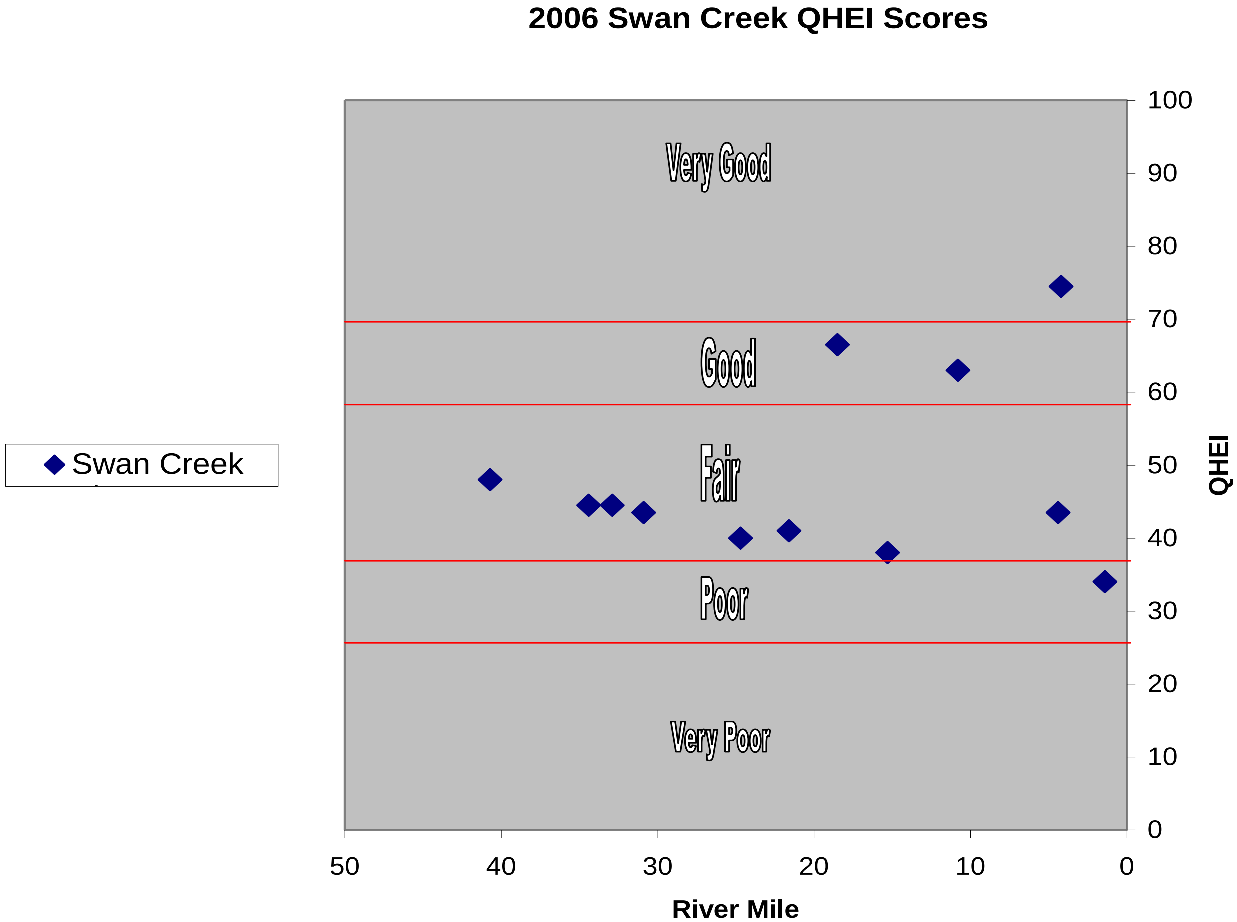

Figure 22. Narrative ratings for QHEI scores listed by RM for the 2006 Swan Creek sample sites.

Swan Creek upstream of County Road 2 (RM 32.9) was completely embedded with silt. A wide riparian zone in excess of 50m buffered the sample site along both sides. The overall physical habitat features were fair. The channel was moderately sinuous, however the developmental characteristics scored in the fair to poor range. As a result of unstable substrates from upstream sediment loads this stream reach lacked a defined channel and was without a riffle throughout the entire 150m sampling zone.

Immediately downstream of the Swanton water treatment plant's outfall (RM 30.9), the substrates of Swan Creek were smothered by lime sludge deposits greater than a meter deep in spots for the entire 150m sampling zone. A plume of lime sludge was witnessed originating from the outfall pipe coming from the plant's settling pond (Fig. 23). The only riffle in the sampling zone was the riprap dumped around the bridge pilings for the purposes of erosion control.

Figure 23. The drainage pipe from a lime sludge settling pond at Swanton WTP that drained into Swan Creek (RM 30.9).

Upstream of Whitehouse Spencer Road (RM 24.7) the substrate origins were tills and rip/rap with silt being the predominant substrate type. Sinuosity was low and the stream development was poor with no riffles present. The current velocity was very slow and the maximum depth was greater than a meter, despite the absence of any significant pools within the zone. Evidence of torrential flows during storm events was obvious by the eroded and incised banks throughout the length of the sampling zone.

Swan Creek upstream of Stitt Road (RM 21.6) scored a low QHEI resulting from silty substrates and a lack of instream fish cover. Beyond the moderate to narrow wooded riparian the surrounding land use was residential. Eroded and incised banks were strong evidence of torrential flows during storm events. This has likely resulted from a lack of storm sewer retention ponds and/or natural wetlands to buffer Swan Creek from the general degradation that is associated with increased impervious surfaces and decreased buffers within a watershed.

The last site scoring within the fair range was Swan Creek (RM 4.4) upstream of the South Avenue Dam. Both banks have been steeply leveed and the channel straightened. The impoundment has slowed the natural flow of an already low gradient stream. Sand and silt were the dominant substrates. Woody debris and rootwads offered the greatest amount of instream cover for fish in this zone.

The final two sites on the mainstem of Swan Creek both scored in the poor range. At RM 15.3, downstream of Salisbury Road and on the Brandywine Golf Course property, Swan Creek had the poor substrate types of silt and riprap. The overall fish habitat was sparse. Aside from a couple large trees near the golf cart path, there was no wooded riparian or dense vegetation to buffer the stream from nutrient runoff. Sand and silt comprised the instream substrates along with riprap that lined the outside bends along the banks (Fig. 24).

Figure 24. Swan Creek, (RM 15.3) at Brandywine golf course.

At RM 1.4 a QHEI of 34 was scored, making it the lowest scored Swan Creek site with the worst available habitat for aquatic life. This site was lacking in all six QHEI habitat categories.

Swan Creek Tributaries
QHEI scores ranged from the highest at 49 (Ai Creek, RM 8.3) to the lowest being 24 (Blue Creek RM 5.5 and Fewless Creek RM 1.8). All of the tributaries were comprised of muck or silt as their predominant substrate material and had very sparse instream cover overall. Sinuosity was not a common habitat feature among the tributaries. Many tributaries were either channelized or recovering from channelization in all or most of their respective sampling lengths. Riparian areas were sparse along the tributaries and less than five meters wide at best. None of the Swan Creek tributaries scored within the good range or very good range (Fig. 30, pg. 76).

Blystone Ditch
Blystone Ditch (RM 0.6) upstream of Monclova Road had fair habitat for aquatic life. This was the only tributary having a good riparian corridor in excess of 50 m wide along both banks featuring many mature cottonwoods, *Populus deltoids*. Past the 100 m riparian zone along both sides of the stream were subdivisions, upstream tiled fields drained into the stream. Despite the strong buffer surrounding Blystone Ditch the deleterious effects from flashy storm water discharges coming from neighboring communities and agricultural drainages have extensively embedded the stream substrates with silt.

Fewless Creek
One sampling site was completed on Fewless Creek (RM 1.8) upstream of County Road 4. There was no riparian zone along Fewless Creek, with rowcrops planted up to the edge of the steeply leveed and straightened stream banks. The stream substrates were heavily embedded with silt. This was one of the two most poorly developed Swan Creek tributaries. It was devoid of habitat and not capable of supporting a diverse aquatic community. Visibility was low (<20 cm) with nuisance scum/foam covering parts of the streams surface.

Wolf Creek
The headwaters of Wolf Creek (RM 4.1) at Albon Road are drained by a primarily agricultural and residential landscape. Sand and silt were the two main substrate types. Home septic system pipes and a field drainage pipe emptied into Wolf Creek upstream of Albon Road. The banks were recovering from channelization. A very narrow riparian buffer (<5 m) was noted along both banks.

The downstream sample locations on Wolf Creek (RM 2.0 and RM 0.5) at McCord Road and Holland –Sylvania Road were surrounded by highly industrialized and urbanized areas. The banks of the McCord Road site were permanently confined by concrete levees with no hope of recovery. The moderately sized riparian corridor (10-50 m) extending beyond the concrete levee was ineffective at buffering Wolf Creek from the adjacent parking lot runoff, as storm sewer pipes drained to the stream directly. Clarity in the creek was low (<20 cm). There was also abundant trash within the channel.

Wolf Creek (RM 0.5) at Holland-Sylvania Road was buffered by a very narrow (<5 m) riparian corridor adjacent to its steeply incised banks. A large storm water pipe and a roadside ditch draining into Wolf Creek on the upstream side of the bridge appeared to be actively eroding the bank (Fig. 25). The substrates were extensively embedded in muck and silt. Strong smells indicating failing septic systems were noticed about 50 m upstream of the bridge.

Figure 25. Wolf Creek (RM 0.5) upstream of the Holland-Sylvania Road Bridge. Flashy storm water drainage has eroded the stream bank and washed sediments into Wolf Creek.

Cairl Creek

The habitat in Cairl Creek (RM 1.3) upstream of Pilliad Road was affected by the dam at the downstream end of the site and had poor physical habitat overall (Fig. 39, pg. 96). Instream substrates were extensively embedded with silt and the banks were incised as a result of flashy storm events associated with an urbanized watershed.

Blue Creek

Hypereutrophic conditions existed in Blue Creek (RM 9.97) at County Road 2 with excessive algae on the surface and rooted aquatic plants growing below (Fig. 26). The stream channel was straightened with deeply incised banks and no riparian cover. Row crops were planted right up to the edge of the leveed stream bank, river left. Stream substrates were completely covered in silt. The overall physical habitat for aquatic life was very poor at this site (Fig. 30).

Figure 26. Blue Creek (RM 9.97) upstream of County Road 2. Excessive macrophytes as a result of eutrophication, channelization, and the lack of riparian cover have polluted Blue Creek.

Blue Creek (RM 7.80) downstream of Manore Road flows between rowcrops and Neapolis-Waterville Road. Leveed stream banks have very little possibility of recovery (Fig 27). Substrates of cobble, gravel, and sand were present at this location, but they were of little use as instream cover because they were filled in with silt.

Figure 27. Blue Creek (RM 7.80) upstream of Manore Road has been channelized with little possibility of recovery.

Blue Creek (RM 5.6) downstream of Rt. 295 was recovering from channelization. Tall grasses are beginning to fill in the stream banks (river left) and the stream was beginning to take on some meandering characteristics. However the narrative habitat rating was still very poor. The substrates were heavily silted over and no riffle was present. Instream cover for aquatic life was relatively sparse (Fig 28).

Figure 28. Blue Creek (RM 5.6) downstream of Rt. 295 was recovering from channelization. The land owner (river left) was allowing the riparian to grow back.

Before flowing into Swan Creek, Blue Creek (RM 0.8) runs through a highly urbanized drainage area just two miles northeast of Whitehouse at Finzel Road (Fig. 29). Although this location was impaired by the usual trash and flashy storm water events associated with urbanization, it possessed other habitat features that the upstream sites lacked. This was the only Blue Creek site that was not channelized or leveed. Mature trees lined the stream in the narrow (< 5 m) riparian corridor which was an improvement from the upstream sample locations. However, the stream substrates were completely embedded with silt and there was no riffle in the sample zone. This location scored very poorly in the narrative habitat rating (Fig. 30).

Figure 29. Blue Creek (RM 0.8) at Finzel Road had very poor habitat for aquatic life.

Harris Ditch (Formerly named South Swan Creek)
Upstream of Route 295 (RM 1.6) Harris Ditch was channelized and had very poor stream habitat overall (Fig. 30). The substrates were heavily covered in silt from agricultural runoff. The riparian buffer was very narrow (<5 m) and rowcrops were planted along both sides of the stream. The amount of instream habitat was sparse for aquatic life.

Ai Creek
Within the town of Ai, Ai Creek (RM 10.4) was recovering from being channelized and had very poor habitat for aquatic life. Trash was noticed throughout the 150 m site and about 100 m upstream of County Road L there was a small foot bridge with large amounts of trash dumped along the stream banks and in the stream channel indicating a possible source of the litter. There also was a strong odor from failing septic systems.

The only sample site Ai Creek did not appear to be channelized was at County Road L (RM 8.3) were there was a fair amount of habitat to support aquatic life. Despite being completely embedded with silt there was a fair amount of woody debris within the stream channel for habitat. Artificial substrates created a riffle downstream of the bridge. Protecting the stream through this reach was a narrow riparian buffer (5-10 m wide) with rowcrops planted up to the edge (river right).

Downstream of Scott Road (RM 2.1) Ai Creek was completely embedded with silt as it flowed into the Valleywood Golf Club. The stream banks and channel had been modified around the golf course features. Downstream at State Route 2 Ai Creek (RM 1.66) was extensively embedded with silt and littered with golf balls from Valleywood Golf Club, which was immediately upstream of the sample site. Ai Creek has been straightened and had deeply incised banks throughout the 150 m sample zone. As a result the channel morphology was homogeneous, functioning as one long glide efficiently exporting sediment downstream filling up Maumee Bay and directly contributing to the open lake dredge disposal problem bedeviling water quality in Lake Erie.

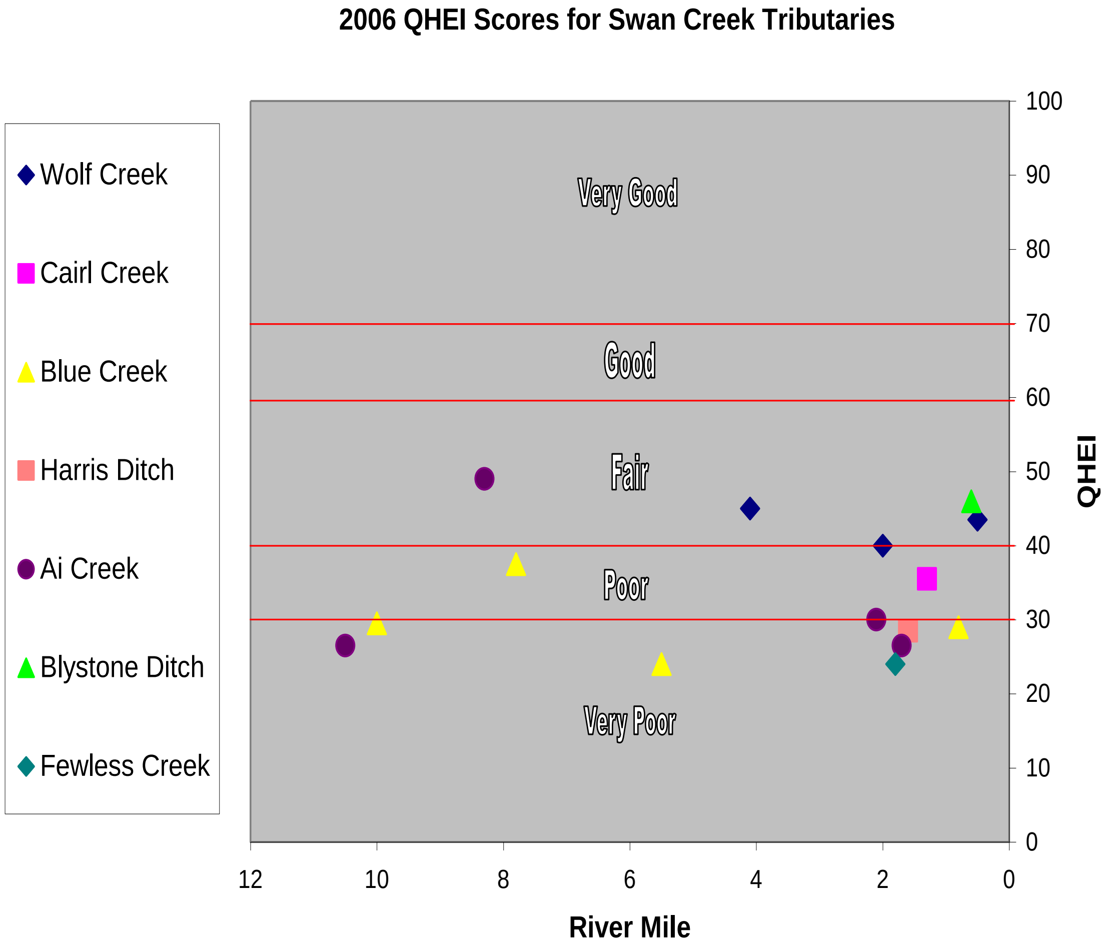

Figure 30. Narrative ratings for QHEI scores listed by River Mile for the 2006 Swan Creek tributary sample sites.

Macroinvertebrate Community Assessment

Macroinvertebrate communities were evaluated at 28 stations in the Swan Creek basin (Table 1). The community performance was evaluated as exceptional at one station, good at six stations, marginally good at four stations, fair at 14 stations, poor at two stations and very poor at one station. Two stations had the highest total mayfly (Ephemeroptera), stonefly (Plecoptera) and caddisfly (Trichoptera) taxa richness (EPT): Swan Creek upstream at Salisbury Road (RM 15.3) and Blue Creek upstream of State Route 295 (RM 5.5) each had 13 taxa. The station with the highest number of total sensitive taxa was at Swan Creek upstream of Salisbury Road (RM 15.3) with 21 taxa.

Swan Creek

The macroinvertebrate community narrative evaluations for the upstream portions of Swan Creek (RM 40.6 – 24.6) were in the fair to good ranges for WWH biocriteria in the HELP ecoregion. Predominant organisms in these upstream stations included midges, riffle beetles, blackflies, sow bugs, and hydropsychid caddisflies. Degraded physical characteristics of the upstream sites were sparse to moderate riffle development, poor to fair riffle quality, embedded substrates, organic enrichment and channel modification. The community upstream from County Road 2 (RM 32.9) contained increased numbers of total EPT taxa (6) and total sensitive taxa (20) and an ICI score (36) in the good range (Fig. 31, Table 13). Sensitive taxa found at this station included the pollution intolerant baetid mayfly *Pseudocloeon frondale*, the moderately intolerant burrowing mayfly *Hexagenia limbata*, three taxa of dryopoid beetles, and 15 taxa of midges. Physical characteristics of this stream station that were not indicative of other sites included: natural channel morphology, increased canopy cover (25% to closed), dominant riparian vegetation width of 100 feet composed of large trees and forested land use. Notwithstanding, this site continued to exhibit the low density and diversity of organisms characteristic of the other stations in this reach.

Swan Creek stations between RM 21.7 and 10.9 had good macroinvertebrate communities with higher diversities of EPT and sensitive taxa (Fig. 31, Table 13). These stations were characterized by good riffle quality, natural channel morphology and a nearly closed canopy. A mussel bed was discovered upstream from Salisbury Road (RM 15.65) that contained a large population of the state endangered freshwater mussel Rayed Bean (*Villosa fabalis*) along with 10 other species (Grabarkiewicz 2006). This species has been extirpated from much of its range in Ohio and is becoming rare. The mussel bed is located just east of the beach ridge glacial aquifer. This aquifer has the highest water yield (25-100 Gals./minute) in the watershed. It is possible that groundwater flux is providing stable stream flows and improving mussel persistence at this station.

The macroinvertebrate communities sampled between RM 4.4 and 1.6 performed at only a fair level with ICI scores between 16 and 22. These scores were significantly below the WWH ecoregional biocriterion (ICI = 34). Throughout this reach overall densities were low. EPA taxa were restricted to low abundances of facultative taxa of baetid, heptageniid, and *Caenis* mayflies and hydropsychid and hydroptilid caddisflies. Riffle development was sparse or nonexistent. The substrate was composed of fine grained silt and clay characteristic of lacustrine deposits adjacent to Lake Erie. Channel morphology was impounded by a low-head dam at the upstream site (RM 4.4) and impounded by the Maumee River/Bay estuary at the downstream site (RM 1.6).

Fewless Creek

Poor macroinvertebrate communities were present in Fewless Creek (RM 1.8). Only four sensitive taxa were found. Hydropsychid caddisflies were the only EPT taxa collected. Predominant organisms included: midges, blackflies, and sowbugs. Problems noted in the immediate vicinity included siltation, channel modification and possible agricultural run off from row crops.

Ai Creek

Macroinvertebrate communities were sampled at four stations in Ai Creek. All stations were evaluated as fair. The predominant organisms consisted of midges, blackflies, a few facultative EPT taxa, and flatworms. All stations had embedded substrates, an indication of siltation, sparse riffle development and poor to fair riffle quality. The two upstream stations (RM 10.4 – 8.3) showed signs of channel modification but bank erosion was slight. There was evidence of nutrient enrichment (excessive algal growth) at the upstream station (RM 10.4) in the village of Ai. Potential sources may include: failing on site septic systems and/or crop production with subsurface drainage. The two downstream stations (RM 2.1 – 1.6) were sampled below the Swanton WWTP (~RM 3.5). There is likely a nutrient enrichment effect from the WWTP discharge and a golf course upstream of SR 2, as evidenced by high densities of facultative midges and flatworms along with an increase in the abundance of tolerant aquatic segmented worms (Oligochaeta) and midges. The presence of woody debris created fair riffle quality conditions allowing for a large percentage (36.8%) of tanytarsini midges to be collected at this station.

Blue Creek

Four stations were sampled on Blue Creek between RM 10.0 and 0.7. Narrative evaluations ranged from fair (RM 10.0) to exceptional (RM 5.5) with an ICI of 46. The upstream site (RM 10.0) was characterized by an absence of riffles and runs, highly channelized morphology, slow current velocity, and a lot of aquatic macrophytes, giving this station the appearance of a wetland. Pool and margin macroinvertebrates consisted of high densities of flatworm and scuds. Diversity was low with a few baetid and caenid mayflies present. Undoubtedly the physical characteristics of this station were impacting the macroinvertebrates and preventing them from reaching their full diversity potential.

The station at Manore Road (RM 7.8) had an uncharacteristically good riffle habitat, created by an accumulation of riprap in the stream near the bridge. This improved habitat resulted in a relatively high EPT diversity of ten, for this basin, and a narrative evaluation of marginally good. However, the station was predominated by mostly facultative taxa of blackflies, mayflies and caddisflies. The sensitive EPT taxa present at this site were *Pseudocloen propinquus*, *Hexagenia limbata*, and *Mystacides sepulchralis*.

The macroinvertebrate community at SR 295 (RM 5.5) achieved an ICI score of 46, at the low end of the exceptional range. However, relatively low EPT (13) and sensitive taxa (17) diversity in the total sample was an indication that the ICI score may be inflated. The only sensitive EPT collected at the site were the mayflies *Pseudocloeon sp.* and *Leucrocuta sp.* and the caddisflies *Nectopsyche diarina*, *Mystacides sepulchralis*, and *Triaenodes sp.* Macroinvertebrates observed to be predominant on the natural substrates were mostly facultative taxa of midges, water mites, and flatworms. The station had a paucity of physical characteristics that one would expect to find in exceptional communities; natural channel morphology, extensive riffle development, adequate current velocity, and closed canopy.

The macroinvertebrate community sampled at Finzel Road (RM 0.7) achieved an ICI score of 30, the low end of the marginally good range. However, relatively low EPT (7) and sensitive taxa (14) diversity in the total sample was an indication that the ICI score may be a little inflated. The only sensitive EPT collected at the site were the mayflies *Pseudocloeon frondale* and *Pseudocloeon propinquum.* Macroinvertebrates observed to be predominant on the natural substrates were mostly facultative taxa of midges, sow bugs, and blackflies. The riparian vegetation has recovered since the last survey at this station in 1992. The current survey noted large trees present within a distance of 50 ft. on the right side of the bank and up to 10 ft. on the left side. It was also observed that yard grass clippings were being dumped into the stream.

Harris Ditch (Formerly named South Swan Creek)

The macroinvertebrate community sampled in Harris Ditch (RM 1.6) had a fair number of EPT taxa (9) but the community was predominated by more tolerant taxa (flatworms, scuds and sow bugs). Siltation and channelization were negatively impacting this segment. These impacts were aggravated by low flow conditions present at the time of collection. This station was evaluated as fair.

Blystone Ditch

The macroinvertebrate community was evaluated as fair. Predominant taxa were midges, damselflies and beetles. The only sensitive EPT taxa found was the caddisfly *Mystacides sepulchralis*. Density and diversity of organisms were considered low to moderate. This station exhibited historic channelization which diminished riffle development and quality.

Wolf Creek

The macroinvertebrate community performance in Wolf Creek was evaluated as fair at Albon Road (RM 4.2) and Perrysburg-Holland Road (RM 2.0). Both stations contained low number of EPT taxa with midges and hydropsychid caddisflies as the predominant organisms. Density and diversity of the community were low to moderate. Both stations exhibited similar physical and substrate characteristics (recovering channelization, silt and sand embeddedness). The macroinvertebrate community sampled at Holland-Sylvania Road (RM 0.5) achieved an ICI score of 34, the low end of the good range. However, relatively low EPT (6) and sensitive taxa (10) diversity in the total sample and the complete lack of sensitive EPT taxa in the sample were indications that the ICI score may be inflated. Macroinvertebrates observed to be predominant on the natural substrates were facultative taxa of baetid mayflies, sow bugs, and water mites. The station was characterized by a channelized morphology, sparse riffle development, murky water clarity and a closed tree canopy. The presence of algae indicates nutrient enrichment as a potential pollution source impacting this station.

Cairl Creek

This station was evaluated as poor. The only EPT taxa collected was the facultative caddisfly *Cheumatopsyche sp.* Predominant organisms consisted of facultative and tolerant midges and blackflies. Riffle quality was poor to fair. The stream channel was recovering from channelization and the substrates were composed primarily of silt, sand, and detritus. A potential pollution source was urban run-off from the surrounding residential land use. Habitat is unquestionably a limiting factor impacting this aquatic community, however, it was sufficient to support a greater diversity than what was collected.

Heilman Ditch

The aquatic community was evaluated as very poor. There were only eight taxa collected. The predominant organisms were four taxa of very tolerant midges. Other organisms present were segmented worms (Oligochaete), the turtle leech *Placobdella ornata*, mosquitoes (*Culex sp*.), and the snail *Physella sp.* The stream channel flows underground upstream from this site through a culvert. The channelized stream banks were mostly lined with rip rap. The water clarity was turbid and the color was a milky gray. This station is located in an urban area and more than likely is receiving inputs of industrial pollution and urban runoff.

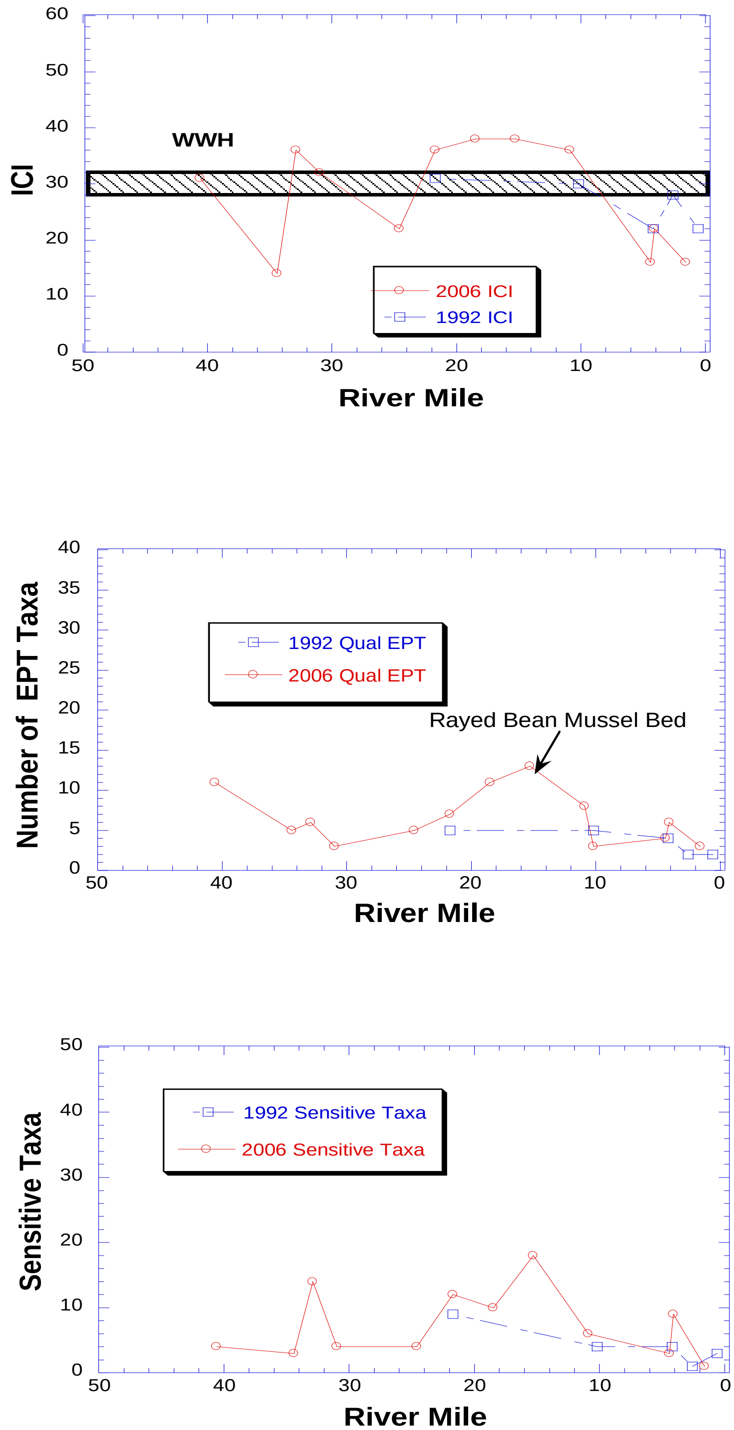

Figure 31. Longitudinal trend of Invertebrate Community Index (ICI), Qualitative EPT and the number of sensitive taxa in Swan Creek, 2006 and 1992. ICI values for RM 40.6 and 34.4 are approximations based on narrative evaluations.

Table 2. Summary of macroinvertebrate data collected from artificial substrates (quantitative sampling) and natural substrates (qualitative sampling) in the Swan Creek study area, July to October, 2006.

RM	Dr. Ar. (sq. mi.)	Data Codes	Qual. Taxa	EPT Ql. / Total	Sensitive Taxa Ql. / Total	Density Ql. / Qt.	CW Taxa	Predominant Organisms on the Natural Substrates With Tolerance Category(ies)	ICI[a]	Narrative Evaluation
Swan Creek (04-003)										
40.6	7.5	-	43	11	4	M	0	Midges (F), blackflies (F), hydropsychid caddisflies (F)	-	Marg. Good
34.4	14.6	-	38	5	3	L-M	1	Midges (T,F)	-	Fair
32.9	25.7	15	49	4 / 6	14 / 20	L-M / 611	2	Midges (F,MI)	36	-
31.0	28.2	15	31	3 / 3	4 / 12	L / 437	0	Midges (F)	32	-
24.6	89.0	15	32	5 / 6	4 / 12	L-M / 201	0	Midges (MT,MI), riffle beetles (F,MI), sow bugs (F)	22	-
21.7	140	-	40	7 / 7	12 / 14	L-M / 740	0	Midges (F,MI), baetid mayflies (F), hydropsychid caddisflies (F)	36	-
18.5	146	-	34	9 / 11	10 / 16	L-M / 202	0	Caddisflies (F,MI), mayflies (F), midges (MT,F)	38	-
15.3	160	-	41	12 / 13	18 / 21	M / 572	0	Midges (MI,F), hydropsychid caddisflies (F), baetid mayflies (F)	38	-
10.9	192	-	39	6 / 8	6 / 11	L-M / 261	0	Baetid mayflies (F), hydropsychid caddisflies (F), blackflies (F)	36	-
4.4	200	2,8	30	3 / 4	3 / 7	M / 424	0	Damselflies (F), sow bugs (MT), fingernail clams (F)	16	-
4.1	200	12	37	6 / 6	9 / 12	L-M / 140	0	Hydropsychid caddisflies (F), baetid mayflies (F), midges (F,MI)	22	-
1.6	203	11,15	19	3 / 3	1 / 2	L / 422	0	Midges (MT,F,T)	16[b]	-
Fewless Creek (04-097)										
1.8	5.9	-	23	1	4	M	0	Midges (F,MI), blackflies (F)	-	Poor

RM	Dr. Ar. (sq. mi.)	Data Codes	Qual. Taxa	EPT Ql. / Total	Sensitive Taxa Ql. / Total	Density Ql. / Qt.	CW Taxa	Predominant Organisms on the Natural Substrates With Tolerance Category(ies)	ICI[a]	Narrative Evaluation
Ai Creek (04-010)										
10.4	6.8	-	37	7	5	L-M	0	Midges (MI,T,F)	-	Fair
8.3	12.5	-	33	4	1	L	0	Blackflies (F), midges (F), baetid mayflies (F)	-	Fair
2.1	19.5	-	32	4	3	M-H	0	Midges (F,T), hydropsychid caddisflies (F), blackflies (F)	-	Fair
1.6	49.3	-	35	4 / 4	6 / 8	M / 1126	0	Flatworms (F), midges (F,MI)	28	-
Blue Creek (04-006)										
10.0	6.7	-	24	3	0	M-H	0	Flatworms (F), scuds (F)	-	Fair
7.8	12.7	-	41	10	7	L	0	Blackflies (F), mayflies (F,MI), caddisflies (F)	-	Marg. Good
5.5	27.0	-	59	9 / 13	10 / 17	M / 589	0	Midges (MT,F,MI), water mites (F), flatworms (F)	46	-
0.7	44.5	-	40	6 / 7	7 / 14	L / 320	1	Midges (F,MI), sow bugs (F), blackflies (F)	30	-
Harris Ditch (Formerly named South Swan Creek) (04-008)										
1.6	7.7	-	40	9	5	L-M	0	Flatworms (F), scuds (F), sow bugs (F)	-	Fair
Blystone Ditch (04-081)										
0.6	6.5	-	31	5	3	L-M	0	Midges (T,F,MI)	-	Fair
Wolf Creek (04-004)										
4.2	7.9	-	36	5	3	M	0	Midges (T,F,MT,MI), hydropsychid caddisflies (F), elmid beetles (F,MI)	-	Fair
2.0	12.9	-	35	7	7	L-M	0	Midges (F,T,MI), hydropsychid caddisflies (F)	-	Fair
0.5	26.1	-	32	5 / 6	6 / 10	L-M	1	Baetid mayflies (F), sow bugs (F), water mites (F)	34	-
Cairl Creek (04-005)										
1.3	10.3	-	35	1	4	M	0	Midges (F,T), blackflies (F)	-	Poor
Heilman Ditch (04-098)										
3.0	1.0	-	8	0	0	L-M	0	Midges (VT)	-	Very Poor

RM: River Mile.
Dr. Ar.: Drainage Area
Data Codes: 2=Dam Pool, 8=Non-Detectable Current, 11=Lake Erie Influence (Lacustuary), 12=Suspected High Water Influence, 15=Current >0.0 fps but <0.3 fps.
Ql.: Qualitative sample collected from the natural substrates.
Sensitive Taxa: Taxa listed on the Ohio EPA Macroinvertebrate Taxa List as MI (moderately intolerant) or I (intolerant).
Qt.: Quantitative sample collected on Hester-Dendy artificial substrates, density is expressed in organisms per square foot.
Qualitative sample relative density: L=Low, M=Moderate, H=High.
CW: Coolwater/Coldwater.
Tolerance Categories: VT=Very Tolerant, T=Tolerant, MT=Moderately Tolerant, F=Facultative, MI=Moderately Intolerant, I=Intolerant
[a] ICI values in parentheses are invalidated due to insufficient current speed over the artificial substrates. The station evaluation is based on the qualitative sample narrative evaluation

Fish Community Assessment

Swan Creek

Fish communities were assessed at 12 sites on Swan Creek (from River Mile 40.68 to River Mile 1.40). The IBI scores ranged from 45 (RM 1.4) to 28 (RM 40.7). As shown in Figure 30, IBI scores increased linearly from upstream to downstream with the exception of RM 4.4, the South Avenue dam, which scored 31. Seven sites fully met WWH criteria. Five sites partially met WWH criteria (Fig. 32). Low MIwb scores were responsible for the partial attainment as shown in Table 12. Percentages of pollution tolerant fish declined from the headwaters towards the mouth, indicating a dilution of nonpoint source pollutants as a result of an increase in drainage area and stream volume (Fig. 35). Over time there has been an overall improvement in IBI scores (Fig. 33).

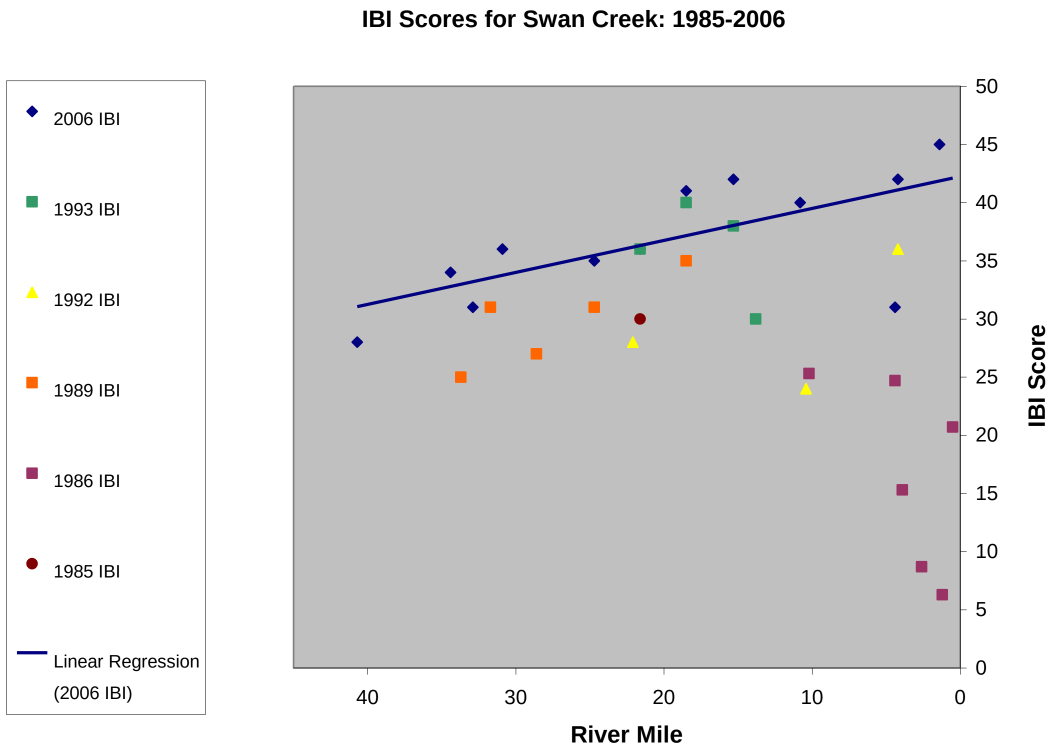

Figure 33. Comparison of IBI scores for Swan Creek sample locations from 1985-2006 shows an overall improvement.

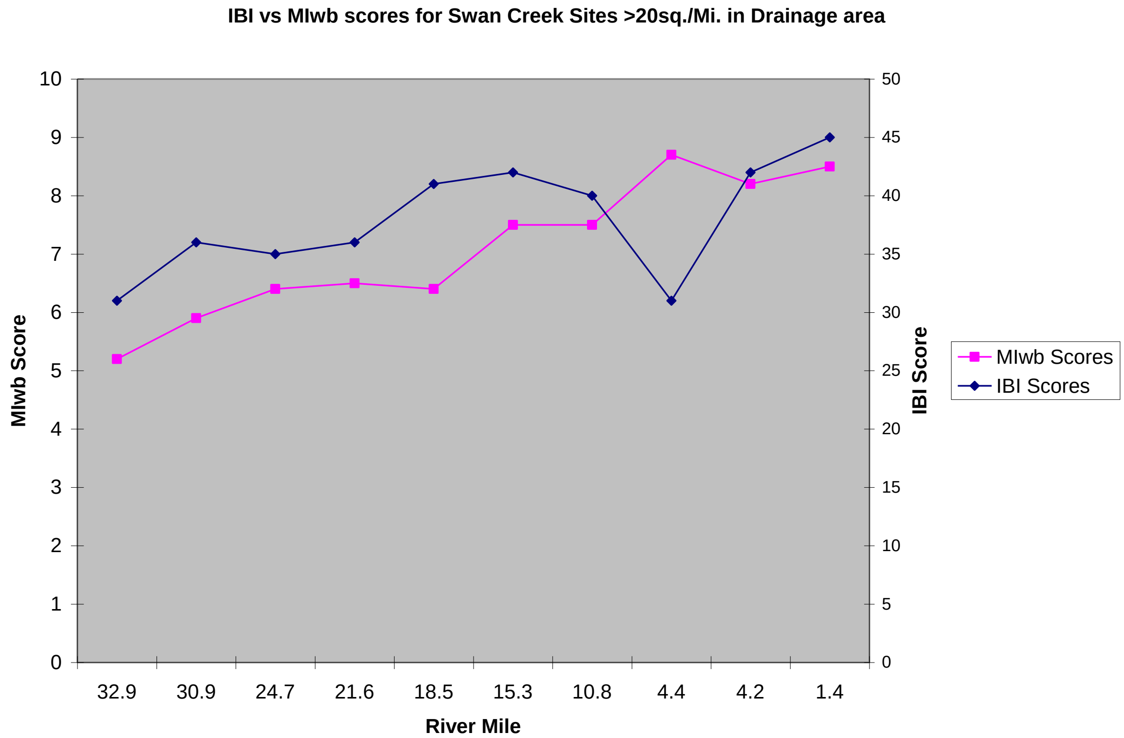

Figure 34. 2006 IBI and MIwb scores plotted by River Mile for Swan Creek sample sites ≥20 sq/mi in drainage area.

The most upstream site sampled on Swan Creek (RM 40.7, upstream of Fulton County Rd 6-1) met WWH criteria despite diminished habitat conditions. According to Figure 35 this site numerically had one of the highest percentages of pollution tolerant fish at 59%, comprised mainly of stoneroller minnows, *Campostoma anomalum,* (14.33%) and creek chubs, *Semotilus atromaculatus,* (38.04%). Together, stonerollers and creek chubs accounted for 64.08% of the fish community by mass (Appendix B). Creek chub populations often increase after a stream has been channelized or dredged, therefore becoming a dominant species of a once diverse fish community (Trautman and Gartman, 1974: 168). Only 28% of the total sample was insectivores. High percentages of stoneroller minnows are indicative of eutrophication within the stream community, which suggests possible nutrient runoff from the adjacent and upstream rowcrops.

The fish community was limited by poor substrates predominantly comprised of silt at RM 34.4 (upstream of County Road 3). Forty eight percent of the fish sampled were tolerant of pollution and 53% were pioneering fish species. Insectivores comprised only 31% of the fish community. This site is not meeting Warmwater Habitat criteria (Table 3). Stoneroller minnows and creek chubs were the chief components of the fish fauna once again in mass (14.43% and 52.29%, respectively) and numerically (17.31% and 33.24%, respectively) suggesting NPS nutrient enrichment.

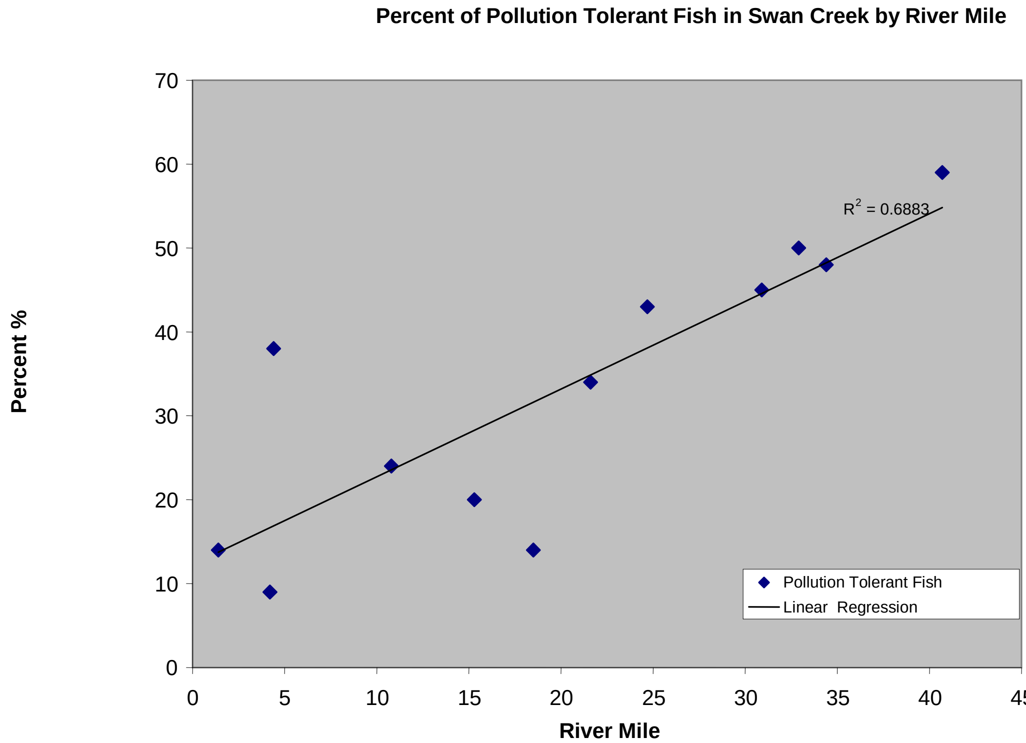

Figure 35. Percentages of pollution tolerant fish by River Mile for the 2006 Swan Creek sample locations.

Swan Creek at RM 32.9 (TWP Rd 2) yielded a MIwb of 5.2, the lowest overall score for that index on Swan Creek. Eleven fish species were present at this site; however, creek chubs accounted for 37.32% of the population by number (Appendix B). Species indicative of good water quality represented a very small percentage of the population both by mass and by number (Appendix B). Creek chubs, white suckers *Catostomus commersonii*, and redfin pickerels *Esox americanus vermiculatus* accounted for 89.12% of the total fish biomass. These species dominate and fill vacant niches from otherwise intolerant species unable to survive in this impaired stream. Three species of darter were found within the sampling zone: johnny darter, *Etheostoma nigrum*, greenside darter *E. blenniodes*, and orangethroat darter *E. spectabile*. Historically, greenside and orangethroat darters have been found to be tolerant of only moderate amounts of silt within streams. Johnny darters are much more common and are a more tolerant species. As shown in Appendix B, percentages of darters by number further indicate this site is not meeting Warmwater Habitat Criteria. Johnny darters accounted for 19.01% of the total catch, while greenside darters accounted for 2.82%, and orangethroat daters represented only 0.7% of the total sample.

The next four sample sites downstream partially attained WWH standards (Table 3). All four of the sites significantly departed from applicable biocriteria in the MIwb. The Swanton WTP (RM 30.9, upstream of St. Rt. 64) is polluting Swan Creek with lime sludge draining from their settling pond. Disturbance of the extensive lime deposits during sampling turned the water gray and opaque from the suspended lime sludge.

Swan Creek from RM 24.7 (Spencer Rd) down to River Mile 21.0 (Stitt Rd) lacked sufficient habitat to support diverse fish communities. The partial attainment scores relate to high numbers of pollution tolerant fish (Fig. 35). Communities at both sites were dominated by green sunfish, *Lepomis cyanellus*. The only intolerant species found among the four sampling zones were the three stonecat madtoms, *Noturus flavus* (Fig. 36), at RM 18.5 (Monclova at Albon Rd). Trautman (1981) describes this species as occurring only as strays where habitat alterations have eliminated chutes and silted over gravel bars (Trautman, 1981: 496). He also noted that stonecat madtoms were a key indicator of smallmouth bass, *Micropterus dolomieui* abundance. Coincidentally, the number of smallmouth bass at RM 18.5 closely matched that of the stonecat madtom with two individuals sampled. The pollution and decimation of habitat through these reaches can be attributed to tiled fields and channelized ditches, as well as the urbanization of the watershed. These activities have led to flashy storm water and torrent flows scouring the stream substrates of parent materials and filling interstitial spaces with silts from unbuffered fields and eroded stream banks.

Figure 36. One of three stonecat madtoms, *Noturus flavus*, a species intolerant of pollution, caught in Swan Creek (RM 18.5).

Swan Creek at RM 15.3 (upstream of Salsibury Rd) and 10.9 (St. Rt. 20, Reynolds Rd.) is in full Warmwater Habitat attainment (Table 3). Despite full biological attainment in this section there are issues with the habitat and chemical water quality. Please reference these two sections of the report for further explanation.

The remaining three sites downstream on Swan Creek, RM 4.4 (upstream of the South Ave. Dam), 4.2 (downstream of the South Ave. Dam), and 1.6 (downstream of City Park Avenue), partially met their designated WWH use (Table 3). Upstream of the South Avenue low head dam, RM 4.4, the fish are limited by poor homogeneous habitat associated with the dam impounding the flow. Figure 35, IBI scores increase from its headwaters to the mouth, with the exception of RM 4.4. The site scored a MIwb of 8.7, but the low numbers of intolerant species and high numbers of tolerant species resulted in a lower IBI score (Fig. 34). The invasive round goby, *Neogobius melanostomus*, was found in great numbers downstream of the South Avenue dam, but was found upstream of the impoundment as well. The emerald shiner, *Notropis atherinoides* and the round goby were the top two species found downstream of the South Avenue Dam at 187 and 123 individuals, respectively. Round gobies and emerald shiners had the lowest density of fish species found above the dam with only one goby and seven shiners recorded. This further demonstrates the habitat limitations within the impoundment and that the dam limits fish passage. In addition to the habitat limitations, stormwater runoff is also a source for pollution to Swan Creek, up and downstream of the South Avenue Dam. Storm sewers continue to impact the water quality in Swan Creek further downstream at RM 1.6, which is also heavily impacted by CSO's. Further explanation of these impacts are provided in the chemistry section.

Swan Creek Tributaries

Fish communities were assessed at 15 sites on 8 Swan Creek tributaries. The IBI scores ranged from 34 (Blystone Ditch RM 0.6 and Ai Creek RM 1.7) to 12 (Harris Ditch RM 1.6) (Fig. 37). Blue Creek at RM 7.8 (Manoore Rd.) scored a 30 on the IBI and was the only Swan Creek tributary attaining its WWH aquatic life use designation (Table 3). The other 14 sites were not attaining or partially attaining their designated WWH aquatic life use. Causes and sources for impairment on these streams are listed in the attainment table (Table 3).

Fewless Creek

Fewless Creek at Fulton County Road 4 (RM 1.8) had a poor fish community with the top species being fathead minnows, *Pimephales promelas*, at 151 individuals (Appendix B). Fathead minnows are common to turbid streams of poor water quality and are numerous when competition is low from more intolerant species of fish. Fewless Creek is impacted by crop production with subsurface drainage, stream bank channelization, and failing septic systems (Table 3).

Ai Creek

All four sites on Ai Creek, RM 1.6 (St. Rt. 2), 2.1 (Scott Rd.), 8.3 (Co. Rd. L, east of the town of Ai), and 10.5 (Co. Rd. L. in the town of Ai), scored IBI values within the acceptable range for WWH attainment (Table 3). However, ICI scores did not meet WWH criteria (please see Macroinvertebrate Community section) and therefore the entire length of Ai Creek sampled is listed as impaired.

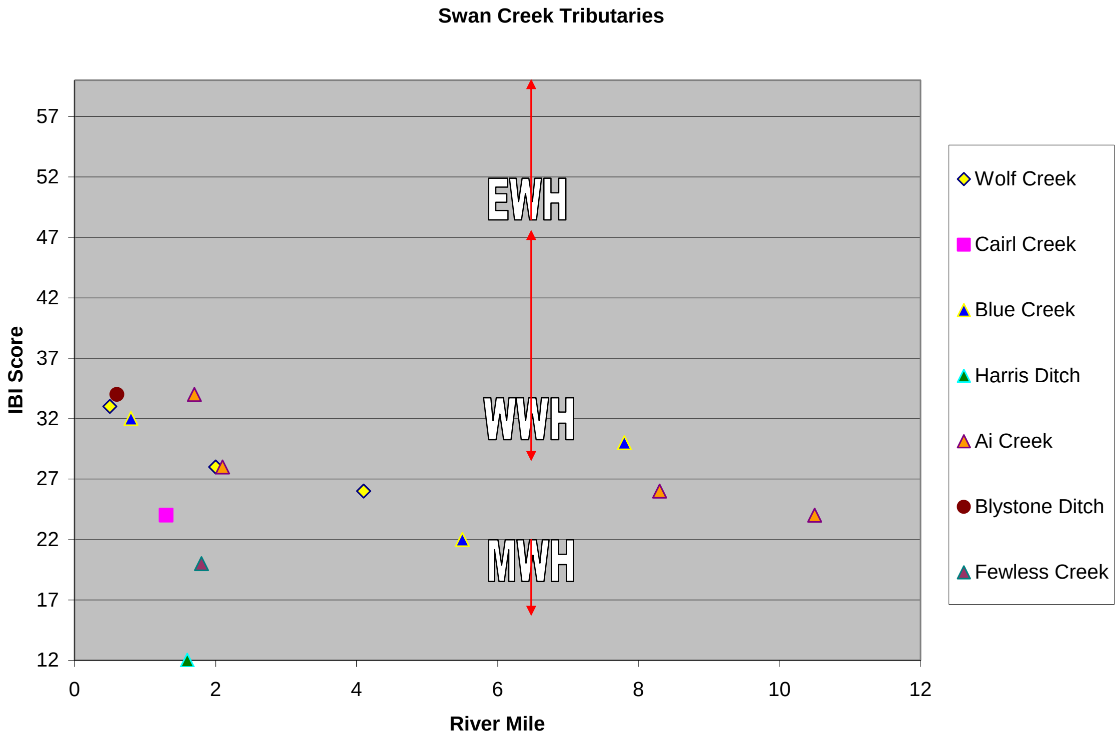

Figure 37. IBI scores plotted by River Mile for Swan Creek tributary sites sampled in 2006.

Blue Creek

Fish were sampled at three locations on Blue Creek, RM 7.8 (Manore Rd.), 5.5 (St. Rt. 295), and 0.8 (Finzel Rd.). Blue Creek at Fulton County Road 4 (RM 10.0) was not sampled for fish due to excessive macrophytes suspended on the surface of the stream. However, macroinvertebrates were sampled and a QHEI (please see physical habitat section) was completed to verify the gross habitat impairment of the site (Fig. 38). The fish community at RM 0.8 was dominated by green sunfish, with 59 individuals caught (Appendix B). Only six bluegill, *Lepomis macrochirus*, and seven rock bass, *Ambloplites rupestris*, were sampled at this location. Green sunfish are more pollution tolerant than other sunfish species and thrive in locations where competition is low from other sunfish. A MIwb of 4.8 was scored for this location due to the low numbers of pollution intolerant species (Table 3).

Blue Creek at State Route 295 (RM 5.5) was also dominated by a pollution tolerant fish community, scoring an MIwb of 5.5 (Table 3). The most numerous species was bluntnose minnow, *Pimephales notatus*, with 70 individuals caught (Appendix B). Bluntose minnows are the most common cyprinid in Ohio and are found to be more numerous within a fish community when the water quality is unfavorable to intolerant cyprinids. Blue Creek at Manore Road (RM 7.8) is within full WWH attainment.

Harris Ditch (Formerly named South Swan Creek)

Harris Ditch at State Route 295 (RM 1.6) was found to have a very poor fish community having only ten total fish caught within a 150m sampling zone, scoring a 12 on the IBI (Appendix B). Twelve is the lowest possible score on the Index of Biotic Integrity. Only five species were found in Harris Ditch (redfin pickerel, white sucker, creek chub, redfin shiner *Notropis umbratilis*, and rock bass) and none of them are indicative of good water quality.

Blystone ditch

Blystone ditch at Monclova Road (RM 0.6) scored 34 for the IBI, but did not meet WWH criteria based upon the low ICI score it attained (please see macroinvertebrate section for further explanation).

Figure 38. Excessive macrophytes as a result of nutrient runoff and habitat impairment at Blue Creek upstream of Fulton County Rd., RM 10.0.

Wolf Creek

Three sites were sampled on Wolf Creek, RM 0.5 (Holland-Sylvania Rd.), 2.0 (Perrysburg-Holland Rd.), and 4.1 (Albon Rd.). Wolf Creek at RM 0.5, Holland-Sylvania road, scored poorly on the MIwb at 5.5 (Table 3). Almost half of the fish community was comprised of pollution tolerant fish species (Appendix C). This zone also had the highest percentage of fish having DELT anomalies among all sites sampled in this survey, having 5.9% of the first pass fish community afflicted with an anomaly (Appendix C). This was the only Wolf Creek site that did not meet WWH criteria for either fish or macroinvertebrate indexes. Sites at RM 2.0 and 4.1 scored within the acceptable IBI range at 28 each; however, the ICI scores were poor (please see macroinvertebrate section for further explanation).

Cairl Creek

Cairl Creek at Pilliad Road (RM 1.3) is partially attaining WWH criteria with an IBI of 24 (Table 3). Only one sensitive species was found at this location, the greenside darter with only one individual found (Appendix B). The fish community is dominated by pollution tolerant species with 98% of the total catch consisting of tolerant fish (Appendix C). The percentage of pioneering fish species was 89% which is indicative of an unstable biological community. Evidence of torrent flows as a result of impervious surfaces in a highly urbanized area is visible by silt stained leaves, shown in Fig. 39. Flashy storm events within a historically wetland dominated watershed make it difficult for stable biological communities to develop. Despite a narrow wooded riparian corridor the banks are strongly incised and the substrates were scoured by a moving bed load.

Figure 39. Scoured banks and silt stained leaves from flashy storm events and urbanization in Cairl Creek (RM 1.3).

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