Ohio EPA

State of Ohio
Environmental Protection Agency

Division of Surface Water

Total Maximum Daily Loads for the Wakatomika Creek Watershed

Final Report
August 21, 2006

Bob Taft, Governor
Joseph P. Koncelik, Director

Table of Contents

List of Tables

List of Figures

Acknowledgements

The following Ohio EPA staff provided technical services for this project:

Biological and Chemical Water Quality – Ed Moore, Brian Alsdorf, Kelly Capuzzi
Recreational Use Issues – Chris Skalski
Point Source Issues – Tim Campbell and Larry Korecko
Storm Water Issues – Aaron Wolfe and Chris Hunt
Nonpoint source issues – Dan Imhoff
Water Quality Modeling – Keith Orr
Project Leaders – Kelly Capuzzi and Dan Imhoff
Reviewer – Dave Altfater

The Ohio EPA appreciates the cooperation of the property owners who allowed access to Wakatomika Creek and its tributaries.

1.0 Introduction

The Clean Water Act (CWA) Section 303(d) requires States, Territories, and authorized Tribes to list and prioritize waters for which technology-based limits alone do not ensure attainment of water quality standards. Lists of these impaired waters (the Section 303(d) lists) are made available to the public and submitted to the U.S. Environmental Protection Agency (U.S. EPA) for approval in even-numbered years. Further, the CWA and U.S. EPA regulations require that Total Maximum Daily Loads (TMDLs) be developed for all waters on the Section 303(d) lists.

In simple terms, a TMDL can be thought of as a cleanup plan for a watershed that is not meeting water quality standards. A TMDL is defined as a calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards and an allocation of that quantity among the sources of the pollutant. Ultimately, the goal of Ohio's TMDL process is full attainment of Water Quality Standards (WQS), which would subsequently lead to the removal of the water bodies from the 303(d) list.

The Ohio Environmental Protection Agency (Ohio EPA) has traditionally listed impaired waters and developed TMDLs on a watershed basis, defining the watershed assessment unit as the 11-digit Hydrologic Unit Code (HUC) system (as established by the Natural Resources Conservation Service (NRCS, www.oh.nrcs.usda.gov)). The Ohio EPA identified Wakatomika Creek as impaired on the 2004 303(d) list, and the 2006 303(d) listing is based on the data used to complete this report. Wakatomika Creek is comprised of two assessment units:

- 05040004 020 (upper, headwaters to below Brushy Fork)
- 05040004 030 (lower, below Brushy Fork to Muskingum River).

Copies of the 2004 and 2006 303(d) lists can be accessed at:
http://www.epa.state.oh.us/dsw/tmdl/index.html

1.1 Study Area

Wakatomika Creek is a sub-watershed of the Muskingum River (Ohio River drainage) and is located in east central Ohio in Knox, Licking, Coshocton, and Muskingum counties (Figure 1). The total drainage area is 234 square miles. The mainstem of Wakatomika Creek is 42 miles long, beginning in Knox County near the town of Bladensburg and entering the Muskingum River near the town of Dresden. Summaries of land use statistics are found in Table 1.

The Wakatomika watershed lies in two ecoregions that are roughly defined by the southern glacial boundary in the region. The western portion is in the glaciated Erie and

Ontario Drift and Lake Plain (EOLP). The eastern half of the watershed is in the non-glaciated Western Allegheny Plateau (WAP). The glaciated portion is characterized by rolling hills and valleys. The non-glaciated portion has steeper topography with coal and clay deposits. Generally, row cropping (agriculture) is found in the flat floodplain of the valleys. Pasture is also found in the valleys but extends further up the hillsides and the flatter ridges. Forests are found on the steep hillsides and ridges. Both strip and deep coal mining has occurred in the eastern portion of the Wakatomika Creek watershed.

Table 1. Land use in the Wakatomika Creek watershed

	5040004 020		05040004 030	
Land use	**Acres**	**%**	**Acres**	**%**
Water	236.3	0.31	686.6	0.94
Commercial	21.7	0.03	56	0.08
Agriculture	12884.5	17.04	12264.2	16.85
HD-Residential	0.7	0.00	14.8	0.02
LD-Residential	39.2	0.05	300.8	0.41
Grass/Pasture	24718.7	32.69	19951.7	27.41
Forest	37710.4	49.87	39416.7	54.15
Industrial	0	0.00	106.1	0.15
Total Area	75611.5		72796.9	

The watershed is mostly rural with only one incorporated community (Village of Frazeysburg) located in the lower portion of the watershed. The homes within the Village of Frazeysburg are serviced by a central sewage treatment plant. According to census data, the population in the Village of Frazeysburg in 1990 was 1,165 and in 2000 the population was 1,201. The total population within the Wakatomika Creek watershed is estimated to be 4,680 (20 people per square mile). (http://factfinder.census.gov/home/saff/main.html?_lang=en)

The community of Bladensburg is located in the headwaters of the Wakatomika Creek watershed in Knox County. The homes in the community of Bladensburg, as well as the homes outside of the Village of Frazeysburg, are not serviced by a central sewage treatment plant but instead have on-lot home septic treatment systems (HSTS). Although census data is not directly available for Bladensburg, the population is estimated at 166. This estimate was developed by multiplying the 73 homes in the Bladensburg metropolitan area times the population per household (2.28) in the nearest Village (Frazeysburg).

There are currently three facilities with National Pollutant Discharge Elimination System (NPDES) permits to discharge wastewater within the Wakatomika Creek watershed: Longaberger, Frazeyburg waste water treatment plant (WWTP), and East Knox Elementary (Table 2). Both Longaberger and Frazeysburg WWTP discharge directly to the lower Wakatomika Creek in the village of Frazeysburg. East Knox Elementary discharges to a tributary of Harrod Run in

Bladensburg.

Table 2. Point source dischargers (NPDES permitted) in the Wakatomika Creek watershed

Facility	County	Ohio Permit# (USEPA ID)	Latitude/ Longitude	Receiving Stream	Design Flow (MGD)
05040004 020					
East Knox Elementary	Knox	4PT00103 (OH0120979)	40.2861 / -82.2861	Trib to Harrod Run	0.005
05040004 030					
Frazeysburg WWTP	Muskingum	0PB00015 (OH0020800)	40.1075 / -82.1267	Wakatomika Creek	0.183
Longaberger	Muskingum	0IM00018 (OH0107786)	40.1392 / -82.0736	Wakatomika Creek	0.20

1.2 Condition of the Watershed

Under the Clean Water Act, every state must adopt water quality standards to protect, maintain and improve the quality of the nation's surface waters. These standards represent a level of water quality that will support the goal of swimmable/fishable waters. Further information is available in Chapter 3745-1 of the Ohio Administrative Code (OAC) (http:/www.epa.state.oh.us/dsw/wqs/criteria.html).

In the Wakatomika Creek study area, the aquatic life use designations that apply to various segments are Exceptional Warmwater Habitat (EWH), Warmwater Habitat (WWH), and Cold Water Habitat (CWH). Waters designated as EWH are capable of supporting exceptional or unusual assemblages of aquatic organisms which are characterized by a high diversity of species, particularly those which are highly pollutant intolerant and/or are rare, threatened, or endangered. Waters designated as WWH are capable of supporting and maintaining a balanced integrated community of warm water aquatic organisms.

Attainment of aquatic life uses is determined by directly measuring fish and aquatic macroinvertebrate populations to see if they are comparable to those seen at least impacted reference sites that are about the same size and located within the same ecoregion in Ohio. Attainment benchmarks from these least impacted areas are established in the WQS in the form of biocriteria, which are then compared to the measurements obtained from the study area. If measurements of a stream do not achieve the three biocriteria (fish: Index of Biotic Integrity (IBI) and Modified Index of Well-being (MIwb); aquatic macroinvertebrates: Invertebrate Community Index (ICI)) the stream is considered in non attainment. If the stream measurements achieve some of the biological criteria but not others, the stream is said to be in partial attainment. A stream that is in partial attainment is not achieving its designated aquatic life use, whereas a stream that meets all of the biocriteria benchmarks is in full attainment.

Another type of use in the WQS is for recreational purposes. The recreational use for the majority of the Wakatomika Creek study area is Primary Contact Recreation (PCR). The criterion for the PCR designation is being suitable for full-body contact recreation. Ohio EPA assigns the PCR use designation to a stream unless it is demonstrated through use attainment analysis that the combination of remoteness, accessibility, and depth makes full-body contact recreation by adults or children unlikely. In those cases, the Secondary Contact Recreation (SCR) designation is assigned. The attainment status of PCR and SCR is determined using bacterial indicators; the criteria for each are specified in the Ohio WQS.

1.3 Causes and Sources of Impairment

Ohio EPA surveyed the status of the water quality in assessment units 05040004 020 and 05040004 030 during 2003 and 2004. The study found impairment of both the Aquatic Life Use and the Recreation Use. The main causes of impairment along with associated sources from the 2006 Integrated Report (draft) are listed in Table 3. Figure 1 also illustrates the stream health based on both the fish and macroinvertebrate community.

The primary causes of impairment in the Wakatomika Creek watershed are bacteria, sedimentation, mining and habitat alteration. Actions taken to reduce bacteria (originating from livestock with free access to the creek and poor manure management) will also reduce sedimentation, nutrient enrichment and will improve habitat. For that reason TMDLs are calculated for bacteria and habitat improvements.

Mining in the eastern portion of the basin is also the primary cause of impairment in Sand Fork, Moscow Brook, and Mill Creek. These areas were mined in the 1940s and again in the 1980s. Reclamation of these mined areas took place in the 1980s. This mining has produced high sulfate and conductivity conditions in the receiving streams. Limestone is present in sufficient quantities to mitigate acid produced from the exposed coal and refuse material (Lamborn, 1954). The data from the 2003 survey indicates that while these streams are only partially attaining the warm water habitat use designation, they are in a state of recovery and will most likely continue to improve with natural attenuation.

1.4 Scope of this Report

This report summarizes the water quality and habitat condition of the Wakatomika Creek, quantitatively assesses the factors causing the impairment, provides for tangible actions to restore and maintain the streams, and specifies monitoring to ensure actions are carried out and to measure the success of the actions taken.

Figure 1. Wakatomika Creek Watershed study area and stream health (based on the in-stream biological community)

Table 3. Aquatic Life Use (ALU) and Recreation Use (RU) Attainment Status for the Wakatomika Creek watershed (assessment units 05040004 020 and 030)

Stream & RM	Attainment Status		QHEI	Impairment Cause	Impairment Source	Addressed in TMDL
	ALU	RU				
Assessment Unit 05040004 020						
Wakatomika Creek (17-960) EWH & CWH						
45.0/44.9	FULL	NON	60.0	Bacteria	Unrestricted livestock access to the creek	Yes
43.8	FULL	NON	82.5	Bacteria	Unrestricted livestock access to the creek	Yes
41.2	FULL	NON	83.0	Bacteria	Unrestricted livestock access to the creek, poor manure management	Yes
37.7/37.8	FULL	NON	75.0	Bacteria	Unrestricted livestock access to the creek, septic discharges	Yes
36.7	FULL	NON	77.0	Bacteria	Unrestricted livestock access to the creek, septic discharges	Yes
Wakatomika Creek (17-960) EWH						
31.4	FULL	FULL	78.5			No
29.8	FULL	FULL	93.5			No
24.7	FULL	FULL	86.5			No
Trib. to Wakatomika at RM 40.93 (17-959) - EWH & CWH						
0.2	FULL	NON	78.5	Bacteria	Unrestricted livestock access to the creek	Yes
Harrod Run (17-977) - EWH						
2.2/2.3	FULL	NON	60.5	Bacteria	Unrestricted livestock access to the creek	Yes
1.0/0.9	FULL	NON	66.0	Bacteria	Unrestricted livestock access to the creek	Yes
0.2	FULL	NON		Bacteria	Unrestricted livestock access to the creek	Yes

Table 3. Aquatic Life Use (ALU) and Recreation Use (RU) Attainment Status for the Wakatomika Creek watershed (assessment units 05040004 020 and 030) – Continued

Stream & RM	Attainment Status		QHEI	Impairment Cause	Impairment Source	Addressed in TMDL
	ALU	RU				
Trib to Wakatomika (Bladensburg Trib) - undesignated						
0.2	NA	NON		Bacteria	Unrestricted livestock access to the creek, septic discharges	Yes
Jug Run (17-975) EWH & CWH						
1.6	FULL	NON	63.5	Bacteria	Unrestricted livestock access to the creek	Yes
0.3/0.4	FULL	FULL	73.5			No
Trib. to Jug Run @ RM 1.69 (17-955) - EWH & WWH						
0.5	FULL	FULL	89.5			No
Winding Fork (17-973) WWH & CWH						
4.2/4.1	FULL	NON	56.5	Bacteria	Unrestricted livestock access to the creek	Yes
3.1	FULL	FULL	54.5			No
Brushy Fork (17-971) WWH						
6.0	FULL	NON	55.0	Bacteria, sedimentation habitat alteration	Unrestricted livestock access to the creek, poor manure management	Yes
4.2	NON	NON	52.5	Bacteria, sedimentation habitat alteration	Unrestricted livestock access to the creek, poor manure management, riparian removal	Yes
1.9	PART	NON	56.0	Bacteria, sedimentation habitat alteration	Unrestricted livestock access to the creek, poor manure management, riparian removal	Yes
Priest Run (17-972) WWH & CWH						
0.4	FULL	FULL	43.0			No

Table 3. Aquatic Life Use (ALU) and Recreation Use (RU) Attainment Status for the Wakatomika Creek basin (assessment units 05040004 020 and 030) – Continued

Stream & RM	Attainment Status		QHEI	Impairment Cause	Impairment Source	Addressed in TMDL
	ALU	RU				
Trib to Priest Run @ RM 1.62 (17-909) WWH						
0.3	PART	FULL	47.0	Habitat	Habitat alteration	Yes
Assessment Unit 05040004 030						
Wakatomika Creek (17-960) EWH						
18.7	FULL	FULL	85.0			No
14.9	FULL	FULL	92.0			No
12.2/12.5	FULL	FULL	73.0			No
6.8/6.7	PART	FULL	61.0	Sedimentation, storm water	Highway construction, storm water runoff, riparian removal	Yes
2.3/2.1	PART	FULL	86.5	Sedimentation, storm water	Highway construction, storm water runoff	Yes
Nickel Valley Run (17-970) EWH						
0.3	FULL	FULL	59.0			No
Fivemile Run (17-969) WWH						
5.2/5.1	NON	FULL	46.5	Habitat alteration, sedimentation	Unrestricted livestock access to the creek, agricultural activities, riparian removal	Yes
3.4	FULL	NON	65.5	Bacteria	Unrestricted livestock access to the creek	Yes
0.3/0.5	FULL	NON	79.0	Bacteria	Unrestricted livestock access to the creek	Yes
Black Run (17-968) WWH						
3.0/2.8	PART	FULL	38.0	Habitat	Habitat alteration, Unrestricted livestock access to the creek	Yes
0.3	FULL	NON	48.5	Bacteria	Unrestricted livestock access to the creek	Yes

Table 3. Aquatic Life Use (ALU) and Recreation Use (RU) Attainment Status for the Wakatomika Creek basin (assessment units 05040004 020 and 030) – Continued

Stream & RM	Attainment Status		QHEI	Impairment Cause	Impairment Source	Addressed in TMDL
	ALU	RU				
Little Wakatomika Creek (17-961) WWH						
9.6/9.5	FULL	FULL	49.0			No
Little Wakatomika Creek (17-961) WWH						
7.8	FULL	FULL	53.0			No
6.8/6.7	FULL	FULL	80.0			No
2.8	FULL	FULL	43.0			No
0.6/0.4	FULL	FULL	61.0			No
Dickinson Run (17-966) WWH						
0.1	FULL	NON	61.0	Bacteria	Unrestricted livestock access to the creek	Yes
Sand Fork (17-964) WWH & CWH						
4.6	PART	FULL	71.5	Conductivity, TDS	Mining	Yes[1]
Sand Fork (17-964) WWH						
1.3	FULL	NON	50.0	Bacteria	Unrestricted livestock access to the creek	Yes
Mill Fork (17-962) WWH						
7.1	PART	FULL	63.0	Conductivity, TDS	Mining	Yes[1]
6.3	PART	FULL	88.0	Conductivity, TDS	Mining	Yes[1]
3.3	PART	FULL	67.5	Conductivity, TDS	Mining	Yes[1]
0.1/0.2	FULL	NON	47.0	Bacteria	Unrestricted livestock access to the creek	Yes
Moscow Brook (17-963) WWH & CWH						
2.6/2.5	PART	FULL	77.0	Conductivity, TDS	Mining	Yes[1]

Table 3. Aquatic Life Use (ALU) and Recreation Use (RU) Attainment Status for the Wakatomika Creek basin (Assessment Unit 05040004 020 and 030) – Continued

Stream & RM	**Attainment Status**		**QHEI**	**Impairment Cause**	**Impairment Source**	**Addressed in TMDL**
	ALU	**RU**				
Moscow Brook (17-963) WWH						
0.3/0.1	PART	NON	44.0	Conductivity, TDS Bacteria	Mining, unrestricted livestock access to the creek	Yes – bacteria Yes[1] – mining

Key for attainment status notations:
FULL - Full attainment meets all applicable criteria for designated uses
PART - Partial attainment meets some but not all criteria for designated uses
NON - Non-attainment does not meet any criteria for designated uses

[1] Mining indicator parameters (iron, manganese, aluminum, and alkalinity) were used in calculations as surrogates for conductivity and TDS.

2.0 Loading Analysis

TMDLs are tools used to bring water resources into attainment of applicable water quality standards. This is achieved through analysis of the factors leading to non-attainment, such as pollution loads to receiving waters. The analysis accounts for all relevant sources, such as point, non-point and natural, and estimates the contribution to the overall problem, or load, that each one makes.

Target conditions for the water resource are established based on either direct compliance with water quality standards or on documented relationships between the biocriteria and the factors causing impairment (OEPA, 1999). Through an interpretation of these relationships, a determination of the conditions necessary for meeting the applicable biocriteria standards (e.g., threshold concentrations for total phosphorus) can be made with confidence. Such conditions represent the assimilative capacity or the loading capacity of the system, which is defined as the quantity of a pollutant that a waterbody can receive and still maintain water quality standards. The loading capacity is dependent upon the physical, chemical, and biological processes occurring in the waterbody.

TMDL development requires the definition of the existing load, calculation of the loading capacity, and allocation of the TMDL. The existing conditions of the system are determined by monitoring data and/or are estimated using mathematical models of the system. Allocations are set for the respective sources so that their sum does not exceed the assimilative capacity of the system. Allocation of the TMDL involves a reasonable and/or equitable distribution of the loading capacity to all known sources in consideration of technical and economical feasibility as well as water-quality related implications.

The technical definition of a TMDL is the sum of its load allocations, wasteload allocations, and a margin of safety. Load allocations (LA) and wasteload allocations are the portion of the TMDL reserved for non-point sources and point sources respectively. The margin of safety (MOS) is a portion of the TMDL reserved for uncertainty in the method of calculation. MOS may be included explicitly or implicitly. TMDLs are required to consider both critical condition and seasonality for each parameter of concern.

TMDL allocations provide the basis for new effluent limits on point source discharges as well as other regulatory actions that may be taken (e.g., stormwater permit specifications). Actions recommended in the implementation plan (see Chapter 4 of this report) that address non-point sources should also be sufficient to meet the reductions needed.

In the Wakatomika Creek watershed TMDLs were developed to address the following causes of impairment: bacteria, habitat alteration, and TDS/conductivity associated with historic mining activity. Acid mine drainage indicator parameters (alkalinity, iron, manganese and aluminum) were used as surrogates for conductivity. Since these parameters are a major component of TDS and conductivity, they are an excellent fit to use in place of conductivity.

2.1 Bacteria

A study within the Wakatomika Creek watershed in 2003 revealed that many sites are likely exceeding the water quality criteria for primary contact recreational use. This was not confirmed for sites where 5 samples or more had not been taken within a thirty day period as required in the water quality standards. The cause of impairment is bacteria and the sources are livestock with unrestricted access to the stream, improper manure management, and failing home septic treatment systems (HSTS). To better quantify the impairment, a more intense study of the sources of bacteria was performed in 2004 using a paired watershed approach.

Specific objectives of the paired watershed study were to:

- Quantify the needed reduction of instream bacteria
- Demonstrate that the use of livestock exclusion and manure handling Best Management Practices (BMPs) reduces the loading of fecal coliform bacteria to streams
- Determine if the reduction resulting from the BMPs is adequate to meet bacteria targets.

Data used in this study comes from four sites that are believed to be representative of streams of their size throughout the Wakatomika Creek watershed that have a high potential for exceeding bacteria Water Quality Standards (Figure 2). The recommendations set forth for these sites will therefore also be ascribed to streams throughout the basin.

The focus of this study was placed on areas with high bacteria concentrations based on the 2003 survey data. The data collected and field observations from 2003 showed that the majority of the bacteria loading stems from livestock with unrestricted access to the creek as well as inappropriate manure handling. However, a small tributary that runs through the unsewered community of Bladensburg also had very high bacteria counts. The most likely source of the high bacteria loads were failing HSTSs. The results of studies conducted in 2004 indicate that both livestock and HSTS were the primary sources of the bacteria.

Based on monthly operating report (MOR) data (Table 4), none of the three permitted dischargers in the basin (Table 2) exceed WQS. Therefore, the 2004 study did not target these facilities.

2.1.1 Bacteria Methods

Paired watershed studies are often designed to measure the effectiveness of BMPs. Two or more basins with similar attributes, such as size and land uses, are selected. One basin serves as the control and the other(s) as a treatment basin. Data is collected from both basins for an amount of time, usually years, before any treatments are made. Once treatments are made data is collected for an amount of time, again usually years. The before treatment and after treatment data are compared and the changes, if any, are summarized. The goal is to quantify the improvements made to water quality as a result of the establishment of BMPs.

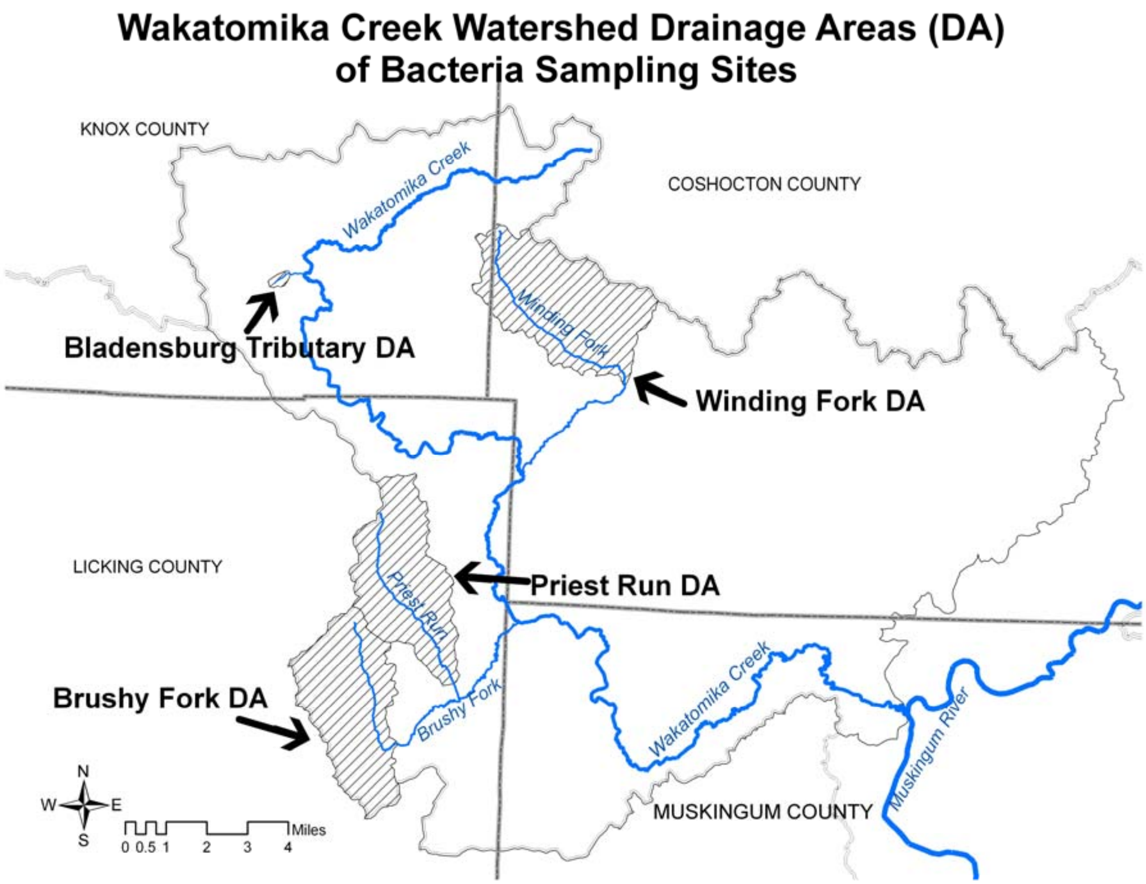
The Wakatomika Creek paired watershed study attempts to demonstrate that a stream site near a farm with pre-existing manure BMPs contains lower concentrations of fecal coliform bacteria than stream sites near farms without manure BMPs.

Site Selection

Based on the results of the 2003 water quality study, fourteen sites were selected for further sampling. The selected sites were likely to either have chronically high bacteria concentrations (i.e., above the WQS) or low values (not likely to exceed the WQS). The sites are located in four distinct basins: Brushy Fork, Bladensburg Tributary, Priest Run and Winding Fork (Figure 2).

The land use surrounding all of the sites, with the exception of a site on the Bladensburg Tributary, is agriculturally based livestock (pasture), hay and corn/soybean combinations. The most downstream site in the Bladensburg Tributary is downstream of an unsewered community with approximately 16 houses whose backyards include the stream and a barn lot. During the 2004 study, bacteria samples were taken approximately once per week at all 14 sites from April to November. Flow measurements were taken at three of the sites so that a flow relationship could be built between the USGS gage 03144000 in Wakatomika Creek near Frazeysburg, and the unmeasured sites in the study. Based on measured flows, daily USGS gage flows, and respective drainage areas, a daily flow value was determined for each site for every day of the study period. This information was used to determine trends between flow rates and bacteria concentrations and to calculate bacteria loads. Because bacteria samples have a short holding time (six hours), the same sampling routine was used for each survey to ensure greater time efficiency. For this routine the first sample was taken around 9:00 AM and the last sample around 1:00 PM. This standard routine meant that each site was sampled at about the same time of day from April to November meaning that time of year comparisons could be made without having variability introduced by the time of day that the sample was taken.

Figure 2. Overview of four study subbasins within the Wakatomika Creek watershed



Sample dates were compared to the hydrograph from the United States Geological Survey (USGS) Ohio stream gage 03144000 (Wakatomika Creek near Frazeysburg) to determine stream flow levels (Figure 3). Numerous sampling events were conducted throughout 2004 to collect data at variety of flow conditions. Stream flows were measured or calculated for each site and flows were compared to one another to determine if samples were taken during high, low or normal flows. However, that comparison does not help in determining if the flows were increasing, decreasing or holding steady. Figure 4 illustrates when, in relation to the hydrograph, the samples were taken. This illustration is useful since livestock farming is a major component of land use in this basin and it was assumed that storm events would cause manure runoff and subsequently high instream fecal coliform concentrations. This initial manure wash off would be indicated if bacteria counts were highest during and just after the hydrograph began an increase.

Failing HSTS can be a significant source of bacteria in streams. Of the four sites described here, HSTS are not considered to be a significant source with the exception of the Bladensburg Tributary. Although there are homes upstream of the sites at Winding Fork, Brushy Fork and Priest Run they are few and none are near the sampling sites. Additionally, most of the homes were located near livestock operations therefore the livestock source would likely overwhelm any contribution made by failed HSTS. Cattle then, are the most important variable and source of bacteria for the sites used, and the cause and source associations made regarding bacteria are assumed to be resulting from livestock. However in the Bladensburg area, failing home sewage treatment systems (HSTS) as well as livestock were both found to be a significant source of in-stream bacteria.

Of the fourteen sample site datasets, three (Brushy Fork, Priest Run, and Bladensburg Trib) were selected to be used in conjunction with the treatment site (Winding Fork at SR 79) based on their similarities to the treatment site. Table 5 summarizes fecal coliform data, drainage area and livestock counts taken at these four sites. They are all in the Wakatomika Creek drainage basin and all are similar in geology, topography, drainage area (with the exception of the Bladensburg tributary) and land use. All sites have cattle upstream of the sampling site.

Table 4. Bacteria data for the three permitted dischargers to Wakatomika Creek. Fecal Coliform bacteria measure in # colonies/100ml.

Wakatomika Creek downstream Longaberger @ TR 118, RMs 6.7 & 7.2		East Knox Elem. School in Bladensburg		Wakatomika Creek downstream Frazeyburg WWTP, RM 12.32	
Date	Fecal Coliform	Date	Fecal Coliform	Date	Fecal Coliform
6/11/98	106	5/28/98	42	6/4/98	240
8/14/98	133	7/7/98	7	8/4/98	300
6/3/99	163	9/2/98	17	6/24/99	300
6/15/00	204	10/15/98	15	8/18/99	500
8/17/00	250	5/27/99	16	6/28/00	50
6/7/01	1800	6/1/99	6	8/10/00	1000
8/14/01	252	6/9/99	68	8/28/01	350
6/13/02	440	8/26/99	54	8/28/02	670
6/19/03	1060	9/23/99	12	06/25/03	180
07/31/03	320	10/12/99	39	07/02/03	210
08/07/03	500	5/3/00	51	07/09/03	1130
8/7/03	2500	9/4/00	36	07/17/03	230
08/26/03	340	10/3/00	46	07/22/03	280
		5/8/01	78	07/31/03	360
		9/18/01	84	08/07/03	530
		10/2/01	51	8/28/03	2900
		5/28/02	526	6/26/01	1*
		6/25/02	22		
		5/29/03	468		
		8/27/03	562		
		9/17/03	642		
count	13		21		16
geometric mean	379		54		380
max	2500		526		2900
count>2000	1		0		1
%>2000	8		0		6
geomean exceeds 1000?	no		no		no
>10% exceed 2000?	no		no		no
WQS violation	no		no		no

* this value was considered an outlier and was not used in the geomean calculation.

Figure 3. Wakatomika Creek Bacteria Sample Dates vs. Gage Flow (Q)

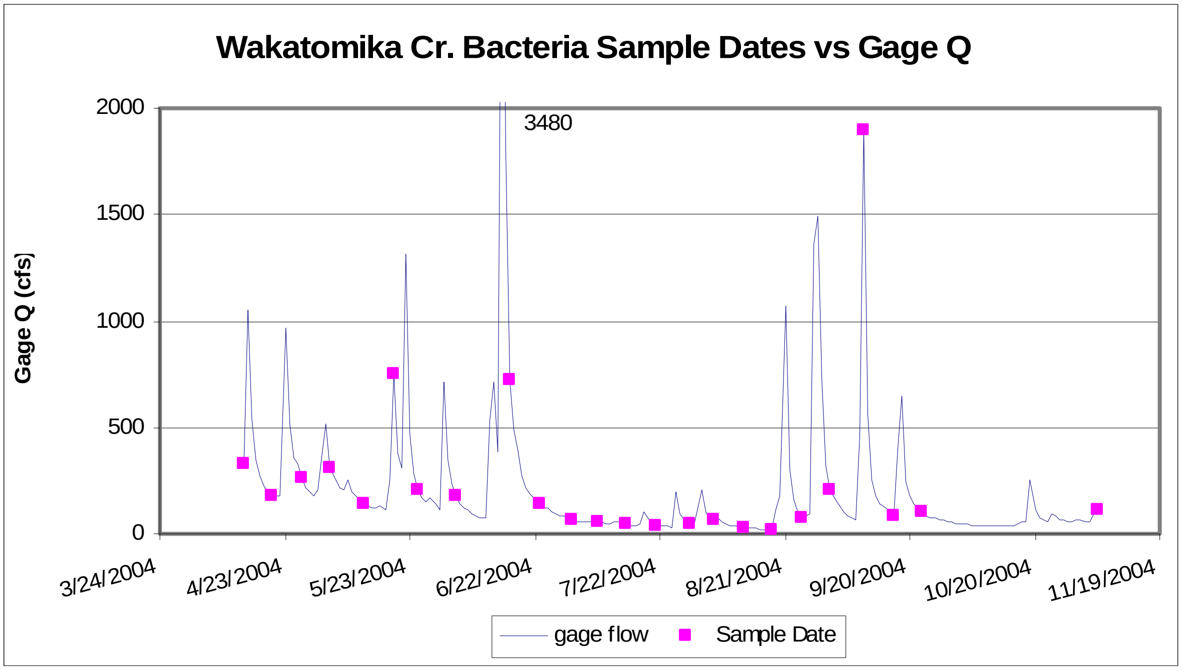
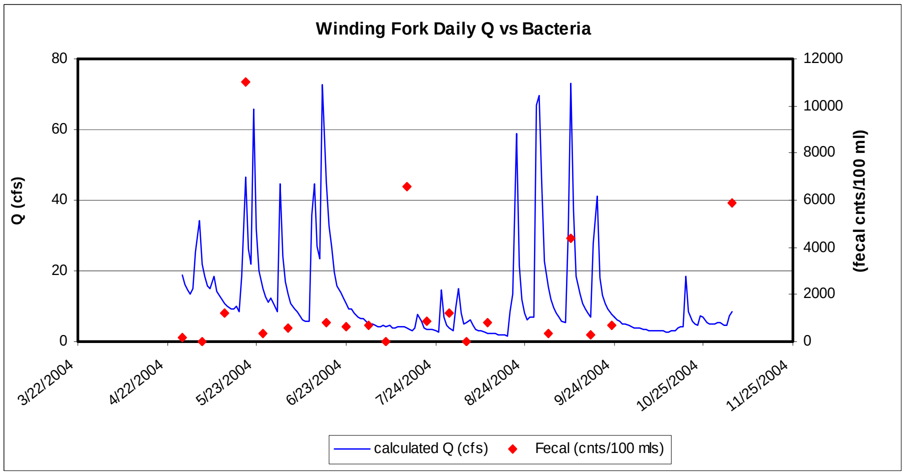


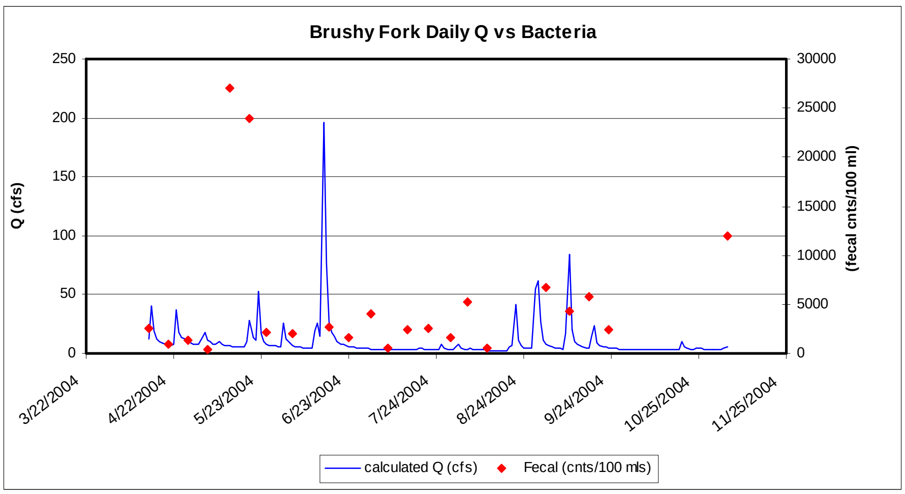
Table 5. Wakatomika Creek site summary

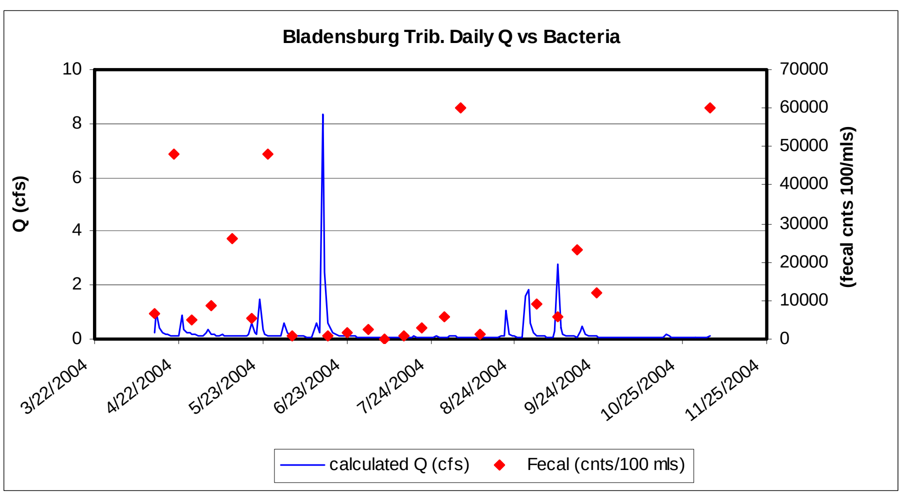
Site Description	Drainage Area (Sq. Mi.)	Livestock Count	Number of Data Points	Fecal Coliform Geomean (counts/100 ml)	Max	count > 2000	% > 2000	Notes
(BMP site) Winding Fork @ SR79, RM 4.1	9.5	820	21	616	11000	5	24	control site
Priest Run @ Licking Valley Rd., RM 0.4	8.2	48	21	584	8700	4	19	No controls, but no stream side barn lots
Brushy Fork. @ Licking Valley Rd., RM 6.0	8.3	68	20	2848	27000	14	70	stream part of barn lot ~ 0.5 miles upst site
Bladensburg Trib. dst cows ust town, RM 37.53/0.40	0.14	12 (55 after 9/1/04)	18	3581	60000	12	67	stream part of barn lot ~ 0.1 mile upst site

Note: This table represents the Recreational Period only (May 1st – October 15th).

Figure 4. Flow vs. Bacteria for Three Sites in the Wakatomika Creek Basin







Winding Fork (Treatment Site)

The Winding Fork site is the treatment site where livestock related BMPs have been used for several years. The Winding Fork site is not a typical treatment site since the implementation (BMPs) was done before any data was collected. Additionally no change in management was made during study period so these effects cannot be measured. The study site is located 4.1 miles upstream of the mouth and was selected as the treatment site based its location in the basin, drainage area, land use (livestock production) and because livestock related BMPs are being used on the farm directly upstream of the sampling location. During this study cattle were grazed upstream from this site from 0.2 miles to approximately 1.0 mile. There was also an active feeder calf barn 0.33 miles upstream, from which manure was spread over 900 acres in nearby upstream crop fields and pastures. Samples from this site reflect the impacts caused by high density cattle operations that use livestock related BMPs.

Brushy Fork

The Brushy Fork site is 6.0 miles upstream from the mouth and was selected, based on its location in the basin, drainage area, land use, proximity to upstream active barn lots, and high bacteria count samples. On June 23, 2004 sixty six cows and two horses were counted in fields or barn lots in the drainage upstream of this site. There are four active barn lots with direct access to the stream, the closest of which is approximately

Figure 5. Unrestricted livestock access upstream of the Brushy Fork Site.

0.55 miles upstream from the sample site, (Figure 5). Samples from this site reflect the impacts caused by high density cattle operations that do not use livestock related BMPs.

Bladensburg Tributary
The Bladensburg tributary site is 0.4 miles upstream from the mouth and was selected for its location, landuse, and proximity to an active barn lot. The barn lot is directly upstream of the sampling site approximately 0.15 miles. For the majority of the study period there were approximately 12 cows in the barn lot and pasture. However, sometime during late summer the herd size increased and on September 1, 2004, fifty to fifty five cows were counted in the pasture. The pasture and barn lot above this sampling site included approximately 95% of the sites drainage. No other influences, such as HSTS pipes were observed between the site and the pasture fence. During the spring months pooled manure near the hay feeding area in the barn lot was observed running off into the stream. Samples from this site reflect the impacts caused by high density cattle operations that do not use livestock related BMPs.

Priest Run
The site at Priest Run is 0.4 miles up from the mouth and was used because of its location in the basin, drainage area, and land use. This is a narrow valley basin with semi steep slopes on either side of the stream. From the sampling site to the upper headwaters 46 cows and 2 horses were counted on May 4, 2004. None of the farms had barn lots with concentrated animals at the stream, though there was one farm approximately 3 miles upstream of the sampling site on the main east tributary which had a hay feeding area near the stream. Grazing mostly occurs in the bottom fields of the Priest Run watershed and the steeper hill sides are wooded. Over the course of the study cattle with free access to the creek were observed at one farm. The closest actively grazed field located upstream from the sampling point is 1.6 miles away.

Table 6 compares the land use breakdown for each study basin. Because all four sites have similar geology, topography and land uses they are comparable, thus differences in instream bacteria concentrations can be associated with upstream land management practices.

Table 6. Land use data for four study sites (USGS, 1992)

	Water	Resid -Lo	Comm -Ind	Forest -Decd	Forst-Evrgn	Forst-Mxd	Pasture	Row Crop	Wetlnd-Wood	Wetlnd-Herb	Total
						Area (mi sq)					
Bladensburg Trib.	0.00	0.00	0.00	0.04	0.00	0.00	0.07	0.03	0.00	0.00	0.14
Winding Fork	0.00	0.00	0.01	4.86	0.10	0.02	3.01	1.86	0.00	0.00	9.86
Priest Run	0.00	0.00	0.00	5.42	0.12	0.02	1.96	0.58	0.00	0.00	8.10
Brushy Fork	0.00	0.02	0.01	3.90	0.15	0.04	3.33	0.92	0.01	0.00	8.38
						% of watershed					
Bladensburg Trib.	0.00	0.00	0.00	30.47	0.00	0.25	49.39	18.92	0.98	0.00	100
Winding Fork	0.01	0.01	0.10	49.28	0.98	0.23	30.51	18.85	0.01	0.01	100
Priest Run	0.03	0.00	0.00	66.94	1.49	0.20	24.13	7.17	0.00	0.02	100
Brushy Fork	0.00	0.19	0.10	46.58	1.83	0.42	39.78	11.00	0.10	0.00	100

The statewide numerical and narrative criteria for primary contact recreational use designation, requires that for each designation at least one of the two bacteriological standards (fecal coliform or E. coli) must be met. These criteria apply outside the mixing zone and for fecal coliform state; “the geometric mean content (either MPN or MF), based on not less than five samples within a thirty-day period, shall not exceed 1,000 per 100 ml and shall not exceed 2,000 per 100 ml in more than 10 percent of the samples taken during any thirty-day period.” The intent of this study was not solely to determine if specific sites met or did not meet the bacteria WQS. This study was more long term, so sample collection was not based on a thirty day time period. However, samples were collected weekly and thus frequent enough that it makes sense to apply the bacteria WQS as a target for the determination of needed reduction.

In order to calculate daily existing instream bacteria loads (kg/d) and target loads from bacteria concentrations (counts/1000 mls), a daily site flow is needed. During each weekly sampling run flows were measured at Winding Fork (RM 4.1), Brushy Fork (RM 6.0) and the Bladensburg Tributary (RM 0.4). Daily flows were derived by relating the weekly site measured flows to the daily USGS gage flows from the USGS gage on the Wakatomika mainstem at RM 14.9. The daily flows derived from weekly measured flows were then used to extrapolate daily flows for the sites with no measured flows, including Priest Run, by using drainage area yields.

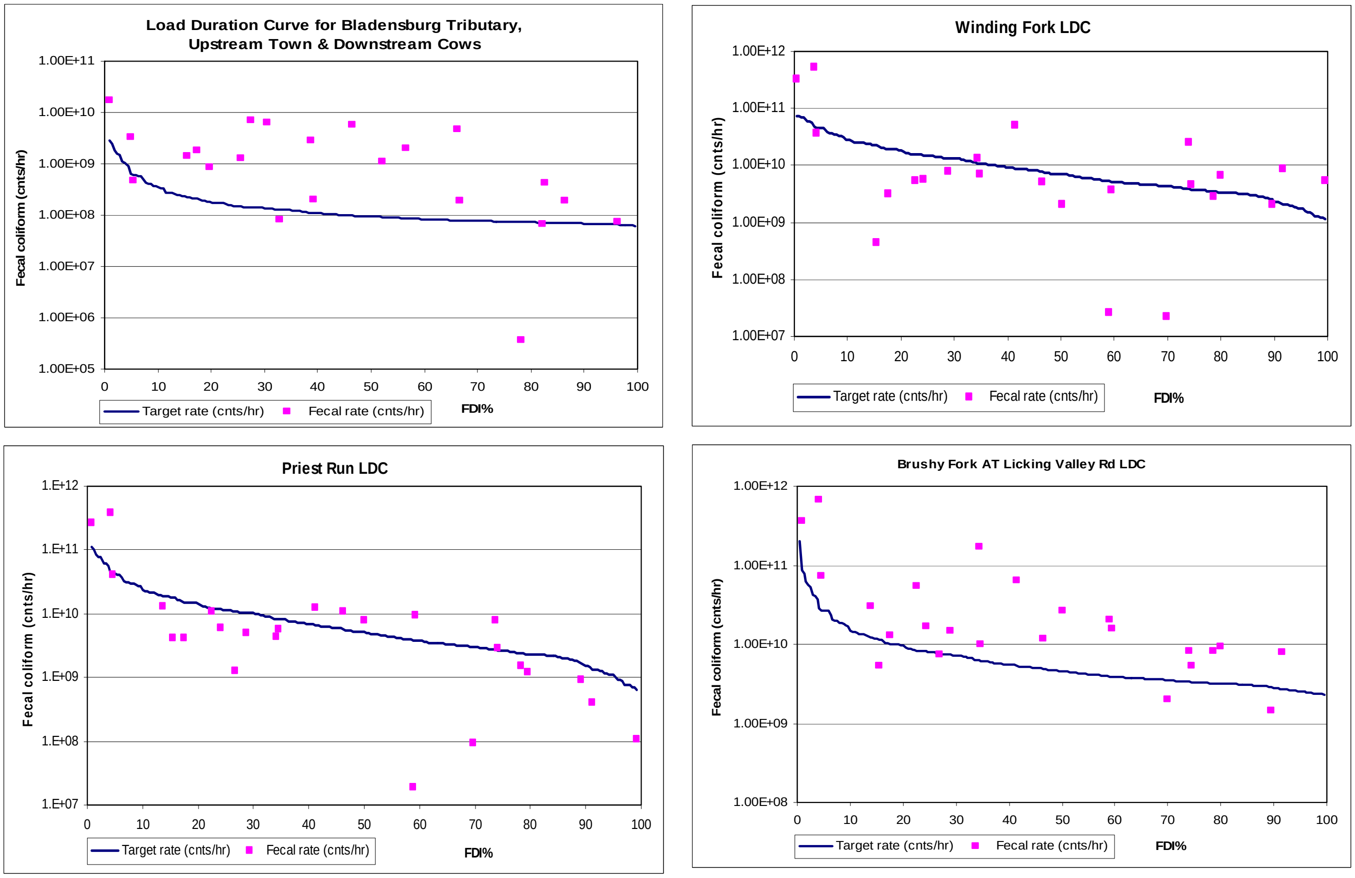
For the sites with measured flows, using polynomial regressions, the R^2 between the measured flows and the daily USGS flows are as such: Winding Fork 0.96, Brushy Fork 0.98, and Bladensburg Tributary 0.66 (with two extreme eliminations). The regression formula for each site was then used to calculate the daily flows. Once daily flows were established for these sites, daily flows for other sites, including Priest Run, in the respective basins were calculated based on drainage area yield.

2.1.2 Bacteria Results

The Load Duration Curves (LDCs) in Figure 6 depict the target load as a blue line and the actual loads based on the field samples as dots. For the purposes of this study there is an exceedance if the calculated load is above the target line while there is no exceedance for load values that fall below the line. The site at Winding Fork is directly down stream of a large cattle producer. To better interpret the results, it is important to know the basic operation of the upstream farm. During the study there were two groups, housed feeder calves and grazing cattle (cows and calves) that totaled 820 head. During the spring and summer there were 650 feeder calves under roof and the rest, 170 cows and calves, were grazed, switching pastures as needed. In some pastures the cattle are excluded from the stream, and in others they have access to the stream, (per conversation with landowners Kenny and Mike Johnson, 04/5/2005). It is difficult to track when the cattle had access to the stream because the operators do not have adequate records. Starting in August of 2004, 100 cattle per month were sold off without replacement until December of that year.

The sampling done for this survey was weekly, which is not frequent enough to consistently capture individual bacteria slugs as cattle enter and leave the stream. Figure 6 compares the flow rate and the bacteria concentration for the Winding Fork site. Due to the wide range of variables such as season, vegetative growth, precipitation, temperature, and cattle access to the stream, predicting bacteria concentration is difficult. This data does not show a strong relationship between flow and bacteria because exceedance are not restricted to either high or low flows. Both the Brushy Fork and Bladensburg sites frequently had exceedances but again there was no relationship between flow and bacteria concentration (Figure 6).

Figure 6. Fecal Coliform load duration curves for Winding Fork, Priest Run, Brushy Fork and the Bladensburg Tributary



Although similar in land use and livestock numbers, the bacteria concentrations are lower in Priest Run than Brushy Fork. Priest Run is 67% forested and 24% pasture, Brushy Fork is 47% forested and 40% pasture. Both have similar quantities of livestock, Priest Run 46 cows and 2 horses, Brushy Fork 66 cows and 2 horses. Significant differences in bacteria concentrations can likely be explained by the location of barn lots and the proximity of the sampling sites to the nearest active pasture. Brushy Fork has four significant barn lots directly adjacent to the stream the first being within 0.6 miles from the sampling site. The Priest Run sampling site is 1.6 miles from the nearest active pasture, the distance allowed for significant bacteria die off before the samples were collected at this site. This pasture does not have a barn lot adjacent to the stream although the cattle do have access to the stream. The feeding area is on the opposite side of the pasture from the stream, so manure that gets entrained in the runoff may be filtered out to some degree before reaching the stream.

Critical Conditions and Load Duration Curves

With daily flows established for each site it is possible to determine load duration curves (LDC) to evaluate critical flow conditions for bacteria. Bacteria enters stream water either through direct input (i.e. cows in streams and failing home sewage treatment systems (HSTS)) or as runoff during a precipitation event. Direct inputs tend to cause high bacteria concentrations during low stream flow conditions, while loading from runoff results in high concentrations during high flow periods. Since one of the study goals is to determine if the use of BMPs reduces bacteria loading within the Wakatomika Creek watershed it is necessary to know the flow conditions at which bacteria concentrations are elevated. Load Duration Curves are used for this purpose.

Figure 7. Houses with waste pipes discharging to streams can add significant bacteria to streams.

The dominant land uses within the Wakatomika Creek basin are low density rural communities, livestock operations (pasture) and row crop production. For many operations in the watershed, livestock have access to the stream therefore bacteria loading can be substantial under low flow conditions. However, this is likely to be reduced at low flow when livestock are excluded from the stream. Similarly, runoff from pastureland, feedlots and improperly stored manure will increase bacteria loading from storm events. Applying manure on land outside of the basin or according to rates recommended by the Natural Resources Conservation Service (NRCS) will also reduce the bacteria load during high flows. The LDCs for the four sub-basins of interest support this view (Figure 6).

The LDCs show that the Winding Fork and Priest Run sites have fewer bacteria exceedances than the Brushy Fork and Bladensburg Tributary sites. Winding Fork is the treatment site for this study because it is downstream of an operation known to be using livestock related BMPs. The results of the Winding Fork site are important because this operation is one out of a relatively small number of operations in the Wakatomika Creek watershed that employs livestock and manure management BMPs (personal communications with staff from Soil and Water Conservation District in Knox, Coshocton, Licking and Muskingum Counties). Despite a concentrated cattle herd just upstream of this site, the fecal coliform concentrations here were substantially lower than the Bladensburg Tributary and Brushy Fork sites. All three of these sites have cattle upstream. The Brushy Fork site, with approximately 66 cows and 2 horses upstream, and the Bladensburg Tributary site, with 12 cows (50 -55 after 9/1/04) upstream, have many more bacteria target exceedances than does the Winding Fork site which had 820 cows upstream. The difference in these results is most likely related to the manure handling in each basin.

Upstream of the Brushy Fork site there are three farms within 4 miles upstream of the site, the nearest one is 0.55 miles upstream. Brushy Fork and a major tributary flow through the barn lots of these farms (Figure 5). During the study, cattle were often observed in the stream at these farms. Also, manure wash off from the barn lots is likely occurring with every substantial precipitation event. Approximately 0.1 miles upstream of the Bladensburg site there was a barn lot and associated pasture. The pasture made up the entire watershed upstream of this site and the tributary flows through the barn lot. Rills carrying liquid manure were observed flowing to the stream from the barn lot during a field sampling event on May 6, 2004. The Winding Fork site had far more cattle but fewer bacteria exceedances, in part, because most of the cattle (650) were under roof. During one sampling run some pastured cattle were observed in the stream at this site, which may explain this site's few exceedances.

The operators were interviewed on April 5, 2005 regarding management practices carried out on the farm. From the interview it was learned that the feeder calf barn was built a few years ago with manure management in mind. The barn is separated longitudinally into two sections, one for feeding and one for bedding. Each side the floor slopes down slightly to the center. The manure is moved around by the cattle and collects toward the center. On the feeding side the manure is wet and on the bedding side where hay and straw are used the manure is dry. Once a month, the manure from the 650 housed cattle is scraped from the concrete barn floor and loaded into a manure spreader or holding tank (Figure 8). The wet manure is applied to the crop fields in the more well-drained soils away from the stream. The dry manure is applied in the valley fields adjacent to the streams.

The farmers also use a rotational grazing program which requires keeping the herd in any one paddock, or pasture, for limited period of time, usually 7 days, before moving them to another field. This benefits the stream by helping to avoid manure build up in the fields and by maintaining dense pasture forage which reduces manure runoff. Presently, the cattle are fenced out of the streams while in some pastures but have stream access in other pastures. However, the operators are in the process of erecting fences around all the pastures which will limit cattle stream access to only crossing areas.

Current Deviation from Targets

Fourteen sites were sampled during this study, to reduce the effects of the variables such as drainage area size, flow volume, number of livestock, number of houses, etc. only sites having similar attributes to the treatment "BMP" site were compared in this report. Table 7 shows how these four sites compare in terms of needed reduction of bacteria concentration.

Figure 8. Manure in tanks at the Winding Fork farm awaiting proper weather conditions for application.

The Bladensburg tributary was targeted to be sampled during the 2003 basin wide survey because it was known that Bladensburg is unsewered, and many of the residential home septic treatment systems discharge to this tributary. As was suspected, high bacteria counts were found at RM 0.4 within the village during the 2003 survey. However, it was also discovered that a farm in the headwaters of the Bladensburg tributary (upstream from the village) was also a potential bacteria source.

Table 7. Bacteria data and statistics for four study sites in the Wakatomika Creek watershed

Site Description/RM	(BMP site) Winding Fork @ SR79 RM 4.1	Brushy Fork. @ Licking Valley Rd. RM 6.0	Bladensburg Trib. Dst cows ust town RM 0.4	Priest Run @ Licking Valley Rd. RM 0.4
DA (mi sq)	9.5	8.3	0.14	8.2
Date	***fecal coliform (cnts/100 mls)***			
7/31/2003	4200	3000		310
8/7/2003	2000	3000		520
8/26/2003	4800			170
5/4/2004	20	470	8800	230
5/12/2004	1220	27000	26000	530
5/19/2004	11000	24000	5200	8700
5/25/2004	370	2100	48000	520
6/3/2004	590	2000	630	480
6/16/2004	810	2700	800	990
6/23/2004	660	1600	1800	700
7/1/2004	720	4100	2400	2500
7/7/2004	5	560	5	30
7/14/2004	6600	2400	920	2900
7/21/2004	840	2600	2700	630
7/29/2004	1200	1600	6000	1100
8/4/2004	5	5300	60000	5
8/11/2004	830	510	1130	540
9/1/2004	340	6700	9000	890
9/9/2004	4400	4300	6000	2400
9/16/2004	300	5800	23000	1500
9/23/2004	670	2400	12000	1900
Geomean	616	2848	3581	584
max value	11000	27000	60000	8700
Count	21	20	18	21
count > 2000	5	14	12	4
% > 2000 (must not be exceeded 10% of the time)	24	70	67	19
geomean exceeds 1000 criteria?	no	yes	yes	no
> 10% exceed 2000 criteria?	yes	yes	yes	yes
needed reduction of geomean for the 1000 target	*	1848	2581	*
needed percentage reduction for the 2000 target**	14	60	57	9

* This standard is not exceeded.
** The number of samples that exceed 2000 must be reduced by this percentage.
Note: This table represents data from the recreational period only (May 1st – October 15th).

The livestock at this farm were found to have unrestricted access to the Bladensburg tributary and there was no apparent manure management. In order to determine the magnitude of each potential bacteria source two sites were selected to be sampled in 2004, one near the mouth at RM 0.1, with a drainage area of 0.23 sq. mi. and downstream of both potential failing HSTSs and the pasture, and one upstream of the village at RM 0.4, with a drainage area of 0.14 sq. mi. downstream of only the pasture.

Table 8 shows the fecal coliform data and associated statistics from 18 samples taken at these sites. The calculated flow measurements taken near the mouth are shown as a basis for stream flow condition. The data shows that fecal coliform enters the stream both in the headwaters from the pasture and barn lot, and as the tributary meanders through the 0.4 miles of villager's backyards. To determine which source was the greater contributor of bacteria the percent change moving from upstream to downstream was calculated, see column 5. Because instream bacteria is so variable the percent change was considered insignificant if it was less than 50%, column 6 shows the samples that were counted. The samples taken on 7/7/2004 were near detection limits, considered outliers, and thus excluded. Of the remaining 17 samples, 11 changed significantly (> 50% change). Of 17 samples, 7 or 41%, more than doubled.

Table 8. Bacteria Data from the Bladensburg Tributary

DA (mi sq) ---->	Bladensburg trib. near mouth 37.53/0.10 0.23	Bladensburg trib. dst cows ust town RM 37.53/0.4 0.14	Bladensburg trib. near mouth 37.53/0.10 0.23	***%change from ust site to dst site***	***dst site change > +/- 50%***
	calculated Q (cfs)	***Fecal coliform (cnts/100 mls)***			
5/4/2004	0.49	8800	15500	76	X
5/12/2004	0.23	26000	19000	-27	
5/19/2004	1.20	5200	7600	46	
5/25/2004	0.32	48000	1700	-96	X
6/3/2004	0.28	630	11500	1725	X
6/16/2004	1.15	800	10600	1225	X
6/23/2004	0.23	1800	8500	372	X
7/1/2004	0.10	2400	18000	650	X
7/7/2004	0.08	5	10	100	NA
7/14/2004	0.07	920	24000	2509	X
7/21/2004	0.07	2700	16000	493	X
7/29/2004	0.07	6000	3100	-48	
8/4/2004	0.10	60000	60000	0	
8/11/2004	0.05	1130	28000	2378	X
9/1/2004	0.33	9000	17000	89	X
9/9/2004	3.02	6000	6000	0	
9/16/2004	0.14	23000	2500	-89	X
9/23/2004	0.16	12000	18000	50	
count		18	18		11
geomean		3581	7560		
max		60000	60000		
count > 2000		12	16		
% > 2000		67	89		
Geomean exceeds 1000 criteria?		yes	yes		
> 10% exceed 2000 criteria?		yes	yes		

The headwater farm nonpoint source and failing HSTSs from the village both contribute egregious amounts of bacteria to the tributary, however the 2004 data indicates that the headwater source contributes slightly more bacteria.

All four sites highlighted in this study fail to meet the bacteria targets. However, the four sites can be grouped into those that barely fail and those that fail significantly. Both the Winding Fork and Priest Run sites fit into the "barely failing" category. They have geometric means < 1000 and thus meet the 1000 cnts/100 ml standard, but they miss meeting the 2000 cnts/100 ml standard by 24% and 19%, for Winding Fork and Brushy Fork, respectively (see Table 7). The distance of the Priest Run site from the nearest source of bacteria likely explains the low bacteria counts. Had this site been closer to the first upstream pasture there may have been an exceedance of the standard. However, the Winding Fork site is very close to a full feeder barn and active pastures, and the low bacteria rates here can be attributed to the manure BMPs utilized at this farm.

The Brushy Fork and Bladensburg sites fail significantly. Both exceed the 1000 and 2000 cnts/100 ml standards and require a reduction of instream bacteria. The geometric mean of the Brushy Fork data upstream of the village is 2848 cnts/100 ml and, therefore, requires a reduction of 1848 to meet the 1000 cnts/100 ml target. The geometric mean of the Bladensburg tributary is 3581 cnts/100 ml, thus needs to be reduced by 2581 cnts/100 ml.

The 2000 cnts/100 ml target is exceeded 70% and 67% of the time by Brushy Fork and the Bladensburg tributary, respectively. Therefore, in order to meet this target, the exceedances of 2000 cnts/100 ml needs to be reduced by 60% and 57% for Brushy Fork and the Bladensburg tributary, respectively (Table 7). These two sites are good representatives of all sections of Wakatomika Creek and tributaries downstream of cattle lots and pastures. A proper manure management plan, as exists upstream of the Winding Fork site, along with fencing cattle out of the stream, would reduce the instream bacteria counts on Brushy Fork, the Bladensburg Tributary and all basin stream sections downstream of livestock, and likely would allow these sites to meet the primary contact recreational use designation.

The Bladensburg tributary was the only site during the preliminary basin wide study in 2003 determined to potentially exceed recreation use water quality standards for bacteria due to failing HSTS. The 2004 study found the tributary to be affected by both cattle and failing HSTSs. Table 8 shows the needed reduction for bacteria upstream of the village and the needed reduction at the mouth, downstream both the cattle and village source. Near the mouth of the tributary the geometric mean and the percentage of times the maximum bacteria target of 2000 cnts/100 ml was exceeded were 7560 and 67, respectively. Therefore, needed reductions to achieve the 1000 cnts/100 ml geometric mean, and 2000 cnts/100 ml maximum targets are 6560 and 57 (>10% is an exceedance), respectively (Table 8).

In order to achieve these reductions, efforts would need to be made towards reducing the effects of the cattle in the headwaters and addressing the unsewered community in the village of Bladensburg. Reducing the effects of livestock has already been discussed. Typically failing HSTSs evokes a movement to install sewerage to the violating municipality but in this small village, that may not be necessary. The number of houses in the vicinity of the tributary are so small (approximately 16) that an effort to simply install, update or clean out the affecting systems should suffice in reducing the instream bacteria to target levels.

Bacteria Margin of Safety

The margin of safety for this paired watershed approach study is implicit because it demonstrates that the manure management BMPs used in the treatment area greatly aid in the reduction of instream fecal coliform. There were exceedances of the target from the treatment basin because the cattle still had stream access at times, depending on which pasture they were in during the study. If fencing had been installed at the Winding Fork treatment site during the 2004 study, it is most likely that the bacteria would have been further reduced. Because the basis for this TMDL report is a paired watershed study and not a model there is very little uncertainty. All statistics and conclusions are drawn from measured data points collected over an entire recreation season. For these reasons there is an inherent implicit margin of safety.

Bacteria Discussion

If the water quality criteria for recreational use are applied as targets for the four sites detailed in this report, all four sites exceed a least one of the two criteria and two sites exceed both criteria. The Winding Fork and Priest Run sites exceeded only the upper criteria (>2000 cnts/100 ml) in 14% and 9% of the samples respectively. Though Winding Fork and Priest Run exceeded this upper target, they did so much less frequently than the Bladensburg tributary and Brushy Fork sites which exceeded the target in 57% and 60% of the samples respectively.

Best Management Practices for manure control are a significant help in keeping instream bacteria concentrations low. Fourteen sites were used to collect bacteria data in Wakatomika Creek and associated tributaries. Of these fourteen sites, four were selected for comparison based on drainage area size or proximity to livestock. Of the four sites, Winding Fork (the treatment site) and Priest Run regularly had lower bacteria values than Brushy Fork and the Bladensburg Tributary even though these sites had equal or more livestock upstream. Despite having the highest number and greatest concentration of livestock, Winding Fork had low bacteria values because the cattle farm utilizes BMPs for manure handling. Priest Run had low instream bacteria concentrations without the utilization of BMPs. The lack of stream side barn lots, low concentration of livestock, and the distance of the closest active pasture in this basin explain the low bacteria concentrations. Both Brushy Fork and the Bladensburg Tributary sites had stream side barn lots upstream of the sampling sites. These barn lots constantly fuel the stream with a source of bacteria from direct manure deposits from cattle, and during precipitation, runoff from excessive manure just feet from the stream. The Winding Fork site shows that BMPs certainly help to keep manure out of the stream and thus keep instream bacteria concentrations low.

Figure 9. Mike and Kenny Johnson standing next to their feeder barn. The barn is critical for proper control and management of their cattle manure.

The cattle farmers upstream of the Winding Fork site housed the majority of their cattle in a feeder barn (Figure 9) and fenced the cattle out of the stream when they were in a pasture on the east side of the creek. However, when they were in the pasture on the west side of the creek they did have stream access. Also, there was little to no riparian zone to act as a filter for overland runoff. Upgrading the farm BMPs by fencing the cattle out of the entire stream and allowing a riparian zone may result in the elimination of bacteria exceedances in Winding Fork.

2.2 Habitat Alteration

Habitat alteration was found to be a cause of impairment for eight sites in the Wakatomika Creek watershed. Habitat alteration includes the straightening, widening or deepening of the stream's natural channel. Habitat alteration can also include the degradation or complete removal of vegetated riparian areas that are essential to a healthy stream (Figure 10). Such activities can effectively transform the stream from a functioning ecosystem to a simple drainage conveyance.

Figure 10. This photo is looking upstream Priest Run shortly after all vegetation had been removed. During the sampling season this stream had short but brushy riparian, which helped the stream system by reducing sunlight and heat, adding food for aquatic insects, and creating cover habitat in the form of woody debris.

Ohio EPA assesses habitat quality using the Qualitative Habitat Evaluation Index (QHEI). The QHEI is a visual assessment tool used to provide a measure of habitat that corresponds to those physical factors affecting fish communities and is generally important to other aquatic life (Rankin, 1989). The QHEI is a composite of six habitat categories: 1) substrate, 2) in-stream cover, 3) channel morphology, 4) riparian zone and bank erosion, 5) pool/glide and riffle/run quality, and 6) gradient. Each category is further divided into individual attributes that are assigned a weighted point-value reflective of the attribute's impact on aquatic life. The highest point-values are assigned to attributes correlated to streams with high biological diversity and integrity, while lower values are assigned to less desirable habitat features. Habitat alteration while a significant cause of impairment is not a load-based chemical parameter for which a TMDL is typically developed. For this reason no loading capacity is calculated as part of the habitat TMDL. Rather, the QHEI is used as a surrogate for loading capacity in developing targets to achieve use attainment. In this context the QHEI serves as a measure of a quantitative non-chemical parameter as specified by USEPA (USEPA, 1991).

The habitat quality of forty six sites in the Wakatomika Creek Watershed was evaluated in 2003. A habitat TMDL was developed for eight sites where habitat was determined to be a cause of impairment. QHEI assessment sites are specifically chosen to be representative of the stream segment on which they are assessed; therefore, the associated TMDLs are applicable to the entire stream segment, not just the assessment site.

2.2.1 Target Development and TMDL Methodology

A QHEI score of 60 is the target for streams designated WWH and 75 for streams designated EWH. These targets are determined by statistical analysis of a database of paired QHEI and IBI scores from sites located throughout the state. Linear and exponential regressions and frequency analyses were performed using combined and individual components of the QHEI and IBI scores (Ohio EPA, 1999). The regressions indicated the QHEI is significantly correlated with the IBI however, the exponential model provides a better fit to the data than the linear. Sites with QHEI scores greater than or equal to 60 were generally associated with IBI scores supportive of a WWH use designation and scores greater than or equal to 75 were generally associated with IBI scores supportive of a EWH use designation.

Through analysis of the QHEI sub-metrics in relation to IBI scores attributes that are associated with degraded biological communities were identified. These attributes are modifications of natural habitat and are classified as having a high-influence or moderate-influence on the biological community, which was based on the statistical strength of the relationships. The presence of these modified attributes influence aquatic biology and are not necessarily reflected in the QHEI score itself. Streams with more than one high-influence or more than four moderate-influence attributes typically do not achieve WWH biocriteria (using an IBI of 40 as a representative WWH biocriterion). Streams that have a high influence or more than two moderate-influence attributes typically do not achieve the EWH biocriteria (using an IBI of 50 as a representative EWH biocriterion). Therefore, stream segments designated as WWH can be impaired due to habitat deficits even with a QHEI scores above 60. Likewise, stream segments achieving QHEI scores above 75 may have habitat impairment to their EWH use designations. For example, the benefit of a good riparian zone and high sinuosity may be undermined by the impact of a thick muck substrate. In such a situation the QHEI may exceed 60 (or 75 for EWH streams) because some components of the habitat are of an excellent quality but impairment may ensue because other poor attributes are limiting the biological community (e.g., poor substrate). These high and moderate influence attributes are presented in Table 9.

The habitat TMDLs presented herein incorporate both the QHEI target of 60 for WWH and 75 for EWH as well as the targets for modified-habitat attributes. The habitat TMDL equation presented in Table 9 reflects the relationship between the QHEI score, high influence modified-habitat attributes, and moderate influence modified-habitat attributes. A value of one or zero is given based on criteria set for the total QHEI score, the number of high influence attributes, and the number of moderate influence attributes. The TMDL target is to achieve the criteria set for each of these three categories. For WWH streams, a QHEI score less than 60 or the presence of more than one high-influence attribute or more than four moderate-influence attributes will prevent a stream segment from achieving its TMDL target. For an EWH stream, a QHEI score less than 75 or the presence of a high-influence attribute or more than two moderate-influence attributes will prevent a stream segment from achieving its TMDL target.

2.2.2 TMDL Scores

Instream habitat was evaluated at forty six sites in the Wakatomika Creek watershed in 2003 using the QHEI. Of the forty six sites, habitat alteration was found to be causing impairment at eight of them (i.e., 20% of the sites). Results from the habitat assessment are presented in Table 10 for the eight sites identified as impaired due to habitat alteration. Table 10 also lists the observed modified-habitat attributes, component scores, and habitat TMDL score.

Table 9. Details of Habitat and Bedload TMDLs

Bedload TMDL Categories

QHEI Category	Target WWH	Target EWH
Substrate	13	15
Channel	14	15
Riparian	5	5
Bedload TMDL ➤	32	35

Habitat TMDL Categories

QHEI Category	Target WWH	Target EWH	Score
QHEI Score	60	75	+1
High Influence #	< 2	0	+1
Total # Modified	< 5	< 3	+1
Habitat TMDL ➤			3

Modified Attributes

High Influence	Moderate Influence
❷ Silt or Muck Substrate	① Channelized, but recovering
❸ Low or No Sinuosity and Drainage Area ≤ 20 sq. mi.	② Sand Substrate (boat sites)
❹ Sparse or Nearly Absent Cover	③ Hardpan Substrate Origin
❺ Max. Pool Depth ≤ 40 cm (wadeable or headwater sites)	④ Fair or Poor Development
❶ Recently Channelized or No Recovery	⑤ Less than 3 Cover Types
	⑦ No Fast Current
	⑧ Extensive or Moderate Substrate Embeddedness
	⑨ Extensive or Moderate Riffle Embeddedness
	⑩ No Riffle
	Silt Heavy or Moderate
	⑥ Intermittent Pools and Max. Pool Depth ≤ 40 cm
	Low or No Sinuosity and Drainage Area > 20 sq. mi.

Table 10. QHEI Assessment Results and Habitat TMDL Scores.

Stream	River Mile	QHEI Score	Modified Attributes[A]		Component Scores			TMDL Score	Is TMDL Target Met?
			High Influence	Moderate Influence	QHEI Score	High Influence	Moderate Influence		
EWH Targets:		>=75	0	<3					
WWH Targets:		>=60	<2	<5	1	1	1	3	yes
Wakatomika Creek (EWH)	6.8	61	❸	④⑧⑨	**0**	**0**	**0**	**0**	no
Wakatomika Creek (EWH)	2.3	86.5		⑧⑨	**1**	**1**	**1**	**3**	yes
Brushy Fork (WWH)	1.9	56	❸❹	②④⑤ ⑦⑧⑩	**0**	**0**	**0**	**0**	no
Brushy Fork (WWH)	4.2	52.5	❷	④⑦⑧⑩	**0**	**1**	**1**	**2**	no
Brushy Fork (WWH)	6	55	❸	④⑤⑦⑧	**0**	**1**	**1**	**2**	no
Trib. To Priest Run (WWH)	0.1	47	❸❹❺	④⑦⑧⑨	**0**	**0**	**1**	**1**	no
Black Run (WWH)	3	38	❷❸	②④⑤ ⑦⑧⑨	**0**	**0**	**0**	**0**	no
Five Mile Cr. (WWH)	5.2	46.5	❸❺	④⑤ ⑦⑧⑨	**0**	**0**	**0**	**0**	no

A **Key to modified habitat attributes**

High-Influence:
❶ Channelized with little to no recovery
❷ Silt or muck substrates
❸ Low sinuosity
❹ Sparse or no cover
❺ Max pool depth less than 40 cm
Moderate-Influence:
① Channelized, but recovering
② Sand substrate
③ Hardpan substrate origin
④ Fair or poor channel development
⑤ Two or less cover types
⑥ Intermittent or interstitial with poor pools
⑦ No fast current
⑧ High to moderate substrate embeddedness
⑨ Extensive to moderate riffle embeddedness
⑩ No riffle

2.2.3 Target Deviation

The deviations for both QHEI and the high and moderate influence QHEI attributes are in Table 11. In order for the Wakatomika Creek stream segments to not be impaired due to habitat modification, improvements would need to be made in order to meet the QHEI target of 60 for WWH and 75 for EWH and the attribute target of 3 as detailed in Table 11.

Table 11. Habitat TMDL Deviation Table

Stream	River Mile	QHEI Score	QHEI deviation from target	TMDL Score	TMDL deviation from target
EWH Targets: WWH Targets:		>= 75 >=60			
Wakatomika Cr. (EWH)	6.8	61	14	**0**	**3**
Wakatomika Cr. (EWH)	2.3	86.5	target met	**3**	target met
Brushy Fork	1.9	56	4	**0**	**3**
Brushy Fork	4.2	52.5	7.5	**2**	**1**
Brushy Fork	6	55	5	**2**	**1**
Trib. To Priest Run	0.1	47	13	**1**	**2**
Black Run	3	38	22	**0**	**3**
Five Mile Cr.	5.2	46.5	13.5	**0**	**3**

Critical Condition

The critical condition for the habitat TMDL is the summer dry period when environmental stress upon aquatic organisms is greatest. It is during this period that the presence of high-quality habitat features, such as deep pools and un-embedded substrate, is essential to provide refuge for aquatic life. QHEI scores, the basis of the habitat and sediment TMDLs, are assessed during the summer field season. The habitat and sediment TMDLs are therefore reflective of the critical condition.

2.2.4 Margin of Safety

A MOS was implicitly incorporated into the habitat TMDL through the use of conservative target values. The target values were developed though comparison of paired IBI and QHEI evaluations. Using an IBI score of 40 as representative of the attainment of WWH, and an IBI score of 50 as representative of the attainment of EWH, individual components of the QHEI were analyzed to determine the magnitude at which WWH or EWH attainment is probable. Attainment does, however, occur at levels lower than the established targets. The difference between the habitat targets and the levels at which attainment actually occurs is an implicit margin of safety.

2.3 Mine Drainage

A small portion in the eastern section of the Wakatomika Basin was mined in the 1940s, then again in the 1980s, after the Surface Mining Control and Reclamation Act of 1977 was adopted into law. Some impacted tributaries are only partially meeting the warm water habitat use designation. These streams are making progress towards recovery through natural attenuation of the pollutant loads. TMDLs have been calculated for three impacted tributaries as a measure of progress toward chemical targets. The TMDLs would be implemented through continued natural attenuation. It is not likely that other resource expenditures (i.e., funding and/or associated restoration activities) would be warranted to address impairment in this system.

The three sub-basins within the Wakatomika Creek basin impaired by the effects of mining are Sand Fork, Mill Fork and Moscow Brook. The cause of the impairment is elevated concentrations of Total Dissolved Solids (TDS). Additionally, stream conductivity has been examined because it is a reliable indicator of TDS that is easily measured. These three streams are located in the only portion of the basin to have been mined and are tributaries to Little Wakatomika Creek (Figure 11).

2.3.1 Mine Drainage Methods

Loads were calculated and examined to determine mine drainage indicator parameter contribution and critical condition. The concentration of mine drainage parameters is the determinant of biological survivability. Therefore, concentration, rather than load, was used for the purposes of target derivation and target deviation.

Elevated levels of iron, manganese, and aluminum indicate mine drainage influences. Since these metals are components of total dissolved solids (TDS), elevated TDS may also be an indicator of mine drainage. High acidity or low alkalinity, also demonstrate mine drainage. The values for these parameters from three mine affected tributaries of Little Wakatomika Creek were compared to values from a site on Little Wakatomika Creek at RM 7.8. The site at RM 7.8 is upstream of the three subbasins, unaffected by mining, and is comparable to the three subbasins in location, geology and drainage area.

Table 12 compares the biological and physical scores of the three mine affected subbasins to that of the unaffected site on Little Wakatomika Creek. Little Wakatomika Creek has higher IBI (fish) scores than the mine effected tributaries even though two of the mine effected tributaries, Sand Fork and Mill Fork have higher QHEI scores (Table 12). This provides supporting evidence that TDS is causing biological impairment. The concentrations of iron, manganese and aluminum (conductivity surrogates), in ug/l, for RM 7.8 on Little Wakatomika Creek were used as the TMDL targets.

Figure 11. Map of Wakatomika Creek Basin with Mined Area (shaded brown) on east edge of basin.

Table 12. Aquatic life use attainment status of mine affected areas: Sand Fork, Mill Fork and Moscow Brook compared to Little Wakatomika Creek, which is unaffected by mining. The Index of Biotic Integrity (IBI), Modified Index of well being (MIwb), and the Invertebrate Community Index (ICI) are scores based on the performance of the biotic community. The Qualitative Habitat Evaluation Index (QHEI) measures the ability of the habitat to support a biotic community. Aquatic life uses for the Wakatomika Creek basin were based on biological sampling conducted during June - October 2003.

RIVER MILE Fish/Invert.	IBI	MIwb	ICI[a]	QHEI	Attainment Status[b]	Site Location
Little Wakatomika Creek						
7.8	46	NA	E	53.0	FULL	CR 18
Sand Fork						
4.6	38*	NA	MG[ns]	71.5	PARTIAL	dst. CR 4 and dst. from trib.
Mill Fork						
3.3	38*	NA	G	67.5	PARTIAL	CR 75
Moscow Brook						
0.3/0.1	36*	NA	MG[ns]	44.0	PARTIAL	dst. CR 6 near mouth

Biological Criteria for Western Allegheny Plateau (WAP)

Site Type INDEX	IBI Headwaters	IBI Wading
EWH Habitat	$\geq$50	$\geq$50
WWH Habitat	$\geq$44-45	$\geq$44-45
MWH Habitat	24	24
LRW Habitat	18	18

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

2.3.2 Mine Drainage Target Deviation and Margin of Safety

The deviation from target for the mine drainage indicators (iron, manganese, aluminum, TDS, and alkalinity) is calculated by the difference in the measured concentrations from the Little Wakatomika Creek (RM 7.8) site and each of the other sites. The concentration values used in this determination came from samples taken on the date of highest flow, which is considered the critical condition (for more detail see critical conditions below). The load reductions necessary for attainment of the WQS are determined as the deviation from targets for all of the parameters except alkalinity. The target deviation for alkalinity represents the amount that is needed to be increased to attain the WQS.

An explicit margin of safety was created by reducing the concentrations in Little Wakatomika Creek (RM 7.8) for iron, manganese, aluminum, and TDS by 10%. The alkalinity concentration in Little Wakatomika Creek (RM 7.8) was increased by 10%, (Table 13). No scientific literature or federal guidance has been found that directly and adequately addresses the issues of margin of safety for TDS. The 10% margin of safety was selected to be a reasonable additional load reduction that the Ohio EPA feels is sufficient to account for any variability in the relationship that has been established between TDS concentrations and the response of the biological community.

Table 13. Target Deviation for Various Mine Drainage Indicator Parameters

Concentrations from sampling date with the highest flow	Little Wakatomika Creek @ CR 18 RM 7.8		Sand Fork RM 1.3		Moscow Brook RM 0.1		Mill Fork @ CR 75 RM 3.3	
	Target conc. (ug/l)	Target with 10% MOS (ug/l)	Conc. (ug/l)	Deviation from target (ug/l)	Conc. (ug/l)	Deviation from target (ug/l)	Conc. (ug/l)	Deviation from target (ug/l)
Iron	1420	1278	6120	4842	21700	20422	30400	29122
Manganese	98	88.2	661	572.8	1850	1761.8	1950	1861.8
Aluminum	591	532	2620	2088	10000	9468	14800	14268
TDS	206	185	290	105	324	139	364	179
Alkalinity	78	86	65	-21	49	-37	42	-44

Of the three subbasins affected by mine drainage (Sand Fork, Mill Fork and Moscow Brook), Mill Fork produced the highest concentrations and loads. Figure 12 shows the mean loads for manganese for the various subbasins. Mill Fork at RM 3.3 also had the highest mean load for iron, aluminum and TDS.

2.3.3 Critical Condition

The critical condition for mine drainage in the effected tributaries of Little Wakatomika Creek is high flow. Six water samples were collected during the summer of 2003 (July 1, 23, 30; August 5, 25; and September 3) under varying flow conditions and the highest concentrations occurred during high flows. However, flow measurements were not taken during sampling therefore the USGS gage 03144000, Wakatomika Creek near

Frazeyburg, was referenced to determine the relative flow magnitude across each of the sampling dates. Using the flows from the gage and concentrations for three parameters, relationships were built between flow and concentration (Figure 13).

Figure 12. A Comparison of Mean Manganese Load

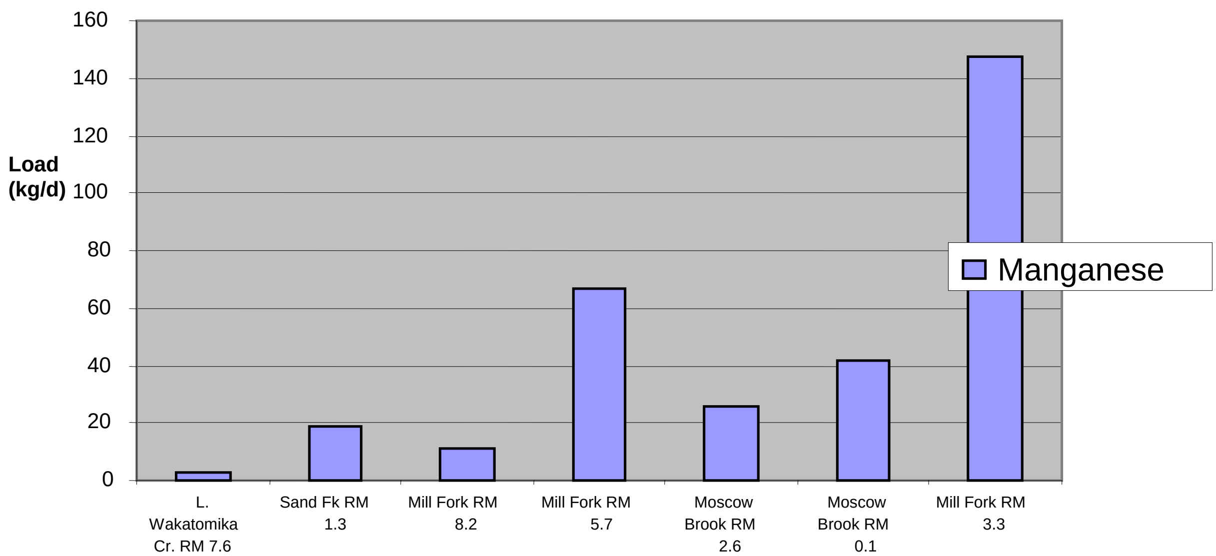
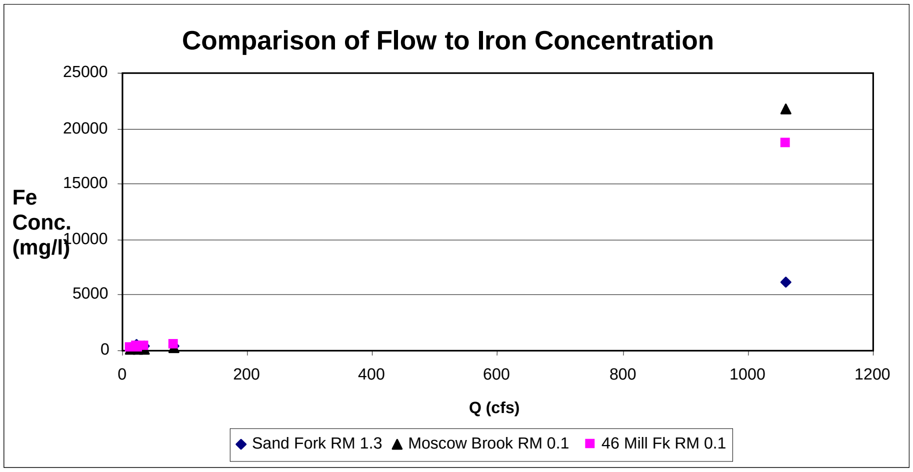
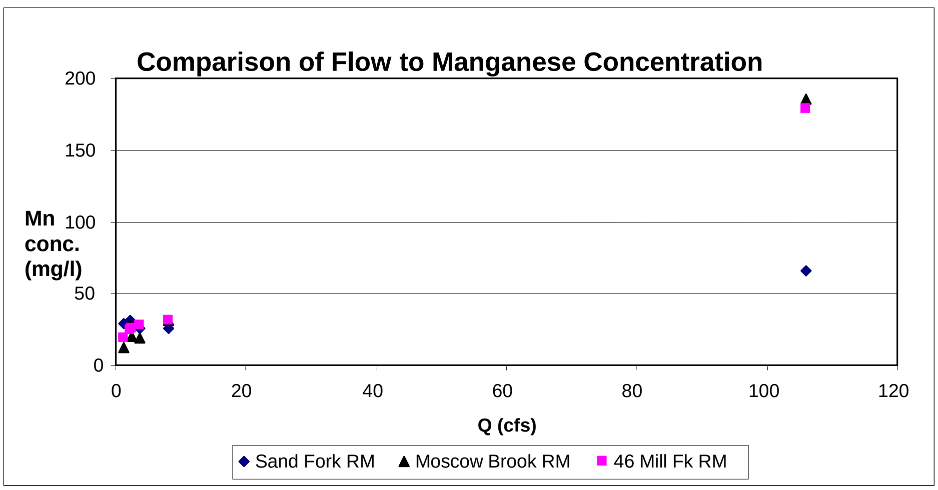


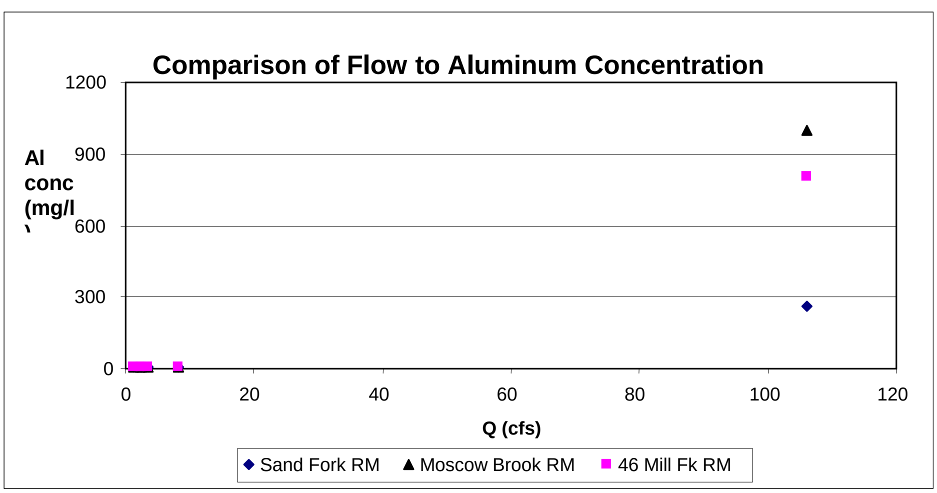
Figure 13 shows that concentrations of mine drainage parameters are elevated at higher flows for the various tributaries of concern. Since load is the product of flow and concentration, higher flows yield higher loads as is shown in Figure 14.

Figure 14 shows concentrations of mine drainage indicators during high flows (critical conditions) moving from upstream to downstream. These parameters show that the upstream portion (Little Wakatomika Creek at RM 9.6) is unaffected by mining and that as you move down into the mined areas, concentrations of mine drainage indicators increase. Moscow Brook and the upper portion of Mill Fork were heavily mined and the influence of mine drainage is clearly reflected in the graph.

Figure 13. Flow to Concentration Relationships for Various Mine Drainage Indicator Parameters.







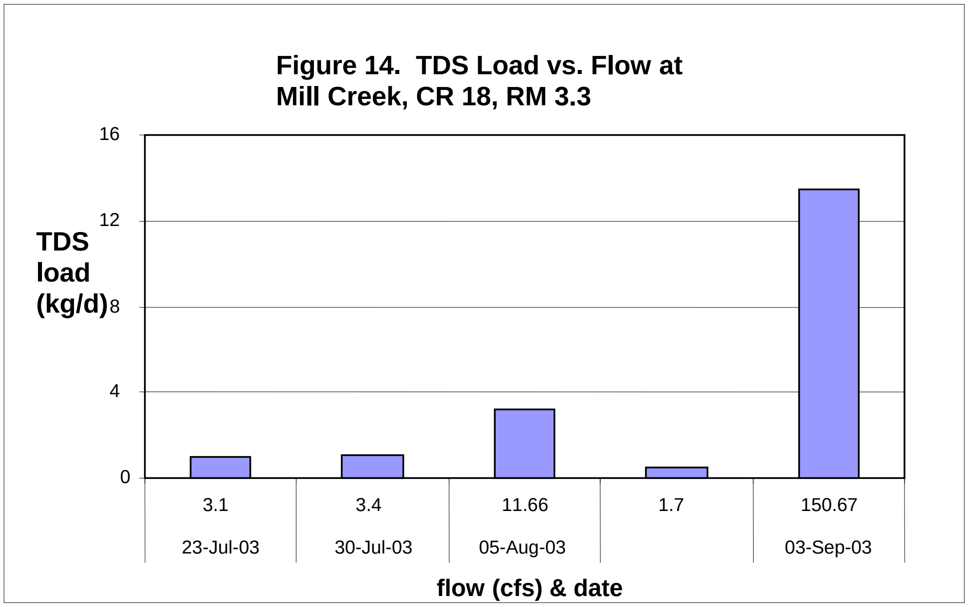
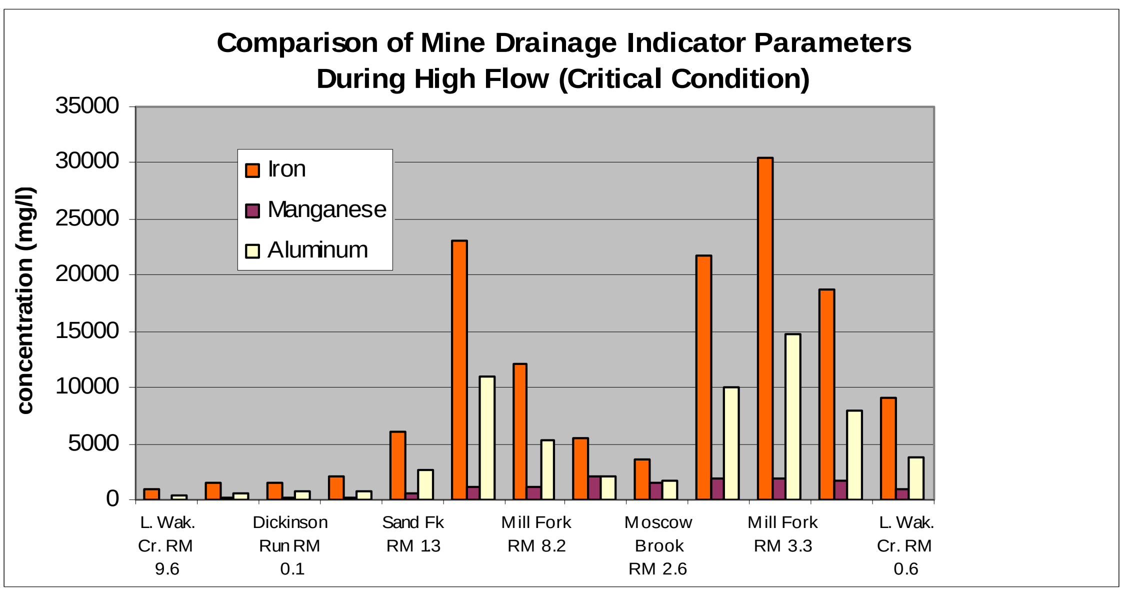


Figure 15. Mine drainage parameters during high flow conditions in the Eastern portion of the Little Wakatomika Creek subbasin.



2.3.4 Summary

Coal mining in the Wakatomika Creek basin was limited to the eastern portion of the Little Wakatomika Creek basin and affected three subbasins: Sand Fork, Mill Creek and Moscow Brook. Little Wakatomika Creek at RM 7.8 is upstream of the three affected tributaries but is not affected by mining. Because it is similar to the effected tributaries in terms of drainage area and geology, concentrations of the mine drainage indicators from the Little Wakatomika Creek were used as targets for the impacted tributaries.

Target deviation was determined by calculating the difference between the concentrations of the mine drainage parameters from the biologically attaining Little Wakatomika Creek (RM 7.8) and the concentrations from the effected tributaries. An explicit MOS was added by reducing the Little Wakatomika Creek (RM 7.8) iron, aluminum and manganese concentrations by 10% and adding 10% to the alkalinity concentration. Critical condition are high flow events when both elements of load, concentration and flow, are highest. Table 14 contains the TMDL loads (expressed as daily loads) calculated at the high flow associated with the critical condition.

Areas around Sand Fork, Mill Creek and Moscow Brook were mined in both the 1940s and again in the 1980s. These tributaries, though now only partially attaining the warm water habitat use attainment, are in a state of recovery, which is likely a result of the land reclamation that occurred with the mining in the 1980s. Therefore, the suggested implementation for the mining impacts is natural attenuation.

Table 14. Summary of TMDL loads for mining impairments

	Sand Fork RM 1.3			**Moscow Brook RM 0.1**			**Mill Fork @ CR 75 RM 3.3**		
	Existing load (kg/d)	**TMDL (kg/d)**	**% Reduc-tion**	**Existing load (kg/d)**	**TMDL (kg/d)**	**% Reduc-tion**	**Existing load (kg/d)**	**TMDL (kg/d)**	**% Reduc-tion**
Flow* (cfs)	65.9			53.8			150.7		
Iron	987	206	79	2856	168	94	11209	471	96
Manganese	107	14	87	244	12	95	719	33	95
Aluminum	422	86	80	1316	70	95	5457	196	96
TDS	47	30	36	43	24	44	134	68	49
Alkalinity	10	14	NA	6	11	NA	15	32	NA

* Flows derived for high-flow event (Sep 3, 2003) using data from USGS gage 03144000 and a drainage area/yield relationship. Annual 90% flow for this gage would be 347 cfs. Flow on Sep 3, 2003, was 1050 cfs.

3.0 Public Participation

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

Ohio EPA involved the partners and public stakeholders in the Wakatomika Creek TMDL project by soliciting input and recommendation for action during a series of meetings during 2003 and 2004. The public outreach activities have included press releases, presentations, field demonstrations and displays at public events.

The first outreach meeting was held June 18, 2003 at the Coshocton County Soil and Water Conservation (SWCD) office and included members from the Knox, Coshocton, and Muskingum SWCD offices. Ohio EPA conducted a field demonstration on July 25, 2003 for the Licking, Knox, Coshocton, and Muskingum SWCD county offices as well as township trustees, county commissioners and landowners from the Wakatomika Creek basin. The second outreach meeting was held on May 20, 2004 at the Knox County SWCD office for the Knox, Licking, Coshocton, and Muskingum SWCD offices, the Knox County Health Department, and local stakeholders.

In partnership with the Coshocton SWCD office, Ohio EPA presented a display of the Wakatomika TMDL at the Coshocton County Fair during the last week of September 2004. The presentation was also featured during the 2004 Coshocton County Fall Foliage tour.

Consistent with Ohio's Continuous Planning Process, the draft TMDL was made available for public review from April 28, 2006, to May 30, 2006. A copy of the draft report was posted on Ohio EPA's web page (http://www.epa.state.oh.us/dsw/tmdl/index.html). No comments were submitted as a result of the review period.

4.0 Implementation and Monitoring Recommendations

Restoration methods to bring an impaired water body to attainment with water quality standards generally involve an increase in the water body's capacity to assimilate pollutants, a reduction of pollutant loads, or some combination of both. As described in Chapter 2, the causes of impairment in the Wakatomika Creek are:

- bacteria
- habitat
- mining
- sedimentation

Therefore, an effective restoration strategy would include habitat protection and improvements and reductions in pollutant loads, potentially combined with some additional means of increasing the assimilative capacity of the stream.

While specific areas were identified by Ohio EPA as being impaired, the mainstem and numerous tributaries of Wakatomika Creek are Exceptional Warmwater Habitat (EWH) streams. They are characterized by exceptional and diverse aquatic life with significant populations of imperiled species, and high quality instream and riparian habitat. Because Wakatomika Creek is one of the highest quality watersheds in the state of Ohio, an effort needs to be made to educate the landowners in the Wakatomika Creek watershed about the quality and uniqueness of Wakatomika Creek and to prevent future impairment to areas currently in attainment.

4.1 Bacteria

During the 2003 and 2004 study by Ohio EPA, the following areas were found to be impaired due to bacteria: Wakatomika Creek (RM 45 – RM 36.7), unnamed tributary to Wakatomika Creek at RM 40.93, Harrod Run, Bladensburg tributary, Jug Run, Winding Fork, Brushy Fork, Fivemile Run, Black Run, Dickinson Run, Sand Fork, Mill Fork, and Moscow Brook (Table 1C). The sources of impairment were identified as:

- unrestricted livestock access to the creek
- poor management of animal waste
- failing home septic treatment systems in the Bladensburg area.

4.1.1 Livestock and Manure Management

Using the paired watershed approach, it was determined that Best Management Practices for manure control are significant in keeping instream bacteria concentrations low in the Wakatomika Creek watershed. Of the four sites sampled Winding Fork (the treatment site) and Priest Run regularly had lower bacteria values than Brushy Fork and the Bladensburg Tributary even though these sites had equal or more livestock upstream. Despite having the highest number and greatest concentration of livestock, Winding Fork had low bacteria values because the cattle farm utilizes BMPs for manure handling. The BMPS that worked include:

- housing cattle in a feeder barn which reduced manure runoff to the stream
- fencing cattle out of the stream
- keeping a wooded riparian buffer next to the stream to further reduce runoff

Both Brushy Fork and the Bladensburg Tributary have stream side barn lots with no BMPs in place to prevent livestock and manure from entering the stream. The wooded riparian vegetation has also been removed from the banks exacerbating the problem of runoff from the barn lots. These barn lots constantly deliver bacteria to the stream from either direct manure deposits or from runoff during rain events of manure stockpiled adjacent to the stream. The Winding Fork site shows that BMPs help to keep manure out of the stream and thus keep instream bacteria concentrations low.

To address the problem of unrestricted livestock access and poorly managed animal waste, Ohio EPA recommends that the local county SWCD offices assist landowners with funding or information about livestock fencing, watering facilities, livestock waste management plans, stream setbacks, riparian forest buffer initiatives, waste utilization, and livestock use area protection. Landowners can take advantage of several incentive programs that will cover significant costs of adopting Best Management Practices on farmland, while educational initiatives exist to boost participation in these programs. Livestock Environmental Assurance Program, CREP, and other 2002 Farm Bill programs are available through the Farm Service Agency and SWCD offices in each county of the watershed. The watershed partners will be eligible for Section 319 grant funds beginning in FY 2006 to implement projects that address TMDLs. It is recommended that funds and incentive programs be prioritized by geomorphic region where impairments have been identified in the watershed.

The most critical aspect of minimizing water quality impacts from any size animal feeding operation is the proper management of manure. All operations should have updated manure management plans and make every effort to avoid land application of their manure during wet weather and during the winter when runoff is more likely to occur. Ohio EPA is committed to responding promptly to complaints, and will strive to work with our partners to inform producers about emerging technology and BMPs as well as updates to the technical standards for manure handling and application. Continued efforts by local Soil Water Conservation District (SWCD) and Natural Resource Conservation Service (NRCS) staff to work with producers and update plans will be critical as well.

Additional guidelines for livestock operations in Ohio, NRCS publications, and manure and waste management information can be found at the following web sites:

http://ohioline.osu.edu/b604/index.html
http://efotg.nrcs.usda.gov/treemenuFS.aspx?Fips=39031&MenuName=menuOH.zip
http://www.ohiolivestock.org/images/1_livestock_guidelines03.pdf

4.1.2 Home Septic Treatment Systems

Failing home septic treatment systems (HSTS) were found to be a problem in the community of Bladensburg which is located in Knox County. Currently, the County Commissioners for Knox County and the Knox County Health Department is planning to hire a consulting firm, (ADR and Associates, Ltd.), in an effort to study and improve the problem of failing HSTS's in Knox County. Seven communities in Knox County, including Bladensburg, will be included in this study (Brian Bennick, Knox County Health Department, pers. comm.). The Engineering report, if approved, will provide the following information for each community requested by the Commissioners:

- Project Basemap
    - Combine topographical data and aerial photography from the County Engineer's Office into a digital basemap
    - Utilize GIS data to outline parcel and ROW
    - Review landscape and soil conditions for each lot
- Identify wastewater management options
    - Investigate "decentralized" options as well as regional connections
    - Develop options for treatment and disposal
    - Prepare exhibit drawings for alternatives
    - Correspond with EPA personnel, local officials and residents
    - Correspond with equipment suppliers
- Evaluate the economics of each option
    - Prepare construction cost estimates
    - Prepare estimates of operational, maintenance and replacement costs
    - Prepare estimates of final engineering and construction administration costs
- Prepare a report of the results of our investigations, with recommendations for final design
- Meeting Attendance, Correspondence, Project Management

For implementation, Ohio EPA recommends that the County Commissioners for Knox County fund this study and work with the local landowners and Knox County Health Department to develop a plan to address the problem of failing HSTS in the Bladensburg area.

4.2 Habitat and Sedimentation

The following areas were found to be impaired due to habitat impacts: Wakatomika Creek (at RM 6.8), Brushy Fork, Trib to Priest Run, Fivemile Run and Black Run. A habitat TMDL found that none of these sites met the target QHEI scores (≥65 for WWH, ≥75 for EWH) or the attribute target of 3 (Tables 11 and 12). The habitat impairments in the tributaries are typically associated with agricultural activities such as riparian removal, livestock with free access to the creek, and sedimentation from farm run-off. Habitat improvements can be made by following the same recommendations for controlling bacteria from entering the streams:

- housing cattle in a feeder barn to reduce manure and sediment runoff which contributes to smothering in-stream habitat
- fencing cattle out of the stream to prevent unstable banks and sedimentation
- keeping a wooded riparian buffer next to the stream to further reduce runoff , stabilize the banks, and provide shade to prevent excessive algal blooms and increases in water temperature.

Ohio EPA recommends an approach that directs resources to improve the overall habitat and physical stability of streams throughout the watershed. To address habitat improvements, Ohio EPA recommends that the local county SWCD offices assist landowners with funding or information about livestock fencing, watering facilities, livestock waste management plans, stream setbacks, and riparian forest buffer initiatives.

Unlike the standard practices used to reduce sediment and nutrient runoff from crop land, the solutions for habitat and flow impaired streams may not be familiar agricultural BMPs that have well established incentive programs. Improved habitat will rely on long term land use changes and social acceptance of new trends in agricultural drainage practices. Implementation actions could include:

- Promote natural stream management and filter strips to reduce the frequency of maintenance on petition ditches.
- Promote physical stability in streams by restoring active flood plains
- Promote wetlands to provide flood water storage and enhance groundwater recharge.
- Research the feasibility of controlled drainage projects in selected areas.
- Adopt riparian protection ordinances that prevent flood plain encroachment and riparian removal.
- Implement site appropriate methods of stream bank stabilization.

The mainstem of Wakatomika Creek at RM 6.8 did not meet the target EWH QHEI score or the attribute target of 3. The cause of impairment was a combination of habitat impairment as well as an increase in the sediment (sand) bedload. While the habitat scores in the lower section of Wakatomika Creek at RM 2.3 indicates exceptional habitat quality and the targets were met for the habitat TMDL, the QHEI indicates high to moderate substrate embeddedness and extensive to moderate riffle embeddedness (Table 8). This lower section of Wakatomika Creek has significantly lower gradient than upstream and is not able to move the sediment bedload as efficiently as the higher gradient upstream sites. As a result, the sediment bedload has embedded the substrates in the lower section.

The lower sites on Wakatomika Creek are impacted by sedimentation caused by agricultural activities in the upper Wakatomika Creek and tributaries. This includes riparian removal, livestock with free access to the creek, and channel maintenance. Another source of sediment has been caused from the riparian removal of the woody vegetation on the farm located downstream from the new State Route 16 highway. The riparian removal has caused unstable slumping banks, and an increased bedload of sand. Poor stormwater controls during the construction of the SR 16 highway also contributed to the increased sediment bedload to the lower Wakatomika Creek.

Implementation of non-point source reduction measures will be achieved through a locally adopted implementation strategy built around non-regulatory and voluntary incentive programs. Traditional best management practices (BMPs) and barriers should be targeted at the stream segments most vulnerable to erosion during high flow storm events. To address the impairment in the lower Wakatomika Creek, Ohio EPA recommends that a wooded riparian corridor be reestablished below the SR 16 highway to allow the banks to stabilize and to prevent an excessive amount of sediment from entering the steam. The landowner of this property should be contacted by the local county SWCD office (Muskingum County) to provide information and possible assistance with riparian stream restoration and bank stabilization. Implementing agricultural BMPs in the tributaries and the upper mainstream of Wakatomika Creek will prevent an excessive amount of sediment from entering the creek which is causing an increase in the sediment bedload.

The local implementation strategy should evaluate existing conservation programs and seek opportunities for new funding sources for landowners willing to try innovative practices. Voluntary nonpoint source control programs may be available in the Wakatomika watershed such as the Conservation Security Program in the 2002 USDA Farm Bill. This voluntary program supports ongoing conservation stewardship of agricultural working lands by rewarding producers who maintain and enhance the condition of natural resources in these watersheds. A limited number of participants will be considered on the basis of past conservation efforts and willingness to perform additional conservation activities during their five to ten year contracts.

More information on the 2002 Farm Bill Conservation Security Program is available at the web site http://www.nrcs.usda.gov/programs/csp.

Clean Water Act Section 319 provides funding to Ohio EPA for grants to local sponsors to implement nonpoint source controls and stream restoration projects contained in TMDL reports or endorsed Watershed Action Plans. There are no current or past Section 319 Nonpoint Source grant funded projects in this watershed, however Wakatomika Creek will be considered a priority watershed for TMDL implementation funding in FY2006. Local partners will be encouraged to submit proposals that implement recommendations of the TMDL plan.

Storm Water Management

Storm water control is largely achieved through the issuance of general permits under the NPDES program. These permits are issued for construction activities, and for industrial activities, and are issued to control storm water that is discharged from a discrete conveyance, such as pipes or confined conduits. NPDES individual and general permits are issued to individuals, private entities, and local government entities. These permits function together to form a web of state and local authority under which storm water is controlled.

General Permits for Construction Storm Water

Ohio EPA will evaluate issuing general permits for run off associated with construction activities that are specific to the Wakatomika Creek watershed. Construction sites greater than one acre requires a general stormwater permit. The majority of the watershed is rural but if areas in the watershed begin to urbanize, Phase II Storm water rules would require prescribed management practices for construction activities in a Storm Water Pollution Prevention Plan (SWP3) that include:

- Installation and maintenance of sediment and erosion control practices for construction projects which, either by themselves or as part of a total common plan of development or sale, collectively disturb one acre or more
- Implementation of post-construction storm water controls on construction projects which, either by themselves or as part of a total common plan of development or sale, collectively disturb one acre or more

So that receiving stream's physical, chemical, and biological characteristics are protected and stream functions are maintained, post-construction storm water practices shall provide management of runoff quality and quantity. To meet the post-construction requirements of this permit, the SWP3 must contain a description of the post-construction BMPs that will be installed during construction for the site and the rationale for their selection. The rationale must address the anticipated impacts on the channel and floodplain morphology, hydrology, and water quality. The post construction BMP(s) chosen must be able to detain storm water runoff for physical sedimentation and peak flow dampening. This in turn reduces channel sedimentation, stream erosion, and improves water quality.

4.3 Mining

The three subbasins within the Wakatomika Creek basin found to be impaired due to mining are Sand Fork, Mill Fork and Moscow Brook. The causes of the impairment are conductivity and TDS (iron, aluminum, manganese and alkalinity used as TMDL surrogates). These three streams are located in the only portion of the basin to have been mined and are tributaries to Little Wakatomika Creek (Figure 11).

A small portion in the eastern section of the Wakatomika Basin was mined in the 1940s, then again in the 1980s, after the Surface Mining Control and Reclamation Act of 1977 was adopted into law. Some impacted tributaries are only partially meeting the warm water habitat use designation. Based on stream survey results, these streams appear to be in a state of recovery so implementation should be accomplished through natural attenuation.

4.4 Reasonable Assurances

As part of an implementation plan, reasonable assurances provide a level of confidence that the waste load allocations and load allocations in TMDLs will be implemented by Federal, State, or local authorities and/or by voluntary action. The stakeholders will develop and document a list that differentiates the enforceable and non-enforceable selected actions necessary to achieve the restoration targets.

Reasonable assurances for non-enforceable actions (certain nonpoint source activities) include: 1) demonstration of adequate funding; 2) process by which agreements/arrangements between appropriate parties (e.g. governmental bodies, private landowners) will be reached; 3) assessment of the future of government programs which contribute to implementation actions; and 4) demonstration of anticipated effectiveness of the actions. It will be important to coordinate activities with those governmental entities that have jurisdiction and programs in place to implement the nonpoint source actions (e.g. county soil and water conservation district offices, county health departments, local Natural Resource Conservation Service offices of the U.S. Department of Agriculture, municipalities and local government offices).

4.4.1 Minimum Elements of an Approvable Implementation Plan

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

- *Implementation actions/management measures*
- *Time line*
- *Reasonable assurances*

- *Legal or regulatory controls*
- *Time required to attain water quality standards*
- *Monitoring plan*
- *Milestones for attaining water quality standards*
- *TMDL revision procedures*

4.4.2 Reasonable Assurances Summary

This is a summary of the regulatory, non-regulatory and incentive based actions applicable to or recommended for the Wakatomika Creek watershed. Some of these activities deal specifically with the point source discharge regulatory actions. Non-regulatory and incentive based programs are currently delivered through existing local conservation authorities and nonpoint source reduction activities:

Regulatory:

- Statewide Rules for Home Sewage Treatment/Disposal
- Enforcement of Storm Water Phase I and II regulations
- Sediment and erosion control practices for construction projects
- Implementation of post-construction storm water controls on construction projects

Non-regulatory:

- Locally developed watershed implementation plan which includes:
    - Watershed awareness education activities
    - Storm water management programs
    - Septic system improvements
    - Inspection and Operation/Maintenance programs for home septic systems
    - Manure nutrient management plans
    - Agricultural conservation practices
    - Natural stream corridor management and bank stabilization practices
    - Riparian buffer initiatives
    - Recommendations for an updated drainage maintenance program
- Encourage local health departments to implement HSTS Plans
- Periodic stream monitoring to measure progress

Incentive-based:

- Section 319 grant opportunities for implementation projects that support the goals of this TMDL
- USDA Farm Bill programs for agricultural BMPs (CRP, CSP, EQIP, WHIP)
- Clean Ohio Grant Fund opportunities for natural resource protection and improvement and farmland BMPs
- Various loan opportunities for WWTP improvements
- Low interest loan opportunities through WPCLF Linked Deposit program
- Funding opportunities through WRRSP program for riparian/habitat improvements
- FmHA grants and WPCLF loan opportunities for centralized wastewater treatment in small communities
- Ohio Environmental Education Fund grants administered by Ohio EPA

4.5 Process for Monitoring and Revision

An initial monitoring plan to determine whether the TMDL has resulted in attainment of water quality standards and to support any revisions to the TMDL that might be required begins with in-stream water quality chemical monitoring. This sampling will be done at a minimum by NPDES permit holders at locations upstream and downstream of their outfalls and at ambient monitoring stations to be collected by Ohio EPA.

A more detailed and inclusive monitoring plan could be developed by a local watershed group which would describe steps in a monitoring program, including timing and location of monitoring activities, parties responsible for monitoring, and quality assurance and quality control procedures. It may include a method to determine whether actions identified in the implementation plan are actually being carried out and criteria for determining whether these actions are effective in reaching the TMDL targets. It is recommended that a local watershed group work with the Ohio EPA to develop such a monitoring plan.

A biological and water quality study of Wakatomika Creek, similar to that conducted by the Ohio EPA in 2003 will be scheduled when indications exist that major changes in the watershed have occurred. In addition, interim and/or surrogate measures that document progress in water quality improvement are recommended. Consideration must be given to the last time between source control actions (habitat improvements and loading reductions) and observable/measurable instream effects, especially for nonpoint sources.

A tiered approach to monitoring progress and validating the TMDL will be followed; the tiered progression includes:

- Confirmation of completion of implementation plan activities;
- Evaluation of attainment of chemical water quality criteria;
- Evaluation of biological attainment

A TMDL revision will be triggered if any one of these three broad validation steps is not being completed or if the WQS are not being attained after an appropriate time interval. If the implementation plan activities are not being carried forth within a reasonable time frame then an intercession by a local watershed group or other appropriate parties would be needed to keep the implementation activities on schedule. Once the majority of (or the major) implementation plan items have been carried out and/or the chemical water quality has shown consistent and stable improvements, then a full scale biological and chemical watershed assessment would be completed to evaluate attainment of the use designations. If chemical water quality does not show improvement and/or water bodies are still not attaining water quality standards after the implementation plan has been carried out, then a TMDL revision would be initiated. The Ohio EPA would initiate the revision if no other parties wish to do so.

References

Lamborn, R.E. 1954. Bulletin 53, Geology of Coshocton County. Ohio DNR Division of Geological Survey.

Ohio Environmental Protection Agency. 1999. Association Between Nutrients, Habitat, and the Aquatic Biota in Ohio Rivers and Streams, Ohio EPA Technical Bulletin MAS/1999-1-1, P.O. Box 1049, Lazarus Government Center, 122 S. Front St., Columbus, Ohio 43216-1049.

Rankin, E.T. 1989. The Qualitative Habitat Evaluation Index [QHEI]: Rationale, Methods, and Application, Ohio EPA, P.O. Box 1049, 1800 Watermark Dr. Columbus, Ohio 43266-0149.

USEPA. 1991. Guidance for Water Quality-based Decisions: The TMDL Process, Watershed Branch Assessment and Watershed Protection Division (WH-553), U.S. Environmental Protection Agency, 401 M St. SW, Washington D.C. 20460

USGS. 1992. Ohio Land Cover Data Set, raster digital data, online linkage: http://edcwww.cr.usgs.gov/programs/lccp/nationallandcover.html