State of Ohio
Environmental Protection Agency

Division of Surface Water

Total Maximum Daily Loads for the Big Walnut Creek Watershed

Tributary to Alum Creek, Delaware County
(photo courtesy of Friends of Alum Creek and Tributaries (FACT))

Final Report
August 19, 2005

Bob Taft, Governor
Joseph P. Koncelik, Director

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1.0 Introduction

The Clean Water Act (CWA) Section 303(d) requires States, Territories, and authorized Tribes to list and prioritize waters for which technology-based limits alone do not ensure attainment of water quality standards. Lists of these waters (the Section 303(d) lists) are made available to the public and submitted to the U.S. Environmental Protection Agency (USEPA) in even-numbered years. The Ohio Environmental Protection Agency (Ohio EPA) identified the Big Walnut Creek watershed as a priority impaired water on the 1998, 2002, and 2004 303(d) lists.

The Clean Water Act and USEPA regulations require that Total Maximum Daily Loads (TMDLs) be developed for all waters on the Section 303(d) lists. A TMDL is a calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards, and an allocation of that amount to the pollutant's sources. The process of formulating TMDLs for specific pollutants is therefore, a method by which impaired water body segments are identified and restoration solutions are developed. Ultimately, the goal of Ohio's TMDL process is full attainment of biological and chemical Water Quality Standards (WQS) and, subsequently, removal of water bodies from the 303(d) list. The Ohio EPA has found that developing TMDLs on a watershed basis (as opposed to focusing solely on individual impaired segments within a watershed) is an effective approach towards this goal.

This report serves to document the Big Walnut Creek TMDL process and provide for tangible actions to restore and maintain this water body. The main objectives of the report are to describe the water quality and habitat condition of the Big Walnut Creek and to quantitatively assess the factors affecting non or partial attainment of WQS. An implementation plan is not included in this report, but implementation planning and watershed action plans are being developed or implemented in various parts of this watershed.

The primary causes of impairment in the Big Walnut Creek watershed are nutrient enrichment, pathogens and habitat degradation. TMDLs were calculated for total phosphorus, pathogens and habitat degradation. Habitat degradation is not a load based quantity; however, the regulations provide for these types of impairing causes and "TMDL" numbers were calculated for these as well.

A summary of the Big Walnut Creek TMDL report is given in Table 1.A. Figure 1 shows land use in the Big Walnut Creek watershed and Figures 2 and 3 show the Big Walnut Creek watershed and the breakdown within each HUC11 of the 14-digit hydrologic units (HUC14) that are used throughout this report to characterize water quality.

Table 1.A. Summary of the Big Walnut Creek TMDL				
05060001-130: Big Walnut Creek headwaters to Hoover Reservoir				
14-Digit HUC Cause	Segment within 14-Digit HUC	**Segment Cause**	Included in this report?	Comments
130-010: Big Walnut Creek headwaters to above Culver Creek				
Pathogens	Includes all Segments		yes	
	Big Walnut Creek	**Siltation**	yes	QHEI metrics
		Habitat Alteration	yes	
	Reynolds Run	**Habitat Alteration**	yes	
	Long Run	**Flow Alteration**	yes	
	Sugar Creek	**Flow Alteration**	no	The non-attainment in the macroinvertebrate community at this site may be a result of an adjacent, significant sulfur spring. More analysis is needed before a TMDL is established.
130-020: Culver Creek				
Nutrients	Includes all Segments		yes	Phosphorus
Siltation	Includes all Segments		yes	
Organic Enrichment	Includes all Segments		yes	Addressed through nutrient TMDL
Pathogens	Includes all Segments		yes	
130-030: Big Walnut Creek below Culver Creek to above Rattlesnake Creek				
- None- Full Attainment ☺				
130-040: Rattlesnake Creek and Tributaries				
Nutrients	Includes all Segments		yes	Phosphorus

Table 1.A. Summary of the Big Walnut Creek TMDL				
05060001-130: Big Walnut Creek headwaters to Hoover Reservoir				
14-Digit HUC Cause	Segment within 14-Digit HUC	**Segment Cause**	Included in this report?	Comments
Siltation	Includes all Segments		yes	QHEI metrics
Organic Enrichment	Includes all Segments		yes	Addressed through nutrient TMDL
Habitat Alteration	Includes all Segments		yes	
Pathogens	Includes all Segments		yes	
130-050: Big Walnut Creek below Rattlesnake Creek to above Little Walnut Creek				
	Big Walnut Creek	**Pathogens**	yes	
	Prairie Run	**Nutrients**	yes	Phosphorus
		Habitat Alteration	yes	
130-060: Little Walnut Creek				
Nutrients	Includes all Segments		yes	Included in the nutrient allocation due to the number of home aerators discharging in this watershed.
Flow Alteration	Includes all Segments		yes	
Pathogens	Includes all Segments		yes	
	Butler Run	**Siltation**	yes	QHEI metrics
		Habitat Alteration	yes	
130-080: Duncan Run				
Habitat Alteration	Includes all Segments		yes	

05060001-140: Big Walnut Creek below Hoover Reservoir to Three Creeks Park confluence				
14-Digit HUC Cause	Segment within 14-Digit HUC	**Segment Cause**	Included in this report?	Comments
140-010: Big Walnut Creek below Hoover Reservoir to above Rocky Fork				
Pathogens	Includes all Segments		yes	
	McKenna Creek	**Nutrients**	yes	Phosphorus
		Siltation	no	QHEI data was not collected on this waterbody
140-020: Rocky Fork				
Nutrients	Includes all Segments		yes	
Pathogens	Includes all Segments		yes	
	Rose Run	**Habitat Alteration**	yes	
140-030: Big Walnut Creek below Rocky Fork to above Blacklick Creek				
Pathogens	Includes all Segments		yes	
	Trib. @ RM 27.29	**Habitat Alteration**	yes	
		Flow Alteration	yes	QHEI
140-040: Mason Run				
Pathogens	Includes all Segments		yes	
Habitat Alteration	Includes all Segments		yes	
140-050: Blacklick Creek headwaters to near Brice				
Pathogens	Includes all Segments		yes	
Nutrients	Includes all Segments		yes	
	French Run	**Siltation**	yes	QHEI metrics

05060001-140: Big Walnut Creek below Hoover Reservoir to Three Creeks Park confluence				
14-Digit HUC Cause	Segment within 14-Digit HUC	**Segment Cause**	Included in this report?	Comments
140-060: Blacklick Creek near Brice to Big Walnut Creek				
Pathogens	Includes all Segments		yes	
Nutrients	Includes all Segments		yes	

05060001-150: Alum Creek headwaters to Alum Creek Lake				
14-Digit HUC Cause	Segment within 14-Digit HUC	**Segment Cause**	Included in this report?	Comments
150-010: Alum Creek headwaters to above West Branch Alum Creek				
Pathogens	Includes all Segments		yes	
	Alum Creek	**Habitat Alteration**	yes	
150-020: West Branch Alum Creek				
Habitat Alteration	Includes all Segments		yes	
Flow Alteration	Includes all Segments		yes	
Pathogens	Includes all Segments		yes	
150-030: Turkey Run				
Flow Alteration	Includes all Segments		yes	
Pathogens	Includes all Segments		yes	
150-040: Alum Creek from below West Branch Alum Creek to above Big Run				
	Alum Creek	**Pathogens**	yes	
150-050: Big Run				
Nutrients	Includes all Segments		yes	
Pathogens	Includes all Segments		yes	

05060001-160: Alum Creek from below Alum Creek Dam to Scioto River				
14-Digit HUC Cause	Segment within 14-Digit HUC	**Segment Cause**	Included in this report?	Comments
160-010: Alum Creek from below Alum Creek Dam to near Westerville				
Pathogens	Includes all Segments		yes	
	Alum Creek	**Habitat Alteration**	yes	
160-020: Alum Creek near Westerville to Three Creeks Park confluence				
Pathogens	Includes all Segments		yes	
	Alum Creek	**Habitat Alteration**	yes	
		Sedimentation	yes	
	Spring Run	**Habitat Alteration**	yes	
	West Spring Run	**Habitat Alteration**	yes	
		Flow Alteration	yes	
	Kilbourne Run	**Organic Enrichment**	no	An unsewered area in Franklin County tributary to this stream was recently sewered by the Franklin Co. Commissioners. This will alleviate the organic enrichment .
160-030: Big Walnut Creek from Three Creeks confluence to the Scioto River				
-None- Full Attainment ☺				

2.0 Water Body Overview

For the Big Walnut Creek TMDL, Ohio EPA conducted a detailed assessment of chemical (water column, effluent, sediment), physical (flows, habitat), and biological (fish and aquatic macroinvertebrate) conditions in the summer of 2000 to determine if streams and rivers in the study area were attaining water quality goals. The results of this survey are presented in the 2003 Ohio EPA Report, *Biological and Water Quality Study of the Big Walnut Creek Basin, 2000* (Ohio EPA Technical Report DSW/EAS 2003-11-10), which can be obtained from Ohio EPA's website at http://www.epa.state.oh.us/dsw/document_index/psdindx.html or by contacting Ohio EPA. In addition, it is important to consider that for parts of the lower Alum Creek assessment, particularly in the impounded areas, Ohio EPA relied on the 1999 study *Biological and Water Quality Study of the Middle Scioto River and Alum Creek* (Ohio EPA Technical Report MAS/1997-12-12).

Information from these reports is summarized in Chapter 5 in the detailed stream assessments.

2.1 Study Area Description

Big Walnut Creek rises in Morrow County 1.25 miles southeast of Mt. Gilead and immediately south of U.S. Route 42. The stream flows due south across Morrow County, entering Delaware County south of Pagetown. Continuing due south, it enters the Hoover Reservoir at Galena. Big Walnut Creek reappears south of the reservoir dam, flowing through Gahanna, then to the east of the Port Columbus International Airport before bisecting the communities of Whitehall and Reynoldsburg. The stream turns southwest, flowing to the confluence with the Scioto River approximately .25 mile south of the Pickaway County line. The elevation of Big Walnut Creek at its source is 1165 feet. Elevation at its confluence with the Scioto River is 667 feet. Average gradient for the mainstem is 7.0 feet/mile. The land area drained by the Big Walnut system is 556.7 square miles. This study area included the entire mainstem and selected tributaries between its source and confluence. The largest portion of the watershed, upstream of the reservoir, lies to the east of the mainstem. With the exception of Prairie Run, all notable tributaries above the reservoir enter Big Walnut Creek from higher elevations to the east. Downstream of the reservoir, tributaries enter the mainstem from both east and west. Two major tributaries, Alum Creek and Blacklick Creek conjoin with Big Walnut at Three Rivers Park. Three tributaries included in the study area exceeded an average gradient of 40 feet/mile. They are: Bunker Run - 44.4 feet/mile; Light Creek - 43.1 feet/mile, and East Branch of the Little Walnut - 101.1 feet/mile. This latter stream rises on the Broadway Moraine, west of the mainstem.

Ecoregions

With small exception, the study area lies within the Loamy High Lime Till Plains of the Eastern Corn Belt ecoregion. This sub-ecoregion is characterized by till plains of level

to rolling terrain with low gradient streams, ground moraines, end moraines and glacial outwash features. Soils are derived from loamy, limey glacial deposits of the Wisconsin age. In general, these soils show better drainage characteristics and more natural fertility than Eastern Corn Belt soils encountered north of the Morrow County line (Omernik & Gallant, 1988).

Geology

The Illinoisan and Wisconsin glacial periods strongly influenced the land forms, soil types, and stream substrates of the study area. Terminal and ground moraines are both present in the Big Walnut watershed. The Powell Moraine extends generally northeast from Powell to Sunbury and then along the west side of Big Walnut Creek to the Morrow County line (Soil Survey of Delaware County). The constituents of glacial depositional features and study area substrates also reflect the Mississippian system sedimentary bedrock which underlies the Big Walnut watershed. Bedford Shale, Berea Sandstone, Sunbury Shale, and Cuyahoga Sandstone are present and visibly exposed as alternating beds in both the Big Walnut and Rocky Fork Creek corridors. Similar glaciofluvial deposits are present in the Big Walnut system. They appear in lower level substrates below recent alluvium and on stream terraces. Large amounts of rounded shale fragments and some sandstone fragments are present along Alum Creek and Big Walnut Creek (Soil Survey of Delaware County).

Soils

The interaction of bedrock geology, climate, slope-topography, flora, fauna, and the passage of time produced the soils of the Big Walnut Creek study area. Within the Franklin County portion of the Big Walnut system, the Bennington - Pewamo association, formed in glacial tills, predominates both east and west of the flood plain proper. Upstream of the Delaware County line, the Bennington-Pewamo association continues on upland areas to the Big Walnut's source in Morrow County. The Bennington soils are seen on flats, low knolls and ridges while the Pewamo soils are found in depressions and concavities of the landscape.

Land use on the Bennington - Pewamo association is limited by seasonal wetness, ponding, slow or moderately slow permeability, and low strength. Tiles and surface drains are commonly used to facilitate drainage. The Soil Survey of Franklin County notes that both Bennington and Pewamo soils are severely limited for sanitary facilities because of their slow permeability, seasonal wetness, and low strength. The survey states that in areas of this association, "Sanitary facilities should be connected to central sewers and treatment facilities".

Within the flood plain corridors, the most commonly observed association is the Medway-Genesee-Sloan formed in moderately textured recent alluvium. Each of these soils has a silt loam surface layer and high available water capacity. The Medway soils occur in broad areas of the flood plain. Narrow strips of Genesee soil are seen adjacent to streams while the Sloan soils are encountered in depressions. Flooding hazard and seasonal wetness are the chief land use limitations of this soil association. County soil surveys observe that Medway, Genesee, and Sloan soils are severely limited for

sanitary facilities due to frequent flooding, wetness, and/or slow permeability.

South of Three Rivers Park and to the confluence, Big Walnut Creek flows between areas of the Crosby-Kokomo-Celina soil association. Due to limitations posed by seasonal wetness and slow permeability, the Soil Survey of Franklin County recommends that “Sanitary facilities should be connected to central sewers and treatment facilities, wherever possible”.

The erosion potential of Big Walnut watershed soils is partly a function of soil structure, permeability and the percentage of silt, sand and organic matter. One measure of erosion which takes these factors into account is Factor K, one of six used in the Universal Soil Loss Equation (USLE) to predict the average annual rate of soil loss by sheet and rill erosion in tons per acre per year. The values of K range from 0.05 to 0.69. The higher the value the more susceptible is the soil to sheet and rill erosion. The highest K values within the Big Walnut watershed are associated with the Bennington soils (.43) which are predominant on extensive upland areas in Franklin, Delaware, and Morrow counties, and the Crosby soils (.43) which flank Alum Creek (west of the flood plain, downstream from Bexley) and Big Walnut Creek, downstream of Three Rivers Park.. Figure 1 shows the land use in the basin based on USGS National Land Cover Dataset for Ohio, published March 2000, based on Landsat data from about 1992. The study area is graphically depicted in Figures 2 and 3.

2.2 Water Quality Standards

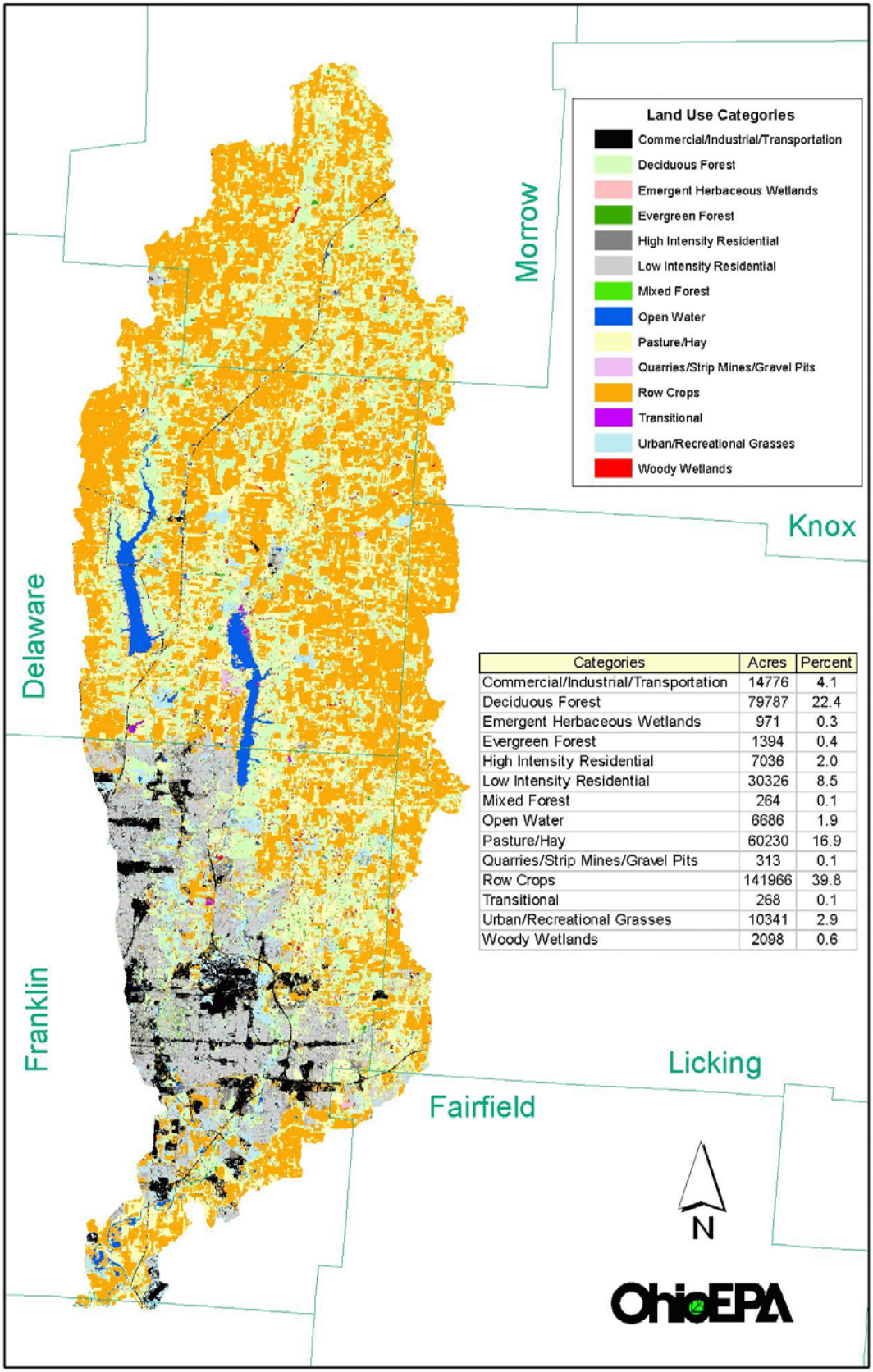
Under the Clean Water Act, every state must adopt water quality standards to protect, maintain and improve the quality of the nation's surface waters. These standards represent a level of water quality that will support the goal of "swimable/fishable" waters. Table 2.A. provides a brief description of Ohio’s water quality standards. Further information is available in Chapter 3745-1 of the Ohio Administrative Code (OAC) (http://www.epa.state.oh.us/dsw/wqs/criteria.html).

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

Attainment of aquatic life uses is 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 benchmarksis in full attainment.

Another type of use in the WQS is for recreational purposes. The recreational use for the majority of the Big Walnut 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 a 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. Bacterial criteria are further described in Section 3.4 in the section entitled “Pathogens”.



Categories	Acres	Percent
Commercial/Industrial/Transportation	14776	4.1
Deciduous Forest	79787	22.4
Emergent Herbaceous Wetlands	971	0.3
Evergreen Forest	1394	0.4
High Intensity Residential	7036	2.0
Low Intensity Residential	30326	8.5
Mixed Forest	264	0.1
Open Water	6686	1.9
Pasture/Hay	60230	16.9
Quarries/Strip Mines/Gravel Pits	313	0.1
Row Crops	141966	39.8
Transitional	268	0.1
Urban/Recreational Grasses	10341	2.9
Woody Wetlands	2098	0.6

Figure 1 Land use in the Big Walnut Creek Watershed.

Table 2.A. Summary of Ohio Water Quality Standards

WQS Components	Examples of:	Description
Beneficial Use Designation	1. Water supply • Public (drinking) • Agricultural • Industrial 2. Recreational contact • Beaches (Bathing waters) • Swimming (Primary Contact) • Wading (Secondary Contact) 3. Aquatic life habitats (partial list): • Exceptional Warmwater (EWH) • Warmwater (WWH) • Modified Warmwater (MWH) • Limited Resource Water (LRW)	Designated uses reflect how the water is potentially used by humans and how well it supports a biological community. Every water in Ohio has a designated use or uses; however, not all uses apply to all waters (they are water body specific). Each use designation has an individual set of numeric criteria associated with it, which are necessary to protect the use designation. For example, a water that was designated as a drinking water supply and could support exceptional biology would have more stringent (lower) allowable concentrations of pollutants than would the average stream. Recreational uses indicate whether the water can potentially be used for swimming or if it may only be suitable for wading.
Numeric Criteria	1. Chemical	Represents the concentration of a pollutant that can be in the water and still protect the designated use of the waterbody. Laboratory studies of organism's sensitivity to concentrations of chemicals exposed over varying time periods form the basis for these.
	2. Biological *Measures of fish health:* • Index of Biotic Integrity • Modified Index of Well Being *Measure of bug (macroinvertebrate) health:* • Invertebrate Community Index	Indicates the health of the instream biological community by using these 3 indices (measuring sticks). The numeric biological criteria (biocriteria) were developed using a large database of reference sites. These criteria are the basis for determining aquatic life use attainment.
	3. Whole Effluent Toxicity (WET)	Measures the harmful effect of an effluent on living organisms (using toxicity tests).
	4. Bacteriological	Represents the level of bacteria protective of the potential recreational use.
Narrative Criteria (Also known as 'Free Froms')	General water quality criteria that apply to all surface waters. These criteria state that all waters shall be free from sludge, floating debris, oil and scum, color and odor producing materials, substances that are harmful to human, animal or aquatic life, and nutrients in concentrations that may cause algal blooms.	
Antidegradation Policy	This policy establishes situations under which the director may allow new or increased discharges of pollutants, and requires those seeking to discharge additional pollutants to demonstrate an important social or economic need. Refer to http://www.epa.state.oh.us/dsw/wqs/wqs.html for more information.	

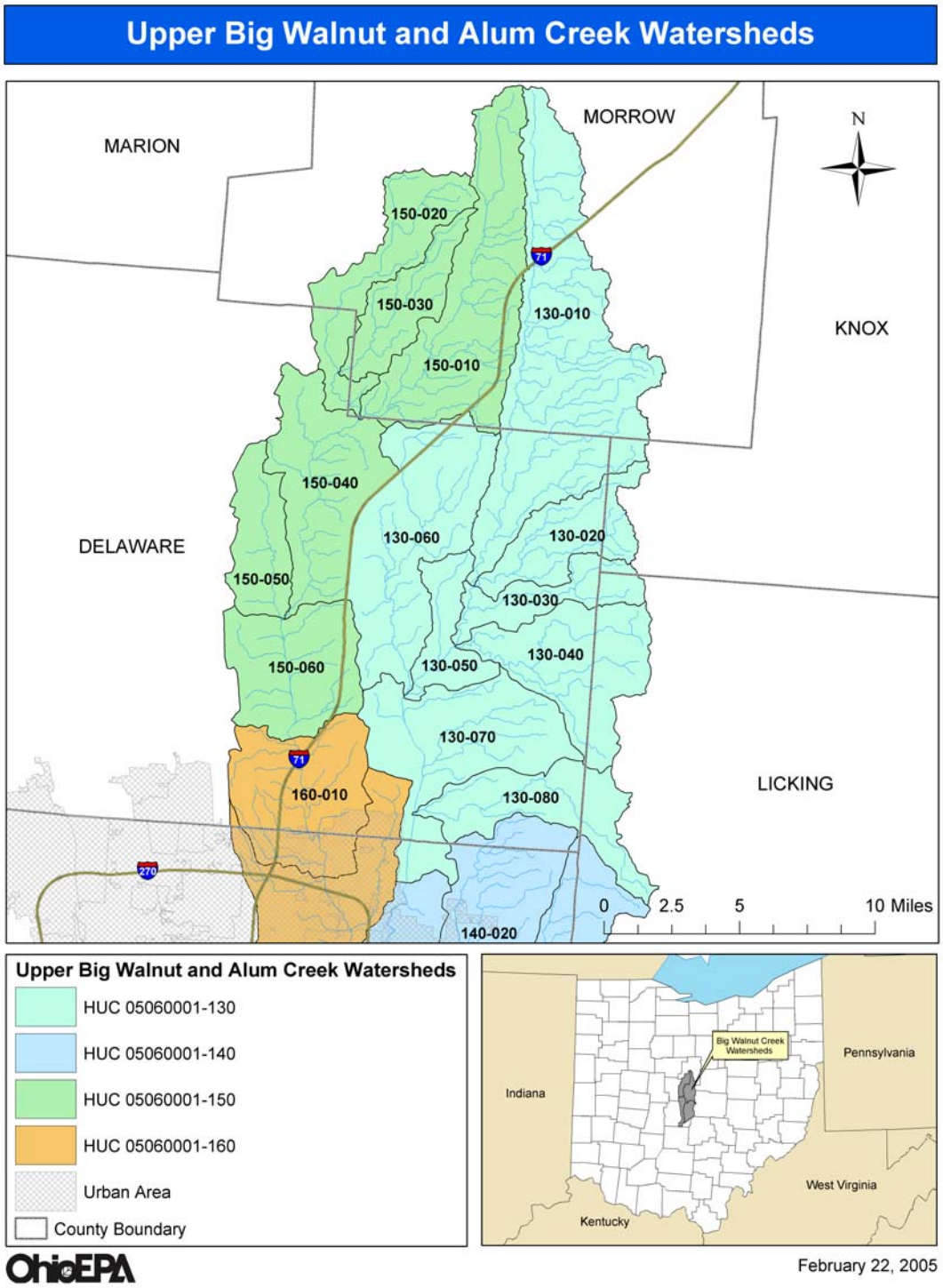


Figure 2 Upper Big Walnut Creek Watershed.

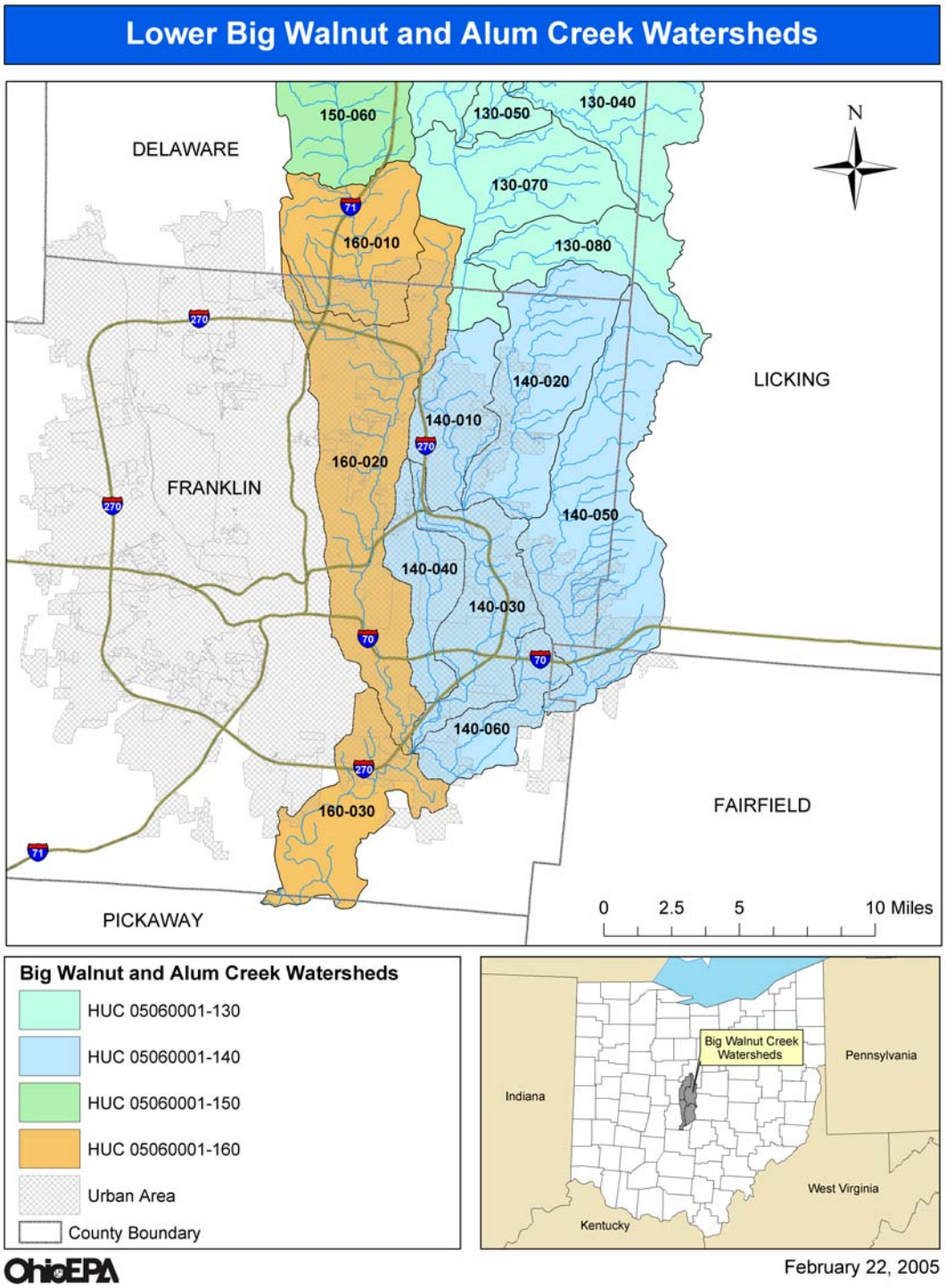


Figure 3 Lower Big Walnut Creek Watershed.

2.3 Causes and Sources of Impairment

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

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

The 2000 biological and water quality study of the Big Walnut Creek basin identified various impairments to its resource quality. These impairments can be traced to a number of anthropogenic activities and land use practices outlined below. A summary of the causes and sources of impairment by stream segment is presented in Table 2.B. Chapter 5 contains detailed listing of attainment by assessment unit.

Table 2.B. Causes and sources of impairment in the Big Walnut Creek basin.

Watershed Stream Segment [Upper River Mile/Lower River Mile]	Aquatic Life Use Designation	Attainment Status (Miles)			Causes of Impairment [1]	Sources of Impairment [1]
		Full	Partial	NON		
Watershed: [05060001 130], Big Walnut Creek (headwaters to Hoover Reservoir)						
Big Walnut Creek (Headwaters to Reynolds Run) [RM 73.60-62.76]	WWH			10.84	Flow alteration-H Habitat alteration-H Siltation-H,M,S Nutrients-M,S Pathogens-S Organic enrichment-S	Nonirrigated crop prod.-H Channelization-H Range land-S Home sewage treatment syst.-S
Big Walnut Creek (Reynolds Run to Culver Cr.) [RM 62.76-53.35]	WWH	9.41				
Big Walnut Creek (Culver Cr. to L. Walnut Cr.) [RM 53.35-46.95]	WWH	6.4				
Castro Run [RM 2.3-0.0]	WWH	0.9				
Mill Creek [RM 2.2-0.0]	WWH	2.2				
Reynolds Run [RM 5.5-0.0]	WWH			1.0	Habitat alteration-H Flow alteration-H Pathogens-M Siltation-M Ammonia-S	Channelization-H Nonirrigated crop prod.-H Removal of riparian veg.-M Range land-M Home sewage treatment syst.-S
Long Run [RM 6.4-0.0]	WWH	2.15		2.75	Flow alteration-H Pathogens-S	Nonirrigated crop prod.-H Range land-S
Sugar Creek [RM 8.0-0.0]	WWH	1.0	1.0		Flow alteration-H Pathogens-S	Nonirrigated crop prod.-H
Culver Creek [RM 7.5-0.0]	WWH	3.9	1.1		Flow alteration-H Organic enrichment-H Nutrients-M Ammonia-M Pathogens-S	Nonirrigated crop prod.-H Home sewage treatment syst.-M

Table 2.B. Causes and sources of impairment in the Big Walnut Creek basin.

Watershed Stream Segment [Upper River Mile/Lower River Mile]	**Aquatic Life Use Designation**	**Attainment Status (Miles)**			**Causes of Impairment [1]**	**Sources of Impairment [1]**
		Full	Partial	NON		
Trib. to Culver Cr. (RM 3.32) [RM 6.06-0.0]	WWH	1.0				
Perfect Creek [RM 7.0-0.0]	WWH	5.0				
Rattlesnake Creek [RM 4.5-0.0]	WWH			1.0	Flow alteration-H Metals-M,S	Source unknown
N. Fk. Rattlesnake Creek [RM 7.0-0.0]	WWH	3.75	1.55	0.7	Habitat alteration-H Nutrients-H Siltation-M Ammonia-M Organic enrichment-M Pathogens-S	Channelization-H Septage disposal-H Nonirrigated crop prod.-S
E. Fk. Rattlesnake Creek [RM 5.7-0.0]	WWH		0.7	4.0	Habitat alteration-H Organic enrichment-H Ammonia-H Nutrients-H Siltation-H Suspended solids-H Pathogens-S	Channelization-H Septage disposal-H Range grazing-riparian-H Land development-H Home sewage treatment syst.-H
S. Fk. Rattlesnake Creek [RM 6.5-0.0]	WWH	2.1		2.1	Siltation-H Suspended solids-M Nutrients-S Pathogens-S	Land development-H Range grazing-upland-M
Prairie Run [RM 3.6-0.0]	WWH		0.5		Habitat alteration-H Siltation-H Pathogens-M	Channelization-H Urban runoff-H
Little Walnut Creek [RM 11.5-0.0]	WWH	3.85		6.05	Flow alteration-H Cause Unknown-H	Dam construction-H Source unknown-H
Trib. to L. Walnut Cr. (RM 9.5) [RM 3.05-0.0]	WWH	1.0				
Butler Run [RM 2.0-0.0]	WWH			1.0	Habitat alteration-H Siltation-H organic enrichment-S Pathogens-S	Channelization-H Nonirrigated crop prod.-H Removal of riparian veg.-M Range land-M

Table 2.B. Causes and sources of impairment in the Big Walnut Creek basin.

Watershed Stream Segment [Upper River Mile/Lower River Mile]	**Aquatic Life Use Designation**	**Attainment Status (Miles)**			**Causes of Impairment [1]**	**Sources of Impairment [1]**
		Full	Partial	NON		
E. Br. L. Walnut Creek [RM 1.8-0.0]	WWH	0.9				
W. Br. L. Walnut Creek [RM 4.4-0.0]	WWH			3.8	Organic enrichment-H Ammonia-M,S Nutrients-M Pathogens-M,S	Home sewage treatment syst.-H Agriculture-H
Duncan Run [RM 10.6-0.0]	WWH			9.5	Habitat alteration-H Siltation-H Pathogens-H,M,S Nutrients-M	Channelization-H Home sewage treatment syst.-H Removal of riparian veg.-M Nonirrigated crop prod.-M Range land-M
Watershed: [05060001 140], Big Walnut Creek (downstream Hoover Reservoir to upstream Alum Creek); Blacklick Creek						
Big Walnut Creek (Hoover Res. Dam to Rocky Fork) [RM 37.6-28.3]	WWH	7.75	1.55		Thermal modifications-H Ammonia-S Nutrients-S Pathogens-S	Upstream impoundment-H Urban runoff-S
Big Walnut Creek (Rocky Fork to Alum Cr.) [RM28.30-15.31]	WWH-EWH	13.0				
Trib. to B. Walnut Cr. (RM 32.6) [RM 2.69-0.0]	WWH			1.0	Unknown-H	Unknown-H Urban runoff-S
McKenna Creek [RM 3.16-0.0]	WWH			1.0	Pathogens-H Nutrients-H Suspended solids-S Ammonia-S	Urban runoff-H Home sewage treatment syst.-H
Rocky Fork [RM 13.0-0.0]	WWH-EWH	2.15	4.6	3.95	Pathogens-H,S Siltation-M Nutrients-M Ammonia-S Habitat alterations-S Metals-M	Home sewage treatment syst.-H,M Land development-H Range land-M Package plants-M Contaminated sediments-M
Sugar Run [RM 5.83-0.0]	WWH	1.0				

Table 2.B. Causes and sources of impairment in the Big Walnut Creek basin.

Watershed Stream Segment [Upper River Mile/Lower River Mile]	Aquatic Life Use Designation	Attainment Status (Miles)			Causes of Impairment [1]	Sources of Impairment [1]
		Full	Partial	NON		
Rose Run [RM 3.4-0.0]	WWH			1.0	Habitat alterations-H Flow alterations-S Siltation-S	Channelization-H Land development-H Urban runoff-M
Trib. to B. Walnut Cr. (RM 27.29) [RM 4.0-0.0]	WWH			1.0	Flow alteration-H Habitat alteration-H Pathogens-M Priority organics-M Metals-H,M,S Organic enrichment-S Ammonia-S Nutrients-S Siltation-S	Land development-H Urban Runoff-H Channelization-M Removal of riparian veg.-H Contaminated sediments-H
Mason Run [RM 1.9-0.0]	WWH			1.0	Flow alteration-H Habitat alteration-M Siltation-M Pathogens-M	Land development-H Urban runoff-H Channelization-M
Blacklick Creek [RM 28.0-0.0]	WWH	17.5	3.9	6.6	Ammonia-H Nutrients-H Organic enrichment-H Pathogens-M Siltation-M Priority organics-M	Home sewage treatment syst.-H Minor muni. point source-H Manure lagoons-M Contaminated sediments-M Land development-M
"Unzinger Ditch" Trib. to Blacklick Cr. (RM 15.88) [RM 1.1-0.0]	LRW-WWH			1.1	Contaminated sediment-H Nutrient enrichment-H Habitat alterations-H	Industrial site runoff-H Raw sewage discharge-H Channelization-H
Dysar Run [RM 4.98-0.0]	WWH		1.15	1.85	Siltation-H Pathogens-S Metals-S Priority organics-S Organic enrichment-S Habitat alterations-S	Land development-H Urban runoff-M Home sewage treatment syst.-S Channelization-S Contaminated sediments-S
Trib. to Dysar Run (RM 1.67) [RM 1.88-0.0]	WWH	0.7				

Table 2.B. Causes and sources of impairment in the Big Walnut Creek basin.

Watershed Stream Segment [Upper River Mile/Lower River Mile]	**Aquatic Life Use Designation**	**Attainment Status (Miles)**			**Causes of Impairment [1]**	**Sources of Impairment [1]**
		Full	Partial	NON		
French Run [RM 5.28-0.0]	WWH		1.0		Siltation-H Pathogens-M	Land Development-H Urban runoff-H Home sewage treatment syst.-M
N. Br. French Run [RM 3.8-0.0]	EWH			1.0	Unknown-H Pathogens-M	Unknown-H Urban runoff-M Home sewage treatment syst.-M
"Lees Creek" Trib. to Blacklick Cr. (RM 11.25) [RM 4.28-0.0]	WWH	0.8				
Trib. to Blacklick Cr. (RM 10.36) [RM 3.62-0.0]	WWH	0.8				
"Powell Ditch" Trib. to Blacklick Cr. (RM 6.50) [RM 3.43-0.0]	WWH			1.0	Habitat alterations-H Siltation-M Pathogens-M	Land development-H Urban runoff-H Home sewage treatment syst.-M Removal of riparian veg.-M
Watershed: [05060001 150], Alum Creek (headwaters to Alum Creek Reservoir)						
Alum Creek (Headwaters to W. Br. Alum Cr.) [RM 56.3-42.8]	WWH	10.1	3.4		Habitat alteration-H Unknown cause-H Siltation-M Organic enrichment-M Ammonia-M Nutrients-M Pathogens-S	Removal of riparian veg.-H Unknown source-H Channelization-M Nonirrigation crop prod.-M
Alum Creek (W. Br. Alum Cr. to Alum Creek Lake Dam) [RM 42.8-26.7]	WWH (RM 42.80-39.50)	3.3				
Bunker Run [RM 2.5-0.0]	WWH	2.3				

Table 2.B. Causes and sources of impairment in the Big Walnut Creek basin.

Watershed Stream Segment [Upper River Mile/Lower River Mile]	**Aquatic Life Use Designation**	**Attainment Status (Miles)**			**Causes of Impairment [1]**	**Sources of Impairment [1]**
		Full	Partial	NON		
W. Br. Alum Creek [RM 12.3-0.0]	WWH	1.95	8.55	1.80	Flow alteration-H Habitat alteration-H Siltation-M Organic enrichment-M Nutrients-M Pathogens-S Metals-S Ammonia-S	Nonirrigated crop prod.-H Channelization-H Range land-M
Turkey Run [RM 7.0-0.0]	WWH		1.9	2.9	Flow alteration-H Nutrients-M Organic enrichment-M Pathogens-S	Nonirrigated crop prod.-H Range land-M
Big Run [RM 4.8-0.0]	WWH			2.6	Nutrients-H Siltation-M Organic enrichment-M Pathogens-S	Nonirrigated crop prod.-H Pasture land-M
Watershed: [05060001 160], Big Walnut Creek (Alum Creek to mouth); Alum Creek (downstream Alum Creek Reservoir to mouth)						
Big Walnut Creek (Alum/Blacklick Cr. to Scioto R.) [RM 15.3-0.0]	EWH	15.3				
Alum Creek (Alum Creek Dam to Columbus Boundary) [RM 26.7-19.9]	WWH	6.8				
Alum Creek (Columbus Boundary to Big Walnut Creek) [RM 19.9-0.0]	WWH	2.25	17.65		Siltation-H Organic enrichment-H Flow alteration-H Direct habitat alteration-H Ammonia-M Cadmium-M Priority organics-M Pathogens-S	Land development-H Urban runoff-H Impoundment-H Channelization-H Storm sewers-M
Trib. to Alum Cr. (RM 25.50) [RM 2.8-0.0]	WWH	0.7				

Table 2.B. Causes and sources of impairment in the Big Walnut Creek basin.

Watershed Stream Segment [Upper River Mile/Lower River Mile]	**Aquatic Life Use Designation**	**Attainment Status (Miles)**			**Causes of Impairment [1]**	**Sources of Impairment [1]**
		Full	Partial	NON		
Trib. to Alum Cr. (RM 23.47) [RM 3.8-0.0]	WWH	1.3				
Spring Run [RM 7.2-0.0]	WWH		1.95	4.05	Habitat alterations-H Pathogens-M Siltation-S Organic enrichment-S Ammonia-S	Urban runoff-H Channelization-H
W. Spring Run [RM 3.1-0.0]	WWH			3.1	Habitat alterations-H Flow alterations-H	Urban runoff-H Channelization-H Natural-M
Kilbourne Run [RM 2.64-0.00]	WWH			1.0	Organic enrichment-H Pathogens-M Siltation-S	Urban runoff-H

1 The magnitude (i.e., relative contribution) of the cause or source of impairment is estimated as follows: H-high magnitude, M-moderate magnitude, S-slight magnitude, T-identifies a threat.

3.0 Priority Causes of Impairment and Target Identification

The 2004 Ohio EPA Integrated Report lists the high-magnitude causes of impairment in the Big Walnut Creek basin. The causes are aggregated by 11-digit HUC, and presented in Appendix D of the report. This study reduces the listed high-magnitude causes to a sub-set of priority causes of impairment. Priority causes are those believed to be the greatest detriment to the basin based upon an extensive Ohio EPA survey in 2000. The priority causes of impairment addressed by this report are nutrient enrichment, habitat alteration and siltation, organic enrichment/dissolved oxygen, and pathogens.

Targeting this sub-set of priority causes is consistent with the adaptive management strategy intrinsic to Ohio EPA's TMDL process. Ohio's TMDL process is a continuous cycle of assessment, development, implementation, and monitoring. The iterative nature of the process allows resources to be focused upon problems whose solution represent the greatest potential benefit to environmental health. The first iteration of the cycle may be sufficient to achieve that stated goal of full attainment. If not, then future efforts will have the advantage of additional information and a better understanding of the processes occurring in the watershed.

Overlap in the linkage between the causes and sources of impairment provides additional justification for targeting a sub-set of the high-magnitude causes. A single source may be contributing to multiple causes of impairment, so control strategies aimed at that source could help to remedy multiple problems. For example, nutrient enrichment is a cause of impairment on Blacklick Creek, and failing home sewage treatment systems are a source of nutrient loading. Failing home sewage treatment systems, however, are also a source of the excessive ammonia loads contributed to the Blacklick. As a result, home sewage treatment system control strategies designed to reduce nutrient loads could concurrently reduce ammonia loads.

The following sections describe the numeric targets used to develop TMDLs for the priority causes of impairment. Numeric targets are critical to the TMDL process because they serve as a measure of comparison between observed instream conditions and conditions that are expected to restore the designated uses of the waterbody.

3.1 Nutrient Enrichment

Nutrient enrichment was identified as a cause of impairment in the Big Walnut Creek basin. For the purpose of this TMDL, phosphorus was used as an indicator of the degree of nutrient enrichment. Phosphorus was selected because it is frequently the limiting nutrient to primary production in streams and rivers of Ohio. While the Ohio EPA does not currently have statewide numeric criteria for phosphorus, potential targets have been identified in a technical report titled *Association Between Nutrients, Habitat, and the Aquatic Biota in Ohio Rivers and Streams* (Ohio EPA, 1999). This document provides the results of a study analyzing the effects of nutrients on the aquatic biological communities of Ohio streams and rivers. The study reaches a number of conclusions

and stresses the importance of habitat and other factors, in addition to instream nutrient concentrations, as having an impact on the health of biologic communities. The study also includes proposed total phosphorus (TP) target concentrations based on observed concentrations associated with acceptable ranges of biological community performance within each ecoregion. The TP targets for the Eastern Corn Belt Plains ecoregion are shown in Table 3.1.A. It is important to note that these nutrient targets are not codified in Ohio's water quality standards; therefore, there is a certain degree of flexibility as to how they can be used in a TMDL setting.

Ohio's standards also include narrative criteria that limit the quantity of nutrients which may enter waters. Specifically, OAC Rule 3745-1-04 (E) states that all waters of the state shall be free from nutrients entering the waters as a result of human activity in concentrations that create nuisance growths of aquatic weeds and algae. In addition, OAC Rule 3745-1-04(D) states that all waters of the state shall be free from substances entering the waters as a result of human activity in concentrations that are toxic or harmful to human, animal, or aquatic life and/or are rapidly lethal in the mixing zone. Excess concentrations of nutrients that contribute to non-attainment of biological criteria may fall under either OAC Rule 3745-1-04 (D) or (E) prohibitions.

Table 3.1.A: WWH TP targets for the Eastern Corn Belt Plains ecoregion

Watershed Size	**TP** *mg/l*
Headwaters (drainage area < 20 mi^2)	0.07
Wadeable (20 mi^2 < drainage area < 200 mi^2)	0.11

3.2 Habitat Alteration and Siltation

Habitat alteration was assessed to be a significant cause of impairment in the Big Walnut Creek basin. Physical habitat quality is an environmental condition, rather than a contributed load, so development of a traditional, load-based TMDL is impossible. In place of this, Qualitative Habitat Evaluation Index (QHEI) scores are used as a surrogate target. The QHEI is a quantitative composite of six physical habitat variables used to evaluate stream habitat. The variables are: substrate, instream cover, riparian characteristics, channel condition, pool/riffle quality, and gradient and drainage area. Analysis of an extensive dataset of paired QHEI and IBI scores has led to the development of target QHEI scores generally shown to be supportive of the biological assemblages typical of WWH (Ohio EPA, 1999). Sites with QHEI scores greater than or equal to 60 were generally associated with IBI scores supportive of a WWH use designation. QHEI scores greater than or equal to 60 are therefore the target used in habitat TMDL development.

In the Big Walnut Creek basin, numeric targets for siltation are also based upon the QHEI metrics. The substrate, riparian characteristic, and channel metrics all evaluate stream attributes related to siltation. The substrate metric includes an assessment of

sediment quality, quantity, and origin. The riparian characteristics metric evaluates riparian width, flood plain quality, and bank erosion. The channel metric describes stream physical morphology including sinuosity and extent of development. Each of these factors influences the degree to which siltation affects a stream, and cumulatively serves as its numeric target. The numeric targets for substrate, channel, and riparian metrics are 14, 14, and 5, respectively. If these metrics score lower than the target in the QHEI scoring, it is indicative of excessive sediment in the stream. See Table 5.1.H for an example of how this target functions.

Habitat alteration can also result in an impairment termed ‘flow alteration’. This type of impairment is an expression of the hydrological consequences of habitat alteration. In an agricultural setting, tiling of fields and removal of riparian vegetation often results in an exacerbation of hydrological extremes, high flows get higher and low flows get lower. The high flows contribute to entrainment of excess sediment in the stream system, and the low flows exhibit reduced dissolved oxygen and increased heat. The QHEI is used as a surrogate measure for evaluating the severity of the problem, and progress towards its solution in those areas where flow alteration is identified as an impairment.

Flow alteration can also be identified as an impairment in the slack water conditions behind impoundments. In some cases, these conditions are seen in the very headwaters of a large reservoir (i.e., Hoover Reservoir), or in other cases it can be the slack water conditions behind a low head dam (e.g., lower Alum Creek). The flow alteration changes the D.O. regime, and can result in low D.O. In these cases, the QHEI is still an effective measure of the quality of the habitat and its relationship to a healthy WWH aquatic community, thus it is used as a surrogate for the altered D.O. regime. Where it is practical and feasible to remove a low head dam, the QHEI can be an effective post-removal evaluation tool to monitor habitat improvements.

3.3 Organic Enrichment/Dissolved Oxygen

Organic enrichment has been assessed as a cause of impairment in areas of the Big Walnut Creek basin. Organic enrichment is descriptive of a situation where excess loading of oxidizable material results in depressed dissolved oxygen (DO) concentrations. The potential sources of organic enrichment are numerous, and the impact upon aquatic life is dependent on a complex array of instream and near-stream processes and conditions. Two such conditions, nutrient enrichment and degraded habitat quality, are believed to be closely related to organic enrichment and are the focus of the DO “TMDL”.

Nutrients, except under unusual circumstances, rarely approach concentrations in the ambient environment that are toxic to aquatic life. However, nutrients, while essential to the functioning of healthy aquatic ecosystems, can exert negative effects at much lower concentrations by increasing algal and macrophyte production (Sharpely et al., 1994), thereby increasing turbidity, decreasing average DO concentrations, and increasing fluctuations in diel DO and pH. Such changes result in shifts in species composition away from functional assemblages of intolerant species, benthic insectivores, and top

carnivores typical of high quality streams towards less desirable assemblages of tolerant species, niche generalists, omnivores, and detritivores typical of degraded streams (Ohio EPA, 1999). Such shifts are reflected in IBI and ICI scores, and may preclude a stream from achieving its aquatic-life use designation.

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

Habitat alterations, such as channelization and the denuding of riparian zones, can also have direct detrimental effects upon instream DO concentrations. Denuding riparian zones eliminates or reduces shade, and increases the intensity of sunlight reaching the stream. The increased intensity of sunlight stimulates algal production and decreases DO solubility by increasing water temperature. Channelized streams affect DO concentrations by limiting the potential for atmospheric reaeration. Atmospheric reaeration occurs more readily in faster-moving, highly agitated streams. Water flowing through a quality riffle consisting of variable substrate can effectively stir oxygen into the stream.

Considering the cause and effect relationship between nutrient enrichment, habitat degradation, and instream DO, improvement of DO levels in the Big Walnut Creek basin is reliant upon the reduction of nutrient loads and the improvement of stream habitat quality. Nutrient TMDLs and Habitat TMDLs are included as part of this report and effectively serve as a DO “TMDL”.

The measurable endpoint of the DO “TMDL” is attainment of the DO water quality criterion. Target values for DO are therefore the minimum concentrations, both instantaneous and average, needed to support a WWH designation. The DO criterion specified for WWH by OAC 3745-01-07 is a 5.0 mg/l average over a 24-hour period and a 4.0 mg/l instantaneous minimum. Attainment of nutrient and habitat targets should also result in the attainment of these DO targets.

3.4 Pathogens

Excessive loading of pathogenic organisms is the cause of recreational use impairment in the Big Walnut Creek sub-basin. The numbers of pathogenic organisms present in polluted waters are generally few and difficult to identify and isolate, as well as highly varied in their characteristic and type. Therefore, scientists and public health officials

typically choose to monitor nonpathogenic bacteria that are usually associated with pathogens transmitted by fecal contamination but are more easily sampled and measured. These associated bacteria are called indicator organisms. For the purpose of this report, fecal coliform bacteria were selected as the indicator organism.

Numeric targets for fecal coliform are derived from bacteriological water quality standards. The criterion for fecal coliform specified in OAC 3745-1-07 are applicable outside the mixing zone, and state that the geometric mean content, 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. As written the standards effectually establish both chronic and acute permissible instream fecal coliform concentration.

To reflect both the chronic and acute standards, pathogen TMDL development was conducted in two parts at two temporal resolutions. First, a TMDL was calculated for the entire recreation season, as defined by OAC, based upon a target of 1000 counts per 100 ml. This TMDL is intended to be protective of the chronic condition, and as such is based upon the thirty-day geometric mean content criteria. Second, a daily TMDL was calculated based upon a target of 2,000 counts per 100 ml. This TMDL is designed to be protective of the acute condition.

4.0 TMDL Development

A TMDL is a tool for implementing water quality standards, and is based on the relationship between pollution sources and in-stream water quality conditions. TMDLs establish allowable loadings or other quantifiable parameters for a waterbody, and thereby provide the basis for states to establish water quality-based controls. These controls should provide the pollution reduction necessary for a waterbody to meet water quality standards.

A TMDL is defined as the sum of its load allocations, wasteload allocations, and a margin of safety. Load allocations (LA) are the portion of the TMDL reserved for non-point sources of pollution. Wasteload allocations are the portion reserved for point sources. 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.

TMDLs may be expressed in terms of either mass per time, toxicity, or other appropriate measure. Additionally, TMDLs may be developed at variable temporal and spatial resolutions. The acronym TMDLimplies that the maximum load is expressed in days; however, TMDLs are often calculated on a monthly, seasonal, or annual basis dependent upon the nature of the parameter of concern. The spatial scale at which a TMDL is calculated is dependent upon the distribution of impairment within the TMDL study area. TMDLs can be calculated for individual stream segments, sub-basins, or even entire watersheds.

TMDL development requires the definition of the existing load, calculation of the loading capacity, and allocation of the TMDL. The existing load is the quantity of a pollutant that, prior to TMDL implementation, is contributed to a waterbody. The existing load includes contributions from all sources, including point, non-point, and natural. The loading capacity is 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. Allocation of the TMDL involves the equitable distribution of the loading capacity to all known sources in consideration of technical and economical feasibility as well as water-quality related implications.

Ultimately, the goal of a TMDL is the attainment of use designation. Attainment of aquatic-life use designation in the State of Ohio is in part dependent upon biocriteria. Biocriteria are defined by multiple biological indices that measure the diversity and relative abundance of aquatic organisms. Aquatic organisms are affected by a combination of variables that are not limited to load based pollutants, such as those for which a traditional TMDL would be developed. Environmental conditions, such as instream dissolved oxygen and physical habitat quality, play an equally important role. As such, TMDLs are often developed for non-load based parameters in a method analogous to that for traditional TMDLs.

TMDL development in the Big Walnut Creek basin was conducted separately for the upper and lower portions of the watershed. The upper watershed is defined by 11-digit HUCs 050600011130 and 050600001150. Narratively, this area is described as Alum Creek above Alum Creek Lake, and Big Walnut Creek above Hoover Reservoir. The lower watershed is defined by 11-digit HUCs 05060001140 and 05060001160. This area includes Alum Creek below Alum Creek Lake to its confluence with the Big Walnut Creek, and Big Walnut Creek below Hoover Reservoir to its confluence with the Scioto River (Figure 3).

TMDL development was conducted separately for the upper and lower watersheds because of the significant difference in land use characteristics that exists between the two areas. The upper watershed is characterized by extensive agricultural areas infrequently interrupted by small cities and villages. The lower watershed is characterized by large urban areas, predominantly the City of Columbus, with agricultural areas on the eastern periphery. The contrasting land-use distribution results in a different prioritization of sources of impairment, which necessitates different methods of TMDL development.

TMDL development methods applicable to the Big Walnut Creek basin in its entirety are presented in Section 4.1. Development methods applicable to the upper and lower watersheds are discussed in Sections 4.2 and 4.3, respectively.

4.1 Methods of TMDL Development Used Basin Wide

4.1.1 Habitat, Siltation, and the QHEI

Description of Method

The QHEI is a quantitative expression of a qualitative, visual assessment of habitat in free flowing streams, and was developed by the Ohio EPA to assess available habitat for fish communities (Rankin 1989, 1994). It is a composite score of six physical 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 of these categories are subdivided into specific attributes that are assigned a point value reflective of the attribute's impact on the aquatic life. Highest scores are assigned to the attributes correlated to streams with high biological diversity and integrity and lower scores are progressively assigned to less desirable habitat features. A QHEI evaluation form is used by a trained evaluator while in the stream itself. Each of the components are evaluated on site, recorded on the form, the score totaled, and the data later analyzed in an electronic database. The evaluation form is shown in Appendix A.

QHEI scores can range from 12 to 100. Scores greater than 75 indicate excellent stream habitat, scores between 60 and 75 indicate good habitat quality, and scores less than 45 demonstrate habitat not conducive to WWH. Scores between 45 and 60 need separate evaluation by trained field staff to determine the potential aquatic life use for the stream.

In the free flowing, typical riverine streams, a concept analogous to a loading capacity for habitat is the use of a target QHEI score. The appropriate target QHEI score was determined by statistical analysis of Ohio's statewide database of paired QHEI and IBI scores. Simple linear and exponential regressions and frequency analyses of combined and individual components of QHEI metrics in relation to the IBI were examined. The regressions indicated the QHEI is significantly correlated with the IBI with the exponential model providing 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.

Further analysis of the QHEI components as they relate to IBI scores led to the development of a list of attributes that are associated with degraded communities. These attributes are modifications of natural habitat and were classified as high-influence or moderate-influence attributes based on the statistical strength of the relationships. The presence of these modified attributes can strongly influence aquatic biology to a degree which the QHEI score itself may not reflect. The analysis indicates that a stream with more than one high-influence or more than four moderate-influence attributes usually precludes attainment of the WWH biocriteria (using an IBI of 40 as a representative WWH biocriterion). The implication of which is a stream segment can be impaired even with a QHEI score above 60 (because other less-influential habitat components are in place, thus raising the score, in spite of other limiting habitat factors that may be present).

The habitat TMDL equation presented below reflects the relationship between the QHEI score, modified attributes, and aquatic community performance. It is based upon a target of three (3), and is the sum of three component scores. Individual component scores exist for the observed QHEI score to target QHEI score ratio, and for the presence/absence of high and/or moderate-influence attributes. A QHEI score less than the target, the presence of more than one high-influence attribute, or more than a total of four modified attributes will prevent a stream segment from achieving the target.

The sediment TMDL equation presented below is a subset of those factors of the QHEI most directly related to sediment type, quality, build up, and source origin. The sediment TMDL is based upon a target score of 33, which is analogous to a loading capacity. The individual components of the sediment TMDL (substrate, channel, and riparian) have individual targets that are analogous to allocations.

•Habitat TMDL	=	QHEI Score to Target Ratio + Modified Attribute Score + High Influence Attribute Score
	=	1 + 1 + 1
	=	3
•Sediment TMDL	=	Substrate + Channel Morphology + Riparian Zone/Bank Erosion
	=	14 + 14 + 5 (minimum numbers)
	=	33 (greater than or equal to)

Table 4.1.A provides additional detail describing the habitat and sediment TMDLs.

Method Evaluation and Assumptions

The QHEI is a macro-scale approach that measures the evident properties of habitat (sinuosity, pool/riffle development) rather than the individual factors that shape these properties (current velocity, depth, substrate size). The QHEI is used to evaluate the characteristics of a stream segment, as opposed to the characteristics of a single sampling site. As such, individual sites may have poorer physical habitat due to a localized disturbance yet still support aquatic communities closely resembling those sampled at adjacent sites with better habitat, provided water quality conditions are similar.

Table 4.1.A Details of Habitat and Sediment TMDLs

QHEI Categories		**Modified Attributes**			
Category	Target	High Influence		Total Modified Attributes	
Substrate	≥14	•Channelized or No Recovery		•Recovering Channel	
Channel	≥14	•Silt/Muck Substrate		•Sand Substrate (boat sites)	
In-Stream Cover	≥12	•Low Sinuosity		•Hardpan Substrate Origin	
Riparian:	≥5	•Sparse/No Cover		•Fair/Poor Development	
Pool/Current	Sum of these ≥15	•Max Pool Depth < 40 cm		•Only 1-2 Cover Types	
Riffle/Run				•No Fast Current	
Gradient				•High/Moderate Embeddedness	
				•Ext/Mod Riffle Embeddedness	
QHEI Score	≥ 60			•No Riffle	
QHEI to target score ratio ≥ 1	**+1**	One or less high-influence attributes present	**+1**	Four or less modified attributes present	**+1**

This method assumes that the significant variables that influence fish communities are included in the index, and that the index is able to distinguish between the relative effects of habitat versus water quality issues. The index is empirically derived and assumes that the empirical relationships remain similar for streams of similar size and type within an ecoregion. The evaluation is somewhat subjective and requires the evaluator to be experienced in the use of the index. The variability between evaluations from different trained investigators and the variability in time at a particular site have been determined to be minimal within the same season and if the investigators are experienced with the method (Rankin, 1989).

The QHEI provides a thorough evaluation of the physical habitat in a quantitative manner. Many of the metrics which comprise the QHEI are surrogate measures of load-based stressors. Some of the metrics may also provide a measure of a cause of impairment, such as the substrate category as a measure of siltation, or the QHEI itself when habitat is listed as the cause of impairment. Because habitat is strongly correlated with the IBI biocriterion, the QHEI can be an indicator for pollutants such as sediment. Therefore, the QHEI can provide a numeric target and framework to help evaluate how habitat or surrogate issues affect attainment of the aquatic life use designations.

The use of the QHEI also assumes that the water courses being evaluated are typical riverine streams and rivers. The QHEI was not calibrated to low gradient wetland dominated streams and application of the QHEI to these habitat types may not be valid. This is not meant to imply that wetlands are “degraded” habitats. Wetlands are valuable natural resources that serve many important ecological functions to aquatic systems, but the habitat and aquatic life associated with that habitat type are not the same as typical free flowing stream and riverine systems. There is no value judgement that one is better than the other, rather an acknowledgment that they are, indeed, different.

The empirical nature of the QHEI and the data that underlie it provide measurable targets that are parallel concepts to a loading capacity for a pollutant. The components provide a way to evaluate whether habitat is a limiting factor for the fish community and which attributes are the likely stressors. It can assess both the source of the sediment (riparian corridor, bank stability) and the effects on the stream itself (i.e., the historic sediment deposition) and thus has aspects of both a loading model and a receiving stream model. When used with biological indices, the numeric measurability of the index provides a means to monitor progress when implementing a TMDL and to validate that a target has been reached. Because stream physical habitat quality is influenced by surrounding land use, and because non-point load reductions are accomplished by changing land uses, habitat quality can be an important measure of TMDL success even when degraded habitat is not the cause of impairment.

4.1.2 Pathogens

As stated in Chapter 3, pathogen TMDL development occurred in two parts. First, a chronic condition TMDL was developed for the entirety of the recreation season. Second, and an acute condition TMDL was developed that is applicable to each day within the recreation season. The method of development of the chronic condition TMDL differs between the upper and lower watershed. The methods as individually related to the upper and lower watersheds are discussed in Sections 4.2 and 4.3, respectively. There is, however, a common element used in both methods, the Bacteria Indicator Tool (BIT), that is discussed below. Additionally, development of the acute condition TMDL is discussed below.

The Bacteria Indicator Tool

The U.S. EPA's Bacteria Indicator Tool (BIT) was employed to estimate the fecal coliform load accumulated within each 14-digit HUC in the Big Walnut Creek Basin. BIT estimates the monthly accumulation rate of fecal coliform bacteria on four land uses (cropland, forested, built-up, and pastureland), as well as the asymptotic limit for the accumulation should no washoff occur. It also estimates the direct input of fecal coliform bacteria to streams from grazing agricultural animals and failing septic systems (USEPA, 2000).

The Bacteria Indicator Tool requires three types of values: user-defined, default, and literature. User-defined values are to be specific to the study area. User-defined values required by the tool are land use distribution, numbers of agricultural animals, wildlife densities, number of home sewage treatment systems (HSTS), and the failure rate of HSTS. Default values are supplied by the tool, but it is suggested that they are modified to reflect patterns in the study area. Default values include fraction of each manure type applied each month, fraction of manure type that is incorporated into the soil, and time spent grazing and confined by agricultural animals. Like default values, literature values are supplied by the tool, but they may be replaced with user values if better information is available for the study area. Literature values required by the tool are animal waste production rates and fecal coliform bacteria content, fecal coliform bacteria accumulation rates for built-up land uses, and raw sewage fecal coliform bacteria content and waste production.

Literature and default values were unchanged for each HUC because limited watershed-specific information was available that would better characterize the area. User-defined values were determined via the following methods:

- The land use distribution for each 14-digit HUC was derived from the National Land Cover Dataset (NLCD) via GIS analysis. The NLCD was compiled from Landsat™ satellite imagery circa 1992 (USGS,2000). NLCD information was reclassified to agree with the land use categories of BIT.

- The number of HSTS and the percentage of those which are failing were also determined via GIS analysis. The number of HSTS in each 14-digit HUC was estimated based upon 1990 and 2000 census demographic information. The percentage of failing HSTS was based upon a probability analysis of pertinent soil properties. For detailed information regarding HSTS values please see Appendix B.

- Populations of agricultural animals, wildlife, and dogs were derived from countywide figures. Information regarding the size of agricultural animal and dog populations was obtained from county census data. Information regarding wildlife populations was obtained from Ohio Department of Natural Resource census data. In each case, the total number of animals within the county was divided by the total number of acres of relevant land use in the county. The resulting animal densities (animals per acre) were used to estimate the animal populations within each 14-digit HUC.

When all values are entered, BIT predicts the maximum surface accumulation rate of fecal coliform, and the asymptotic limit of accumulation should no washoff occur. Additionally, BIT predicts the fecal coliform load contributed directly to the stream from failing HSTS and livestock with stream access. In the upper Big Walnut Creek watershed BIT output was used as input to the Hydrological Simulation Program - Fortran (HSPF) model developed for that portion of the watershed. See Section 4.2 for a description of HSPF in the upper watershed. In the lower Big Walnut Creek watershed BIT output was used in concert with other methods to determine the total fecal coliform load to each HUC (see Section 4.3.3).

Bacteria loading is often difficult to quantify because there is rarely adequate data to accurately characterize individual sources. In the case of the Big Walnut Creek watershed, site-specific data is very limited, as each site was sampled only a handful of times. In such situations, BIT provides a means to make estimations of bacteria loads based upon justifiable values. While the use of such literature and default values results in considerable uncertainty, it is the best option available considering time and resource limitations.

The method assumes that the literature and default values used in the load calculations are accurate representations of the actual watershed conditions. In the case of animal population information, the method assumes that the populations are evenly distributed across the county on the relevant land uses. Assessing the accuracy of these assumptions is beyond the scope of this study.

Acute Condition TMDL

Typically, the calculation of a TMDL on a daily basis requires definition of the critical hydrologic condition. The condition that is critical is dependent upon what hydrologic condition is the most problematic. If the sources of pollution discharge continuously, then low flow, when the potential for pollution is the least, may be critical. If the sources of pollution are precipitation driven, then the critical condition may be high flow when runoff dominates. Since the sources of pathogenic organisms loading in the Big Walnut Creek Basin are numerous as well as variable, it was important to address the entire range of hydrologic conditions in the pathogen TMDL.

For this reason, the acute condition pathogen TMDL was developed using a load duration curve (LDC). A load duration curve is plot of percentile flow versus daily allowable load. Percentile flow is a traditional cumulative relative frequency, with one distinct variation. The cumulative relative frequency of a value in a population of data is typically calculated with the data population sorted in ascending order. However, the percentile flow value is determined with the population of data sorted in descending order. As a result the percentile flow data does not represent the percent of the total distribution that the value exceeds, rather is expressed the percent of time the value will be exceeded.

The data source used to determine percentile flow and the daily allowable load is a continuous flow record. In the upper Big Walnut Creek and upper Alum Creek

watersheds the continuous flow record was generated using the Hydrologic Simulation Program Fortran (HSPF). For more information regarding HSPF and a description of the flow calibration process see Appendix B. In the lower Big Walnut Creek and lower Alum Creek watersheds, the continuous flow record was obtained from long-term USGS gaging stations. In the lower Big Walnut Creek USGS gage #03229500 (Big Walnut Creek at Reese) was used. In the lower Alum Creek USGS gage #03229000 (Alum Creek at Columbus) was used. In both the upper and lower watersheds only the recreation season flow were used to calculate the percentile flow values.

Allowable daily load was calculated as the product of daily flow volume and the acute fecal coliform criteria of 2000 cfu. In the upper watersheds daily flow volume was directly modeled, while in the lower it was estimated from the average daily flow values (cfs) reported at each USGS gage.

Fecal coliform load duration curves for each 11-digit HUC in the study area are presented in Chapter 5.

4.2 TMDL Development for the Upper Big Walnut Creek Watershed

Nutrients, Bacteria, and HSPF

Nutrient loading to the Upper Alum Creek and Upper Big Walnut Creek watersheds were simulated using the Hydrological Simulation Program - Fortran (Bicknell et. al., 2001). This is a detailed, process-based simulation model. HSPF is a comprehensive package for simulation of watershed hydrology and water quality for both conventional and toxic organic pollutants. This model can simulate the hydrologic, and associated water quality, processes on pervious and impervious land surfaces and in streams and well-mixed impoundments. HSPF incorporates the watershed-scale ARM and NPS models into a basin-scale analysis framework that includes fate and transport in one-dimensional stream channels. It is the only comprehensive model of watershed hydrology and water quality that allows the integrated simulation of land and soil contaminant runoff processes with in-stream hydraulic and sediment-chemical interactions.

HSPF simulates three sediment types (sand, silt, and clay) in addition to a single organic chemical and transformation products of that chemical. The transfer and reaction processes included are hydrolysis, oxidation, photolysis, biodegradation, volatilization, and sorption. Sorption is modeled as a first-order kinetic process in which the user must specify a desorption rate and an equilibrium partition coefficient for each of the three solids types.

Resuspension and settling of silts and clays (cohesive solids) are defined in terms of shear stress at the sediment water interface. The capacity of the system to transport sand at a particular flow is calculated and resuspension or settling is defined by the difference between the sand in suspension and the transport capacity. Calibration of the model requires data for each of the three solids types. Benthic exchange is modeled as sorption/desorption and deposition/scour with surficial benthic sediments.

Underlying sediment and pore water are not modeled.

Data needs for HSPF can be extensive. HSPF is a continuous simulation program and requires continuous data to drive the simulations. HSPF produces a time history of the runoff flow rate, sediment load, and nutrient and bacteria concentrations, along with a time history of water quantity and quality at any point in a watershed. HSPF assumes that the "Stanford Watershed Model" hydrologic model is appropriate for the area being modeled. Further, the instream model assumes the receiving water body is well-mixed with width and depth and is thus limited to well-mixed rivers and reservoirs.

The HSPF model was calibrated to streamflow data in the Upper Alum Creek and Upper Big Walnut Creek watersheds using gaging station data from the USGS gages of Alum Creek near Kilbourne, and Big Walnut Creek at Sunbury.

The monthly and annual nutrient, bacteria, and sediment loading for the two basins compares reasonably well to the concentrations recorded in 2000 and 2002. The model was then used to predict average loadings using 1990 to 2002 meteorological data.

Tables 5.1.E, 5.2.E, 5.3.E and 5.4.E list the existing loads, the needed reduction, the TMDL value, and the allocations for total phosphorus and bacteria for each sub-watershed. The existing non-point source (NPS) category covers agricultural and natural background inputs. The TMDL was distributed to the background conditions (natural), waste load allocations (WLA) for point sources and load allocations (LA) for non-point sources. The background or natural conditions were calculated by modeling a “pristine” or forested condition in the sub-watershed. The (minor) point source nutrient allocation was based on the calculated existing total phosphorus, bacteria, and TSS loads. The rest of the TMDL was then allocated to non-point sources.

HSPF sediment results are based on sheet and rill erosion. The total nonpoint source sediment load to the stream would also include bank erosion. HSPF does not have the ability to calculate this part of the sediment load and the data needed to quantify it using another method was not available. The QHEI does take this type of erosion into account and will be used to guide implementation actions to address bank and gully erosion.

4.3 TMDL Development for the Lower Big Walnut Creek Watershed

4.3.1 Nutrients

Description of Method

Nutrient enrichment was assessed to be a cause of impairment in the McKenna Creek, Rocky Fork, and Blacklick Creek sub-basins of the lower Big Walnut Creek watershed. As discussed in Chapter 3, phosphorus was used as an indicator of the degree of nutrient enrichment. TMDL development required definition of the existing load, calculation of the loading capacity, and allocation of the TMDL to the identified sources.

The existing load was defined as the sum of the individual source loads. For the purpose of this study, surface runoff, point sources, HSTS, and groundwater were considered as potential sources. The methods used to calculate the existing load, loading capacity, and allocations are summarized in Table 4.3.A. Each method is described in detail in Appendix B. An evaluation of the method, including critical assumptions made, is presented in Table 4.3.A. below.

Table 4.3.A: Summary of nutrient TMDL development

Development Step	Source	Method
Existing Load	Surface Runoff	Estimated using the Metropolitan Washington Council of Governments' simple method (EPA, 1997).
	Point Source	Discharger self-monitoring data used to estimate phosphorus loading.
	HSTS	Population served by failing HSTS estimated via GIS analysis. Phosphorus load based upon population estimate and a per capita loading rate.
	Ground-Water	Groundwater contribution estimated using USGS's HYSEP. Load is the product of annual groundwater contribution estimate and the observed groundwater phosphorus concentration.
Calculation of Loading Capacity	-	Product of the annual discharge volume from each sub-basin and the phosphorus target concentration.
Allocation	Surface Runoff	LA is equal to the sum of all WLAs and the MOS subtracted from the assimilative capacity.
	Point Sources	Product of median effluent flow rate and technology based effluent limitation of 1.0 mg-TP/ml.
	HSTS	Septic systems are allocated a phosphorus load of zero. The allocation for home aerator systems is the product of the existing aerator load, and the percent reduction need to achieve the TMDL
	MS4	MS4s are allocated a portion of the total LA. MS4s allocations are the product of the percentage of the sub-basin area occupied by MS4s and the sub-basin surface runoff allocation.
	MOS	Ten percent of the assimilative capacity.

Evaluation of Method

The method of development has inherent assumptions that results in uncertainty in the calculated loads. Every effort was made, however, to base each assumption upon a justifiable rationale or value. A description of the assumptions made in the calculation of the source loads and the loading capacity is provided below.

The phosphorus load from surface runoff was dependent upon annual runoff volume and storm event mean concentrations. The predicted runoff volumes for the McKenna

Creek, Rocky Fork, and Blacklick Creek sub-basins were calibrated to per unit area estimates based upon the flow record from the neighboring Licking River gage (USGS #03146500). The Licking River gage was used rather than the downstream Big Walnut Creek gage for three reasons. First, the Licking River gage is listed as the index gage for Blacklick Creek due to hydrological similarity and spatial proximity (USGS, 1997). Second. use of the downstream Big Walnut Cr. gage could result in inaccurate estimations because it is heavily regulated by releases from Alum Creek Lake and Hoover Reservoir, and by large withdrawals by the City of Columbus Hap-Cremean Water Treatment Plant. Third, the land use characteristics of the Licking River watershed more closely resemble the Blacklick Creek and Rocky Fork sub-basins than the remainder of the largely urbanized lower Big Walnut Creek watershed.

The most extensive data available to characterize urban storm event mean concentrations is found in the U.S. EPA's pooled NURP dataset. The NURP dataset provides national median event mean concentrations that are specific to individual land uses, and possess statistical validity. Still, use of the NURP event mean concentrations results in considerable uncertainty because they are old (circa 1983), and a national average. The City of Columbus conducted limited wet-weather event sampling as part of their part II storm water NPDES permit application. The City of Columbus sampled five sites, each representative of an individual land use, five to six times in 1992. Results from the City of Columbus' study generally fell within the range of values in the NURP dataset. While the number of samples taken by the City of Columbus are insufficient to establish statistical validity and be used independently, they do ground-truth the NURP national averages. Since the NURP values were generally consistent with results from the City of Columbus, NURP median event mean concentrations were used in the phosphorus load calculations.

The phosphorus load from conventional point source discharges was largely based on empirical data collected by the individual discharging entities. In the case of several smaller package plants, however, no phosphorus monitoring data was available to characterize the quality of their effluent. For these instances, effluent phosphorus concentrations were based upon the best professional judgement of Ohio EPA staff with knowledge of the operations at each facility. While the estimated effluent concentrations may result in under or over prediction of the contributed loads, the size of the loads are relatively small when compared to the major dischargers in the sub-basin. Additionally, one such facility has already closed, and others are scheduled for closure or sewer connection in the near future.

The phosphorus loads from failing home sewage treatment systems are rough estimates based largely upon literature values. For the purpose of this study, "failing" is defined as any system that is negatively impacting water quality beyond reasonable expectation. Properly installed and functioning septic leach field systems should contribute no phosphorus load, and thus are not considered in the load calculation. The method considers all home aerator systems and "cheater" septic systems to be failing by the stipulated definition. The number of failing systems was estimated as the product of the total number of systems, and a failure rate determined via probability analysis. The probability analysis is based upon pertinent soil properties, and was not

calibrated to any observed data. Despite this, estimates of the number of failing systems showed reasonable agreement with the number of home aerator systems quoted by local health departments. To some degree the agreement serves as a validation of the method, considering “cheater” systems are believed to comprise only a small percentage of the total number of failed systems.

The ground water phosphorus load calculation was depended upon the volume of the ground water contribution to the stream, and the concentration of phosphorus in groundwater. The ground water contribution was estimated using HYSEP. This model is based on a mathematical technique that mimics the way that humans have been separating hydrographs, rather than on the physics of the process (which are currently not well understood). Although HYSEP consistently applies various algorithms that are commonly used for hydrograph separation, hydrograph separation remains a subjective process (USGS, 1996). The advantages of using HYSEP are that it provides a consistent, automated method to determine baseflow which manual hydrograph separation would not provide, and the techniques HYSEP utilizes to separate the flow are long standing, widely accepted techniques. For reasons described previously, mean daily flow values from the Licking River gage were used as input to HYSEP. The resultant per unit area ground water discharge volumes were then used to estimate annual groundwater discharge volumes in the McKenna Creek, Rocky Fork, and Blacklick Creek sub-basins.

The method of calculation to determine loading capacity accounts only for physical dilution as a means of assimilation. The method makes no attempt to account for the chemical and biological cycling of phosphorus through the system that could potentially increase the loading capacity of the streams. No accurate prediction of instream processing is possible without the development of a receiving stream model or extensive empirical data. For the purpose of this TMDL study, a receiving stream model was judged to be unnecessary, and available water quality data is insufficient for empirical methods.

4.3.2 Bacteria

Method of Development

In the lower Big Walnut Creek watershed bacteria TMDLs were developed for 14-digit HUCs in which one or more stream segments were in non-attainment of their recreational use designation. Bacteria TMDLs were developed using fecal coliform bacteria as an indicator of the degree of pathogenic organism loading. TMDL development required definition of the existing load, calculation of the loading capacity, and allocation of the TMDL to the identified sources.

The existing load was defined as the sum of the individual source loads. For the purpose of this study, surface runoff, point source dischargers, home sewage treatment systems (HSTS), cattle in stream, combined sewer overflow (CSO), sanitary sewer overflow (SSO), and upstream flow were considered potential sources. Individual source loads, TMDLs, and allocations are all expressed in colony forming units (cfu) per

season. The methods used to calculate the existing load, loading capacity, and allocations are summarized in Table 4.3.B. Each method is described in detail in Appendix B. An evaluation of the method, including critical assumptions made, is presented below.

Table 4.3.B: Summary of pathogen TMDL development for the lower Big Walnut Creek

Development Step	Source	Method
Existing Load	Surface Runoff	Fecal coliform surface accumulation modeled using the U.S. EPA's Bacteria Indicator Tool (BIT). BIT predictions used in conjunction with a runoff coefficient to estimate washoff.
	Point Source	Discharger self-monitoring data used to estimate fecal coliform loading.
	HSTS	Population served by failing HSTS estimated via GIS analysis. Fecal coliform load based upon population estimate and a per capita loading rate.
	CSO	Load is the product of observed overflow volume and a literature value of fecal coliform content in combined sewage.
	SSO	Load is the product of observed overflow volume and a literature value of fecal coliform content in municipal sewage.
	Cattle in Stream	Load is a prediction of BIT. Model inputs are based upon county averages.
	Upstream Flow	Load is the product of upstream flow volume and observed instream fecal coliform concentrations.
Loading Capacity/TMDL	-	Product of the seasonal discharge volume from each 14-digit HUC and the fecal coliform target concentration.
Allocation	Point Sources	Product of median effluent flow rate and existing fecal coliform permit limit.
	HSTS	Septic systems are allocated a load of zero. The allocation for home aerator systems is the product of the existing aerator load, and the percent reduction need to meet the TMDL.
	CSO	CSO is allocated a fecal coliform load of equal to the product of the existing CSO load and the percent reduction needed to meet the TMDL.
	SSO	SSO is allocated a fecal coliform load of zero.
	Surface Runoff	LA is equal to the sum of all WLAs and the MOS subtracted from the loading capacity.
	Upstream Flow	Product of monthly upstream flow volume and the fecal coliform WQS of 1000 counts/100 ml.

	MS4	MS4s are allocated a portion of the total LA. MS4s allocations are the product of the percentage of the sub-basin area occupied by MS4s and the sub-basin surface runoff allocation.
	MOS	Five percent of the loading capacity.

Evaluation of Method

The sources of pathogenic organism loading to the lower Big Walnut Creek watershed are well known and have been previously identified in multiple documents (Ohio EPA 2000 & 2002). The purpose of this study is to estimate the relative magnitude of each source load, and to demonstrate the potential effects should the individual loads be reduced or eliminated. With this goal in mind, the simple, planning-level method described here was used.

The method used to estimate the fecal coliform load from surface runoff assumes that the load is primarily dependent on three factors, surface accumulation, surface die-off, and washoff. Surface accumulation and die-off were modeled by BIT. See Section 4.1.2 for an evaluation of this model. BIT as a stand-alone model has no means to approximate washoff, because the output of BIT is intended to be used as input to BASINS or HSPF. Implementation of a complex model such as BASINS or HSPF was beyond the scope of this study. As a substitute, washoff was represented by a runoff coefficient derived from daily precipitation data and is essentially the quantitative expression of a qualitative assumption. The method assumes that a bottom threshold of daily precipitation exists below which no washoff occurs. Similarly, the method assumes that there is an upper threshold above which all accumulated bacteria washes off. The runoff coefficient of storm events between these two thresholds was interpolated via an exponential regression equation. The threshold values and regression relationship are based upon a combination of literature values and the best professional judgement of Ohio EPA staff.

The fecal coliform load from point source discharge was largely based on empirical data collected by the individual discharging entities. In the case of several smaller package plants, however, no monitoring data was available to characterize the quality of their effluent. For these, effluent fecal coliform concentrations were based upon the best professional judgement of Ohio EPA staff with knowledge of the operations at each facility. While the estimated effluent concentrations may result in under or over predictions of the contributed loads, the size of the loads are small relative to other sources in the sub-basins. Additionally, one such facility has already closed, and others are scheduled for closure or sewer connection in the near future.

Assumptions of the phosphorus HSTS source load calculation are also relevant to the fecal coliform HSTS load. For a evaluation of the method used to determine the loads from HSTS see Section 4.3.1.

CSO volumes used to calculate the fecal coliform load from overflow events is

incomplete. Documented discharges have occurred for which no volume information is available. The fecal coliform load from CSOs presented here is the load from reported, measured overflow events. However, the monthly CSO volume used to calculate the load is based on an average from the period 1990 to 2003. Due to the relative infrequency of unmeasured overflows throughout the averaging period, their effect is negligible to the overall load.

The City of Columbus has only recently begun measuring SSO volumes. SSO volumes used to calculate the fecal coliform load from these overflow volumes is limited to 2003 data. Further, overflow events occurred in 2003 that were not measured, and thus not included in the calculation. However, the volume measurements used are the best data available to quantify the magnitude of SSO events. The data also represent a substantial improvement in the reporting of SSO events from previous years. Columbus DSD is currently collecting additional data, and has also contracted the modeling of its collection system to more accurately predict overflow activation and magnitude. Completion of the modeling project and future data collection may allow for a more accurate calculation of the fecal coliform load from SSO.

4.4 Critical Condition

4.4.1 Nutrients

The critical condition for nutrient enrichment is the summer warm season, when the potential for primary production is highest. The summer concentration of phosphorus in the water column, however, is dependent upon more than summer phosphorus load contributed to the stream. As phosphorus readily attaches to sediment, detachment of adsorbed phosphorus in bottom sediments can lead to elevated instream concentrations regardless of the magnitude of short-term loads. As a result, it is the long-term, or chronic, phosphorus load that is more directly related to the degradation of water quality. For this reason phosphorus TMDLs were developed on an annual basis. The TMDLs are therefore reflective of all conditions, rather than a single critical condition.

4.4.2 Pathogens

The critical condition for pathogens is the summer dry period when flows are lowest, and thus the potential for dilution is the lowest. Summer is also the period when the probability of recreational contact is the highest. For these reasons recreational use designations are only applicable in the period May 1 to October 15. Pathogen TMDLs were developed for the same May to October time-period in consideration of the critical condition, and for agreement with Ohio WQS.

4.4.3 Habitat and Sediment

The critical condition for the habitat and sediment TMDLs is the summer dry period when environmental stress upon aquatic organisms is the 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.

4.5 Margin of Safety

4.5.1 Nutrients

A margin of safety was incorporated both implicitly and explicitly into the phosphorus TMDL. An implicit margin of safety is incorporated into the 303(d) listing process and the target development process. The explicit margin of safety is a portion of the loading capacity specifically reserved to account for any additional uncertainty.

303(d) Listing

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

Target Development

A conservative assumption implicit in target development lies in the selection of the median statistic used to represent the phosphorus target that corresponds to an unimpaired biological community. Since Ohio EPA's evaluation of phosphorus data for generating target values is based on measured performance of aquatic life and since full attainment can be observed at concentrations above this target (reinforcing the concept that habitat and other factors play an important role in supporting fully functioning biological communities), water quality attainment can occur at levels higher than the target. The difference between the actual level where attainment can be achieved and the selected target is an implicit margin of safety.

Explicit Margin of Safety

Five percent of the loading capacity was reserved as an explicit margin of safety in the upper watershed. Ten percent of the loading capacity was reserved in the lower watershed. The explicit margin of safety was included to account for any remaining uncertainty following the application of the implicit measures described above.

A larger explicit margin of safety was reserved in the lower watershed than in the upper because of greater uncertainty in the method. The more rigorous nature of HSPF (used in the upper) resulted in a more accurate predictions of flow and therefore more accurate estimations of load (see Appendix C for results of the HSPF calibration). The simple method used to predict flow in the lower watershed was based upon percent impervious estimates and annual rainfall. While this method does provide a rough estimate of annual runoff, it does not explain variation with as much consistency as HSPF.

4.5.2 Pathogens

A margin of safety was implicitly incorporated into the pathogen TMDL. Loading of fecal coliform to each 14-digit HUC was quantified, as was the fecal coliform loading capacity at the outlet to each 14-digit HUC. Loading capacity was calculated as the product of the seasonal flow volume and the fecal coliform target concentration. No attempt was made to link downstream loading capacity with upstream loading via instream processing. Rather, the load reductions recommended by this report are based upon a direct comparison between the two quantities. In reality, considerable die-off occurs between the source of loading and the TMDL endpoint and this loss represents an implicit margin of safety.

4.5.3 Habitat and Sediment

A MOS was implicitly incorporated into the sediment and habitat TMDLs 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, individual components of the QHEI were analyzed to determine their magnitude at which WWH attainment is probable. Attainment does, however, occur at levels lower than the established targets. The difference between the habitat and sediment targets and the levels at which attainment actually occurs is an implicit margin of safety.

4.6 Future Growth

Based upon data from the 1990 and 2000 census, Delaware County is the fastest growing area in Ohio. Franklin, Fairfield, Licking, Morrow, and Knox Counties all exhibited growth rates larger than the statewide average. Table 4.6.A presents population data and growth rates for counties in the Big Walnut Creek study area (Ohio Dept. of Development, 2004).

Table 4.6.A Population growth figures for Big Walnut Creek counties

County	Census		2003 Estimate	1990-2000		2000-2003	
	1990	2000		Percent Change	Rank by Percent Change	Percent Change	Rank by Percent Change
Delaware	66,929	109,989	132,797	64.3%	1	20.7%	1
Fairfield	103,461	122,759	132,549	18.7%	7	8.0%	3
Franklin	961,437	1,068,978	1,088,944	11.2%	19	1.9%	25
Knox	47,473	54,500	56,930	14.8%	11	4.5%	8
Licking	128,300	145,491	150,634	13.4%	17	3.5%	11
Marion	64,274	66,217	66,393	3.0%	56	0.3%	54
Morrow	27,749	31,628	33,568	14.0%	16	6.1%	6

Population growth is expected to continue, particularly in southern Delaware and western Licking and Fairfield Counties, as the Columbus Metropolitan area expands. For this reason an allowance for future growth was incorporated both implicitly and explicitly in the TMDLs. The future growth term is a portion of the loading capacity reserved for expected increases in waste loadings.

Implicit future growth terms are included in some of the wasteload allocations. For example, some wastewater treatment plants in the study area are currently operating well below their design capacity. Allocating to such a facility at design flow is an implicit allowance for future growth. In other sub-watersheds wastewater treatment plants may be operating at or near design capacity, or no wastewater treatment may exist at all. In such instances an explicit allowance for future growth is included in the TMDL, and it is meant to account for the expected increase in waste loading even though the future waste management scenario in currently unknown.

Explicit future growth allowances are presented in the various TMDL tables in Chapter 5.

5.0 Water Quality Assessment and TMDLs

Detailed chemical and physical water quality assessments and water quality modeling of the Big Walnut Creek watershed provide the foundation for determining the need for and establishment of TMDLs. In Chapter 5, this detailed information has been summarized and organized by 11 digit hydrologic units (assessment unit) in order to facilitate the direct lifting of this information to support watershed action planning processes. Each assessment unit will contain a summary of the water quality condition, the deviation from water quality target, the existing loads, and the TMDLs which allocate the loads to various sources. While implementation issues are discussed further in Chapter 6, the information in this chapter should provide a foundation for TMDL implementation.

5.1 Upper Big Walnut Creek (Assessment Unit 05060001-130)

This assessment unit consists of the Big Walnut Creek above Hoover Reservoir and its tributaries.

5.1.1 Assessment Results

Big Walnut Creek Mainstem

The Big Walnut Creek mainstem in this area flows primarily through agricultural land, and influences on the water reflect that land use. Fair biological communities in the headwaters of Big Walnut Creek down to Prospect-Mt. Vernon Rd. (RM 66.6) were impacted by channel modifications (especially at RM 72.5/73.6), siltation (heavy at 72.5/73.6 and moderate at downstream areas), stream dewatering (probably from agricultural drainage systems), and nutrient enrichment from agricultural activities. Exceedences of fecal coliform (as high as 26,000/100 ml at RM 66.6) and E. coli (as high as 17,000/100 ml at RM 66.6) were indications of livestock manure runoff and possibly failing home sewage treatment systems (HSTS).

The biological communities improved into the good to very good range by Chambers Rd. (RM 60.0) and remained in FULL attainment of the WWH aquatic life use downstream to the upper reaches of Hoover Reservoir. However, elevated nutrients (ammonia at RM 54.6 and phosphorus at RM 61.9) and bacteria (RM 61.9) may have been caused by the hydraulic overflows from the Village of Marengo WWTP (RM 65.8) during rain events or indications of moderate agricultural runoff and possibly failing HSTS.

Results of the biological assessment are given in Table 5.1.A.

The recreational use in the upper Big Walnut mainstem is Primary Contact Recreation. Evaluation of the bacterial data for the upper Big Walnut mainstem reveals that average levels of fecal coliform bacteria are in an acceptable range, but that the frequency and magnitude of the peak values do not comply with the WQS of 2000 colony forming units

(cfu) in no more than 10% of the samples. The 90th percentile (n=28 samples) is 2820 which shows that the Big Walnut Creek mainstem is not meeting its recreational use designation.

Tributaries to Big Walnut Creek

The biological community was primarily impacted by very low to intermittent stream flow in Reynolds Run (RM 0.7), Long Run (RM 3.6), Sugar Creek (RM 0.1), and Culver Creek (RM 4.5). These stations had adequate flow in mid July when fish sampling was conducted but were characterized by very low to intermittent flow by mid September when the macroinvertebrate sampling was conducted. The results of the Sugar Creek macroinvertebrate sampling (the cause of partial attainment) may have been influenced by a nearby, significant sulfur spring. Effects from this spring would have been exacerbated by the low flow condition. Further study of this situation is needed. Reynolds Run (RM 0.7) was impacted by channelization and the removal of the woody riparian corridor, and Culver Creek (RM 4.5) was impacted by water quality impairments (low D.O. and elevated nutrients), the suspected cause being HSTS and agricultural runoff.

The upper portions of North Fork Rattlesnake Creek and East Fork Rattlesnake Creek were impacted by water quality impairments (low D.O. in the E. Fk. and high nutrients in both) from land application of chicken manure generated by Buckeye Egg Farm's Croton facility in addition to channelization, livestock runoff, and possibly failing HSTS. The lower portions of East Fork Rattlesnake Creek and South Fork Rattlesnake Creek were impacted by runoff from the construction of the Rattlesnake Ridge Golf Club. The water column of both streams became turbid brown downstream from the golf course construction during sampling in September, 2000 with heavy siltation at the South Fork station downstream from Longshore Rd. (RM 0.2).

West Branch Little Walnut Creek (RM 1.5) was impacted by water quality impairments (low D.O., elevated nutrients, high bacterial counts) apparently from failing HSTS and agricultural activities. Butler Run was impacted primarily by channelization, siltation, and the removal of the woody riparian corridor.

Duncan Run was impacted by channelization and siltation, especially in the upper reach, along with elevated nutrients and high bacterial counts from agricultural activities and failing HSTS.

Results of the biological survey are presented in Table 5.1.A.

Recreational uses for the tributaries to Big Walnut Creek are Primary Contact Recreation (PCR), with the exception of Prairie Run, which is designated Secondary Contact Recreation (SCR). Of the tributaries, Reynolds Run, Culver Creek, and Mill Creek/Light Creek are not attaining their recreational use for both average and peak bacterial levels. Rattlesnake Creek and Duncan Run are periodically not attaining their use at peak bacteria levels for one or both bacteria.

Table 5.1.A Aquatic life use attainment status of the Big Walnut Creek basin, June-October, 2000. The Index of Biotic Integrity (IBI), Modified Index of Well Being (MIwb), and Invertebrate Community Index (ICI) scores are based on the performance of fish (IBI, MIwb) and macroinvertebrate communities (ICI). The Qualitative Habitat Evaluation Index (QHEI) is a measure of the ability of the physical habitat to support biological communities.

River Mile		IBI	MIwb	ICI[b]	QHEI	Attainment Status	Comment
Fish[a]	Invert.						
Big Walnut Creek (02-100) *WWH Use Designation (Existing)*							
72.5[E]	73.6	32*	NA	Low F*	55.5	**NON**	Cardington-East Rd.
-	70.7	-	-	F*	-	**(NON)**	Waldo-Fulton-Chesterville Rd.
66.6[D]		34*	NA	F*	58.5	**NON**	Prospect-Mt. Vernon Rd.
-	60	-	-	42	-	(FULL)	Chambers Rd.
54.6[D]		46	8.4	VG	73	FULL	Stockwell Rd.
52.4[D]	52.3	38ns	8.0[ns]	44	69.5	FULL	North Old 3C Rd.
49.0[E]	48.9	46	8.4	46	78.5	FULL	Dst. Sunbury
Reynolds Run (02-104) *WWH Use Designation (Existing)*							
4.9[E]	-	28	NA	-	53.5	N/A	PHWH, Turney Center Rd.
0.7[E]		32*	NA	F*	59	**NON**	East Liberty North Rd.
Long Run (02-103) *WWH Use Designation (Existing)*							
4.9[E]	-	20*	NA	-	56.5	**(NON)**	Trimmer Rd.
3.6[E]		34*	NA	F*	69	**NON**	Porter Central Rd.
0.7[E]		48	NA	G	73	FULL	Ulery Rd.
Sugar Creek (02-102) *WWH Use Designation (Existing)*							
5.3[E]	-	46	NA	-	71	(FULL)	Trimmer Rd.
0.1[E]		46	NA	F*	77	PARTIAL	Adj. Monkey Hollow Rd.
Culver Creek (02-101) *WWH Use Designation (Existing)*							
4.5[E]		38[ns]	NA	F*	56.5	PARTIAL	Patrick Rd.
3.3[E]		40	NA	VG	75	FULL	Centerburg Rd.
-	0.1	-	-	VG	-	(FULL)	Near mouth
Tributary to Culver Creek (RM 3.32) (02-336) *WWH Use Designation (Recommended)*							
0.7[E]	0.1	40	NA	G	67	FULL	Porter Central Rd./Fredricks Rd.
Perfect Creek (02-160) *WWH Use Designation (Existing)*							
4.7[E]	4.9	36[ns]	NA	MG[ns]	71.5	FULL	Old SR 3
1.0[E]	0.1	36[ns]	NA	VG	59	FULL	Near mouth
Rattlesnake Creek (02-150) *WWH Use Designation (Existing)*							
0.1[E]		37[ns]	4.9*	38	66.5	**NON**	Near mouth
North Fork Rattlesnake Creek (02-151) *WWH Use Designation (Existing)*							

River Mile Fish[a]	River Mile Invert.	IBI	MIwb	ICI[b]	QHEI	Attainment Status	Comment
5.8[E]	-	32*	NA	-	41	**(NON)**	Foundation Rd. (E)
4.8[E]	-	40	NA	-	58.5	(FULL)	North County Line Rd.
3.4[E]		30*	NA	G	37.5	PARTIAL	Hartford Rd. (East Crossing)
1.7[E]	0.1	40	NA	G	59.5	FULL	Near mouth
East Fork Rattlesnake Creek (02-152) *WWH Use Designation (Existing)*							
4.2[E]	-	12*	NA	-	48.5	**(NON)**	Tagg Rd.
-	1.2	-	-	Low F*	-	**(NON)**	Dent Rd.
0.2[E]		38ns	NA	Low F*	56	PARTIAL	SR 605
South Fork Rattlesnake Creek (02-153) *WWH Use Designation (Existing)*							
3.7[E]	3	44	NA	MG[ns]	59.5	FULL	Ross Rd./Dent Rd.
0.5[E]	0.2	24*	NA	F*	53	**NON**	Longshore Rd.
Prairie Run (02-125) *WWH Use Designation (Existing)*							
0.7[E]	0.4	44	NA	F*	51	PARTIAL	Ust. Sunbury WWTP
Little Walnut Creek (02-140) *WWH Use Designation (Existing)*							
-	9.4	-	-	G	-	(FULL)	Blue Church Rd.
7.4[E]		46	NA	G	66.5	FULL	Dst. E. Br. L Walnut Cr.
3.2[E]	4.7	30*	6.4*	28*	62	**NON**	Ust. Cheshire Rd./US 36 & SR 37
Tributary to Little Walnut Creek (RM 9.5) (02-341) *WWH Use Designation (Recommended)*							
1.5[E]	-	38[ns]	NA	-	68	(FULL)	Blue Church Rd.
Butler Run (02-141) *WWH Use Designation (Existing)*							
1.2[E]		20*	NA	F*	45	**NON**	Wilson Rd.
East Branch Little Walnut Creek (02-142) *WWH Use Designation (Existing)*							
0.4[E]	-	38[ns]	NA	-	73	FULL	Rosecrans Rd.
West Branch Little Walnut Creek (02-143) *WWH Use Designation (Existing)*							
-	1.5	-	-	F*	-	**(NON)**	Twigg-Hupp Rd.
Duncan Run (02-124) *WWH Use Designation (Existing)*							
-	9	-	-	Low F*	-	**(NON)**	Robins Rd.

* 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 Fish sampling methods: A=Boat, D=Wading, E=Longline.
b Narative evaluation based on qualitative macroinvertebrate sample (E=Exceptional, VG=Very Good, G=Good, F=Fair, Low F=Low Fair, P=Poor, and VP=Very Poor).
c Macroinvertebrate sample was collected in 2001 and may be replacing a 2000 sample.

5.1.2 Causes and Sources of Impairment

Big Walnut Creek Mainstem

The upper 10 river miles of the headwaters of Big Walnut Creek mainstem are not meeting the aquatic life use designation. Biological performance in terms of the IBI and the narrative evaluation for aquatic macroinvertebrates fails to achieve the levels established in the WQS. The causes of this impairment are flow alteration, habitat alteration and siltation, the sources of which are attributed to crop production and direct alteration of the stream channel. The ramifications of this activity are discussed in detail in Chapter 3.

Recreational Use impairment is attributed to influences from livestock, and to potentially failing HSTS. This is supported by the pattern of excessive peak values of bacteria, which may be caused by runoff events.

Big Walnut Creek Tributaries

Reynolds Run, Long Run, and Sugar Creek are impacted by habitat alteration and flow alteration. The sources of these impacts are attributed to direct modification of the channel, and disruption of a normal flow regime by agricultural drainage modifications, except in the case of Sugar Creek. The macroinvertebrate site at Sugar Creek was potentially influenced by a large sulfur spring, that would have a disproportionate effect on the macroinvertebrate community during the low flow that was sampled, compared to its normal influence. Recreational use impairments to Reynolds Run are due to elevated fecal coliform and *E. coli* sample results. Sources of these impairments are primarily attributed to HSTS that do not adequately treat for bacteria.

Causes of impairment in Culver Creek are flow alteration and organic enrichment. Sources of this impairment were attributed to row crop agricultural activity, with some potential for contributions by failing HSTS. Culver Creek is not attaining its recreational use for both *E. coli* and fecal coliform, except that the fecal coliform non-attainment is only occurring at peak levels of bacteria. The source of the non-attainment is attributed to HSTS that do not adequately treat for bacteria, although agricultural runoff may be contributing to some of the peak values observed, particularly for the fecal coliform bacteria.

Rattlesnake Creek has three major tributaries, East Fork, North Fork and South Fork. Impairment in Rattlesnake Creek proper cannot be considered in isolation of contributions from other parts of the watershed. Organic Enrichment is a problem, as shown by D.O. violations recorded in East Fork Rattlesnake Creek and North Fork Rattlesnake Creek. The wide swings in D.O. readings throughout this watershed are indicative of periodic organic loadings that are resulting in impairment of the aquatic life use that is seen in Rattlesnake Creek. Additional causes of impairment are identified as nutrients, siltation, and ammonia, which are variously attributed to land application of animal wastes, failing HSTS, livestock grazing, and to land development in the form of construction of a golf course. Rattlesnake Creek is impaired for its recreational use due

to elevated peak levels of bacteria for both fecal coliform and *E. coli*. This source of the non-attainment is attributed to agricultural runoff from livestock management in the watershed.

Causes of impairment in Prairie Run are habitat alteration and siltation, which are a result of direct physical alteration of the channel. Sources of this impairment are attributed to habitat alteration, and urban runoff from the Village of Sunbury. This stream is designated secondary contact recreation (wading use only) and is attaining its recreational use.

The cause of impairment in Little Walnut Creek is flow alteration.

Causes of impairment in Duncan Run are habitat alteration, siltation, and pathogens. Sources of the impairment are attributed to the direct physical alteration of the channel, and the concomitant sedimentation and enrichment problems that result from that type of activity. The recreational use is impaired for both fecal coliform and *E. coli* in that peak values of these bacteria exceed allowable levels and targets. The source of the recreational use impairment is attributed to HSTS that do not adequately treat for bacteria.

5.1.3 Deviation from Target

The QHEI target of 60 is used to establish a level of habitat quality that is generally associated with biological community performance that will attain the standards established in the WQS. In addition to the QHEI level of 60, various habitat attributes are evaluated to provide better clarity on parts of the the QHEI score that are most directly related to impairment. This evaluation is presented in Section 5.1.5. Bacterial standards are established in the WQS for fecal coliform as 1000 colony forming units (cfu) per 100 ml on average and 2000 cfu in no more than 10% of the samples taken. The latter criteria is usually evaluated by comparing the 90th percentile of the available data to the target. The deviation from target is presented in Table 5.1.B.

Table 5.1.B. Deviation from Target in HUC 05060001-130, Upper Big Walnut Creek

05060001-130: Big Walnut Creek headwaters to Hoover Reservoir					
Waterbodies Affected	**Cause of Impairment**	Target Parameter *units*	Target	Observed Condition	Deviation from Target
130-010: Big Walnut Creek headwaters to above Culver Creek					
All within 14 digit HUC	**Pathogens**	Fecal Coliform *cfu*[1]	2000 (90th percentile)	2,900	31 %
Big Walnut Creek	**Siltation**	QHEI metrics	33	30	10 %
	Habitat Alteration	QHEI	60	55.5-58.0	3.4 - 8.1 %
Reynolds Run	**Habitat Alteration**	QHEI	60	53.5 - 59	1.7 - 12 %
Long Run	**Flow Alteration**	QHEI	60	56.5 - 69	0 - 6.2 %
130-020: Culver Creek					
All within 14 digit HUC	**Siltation**	QHEI metrics	33	31.5	4.7 %
	Organic Enrichment	D.O. mg/l (minimum)	5.0 Average / 4.0 Minimum	3.4 -10.5 / 2.06 - 12.1	0 - 47 % / 0 - 94.2 %
	Pathogens	Fecal Coliform *cfu*[1]	2,000 (90th percentile)	2377	15.8 %
	Nutrients	Phosphorus mg/l	0.11	0.05 - 0.79	0 - 86 %
130-030: Big Walnut Creek below Culver Creek to above Rattlesnake Creek					
All within 14 digit HUC	-None- Full Attainment ☺				
130-040: Rattlesnake Creek and Tributaries					
All within 14 digit HUC	**Nutrients**	Phosphorus mg/l	0.11	0.05 - 0.96	0 - 88.5 %
	Siltation	QHEI metrics	33	22 - 32	0 - 50 %
	Organic Enrichment	D.O. mg/l (minimum)	5.0 Average / 4.0 Minimum	2.3 / 1.4	117% / 186%
	Habitat Alteration	QHEI	60	37.5 - 66.5	0 - 37.5 %

Waterbodies Affected	**Cause of Impairment**	Target Parameter *units*	Target	Observed Condition	Deviation from Target
	Pathogens	Fecal Coliform *cfu*[1]	2,000 (90th percentile)	2,287	13%
130-050: Big Walnut Creek below Rattlesnake Creek to above Little Walnut Creek					
Prairie Run	**Nutrients**	TP *mg/l*	0.11	0.13 - 0.17	15 - 35%
	Habitat Alteration	QHEI	60	51	15 %
130-060: Little Walnut Creek					
All within 14 digit HUC	**Flow Alteration**	QHEI metrics	< 5 moderate influence modified attributes	5	20 %
	Pathogens	Fecal Coliform *cfu* 10^3/y*season*	10.6	49	78 %[2]
Butler Run	**Siltation**	QHEI Metrics	>33	22	50 %
	Habitat Alteration	QHEI	60	45	33 %
130-080: Duncan Run					
All within 14 digit HUC	**Habitat Alteration**	QHEI	60	57.5	4%

[1] Fecal Coliform counts expressed as cfu (colony forming units) equates to the measurement of fecal coliform, number per 100ml.
[2] The deviation from target in indicated HUC14's are calculated from the HSPF model.

5.1.4 Existing Loads, Loading Capacity, and Allocations

Existing total phosphorus and fecal coliform loads were calculated for each 14-digit HUC in the assessment unit. The existing loads were calculated using HSPF, by methods described in Section 4.2 and Appendix C. Total phosphorus loads are expressed in pounds per year, and fecal coliform loads are expressed in cfu per recreation season. For modeling purposes the recreation season is defined as May 1st to October 31st.

Existing point source loads are presented in Table 5.1.C. Existing non-point source loads are presented in Table 5.1.D. Non-point sources considered in the assessment unit are cropland, pasture, forest, cattle instream, home septic systems, and home aerator systems.

Total existing loads, TMDLs, WLAs, and LAs for the assessment unit are presented in Table 5.1.E. Also included in the table is the percent existing load reduction needed to achieve the TMDL. WLAs and LAs are 14-digit HUC totals; individual allocations for

point source entities are presented in Table 5.1.F, and allocations for each non-point source are given in Table 5.1.G.

Table 5.1.C Existing Point Source Loads

14-Digit HUC[1]	**Facility Name** *NPDES Permit #*	**Median Q** *MGD*	**[TP]**[1] *mg/l*	**[FC]**[2] *cfu/ 100 ml*	**Facility Loads**		**HUC Loads**	
					TP *lb/year*	FC *cfu/season*	TP *lb/year*	FC *cfu/season*
130-010	Town of Marengo *4PA00101*	0.02	3.00[3]	60	203	2.05e+10	203	2.05e+10
130-030	Morning View Care Center *4PS00016*	0.006	3.00[3]	19	53	4.92e+10	53	4.92e+10
130-050	Town of Sunbury WWTP *4PB00010*	0.352	3.00[3]	67	3827	2.45e+12	3850	2.46e+12
	Town of Galena WWTP *4PB00106*	0.014	0.72	7	23	4.34e+09		

[1]Values in this column represent the historical total phosphorus effluent concentration for each facility.
[2]Values in this column represent the historical fecal coliform effluent concentration for each facility.
[3]Estimated effluent value.

Table 5.1.D Existing Non-Point Source Loads

14-Digit HUC[1]	Sub-Watershed	Sub-Watershed Extent (Upper RM-Lower RM)	Parameter (units)	Existing Non-Point Source Loads						
				Cropland	Pasture	Forest	Cattle Instream	Septic	Aerator	**Total**
130-010	Big Walnut Cr.	76.6 - 53.4	FC (cfu •10^{13} •season^{-1})	4.99	4.52	0.01	173	0.41	0.10	**183**
			TP (lbs • year^{-1})	25570	6234	---	1460	1551	385	**35,200**
130-020	Culver Creek	entirety	FC (cfu •10^{13} •season^{-1})	1.09	0.51	0.002	17.5	0.44	0.17	**20**
			TP (lbs • year^{-1})	7,925	1283	---	147	1649	657	**11,661**
130-030	Big Walnut Cr.	53.4 - 50.4	FC (cfu •10^{13} •season^{-1})	0.86	0.41	0.001	13.2	0.38	0.15	**15**
	Perfect Creek	entirety	TP (lbs • year^{-1})	6269	1035	---	111	1433	571	**9,419**
130-040	Rattlesnake Creek	entirety	FC (cfu •10^{13} •season^{-1})	2.16	0.95	0.002	30.4	0.31	0.12	**34**
			TP (lbs • year^{-1})	15737	2416	---	256	1159	462	**20,030**
130-050	Big Walnut Creek	50.4 - 47.9	FC (cfu •10^{13} •season^{-1})	0.57	0.36	0.001	10.6	0.38	0.15	**12**
	Prairie Run	entirety	TP (lbs • year^{-1})	4119	900	---	90	1430	570	**7,109**
130-060	Little Walnut Creek	entirety	FC (cfu •10^{13} •season^{-1})	2.50	1.61	0.005	43.9	0.51	0.20	**49**
			TP (lbs • year^{-1})	18010	4054	---	370	1935	766	**25,135**

[1]All presented 14-digit HUCs are within the 8-digit HUC 05060001. The complete HUC identifier is the 8-digit stem followed by the 14-digit extension.

Table 5.1.E Total Existing Load, TMDL, Allocations

14-Digit HUC	Sub-Watershed	Sub-Watershed Extent (Upper RM-Lower RM)	Parameter (units)	Existing Loads			% Reduction	TMDL	Allocations		
				PS	NPS	Total			WLA	LA	MOS
130-010	Big Walnut Cr.	76.6 - 53.4	FC (cfu •10^{13} •season^{-1})	0.002	183	183	91	16.3	0.03	16.3	---
			TP (lbs • year^{-1})	203	35,200	35,403	65	12,368	203	11547	618
130-020	Culver Creek	entirety	FC (cfu •10^{13} •season^{-1})	0	20	20	78	4.3	0	4.3	---
			TP (lbs • year^{-1})	0	11,662	11,662	83	2,027	0	1,926	101
130-030	Big Walnut Cr.	53.4 - 50.4	FC (cfu •10^{13} •season^{-1})	0.005	15	15	78	3.3	0.007	3.3	---
	Perfect Creek	entirety	TP (lbs • year^{-1})	53	9,418	9,471	62	3,592	53	3359	180
130-040	Rattlesnake Creek	entirety	FC (cfu •10^{13} •season^{-1})	0.001	34	34	77	7.8	0	7.8	---
			TP (lbs • year^{-1})	11	20,028	20,039	72	5,671	0	5,388	284
130-050	Big Walnut Creek	50.4 - 47.9	FC (cfu •10^{13} •season^{-1})	0.25	12	12.3	68	3.9	1.9	2	---
	Prairie Run	entirety	TP (lbs • year^{-1})	3850	7,109	10,959	44	6135	4306	1704	126 [1]
130-060	Little Walnut Creek	entirety	FC (cfu •10^{13} •season^{-1})	0	49	49	78	10.6	0	10.6	---
			TP (lbs • year^{-1})	0	25,135	25,135	69	7,757	0	7,369	388

[1] Represents a 2% MOS, acceptable in this case because of point source dominance (closely regulated and monitored).

Table 5.1.F Point Source Allocations

Facility Name	NPDES Permit #	Receiving Stream	Parameter	Permit Limits		Allocated Load[1]
				Existing	Proposed	
Town of Marengo	4PA00101	Big Walnut Creek	FC	1000 cfu	1000 cfu	0.03
			TP	none	none	existing
Morning View Care Center	4PS00016	Perfect Creek	FC	1000 cfu	1000 cfu	0.007
			TP	none	none	existing
Town of Sunbury WWTP	4PB00010	Big Walnut Creek	FC	1000 cfu	1000 cfu	0.78
			TP	none	0.5 mg/l	1715
Town of Galena WWTP[2]	4PB00106	Big Walnut Creek	FC	1000 cfu	1000 cfu	1.18
			TP	1.0 mg/l	0.5 mg/l	2591

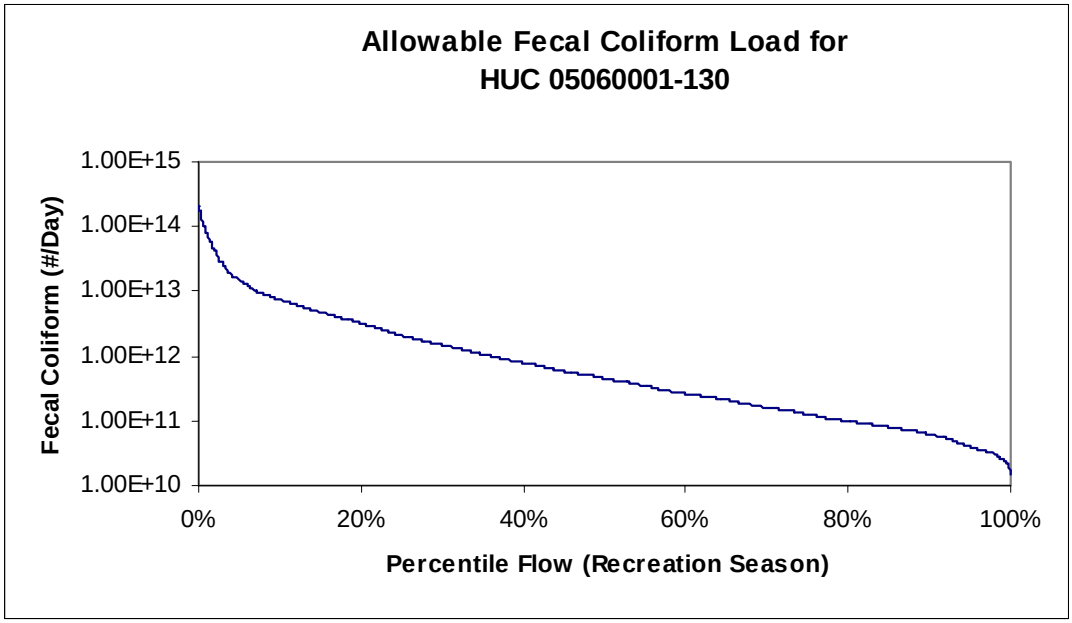
[1]Allocated loads are expressed in cfu $\bullet 10^{13} \bullet$ season^{-1} for fecal coliform and lbs $\bullet$ year $^{-1}$ for total phosphorus.
[2]For proposed expansion to 1.7 MGD.

Table 5.1.G Non-Point Source Allocations

14-Digit HUC[1]	Sub-Watershed	Sub-Watershed Extent (Upper RM-Lower RM)	Cause[2]		Individual Non-Point Sources					
					Cropland	Pasture	Forest	Cattle Instream	Septic	Aerator
130-010	Big Walnut Cr.	76.6 - 53.4	FC	Allocation	4.99	4.52	0.01	6.71	0	0.04
				% Reduction[3]	0%	0%	0%	96%	100%	66%
			TP	Allocation	8774	2139	0	501	0	132
				% Reduction[3]	66%	66%	0%	66%	100%	66%
130-020	Culver Creek	entirety	FC	Allocation	1.09	0.51	0.002	2.70	0	0.034
				% Reduction[3]	0%	0%	0%	85%	100%	81%
			TP	Allocation	1,524	247	0	28	0	126
				% Reduction[3]	81%	81%	0%	81%	100%	81%
130-030	Big Walnut Cr.	53.4 - 50.4	FC	Allocation	0.86	0.41	0.001	2.01	0	0.06
				% Reduction[3]	0%	0%	0%	85%	100%	58%
	Perfect Creek	entirety	TP	Allocation	2637	435	0	47	0	240
				% Reduction[3]	58%	58%	0%	58%	100%	58%
130-040	Rattlesnake Creek	entirety	FC	Allocation	2.16	0.95	0.002	4.63	0	0.04
				% Reduction[3]	0%	0%	0%	85%	100%	71%
			TP	Allocation	4493	690	0	73	0	132
				% Reduction[3]	71%	71%	0%	71%	100%	71%
130-050	Big Walnut Creek	50.4 - 47.9	FC	Allocation	0.57	0.35	0.001	1.0	0	0.02
				% Reduction[3]	0%	0%	0%	90%	100%	90%
	Prairie Run	entirety	TP	Allocation	1236	270	0	27	0	171
				% Reduction[3]	70%	70%	0%	70%	100%	70%
130-060	Little Walnut Creek	entirety	FC	Allocation	2.50	1.61	0.005	6.40	0	0.06
				% Reduction[3]	0%	0%	0%	85%	100%	68%
			TP	Allocation	5721	1288	0	118	0	243
				% Reduction[3]	68%	68%	0%	68%	100%	68%

The fecal coliform TMDLs and allocations presented above are the core of the pathogen TMDL. It should be noted, however, that the acute fecal coliform criterion of 2000 cfu must be maintained to ensure complete attainment of recreational designated use. The load duration curve presented in Figure 4 is a visual depiction of the allowable daily fecal coliform as specified by OAC. To achieve full attainment, no more than ten percent of fecal coliform samples collected may be plotted above the line on the graph. To plot a sample it must be converted to a load by multiplying by daily flow volume. The daily load is then plotted with percentile flow as the independent variable.

Figure 4: Allowable daily fecal coliform load



5.1.5 Habitat and Sediment TMDLs

QHEI assessment results for habitat and flow limited streams are presented in Table 5.1.H. The observed condition for individual variables (e.g. substrate, cover, etc.) and the total QHEI score are provided. The presence of modified habitat attributes, and their relative magnitude (high vs. moderate), is also noted for each assessment site.

Habitat and sediment TMDL scores are also presented in Table 5.1.H. Sediment scores are the sum of the substrate, channel, and riparian categories. The target sediment score of ≥33 is analogous to a loading capacity, and the target scores for substrate, channel, and riparian are the rough equivalent of allocations. The habitat score is the sum of the high and moderate influence attribute scores, and the QHEI to target ratio score. See Section 4.1.1 for more information.

Table 5.1.H Existing and Target Habitat and Sediment Conditions

Habitat Limited Stream	River Mile	Assessment Results										TMDL Scores	
		QHEI Categories							QHEI	Modified Attributes		Sediment	Habitat
		Substrate	Cover	Channel	Riparian	Pool	Riffle	Gradient		High Influence	Moderate Influence		
Targets		*≥14*	*≥12*	*≥14*	*≥5*	*Sum ≥15*			*≥60*	*<2*	*Total Modified Attributes <5*	*≥33*	*3*
Big Walnut Creek	72.5	14.0	14.0	9.0	7.0	7.5	0.0	4	55.5	③	①③④⑦⑧⑨	30.0	1
	66.6	13.0	15.0	12.0	5.5	7.0	0.0	6	58.5		③④⑦	30.5	2
Reynolds Run	4.9	12.0	6.0	15.0	8.5	2.0	0.0	10	53.5	④⑤	③④⑥⑦	35.5	0
	0.7	15.0	12.0	8.5	4.5	7.5	1.5	10	59.0	③④	③④⑦⑧⑨	28.0	0
Culver Creek	4.5	11.0	12.0	14.5	6.0	3.0	0.0	10	56.5	⑤	③④⑦	31.5	2
N. Fork Rattlesnake Creek	5.8	11.0	5.0	9.5	4.0	5.5	0.0	6	41.0	③④	①④⑤⑦⑧	24.5	0
	4.8	10.0	15.0	15.0	6.0	6.5	0.0	6	58.5		③④⑦	31.0	2
	3.4	11.5	5.0	7.5	3.0	4.5	0.0	6	37.5	③④	①③④⑤⑦⑧	22.0	0
	1.7	15.5	12.0	13.0	4.0	5.0	0.0	10	59.5	③	④⑦⑧	32.5	2
E. Fork Rattlesnake Creek	4.2	11.0	11.0	11.0	4.5	3.0	0.0	8	48.5	③⑤	①③④⑦	26.5	0
	0.2	9.5	13.0	14.5	4.0	5.0	0.0	10	56.0		③④⑦⑧	28.0	2
S. Fork Rattlesnake Creek	3.7	10.0	14.0	16.0	5.0	6.5	0.0	8	59.5		③⑦	31.0	2
	0.5	11.5	10.0	13.5	7.0	5.0	0.0	6	53.0		③④⑦⑧	32.0	2
Long Run	4.9	7.5	11.0	15.0	10.0	3.0	0.0	10	56.5	⑤	③④⑦⑧	32.5	1
Prairie Run	0.7	12.0	8.0	9.5	4.0	5.5	2.0	10	51.0	③④	①③④⑦⑧⑨	25.5	0
Butler Run	1.2	14.0	10.0	5.5	2.5	4.0	1.0	8	45.0	①③④	①③④⑦⑧⑨	22.0	0
Duncan Run	5.0	12.0	12.0	16.0	5.5	4.0	0.0	8	57.5		④⑦	33.5	2

Key to High-Influence Modified Attributes:

① Channelized with no recovery
② Silt or muck substrates
③ Low sinuosity
④ Sparse or no cover
⑤ Max. pool depth less than 40 cm

Key to Moderate Influence Modified Attributes:

① Channelized, but recovering
② Sand substrate
③ Hardpan substrate origin
④ Fair or poor channel development
⑤ Only one or two cover types
⑥ Intermittent or poor pool quality
⑦ No fast current
⑧ High to moderate substrate embeddedness
⑨ Extensive to moderate riffle embeddedness
⑩ No riffle

5.2 Lower Big Walnut Creek (Assessment Unit 05060001-140)

This Assessment Unit includes the mainstem of Big Walnut Creek below Hoover Reservoir to its confluence with Alum Creek and Blacklick Creek, and the tributaries to Big Walnut Creek in this area. The Assessment Unit also includes Blacklick Creek and its tributaries.

5.2.1 Assessment Results

Big Walnut Creek Mainstem

The biological community performance decline downstream from Hoover Reservoir at RM 37.2 was attributed to the effects of the reservoir's hypolimnetic release. The fish and macroinvertebrate communities improved into the good to exceptional range by SR 161 (RM 34.9) and remained in FULL attainment of the designated aquatic life uses until its confluence with the Scioto River. Elevated nutrients at RMs 37.2 and 34.9, high bacterial counts from RMs 37.2 to 27.0 (E. coli as high as 23,000/100 ml at RM 28.3 and fecal coliform as high a 20,000/100 ml at RM 28.3), and sediment contamination throughout this section (metals, PAHs, and pesticides) were indications of runoff from surrounding suburban areas.

Biological community performance in Big Walnut Creek has remained about the same or slightly improved compared to previous sampling. Surface water chemistry sampling demonstrated an improvement downstream from the Marengo WWTP and the Columbus Airport tributary. An area that declined in 2000 was downstream from Rocky Fork Big Walnut Creek with increased mean bacterial counts and total suspended solids.

The results of the biological survey are presented in Table 5.2.A.

The recreational use of the Big Walnut Creek mainstem in this assessment unit is Primary Contact Recreation (PCR). The recreational use bacteriological criteria are being met on an average basis, but the frequency and magnitude of peak events are exceeding the criterion for fecal coliform. Therefore, there is an impairment of the recreational use for the Big Walnut Creek mainstem.

Tributaries to Big Walnut Creek

Biosurvey sampling was conducted at 12 stations in eight streams that are minor tributaries (including Rocky Fork) to Big Walnut Creek downstream from Hoover Reservoir. Of these, two stations were in FULL attainment of their existing or recommended aquatic life use designation, two were PARTIAL, seven were NON, and one was located in a primary headwater stream.

McKenna Creek is a small suburban stream that was apparently impacted by failing HSTS and urban runoff. Biological results (macroinvertebrate) reflected fair resource quality.

Rocky Fork Big Walnut Creek was impacted primarily from runoff and siltation from increasing land development in the basin and from poorly treated sewage from failing HSTS and several small package plants. The biological communities in the upper part of Rocky Fork were performing as bad or worse than any time since the initial study in 1991 (Ohio EPA 1992). Sugar Run and Rose Run were showing varying degrees of impact from land development in the New Albany area.

The "Columbus Airport Tributary" was impacted by channelization, removal of the woody riparian corridor, runoff from Port Columbus International Airport including the persistent spillage of large quantities of airplane deicing solution (ethylene glycol), and sediment contamination (metals, PAHs). The resource quality is similar to the 1996 survey results (Ohio EPA 1997) except for the detection in the sediment sample of six PAHs in excess of the threshold effect concentration or the probable effect concentration.

The Mason Run basin is highly urbanized. The headwaters of Mason Run originate in an industrial area and then flow through a section that is highly modified including an underground culvert from RMs 3.4 to 1.9. The fair to poor biological communities reflected the negative impacts from habitat alterations, flow alterations, and polluted runoff from the upstream urban areas. The resource quality has declined since the 1996 survey (Ohio EPA 1998a) when at least the fish community was meeting WWH expectations.

Results of the Biological Survey are shown in Table 5.2.A.

McKenna Creek, and the Unnamed Tributary to Big Walnut at the Columbus Airport were not attaining their recreational use of PCR for both geometric mean and for 90th percentile on one or both bacterial indicators. Rocky Fork was not attaining its recreational use for 90th percentile fecal coliform values as compared to the target.

<u>Blacklick Creek Mainstem</u>

The study area included 13 stations on the Blacklick Creek mainstem from the headwaters at Walnut St. (RM 27.1) to near its confluence with Big Walnut Creek at Hamilton Rd. (RM 2.6). Seven stations were in FULL attainment of their existing or recommended aquatic life use designation, one was PARTIAL, three were NON, and two were in WWTP mixing zones.

The biological communities in the headwaters of Blacklick Creek were severely impacted by failing HSTS. Both the fish and macroinvertebrate communities were in poor condition at this station and the water quality was likewise highly degraded with very high bacterial counts, low D.O. concentrations, and very high BOD_5 and nutrient concentrations. In addition to HSTS, Hendren Farms (250 dairy cows) has recently been having problems with manure spillage into Blacklick Creek near Central College Rd. (RM 26.0). Sediment sampling at Morse Rd. (RM 22.4) found one PAH in excess of the threshold effect concentration and five PAHs in excess of the probable effect

concentration. The biological communities gradually improved downstream until the WWH use was fully attained at Havens Rd. (RM 20.4).

The Jefferson Township Wengert Rd. WWTP (RM 18.10) was not specifically evaluated during this study. The WWH aquatic life use was fully attained upstream and downstream from the discharge, however, an unusually high relative predominance of pollution facultative and tolerant macroinvertebrate organisms observed on the natural substrates and increases in elevated nutrient concentrations recorded downstream from the WWTP discharge at Broad St. (RM 16.6) suggested a mild impact from the WWTP. This WWTP was abandoned and connected to the Columbus sewage system on June 25, 2003.

Biological and water chemistry sampling in the vicinity of the Fairfield County - Tussing Rd. WWTP (RM 11.15) indicated only a mild impact from the WWTP discharge. Biological communities upstream from the discharge were in FULL attainment of the WWH aquatic life use. The samples within the mixing zone did not indicate any significant toxicity from the discharge. Sampling outside the mixing zone and immediately downstream revealed a mild impact to the macroinvertebrate community. The aquatic life use attainment status remained FULL, however, the ICI score dropped from 48 upstream from the WWTP at RM 11.3 to 38 downstream at RM 11.0. This decline indicated mild organic/nutrient enrichment from the WWTP discharge. The macroinvertebrate community improved slightly by Refugee Rd. (RM 8.9) upstream from the Blacklick Estates WWTP discharge. The water column chemistry and bacterial sampling detected concentrations of ammonia (7.32 mg/l) and fecal coliform (25,000/100 ml) in the effluent that exceeded the permit limits. One fecal coliform count of 11,181/100 ml measured at RM 11.0 was substantially higher than any found upstream from the WWTP discharge. Elevated nutrient and demand parameter concentrations downstream from the WWTP discharge were evidence of the pollution loadings from the WWTP.

Biological and water chemistry sampling in the vicinity of the Blacklick Estates WWTP (RM 4.85) indicated only a mild to moderate impact from the WWTP discharge. Biological communities upstream from the discharge were in FULL attainment of the WWH aquatic life use. The samples within the mixing zone did not indicate any significant toxicity from the discharge. Sampling outside the mixing zone and immediately downstream revealed a moderate impact to the macroinvertebrate community resulting in a fair community (ICI=26). The fish community exhibited no decline downstream from the discharge so the attainment status was PARTIAL downstream from the Blacklick Estates WWTP. The biological communities were in FULL attainment farther downstream, upstream from Hamilton Rd. (RM 2.6). The water column chemistry and bacterial sampling did not detect any significant exceedences of water quality criteria attributable to the Blacklick Estates WWTP discharge. A fecal coliform count of 3000/100ml and E. coli counts as high as 2900/100ml collected downstream from the WWTP discharge at RM 4.6 were exceedences of the primary and secondary contact recreation criterion, respectively. However, they are not much different from collection sites upstream from the discharge. Similarly, elevated nutrient and demand parameter concentrations sampled downstream from the WWTP discharge

were not dissimilar to upstream stations. Sediment chemistry sampling at RM 1.9 found concentrations of two PAHs exceeding the threshold effect concentration.

The biological results from 2000 reflected a similar trend compared to the 1996 survey (Ohio EPA 1998b) with the exception of lower macroinvertebrate performance downstream from the Blacklick Estates WWTP. The water chemistry results from the current study were similar to the 1996 survey except for increased mean fecal coliform counts downstream from the Tussing Rd. WWTP, decreased mean BOD_5 concentrations downstream from the Tussing Rd. WWTP and Blacklick Estates WWTP, and decreased mean nitrate+nitrite concentrations downstream from Blacklick Estates WWTP.

The results of the aquatic life use assessment are included in Table 5.2.A.

The Blacklick Creek mainstem is impaired for its recreational use for frequency and magnitude of peak values of fecal coliform.

Tributaries to Blacklick Creek

Biosurvey sampling was conducted at eight stations in seven streams that were tributaries to Blacklick Creek. Of these, three stations were in FULL attainment of their existing or recommended aquatic life use designation, two were PARTIAL, and three were NON.

The stations on Blacklick Creek tributaries were generally all similar in that the fish communities were meeting biocriteria benchmarks and the macroinvertebrate communities were not. Diversity of pollution sensitive macroinvertebrate taxa was relatively low and facultative or tolerant taxa were present in higher numbers than expected. Persistently high bacterial counts, mild nutrient enrichment and sedimentation at these stations were indications of the increasingly suburbanized nature of this watershed.

“Unzinger Ditch”, a tributary to Blacklick Creek at RM 15.88, was not evaluated during this study, but was assessed by Ohio EPA (2001). That study found the biological communities to be in non-attainment of aquatic life uses due to stream channel modifications, toxicity associated with contaminated sediments, and nutrient enrichment from sewage. The most severe sediment contamination was found downstream from the discharge and potential runoff from the Columbus Steel Drum Company.

The results of the aquatic life use assessment are presented in Table 5.2.A.

Powell Ditch, Tributaries to Blacklick Creek at SR 256 and at Waggoner Road, French Run and Dysar Run were not attaining their Recreational Uses for geometric mean values and for frequency and magnitude of peak values of fecal coliform.

Table 5.2.A. Aquatic life use attainment status of the Big Walnut Creek basin, June-October, 2000. The Index of Biotic Integrity (IBI), Modified Index of Well Being (MIwb), and Invertebrate Community Index (ICI) scores are based on the performance of fish (IBI, MIwb) and macroinvertebrate communities (ICI). The Qualitative Habitat Evaluation Index (QHEI) is a measure of the ability of the physical habitat to support biological communities.

River Mile		IBI	MIwb	ICI[b]	QHEI	Attainment Status	Comment
Fish[a]	Invert.						
Big Walnut Creek (02-100) *WWH Use Designation (Existing)*							
37.2[A]		32*	8.1[ns]	34ns	84.5	PARTIAL	Dst. Reservoir
-	34.9	-	-	40	-	(FULL)	SR 161
28.5[A]	28.3	49	10.2	40	82	FULL	Dst. Morse Rd. WTP, ust. airport trib.
26.7[A]	27	52	9.8	48	83.5	FULL	Dst. airport trib.
EWH Use Designation (Existing)							
15.8[A]		48	10.1	46	84.5	FULL	Williams Rd.
7.1[A]	7.0[c]	48	9.5[ns]	44ns	83	FULL	SR 317
-	3.6	-	-	46	-	(FULL)	Rowe Rd., dst. Rickenbacker
1.7[A]		52	9.3[ns]	42ns	84	FULL	US 23
Trib. to Big Walnut Creek (RM 32.6) (02-334) *WWH Use Designation (Recommended)*							
0.2[E]	-	34*	NA	-	58.5	**(NON)**	Off Cherry Bottom Rd.
McKenna Creek (02-347) *WWH Use Designation (Recommended)*							
-	0.2	-	-	F*	-	**(NON)**	Cherry Bottom Rd.
Rocky Fork (02-123) *WWH Use Designation (Existing)*							
10.2[E]		32*	NA	F*	60	**NON**	Ust. Walnut St., ust. trib.
7.1[D]		38[ns]	NA	MG[ns]	60	FULL	Old SR 161
5.9[D]		28*	NA	F*	73.5	**NON**	Thompson Rd.
EWH use Designation (Existing)							
3.3[D]	3.2	36*	7.4*	50	66	PARTIAL	Clark State Rd.
1.1[E]	1	46[ns]	8.6*	46	81	PARTIAL	Hamilton Rd.
Sugar Run (02-260) *WWH Use Designation (Existing)*							
0.7[E]		38[ns]	NA	MG[ns]	66.5	FULL	Old SR 161
Rose Run (02-252) *WWH Use Designation (Existing)*							
0.5[E]	-	32*	NA	-	55.5	**(NON)**	Harlem Rd.
Trib. to Big Walnut Creek (RM 27.29) (02-280) *WWH Use Designation (Recommended)*							
0.2[E]		26*	NA	P*	53.5	**NON**	Dst. Columbus Airport
Trib. to Big Walnut Creek (RM 27.25) (02-335) *Potential PHWH Use Designation*							
0.1[E]	-	12	NA	-	54.5	NA	Dst. Columbus Airport

River Mile Fish[a]	Invert.	IBI	MIwb	ICI[b]	QHEI	Attainment Status	Comment
Mason Run (02-122) *WWH Use Designation (Existing)*							
1.4[E]	0.5	28*	NA	P*	55.5	**NON**	Petzinger Rd./Refugee Rd.
Blacklick Creek (02-130) *WWH Use Designation (Existing)*							
27.1[E]		20*	NA	P*	53.5	**NON**	Walnut St.
24.7[E]		34*	NA	Low F*	76	**NON**	SR 161
22.4[E]	23	32*	NA	F*	70.5	**NON**	Morse Rd.
20.4[E]		46	NA	G	63	FULL	Havens Rd.
16.6[D]		44	8.7	44	70	FULL	Broad St.
13.7[D]		46	8.5	MG[ns]	71.5	FULL	Main St.
11.3[D]		39[ns]	8.0[ns]	48	76.5	FULL	Ust Tussing Rd. WWTP
11.14[D]	11.1	40	7	F/F	NA	NA	Tussing Rd. WWTP mixing zone
11.0[D]		44	8.6	38	70	FULL	Dst. Tussing Rd. WWTP
8.8[D]	8.9	46	9.4	40	70.5	FULL	Refugee Rd.
4.83[D]		39	8.5	F/F	NA	NA	Blacklick Estates WWTP mix zone
4.6[D]	4.5	46	8.9	26*	69	PARTIAL	Dst. Blacklick Estates WWTP
2.6[D]		43	8.4	42	78	FULL	Ust. Hamilton Rd.
Unzinger Ditch (Trib. To Blacklick Cr. (RM 15.88)) (02-333) *LRW Use Designation (Existing)*							
0.9	-	12	NA	P	27.5	**NON**	Ust. Columbus Steel Drum
WWH Use Designation(Existing)							
0.5	-	30*	NA	VP*	51.0	**NON**	Dst. Columbus Steel Drum
0.1	-	32*	NA	VP*	57.0	**NON**	Near mouth
Dysar Run (Trib. to Blacklick Cr. (RM 14.64)) (02-281) *WWH Use Designation (Existing)*							
3.0[E]	2.1[c]	40	NA	F*	49	PARTIAL	Railroad bridge/Waggoner Rd.
1.9[E]	1.6	42	NA	P*	68	**NON**	SR 16
Tributary to Dysar Run (RM 1.67) (02-342) *WWH Use Designation (Recommended)*							
0.2[E]	-	42	NA	-	52	(FULL)	Waggoner Rd.
French Run (Trib. to Blacklick Cr. (RM 13.66)) (02-290) *WWH Use Designation (Existing)*							
0.6[E]	0.7	48	NA	F*	55	PARTIAL	Waggoner Rd.
North Branch French Run (Trib. to French Run (RM 0.33)) (02-291) *EWH Use Designation (Existing)*							
-	0.2	-	-	MG*	-	**(NON)**	Behind French Run Elem. Sch.
"Lees Creek" (Trib. to Blacklick Cr. (RM 11.25)) (02-288) *WWH Use Designation (Existing)*							
0.3[E]	-	48	NA	-	73.5	(FULL)	Ust. SR 256

River Mile Fish[a]	Invert.	IBI	MIwb	ICI[b]	QHEI	Attainment Status	Comment
Tributary to Blacklick Creek (RM 10.36) (02-287) *WWH Use Designation (Existing)*							
0.2[E]	-	42	NA	-	70	(FULL)	Dst. SR 256
"Powell Ditch" (Trib. to Blacklick Cr. (RM 6.50)) (02-286) *WWH Use Designation (Existing)*							
0.8[E]	0.9	36[ns]	NA	P*	49.5	**NON**	Dst. Brice

* 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 Fish sampling methods: A=Boat, D=Wading, E=Longline.
b Narative evaluation based on qualitative macroinvertebrate sample (E=Exceptional, VG=Very Good, G=Good, F=Fair, Low F=Low Fair, P=Poor, and VP=Very Poor).
c Macroinvertebrate sample was collected in 2001 and may be replacing a 2000 sample.

5.2.2 Causes and Sources of Impairment

Big Walnut Creek Mainstem

Aquatic life use impairment observed in the mainstem Big Walnut Creek in this Assessment Unit is attributed to the hypolimnetic release from Hoover Reservoir.

Recreational use impairment is attributed to urban runoff and HSTS that do not adequately treat bacteria, resulting in peak bacterial concentrations that are above targets.

Tributaries to Big Walnut Creek

McKenna Creek
Causes of non-attainment for aquatic life use were attributed to be pathogens, nutrients, suspended solids, and ammonia, while the pathogens would be a cause of non-attainment of the recreational use. Sources for these pollutants were attributed to urban runoff and failing HSTS.

Rocky Fork
Causes of non-attainment of the recreational use and the aquatic life use were pathogens, with nutrients being a contributing factor, especially in the headwaters. Sources for these pollutants were determined to be failing HSTS and land development.

Rose Run
Causes of non-attainment of the aquatic life use in Rose Run was direct alteration of the physical habitat of the stream. Sources of the impairment are attributed to channelization and land development.. Sources of the bacteria are HSTS that are either failing, or inadequate to treat for bacteria.

Mason Run

Causes of non-attainment of the aquatic life use in Mason Run are attributed to be flow alteration and direct modification of the habitat. Sources of the nonattainment are land development and urban runoff. Mason Run was not attaining its recreational use for both geometric mean and 90th percentile fecal coliform and *E. coli*. That bacterial contamination of Mason Run is attributed to urban runoff and failing HSTS.

Blacklick Creek Mainstem

Causes of impairment in the Blacklick Creek mainstem were attributed to ammonia, nutrients, and organic enrichment. Sources of these pollutants were attributed to HSTS, and to point source discharges from wastewater treatment plants tributary to Blacklick Creek. Recreational use impairment was attributed to these same sources.

Tributaries to Blacklick Creek

Dysar Run
Causes of impairment in Dysar Run are attributed to siltation, the source of the impairment was attributed to land development. Causes of impairment of recreational use are exceedence of the standard for peak magnitude and frequency of fecal coliform bacteria. Sources of the impairment of the recreational use are attributed to HSTS that do not adequately treat for bacteria.

French Run
Causes of impairment in French Run and North Branch French Run were attributed to siltation, the source of the impairment was attributed to land development and urban runoff. Recreational use impairment in French Run results from exceedence of geometric mean and peak values for fecal coliform, and is attributed to HSTS that do not adequately treat for bacteria.

"Powell Ditch" - Tributatry to Blacklick Creek at RM 6.50
The cause of impairment in Powell Ditch is habitat modification due to direct alteration of the channel, and the source is attributed to land development and urban runoff.

Unzinger Ditch

The causes of impairment in Unzinger Ditch are stream channel modifications, toxicity associated with contaminated sediments, and nutrient enrichment from sewage. Sources of impairment are largely run-off from the Columbus Steel Drum site, and HSTS.

5.2.3. Deviation from Target

Table 5.2.B. Deviation from Target in HUC 05060001-140, Big Walnut and Blacklick Creeks

05060001-140: Big Walnut Creek below Hoover Reservoir to Three Creeks Park confluence					
Affected Waterbodies	**Cause of Impairment**	Target Parameter *units*	Target	Observed Condition	Deviation from Target
140-010: Big Walnut Creek below Hoover Reservoir to above Rocky Fork					
All within 14 digit HUC	**Pathogens**	Fecal Coliform *cfu*[1]	2000 (90th percentile)	6616	97%
McKenna Creek	**Nutrients**	TP *mg/l*	0.11	0.15	26 %
140-020: Rocky Fork					
All within 14 digit HUC	**Nutrients**	TP *mg/l*	0.11	0.05 - 1.18	0 - 90.7 %
Rocky Fork	**Pathogens**	Fecal Coliform *cfu*[1]	2,000	7514	73.4 %
Rose Run	**Habitat Alteration**	QHEI	60	55.5	8.2 %
140-030: Big Walnut Creek below Rocky Fork to above Blacklick Creek					
All within 14 digit HUC	**Pathogens**	Fecal Coliform *cfu*[1]	1000 / 2000	1303 / 10531	23.2 % / 81 %
Trib. @ RM 27.29	**Habitat Alteration**	QHEI	60	53.5	12 %
	Flow Alteration	QHEI	60	53.5	12 %
140-040: Mason Run					
All within 14 digit HUC	**Pathogens**	Fecal Coliform *cfu*[1]	1000 / 2000	1328 / 2618	24.7 % / 23.6 %
	Habitat Alteration	QHEI	60	55.5	8.2 %

Affected Waterbodies	Cause of Impairment	Target Parameter *units*	Target	Observed Condition	Deviation from Target
140-050: Blacklick Creek headwaters to near Brice					
All within 14 digit HUC	**Pathogens**	Fecal Coliform *cfu*[1]	2000 (90th percentile)	4000	50%
	Nutrients	TP *mg/l*	0.11	0.05 - 5.4	0 - 98%
Blacklick above RM 27.1	**Ammonia**	NH_3 *mg/l*	1.1	4.52	75.7 %
French Run	**Siltation**	QHEI Metrics	33	30	9.1 %
140-060: Blacklick Creek near Brice to Big Walnut Creek					
All within 14 digit HUC	**Pathogens**	Fecal Coliform *cfu*[1]	2000 (90th percentile)	2939	31.9 %
	Nutrients	TP *mg/l*	0.11	0.05 - 0.575	0 - 80.9 %

[1] Fecal Coliform counts expressed as cfu (colony forming units) equates to the measurement of fecal coliform, number per 100ml.

5.2.4 Existing Loads, Loading Capacity, and Allocations

Existing total phosphorus and fecal coliform loads were estimated for impacted sub-watersheds in Assessment Unit 05060001-140. Total phosphorus loads were calculated for sub-watersheds where excessive instream nutrient concentration were observed. These sub-watersheds include McKenna Creek, Rocky Fork, and Blacklick Creek. Elevated nutrient concentrations were observed in Unzinger Ditch, but separate loads were not calculated for this sub-watershed as they are included within the Blacklick Creek results. Fecal coliform loads were calculated for all 14-digit HUCs within the assessment unit. Calculating the fecal coliform loads at this scale and for all 14-digit HUCs was both practical and logical because of the scattered distribution of bacteria standards violations.

Existing point source loads for individual entities and as HUC totals are presented in Table 5.2.C. Existing non-point source loads are presented in Table 5.2.D. The non-point sources considered in the assessment unit are surface runoff, cattle instream, home septic systems, home aerator systems, groundwater, and upstream flow.

Total existing loads, TMDLs, WLAs, and LAs for the assessment unit are presented in Table 5.2.E. Also included in the table is the percent existing load reduction needed to achieve the TMDL. WLAs and LAs are 14-digit HUC totals; individual allocations for point source entities are presented in Table 5.2.F, and allocations for each non-point source are given in Table 5.2.G. Wasteload allocations for surface runoff from MS4 areas and load allocations for surface runoff from non-MS4 areas are presented in Table 5.2.H

Table 5.2.C. Existing Point Source Loads in HUC 05060001-140

14-Digit HUC[1]	**Facility Name** *NPDES Permit #*	**Median Q** *MDG*	**[TP]**[2] *mg/l*	**[FC]**[3] *cfu*	**Facility Loads**		**HUC Loads**	
					TP *lb/year*	FC *cfu/season*	TP *lb/year*	FC *cfu/season*
140-020	Taylor Estates *4PA00001*	0.012	3.00	20.8	110	1.72E+09	850	4.06E+10
	Westerville Estates MHP *4PA00011*	0.043	3.00	113.9	393	3.41E+10		
	Jefferson WSD WWTP Windrush Rd. *4PQ00001*	0.38	3.00	18.1	347	4.78E+09		
140-050	Jefferson WSD WWTP Wengert Rd. *4PQ00000*	0.142	1.10	54.8	476	5.42E+10	3597	3.48E+11
	Fairfield County WWTP Tussing Rd. 4PU00004	1.177	0.85	34.5	3047	2.83E+11		
	Modern MHP *4PV00114*	0.004	3.00	200	37	5.58E+09		
	By-Willow MHP *4PV00117*	0.004	3.00	200	37	5.58E+09		
140-060	Ohio-American Water Co. Blacklick Estates WWTP *4PU00002*	0.887	1.43	294.6	3864	1.82E+12	3864	1.82E+12

[1]All presented 14-digit HUCs are within the 8-digit HUC 05060001. The complete HUC identifier is the 8-digit stem followed by the 14-digit extension.
[2]Values in this column represent the historical total phosphorus effluent concentration for each facility. For information regarding the source and period of record for each value, see Table B-4 in Appendix B.
[3]Values in this column represent the historical fecal coliform effluent concentration for each facility. For information regarding the source and period of record for each value, see Table B-18 in Appendix B.

Table 5.2.D. Existing Non-Point Source Loads in HUC 05060001-140

14-Digit HUC[1]	**Sub-Watershed**	**Sub-Watershed Extent** (Upper RM-Lower RM)	**Parameter** (units)	**Existing Non-Point Source Loads**						
				Runoff	Cattle	Septic	Aerator	GW	Upstream	**Total**
140-010	Big Walnut Cr.	37.5 - 29.0	FC (count •10^{13} •season^{-1})	12.6	0	0.169	0.641	0	97.9	111
	McKenna Cr.	Entirety	TP (lbs • year^{-1})	705	0	22	112	37	0	876
140-020	Rocky Fork	Entirety	FC (count •10^{13} •season^{-1})	29.4	25.8	0.125	2.62	0	0	57.9
			TP (lbs • year^{-1})	16,343	0	244	5,124	872	0	22,583
140-030	Big Walnut Cr.	29.0 - 15.5	FC (count •10^{13} •season^{-1})	18.0	0	0.396	0.161	0	118	137
140-040	Mason Run	Entirety	FC (count •10^{13} •season^{-1})	10.3	0	0.016	0.123	0	0	10.4
140-050	Blacklick Cr.	Headwaters - 8.2	FC (count •10^{13} •season^{-1})	58.9	43.0	0.044	3.46	0	0	105
	Blacklick Cr.	Entirety	TP (lbs • year^{-1})	36,041	0	137	6,692	1,761	0	44,631
140-060	Blacklick Cr.	8.2 - Big Walnut	FC (count •10^{13} •season^{-1})	9.55	0	0.035	0.577	0	22.1	32.3

[1]All presented 14-digit HUCs are within the 8-digit HUC 05060001. The complete HUC identifier is the 8-digit stem followed by the 14-digit extension.

Table 5.2.E. Total Existing Load, TMDL, and Allocations for HUC 05060001-140

14-Digit HUC[1]	Sub-Watershed	Sub-Watershed Extent (Upper RM-Lower RM)	Parameter (units)	Existing Loads			%Reduction	TMDL	Allocations		
				PS	NPS	Total			WLA	LA	MOS
140-010	Big Walnut Cr.	37.5 - 29.0	FC (count •10^{13} •season^{-1})	0	111	111	5%	105	5.32	99.7	0
	McKenna Cr.	Entirety	TP (lbs • year^{-1})	0	876	876	58%	368	284	84.1	37.0
140-020	Rocky Fork	Entirety	FC (count •10^{13} •season^{-1})	0.004	57.9	57.9	77%	13.4	6.72	6.68	0
			TP (lbs • year^{-1})	850	22,583	23,433	62%	8,897	2,851	5,156	890
140-030	Big Walnut Cr.	29.0 - 15.5	FC (count •10^{13} •season^{-1})	0	137	137	2%	134	15.8	118	0
140-040	Mason Run	Entirety	FC (count •10^{13} •season^{-1})	0	10.4	10.4	45%	5.71	5.64	0.068	0
140-050	Blacklick Cr.	Headwaters - 8.2	FC (count •10^{13} •season^{-1})	0.035	105	105	78%	23.1	12.3	10.8	0
	Blacklick Cr.	Entirety	TP (lbs • year^{-1})	7,461	44,631	52,092	62%	19,884	11,502	8,382	1,988
140-060	Blacklick Cr.	8.2 - Mouth	FC (count •10^{13} •season^{-1})	0.182	32.3	32.5	5%	30.7	6.21	24.5	0

[1]All presented 14-digit HUCs are within the 8-digit HUC 05060001. The complete HUC identifier is the 8-digit stem followed by the 14-digit extension.
[2]A phosphorus TMDL was developed for the entirety of Blacklick Creek, which includes HUCs 05060001-140-050 and 05060001-140-060.

Table 5.2.F. Point Source Allocations for HUC 05060001-140

Facility Name *NPDES Permit #*	**Design Q** *MDG*	**Permit Limit**		**WLA**	
		TP *mg/l*	FC *cfu*	TP *lb/year*	FC *count/season*
Taylor Estates *4PA00001*	.025	1.0	1000	76	1.59E+11
Westerville Estates MHP *4PA00011*	0.07	1.0	1000	213	4.45E+11
Jefferson WSD WWTP Windrush Rd.[1] *4PQ00001*	0	-	-	0	0
Jefferson WSD WWTP Wengert Rd.[1] *4PQ00000*	0	-	-	0	0
Fairfield County WWTP Tussing Rd. 4PU00004	3.0	0.5	1000	4,569	1.91E+13
Modern MHP *4PV00114*	.004	1.0	1000	12	2.54E+10
By-Willow MHP[1] *4PV00117*	0	-	-	0	0
Ohio-American Water Co. Blacklick Estates WWTP *4PU00002*	1.2	0.5	1000	1,828	7.63E+12

[1] No load allocated. Facility is closed or scheduled for decommission.

Table 5.2.G. Non-Point Source Allocations for HUC 0506000-140

14-Digit HUC[1]	Sub-Watershed (Upper RM-Lower RM)	Parameter		Non-Point Source Allocations				
				Cattle	Septic	Aerator	GW	Upstream
140-010	Big Walnut Cr. (37.5 - 29.0)	FC (count •10^{13} •season^{-1})	Allocation:	0	0	0.606	0	97.9
			% Reduction:	0%	100%	10%	0%	0%
	McKenna Cr. (Entirety)	TP (lbs • year^{-1})	Allocation:	0	0	47.1	37	0
			% Reduction:	0%	100%	58%	0%	0%
140-020	Rocky Fork (Entirety)	FC (count •10^{13} •season^{-1})	Allocation:	0	0	0.606	0	0
			% Reduction:	100%	100%	77%	0%	0%
		TP (lbs • year^{-1})	Allocation:	0	0	1947	872	0
			% Reduction:	0%	100%	62%	0%	0%
140-030	Big Walnut Cr. (29.0 - 15.5)	FC (count •10^{13} •season^{-1})	Allocation:	0	0	0.157	0	118
			% Reduction:	0%	100%	2%	0%	0%
140-040	Mason Run (Entirety)	FC (count •10^{13} •season^{-1})	Allocation:	0	0	0.068	0	0
			% Reduction:	0%	100%	45%	0%	0%
140-050	Blacklick Cr. (Headwaters - 8.2)	FC (count •10^{13} •season^{-1})	Allocation:	0	0	0.761	0	0
			% Reduction:	100%	100%	78%	0%	0%
	Blacklick Cr. (Entirety)	TP (lbs • year^{-1})	Allocation:	0	0	2554	1761	0
140-060			% Reduction:	0%	100%	62%	0%	0%
	Blacklick Cr. (8.2 -Mouth)	FC (count •10^{13} •season^{-1})	Allocation:	0	0	0.545	0	22.1
			% Reduction:	0%	100%	5%	0%	0%

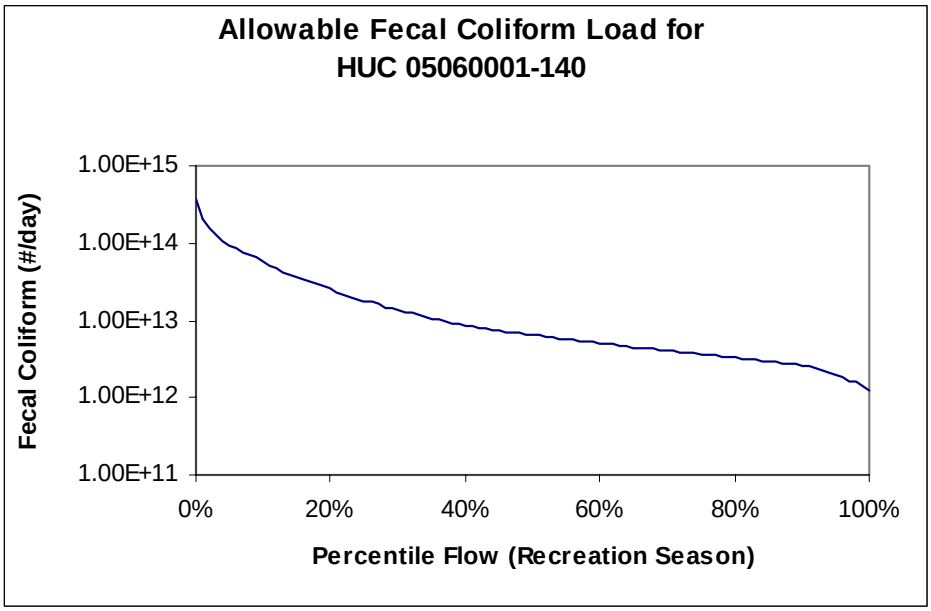
[1]All 14-digit HUCs are within the 8-digit HUC 05060001. The complete HUC identifier is the 8-digit stem followed by the 14-digit extension.
[2]Allocated loads are expressed in cfu •10^{13} • season^{-1} for fecal coliform and lbs • year $^{-1}$ for total phosphorus.

Table 5.2.H: MS4 wasteload allocations and surface runoff load allocations for HUC 05060001-140

14-Digit HUC[1]	**Sub-Watershed**	**Sub-Watershed Extent** (Upper RM-Lower RM)	**MS4 Entities**	**Parameter** (units)	**Remaining Loading Capacity**	**%of Watershed that is MS4**	**MS4 Wasteload Allocation**	**Surface Runoff Load Allocation**
140-010	Big Walnut Cr.	37.5 - 29.0	-City of Columbus -City of Westerville -City of Gahanna	FC (count •10^{13} •season^{-1})	6.49	82.0%	5.32	1.17
	McKenna Cr.	Entirety	-City of Columbus -City of Gahanna	TP (lbs • year^{-1})	247	100%	247	0
140-020	Rocky Fork	Entirety	-City of Columbus -Village of New Albany -City of Gahanna -Jefferson Twsp. -Plain Twp.	FC (count •10^{13} •season^{-1})	12.7	52.3%	6.66	6.04
				TP (lbs • year^{-1})	4,899	52.3%	2,562	2,337
140-030	Big Walnut Cr.	29.0 - 15.5	-City of Columbus -City of Gahanna -City of Reynoldsburg -City of Whitehall -Village of Brice	FC (count •10^{13} •season^{-1})	15.8	100.0%	15.8	0.0
140-040	Mason Run	Entirety	-City of Columbus -City of Whitehall	FC (count •10^{13} •season^{-1})	5.63	100.0%	5.63	0
140-050	Blacklick Cr.	Headwaters - 8.2	-City of Columbus -Village of New Albany -City of Gahanna -City of Pataskala -City of Reynoldsburg -City of Pickerington -Jefferson Twp. -Etna Twp.	FC (count •10^{13} •season^{-1})	20.4	50.8%	10.4	10.0

The fecal coliform TMDLs and allocations presented above are the core of the pathogen TMDL. It should be noted, however, that the acute fecal coliform criterion of 2000 cfu must be maintained to ensure complete attainment of recreational designated use. The load duration curve presented in Figure 5 is a visual depiction of the allowable daily fecal coliform as specified by OAC. To achieve full attainment, no more than ten percent of fecal coliform samples collected may be plotted above the line on the graph. To plot a sample it must be converted to a load by multiplying by daily flow volume. The daily load is then plotted with percentile flow as the independent variable.

Figure 5: Allowable daily fecal coliform load



5.2.5 Habitat and Sediment TMDLs

QHEI assessment results for habitat and flow limited streams are presented in Table 5.2.I. Both the observed and target condition for individual variables (e.g. substrate, cover, etc.) and the aggregate score are provided. The presence of modified habitat attributes, and their relative magnitude (high vs. moderate), is also noted for each assessment site.

Habitat and sediment TMDL scores and targets are also presented in Table 5.2.I. Sediment scores are the sum of the substrate, channel, and riparian categories. The target sediment score of $\geq$33 is analogous to a loading capacity, and the target scores for substrate, channel, and riparian are the rough equivalent of allocations. The habitat score is the sum of the high and moderate influence attribute scores, and the QHEI to target ratio score. See Section 4.1.1 for more information.

Table 5.2.I Existing and Target Habitat and Sediment Conditions

Habitat Limited Stream	River Mile	Assessment Results										TMDL Scores	
		QHEI Categories							QHEI	Modified Attributes		Sediment	Habitat
		Substrate	Cover	Channel	Riparian	Pool	Riffle	Gradient		High Influence	Moderate Influence		
Targets		*≥14*	*≥12*	*≥14*	*≥5*	*Sum ≥15*			*≥60*	*<2*	*Total Modified Attributes <5*	*≥33*	*3*
Rocky Fork	7.1	12.5	13.0	13.5	5.0	9.0	1.0	6	60.0		③④⑦⑧⑨	31.0	2
	5.9	16.0	17.0	13.0	5.0	10.0	2.5	10	73.5		③④⑦⑧⑨	34.0	2
Rose Run	0.5	13.0	9.0	14.0	4.0	4.0	1.5	10	55.5	④⑤	③④⑦⑧⑨	31.0	0
Trib. to BWC at RM 27.29	0.2	12.5	8.0	12.0	5.0	4.5	1.5	10	53.5	④	③④⑦⑧⑨	29.5	1
Mason Run	1.4	14.0	9.0	10.0	5.5	5.0	2.0	10	55.5	③④	①④⑦⑧⑨	29.5	0
Unzinger Ditch	0.9	7.0	3.0	5.0	4.5	-2.0	0.0	10	27.5	①②③④⑤	④⑤⑥⑦⑧	16.5	0
	0.5	8.5	9.0	10.0	5.0	8.5	0.0	10	51.0	③④⑤	①④⑦⑧	23.5	0
	0.1	8.5	12.0	11.0	5.0	9.5	3.0	8	57.0	③④	①④⑦⑧⑨	24.5	0
French Run	0.6	12.5	13.0	13.0	3.5	7.0	2.0	4	55.0		①④⑦⑧⑨	29.5	1
Powell Ditch	0.8	15.5	7.0	12.0	2.5	5.5	1.0	6	49.5	④	④⑤⑦⑧⑨	30.0	1

Key to High-Influence Modified Attributes:

① Channelized with no recovery
② Silt or muck substrates
③ Low sinuosity
④ Sparse or no cover
⑤ Max. pool depth less than 40 cm

Key to Moderate Influence Modified Attributes:

① Channelized, but recovering
② Sand substrate
③ Hardpan substrate origin
④ Fair or poor channel development
⑤ Only one or two cover types
⑥ Intermittent or poor pool quality
⑦ No fast current
⑧ High to moderate substrate embeddedness
⑨ Extensive to moderate riffle embeddedness
⑩ No riffle

5.3 Upper Alum Creek (Assessment Unit 05060001-150)

This assessment unit consists of Alum Creek and its tributaries upstream of Alum Creek Lake.

5.3.1 Assessment Results

Alum Creek Mainstem

The study area included 13 stations on the Alum Creek mainstem from the headwaters at Cardington-East Rd. (RM 56.3) to near its confluence with Big Walnut Creek at Williams Rd. (RM 0.8/0.7). Seven stations were in FULL attainment of their existing or recommended aquatic life use designation, five were PARTIAL, and one was NON.

The biological communities in Alum Creek upstream from Alum Creek Lake were generally performing in the good to exceptional range. The station upstream from the West Branch Alum Creek (RM 42.9) had the best physical stream habitat (QHEI=89.0) of any segment in the entire survey, with a complete absence of modified attributes. The station downstream from the West Branch Alum Creek (RM 42.6) had the highest diversity of EPT taxa (24), a measure of the diversity of pollution sensitive macroinvertebrate taxa, and the highest ICI score of any station in the study. The fair fish community at SR 529 (RM 55.3) was attributed to the negative effects of channel modifications. Elevated nutrient concentrations associated with a rain event, especially in the upper reaches, and high bacterial counts throughout this part of Alum Creek indicated the presence of intermittent and chronic stressors potentially impacting the biological communities. Results of the biological assessment are given in Table 5.3.A.

Sampling for bacteria in the upper Alum Creek watershed reveals that the recreational use is impaired for magnitude and frequency of peak values for fecal coliform bacteria.

Tributaries to Alum Creek

Biosurvey sampling was conducted at nine stations in four streams that were tributaries to Alum Creek upstream from Alum Creek Lake. Of these, four stations were in FULL attainment of their existing or recommended aquatic life use designation, two were PARTIAL, and three were NON.

Biological communities in West Branch Alum Creek, Turkey Run, and Big Run were impacted to varying degrees by low flows, channel modifications, siltation, organic enrichment, high nutrients, and high bacterial counts from agricultural activities. The biological communities in West Branch Alum Creek improved into the good to exceptional range by Worthington-New Haven Rd. (RM 0.5). The Ashley WWTP discharge (RM 4.55) was not specifically evaluated in this study, but did not appear to have an obvious impact on the biology or water chemistry in West Branch Alum Creek.

Results of the biosurvey are presented in Table 5.3.A.

Sampling for bacteria in the upper Alum Creek watershed reveals that the recreational use is impaired for magnitude and frequency of peak values for fecal coliform for the following streams: West Branch Alum Creek, Unnamed tributary to Alum Creek at 40.48, Bunker Run, and Big Run.

Table 5.3.A Aquatic life use attainment status of the Big Walnut Creek basin, June-October, 2000. The Index of Biotic Integrity (IBI), Modified Index of Well Being (MIwb), and Invertebrate Community Index (ICI) scores are based on the performance of fish (IBI, MIwb) and macroinvertebrate communities (ICI). The Qualitative Habitat Evaluation Index (QHEI) is a measure of the ability of the physical habitat to support biological communities.

River Mile		IBI	MIwb	ICI[b]	QHEI	Attainment Status	Comment
Fish[a]	Invert.						
Alum Creek (02-110) *WWH Use Designation (Existing)*							
56.3[E]	-	46	NA	-	47.5	(FULL)	Cardington East Rd.
55.3[E]		32*	NA	G	62.5	PARTIAL	SR 529
-	51.5	-	-	VG	-	(FULL)	Phillips Rd.
49.9[E]		56	NA	VG	83	FULL	Prospect-Mt. Vernon Rd.
45.5[D]	-	47	7.3*	-	71	(PARTIAL)	East Liberty Rd.
42.9[D]		48	8.5	48	89	FULL	Ust. W. Br. Alum Cr.
-	42.6	-	-	54	-	(FULL)	Dst. W. Br. Alum Cr.
Bunker Run (02-121) *WWH Use Designation (Existing)*							
1.8[E]		42	NA	G	75	FULL	South Woodbury Rd.
West Branch Alum Creek (02-118) *WWH Use Designation (Existing)*							
12.3[E]	-	36[ns]	NA	-	50	(FULL)	Waldo-Fulton-Chesterville Rd.
9.9[E]	9.4	30*	NA	Low F*	47.5	**NON**	Waldo-Fulton Rd./Kilbourne Rd.
8.7[E]		40	NA	F*	48.5	PARTIAL	Westfield-Fulton Rd.
3.3[E]		54	NA	MG[ns]	75.5	FULL	Shoemaker Rd.
0.6[D]	0.5	51	8.7	50	72	FULL	Worthington-New Haven Rd.
Turkey Run (02-119) *WWH Use Designation (Existing)*							
3.7[E]	3.6	32*	NA	Low F*	57	**NON**	Pompey Rd.
0.1[E]		34*	NA	VG	74	PARTIAL	Piper Rd.
Big Run (02-112) *WWH Use Designation (Existing)*							
4.8[E]	2.7	34*	NA	F*	57.5	**NON**	From Jumper Rd./US36-SR37
4.8[E]	2.7	34*	NA	F*	57.5	**NON**	

* 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 Fish sampling methods: A=Boat, D=Wading, E=Longline.
b Narative evaluation based on qualitative macroinvertebrate sample (E=Exceptional, VG=Very Good, G=Good, F=Fair, Low F=Low Fair, P=Poor, and VP=Very Poor).
c Macroinvertebrate sample was collected in 2001 and may be replacing a 2000 sample.

5.3.2 Causes and Sources of Impairment

Alum Creek Mainstem

Impairment in the upper Alum Creek watershed is attributed to habitat alteration and an unknown source. Upper Alum Creek is impaired for its recreational use for fecal coliform due to the frequency and magnitude of high values.

Tributaries to Alum Creek

Bunker Run
Bunker Run is in full attainment of its aquatic life use. However, Bunker Run is impaired for its recreational use for fecal coliform bacteria. The sources of this impairment are HSTS and agricultural runoff.

West Branch Alum Creek
Nonattainment of the aquatic life use in West Branch Alum Creek is caused by flow alteration and habitat alteration through direct modification of the channel. Sources of the nonattainment are non-irrigated crop production (row crop agricultural practices) and channelization. The recreational use of West Branch Alum Creek is impaired due to excessive bacterial levels for fecal coliform. The source of the nonattainment is attributed to HSTS and agricultural runoff.

Turkey Run
The cause of nonattainment of the aquatic life use in Turkey Run is attributed to flow alteration due to direct channel modification. The source of this impairment is attributed to row crop agricultural practices.

Big Run
Causes of nonattainment in Big Run are attributed to elevated nutrients. The source of the nutrient load is attributed to agricultural practices in the basin. The cause of nonattainment of the recreational use in Big Run is fecal coliform bacteria that exceed the magnitude and frequency of peak values. The source of the elevated bacteria levels is attributed to runoff from livestock operations and HSTS**.**

5.3.3 Deviation from Target

Table 5.3.B. Deviation from Target in HUC 050600001-150, Upper Alum Creek

05060001-150: Alum Creek headwaters to Alum Creek Lake					
Affected Waterbody	**Cause of Impairment**	Target Parameter *units*	Target	Observed Condition	Deviation from Target
150-010: Alum Creek headwaters to above West Branch Alum Creek					
All within 14 digit HUC	**Pathogens**	Fecal Coliform *cfu*[1]	2000 (90th percentile)	2969	32.6 %
Alum Creek	**Habitat Alteration**	QHEI	60	47.5 - 62.5	0 - 26.3 %
150-020: West Branch Alum Creek					
All within 14 digit HUC	**Habitat Alteration**	QHEI	60	47.5 - 75.5	0 - 26.3 %
All within 14 digit HUC	**Flow Alteration**	QHEI	60	47.5 - 75.5	0 - 26.3 %
All within 14 digit HUC	**Pathogens**	Fecal Coliform *cfu*[1]	2000 (90th percentile)	3684	45.7%
150-030: Turkey Run					
All within 14 digit HUC	**Flow Alteration**	QHEI	60	57 -74	0 - 5.3 %
All within 14 digit HUC	**Pathogens**	Fecal Coliform[1,2] *cfu* $\bullet 10^{13}$ $\bullet season^{-1}$	3.2	48.0	93%
150-040: Alum Creek from below West Branch Alum Creek to above Big Run					
Alum Creek	**Pathogens**	Fecal Coliform[1,2] *cfu* $\bullet 10^{13}$ $\bullet season^{-1}$	2.5	36.0	93%
150-050: Big Run					
All within 14 digit HUC	**Nutrients**	TP *mg/l*	0.11	0.05 - 0.12	0 - 8.3 %
All within 14 digit HUC	**Pathogens**	Fecal Coliform *cfu*[1]	2000 (90th percentile)	3511	43 %

[1] Fecal Coliform counts expressed as cfu (colony forming units) equates to the measurement of fecal coliform, number per 100ml.
[2]Deviation from target is determined by using the HSPF model.

5.3.4 Existing Load, TMDLs and Allocations

Existing total phosphorus and fecal coliform loads were calculated for each 14-digit HUC in the assessment unit. The existing loads were calculated using HSPF, by methods described in Section 4.2 and Appendix C. Total phosphorus loads are expressed in pounds per year, and fecal coliform loads are expressed in cfu per recreation season. For modeling purposes the recreation season is defined as May 1st to October 31st.

Existing point source loads are presented in Table 5.3.C. Existing non-point source loads are presented in Table 5.3.D. Non-point source loads considered in the assessment unit are cropland, pasture, forest, cattle instream, home septic systems, and home aerator systems.

Total existing loads, TMDLs, WLAs, and LAs for the assessment unit are presented in Table 5.3.E. Also included in the table is the percent existing load reduction needed to achieve the TMDL. WLAs and LAs are 14-digit HUC totals; individual allocations for point source entities are presented in Table 5.3.F, and allocations for each non-point source are given in Table 5.3.G.

Table 5.3.C Existing Point Source Loads

14-Digit HUC[1]	**Facility Name** *NPDES Permit #*	**Median Q** *MGD*	**[TP][1]** *mg/l*	**[FC][2]** *cfu/ 100 ml*	**Facility Loads**		**HUC Loads**	
					TP *lb/year*	FC *cfu/season*	TP *lb/year*	FC *cfu/season*
150-020	Town of Ashley *4PB00027*	0.131	3.00[3]	12	1471	3.81e+11	1471	3.81e+11
150-040	Delaware County Home *4PG00033*	0.004	3.00[3]	38	43	1.20e+10	43	1.20e+10

[1]Values in this column represent the historical total phosphorus effluent concentration for each facility.
[2]Values in this column represent the historical fecal coliform effluent concentration for each facility.
[3]Estimated effluent value.

Table 5.3.D Existing Non-Point Source Loads

14-Digit HUC[1]	Sub-Watershed	Sub-Watershed Extent (Upper RM-Lower RM)	Parameter (units)	Existing Non-Point Source Loads						
				Cropland	Pasture	Forest	Cattle Instream	Septic	Aerator	**Total**
150-010	Alum Creek	59.6 - 42.8	FC (cfu •10^{13} •season^{-1})	3.79	3.91	0.006	137	0.51	0.10	**145**
			TP (lbs • year^{-1})	15157	3516	---	1160	1914	378	**22,125**
150-020	West Branch Alum Creek	entirety (except Turkey Run)	FC (cfu •10^{13} •season^{-1})	2.55	1.09	0.001	57.5	0.17	0.04	**61**
			TP (lbs • year^{-1})	11160	1276	---	485	631	151	**13,703**
150-030	Turkey Run	entirety	FC (cfu •10^{13} •season^{-1})	1.68	0.79	0.001	44.6	0.37	0.07	**48**
			TP (lbs • year^{-1})	6756	745	---	376	1384	279	**9,540**
150-040	Alum Creek	42.8 - 31.7	FC (cfu •10^{13} •season^{-1})	1.82	1.08	0.0002	32.9	0.39	0.15	**36**
			TP (lbs • year^{-1})	9482	1724	---	277	1449	577	**13,509**
150-050	Big Run	entirety	FC (cfu •10^{13} •season^{-1})	1.23	0.32	0.0003	14.9	0.35	0.14	**17**
			TP (lbs • year^{-1})	7544	410	---	126	1334	532	**9,946**

[1]All presented 14-digit HUCs are within the 8-digit HUC 05060001. The complete HUC identifier is the 8-digit stem followed by the 14-digit extension.

Table 5.3.E Total Existing Load, TMDL, Allocations For HUC 05060001 150

14-Digit HUC[1]	Sub-Watershed	Sub-Watershed Extent (Upper RM-Lower RM)	Parameter (units)	Existing Loads			% Reduction	TMDL	Allocations		
				PS	NPS	Total			WLA	LA	MOS
150-010	Alum Creek	59.6 - 42.8	FC (cfu •10^{13} •season^{-1})	0	145	145	94	9.4	0	9.4	---
			TP (lbs • year^{-1})	0	22,125	22,125	66	7428	0	7056	371
150-020	West Branch Alum Creek	entirety (except Turkey Run)	FC (cfu •10^{13} •season^{-1})	0.04	61	61	92	5.0	0.13	4.9	---
			TP (lbs • year^{-1})	1471	13,703	15,173	68	4873	1471	3158	244
150-030	Turkey Run	entirety	FC (cfu •10^{13} •season^{-1})	0	48	48	93	3.2	0	3.2	---
			TP (lbs • year^{-1})	0	9,540	9,540	83	1621	0	1540	81
150-040	Alum Creek	42.8 - 31.7	FC (cfu •10^{13} •season^{-1})	0.001	36	36	93	2.5	0.01	2.5	---
			TP (lbs • year^{-1})	43	13,509	13,551	76	3292	43	3137	164
150-050	Big Run	entirety	FC (cfu •10^{13} •season^{-1})	0	17	17	79	3.5	0	3.5	---
			TP (lbs • year^{-1})	0	9,946	9,946	82	1768	0	1699	88

[1]All presented 14-digit HUCs are within the 8-digit HUC 05060001. The complete HUC identifier is the 8-digit stem followed by the 14-digit extension.

Table 5.3.F Point Source Allocations

Facility Name	NPDES Permit #	Receiving Stream	Parameter	Permit Limits		Allocated Load[1]
				Existing	Proposed	
Town of Ashley	4PB00027	West Branch Alum Creek	FC	1000 cfu	1000 cfu	0.13
			TP	none	none	existing
Delaware County Home	4PG00033	Tributary to Alum Creek	FC	1000 cfu	1000 cfu	0.01
			TP	none	none	existing

[1]Allocated loads are expressed in cfu $\bullet 10^{13}$ $\bullet$ season^{-1} for fecal coliform and lbs $\bullet$ year $^{-1}$ for total phosphorus.

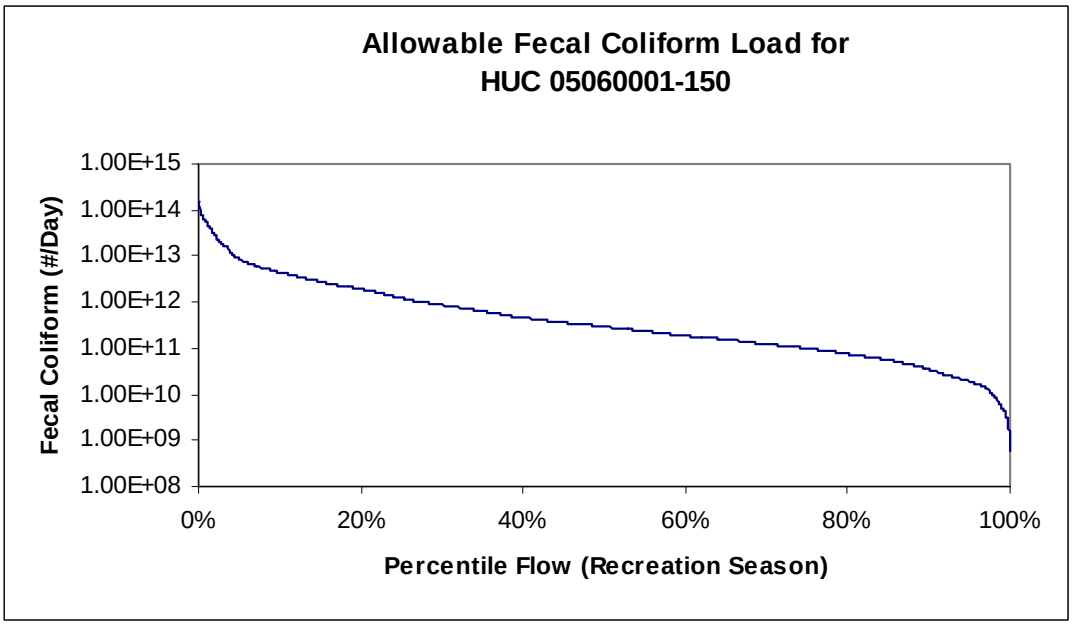
Table 5.3.G Non-Point Source Allocations

14-Digit HUC[1]	Sub-Watershed	Sub-Watershed Extent (Upper RM-Lower RM)	Cause[2]		Individual Non-Point Sources					
					Cropland	Pasture	Forest	Cattle Instream	Septic	Aerator
150-010	Alum Creek	59.6 - 42.8	FC	Allocation	3.79	3.91	0.006	1.60	0	0.04
				% Reduction[3]	0%	0%	0%	99%	100%	65%
			TP	Allocation	5292	1227	0	405	0	132
				% Reduction[3]	65%	65%	0%	65%	100%	65%
150-020	West Branch Alum Creek	entirety (except Turkey Run)	FC	Allocation	2.55	1.09	0.001	1.23	0	0.01
				% Reduction[3]	0%	0%	0%	98%	100%	76%
			TP	Allocation	2696	308	0	117	0	36
				% Reduction[3]	76%	76%	0%	76%	100%	76%
150-030	Turkey Run	entirety	FC	Allocation	1.68	0.79	0.001	0.72	0	0.01
				% Reduction[3]	0%	0%	0%	98%	100%	81%
			TP	Allocation	1275	141	0	71	0	53
				% Reduction[3]	81%	81%	0%	81%	100%	81%
150-040	Alum Creek	42.8 - 31.7	FC	Allocation	1.54	0.92	0.0002	0	0	0.04
				% Reduction[3]	15%	15%	15%	100%	100%	74%
			TP	Allocation	2467	448	0	72	0	150
				% Reduction[3]	74%	74%	0%	74%	100%	74%
150-050	Big Run	entirety	FC	Allocation	1.23	0.32	0.0003	1.96	0	0.03
				% Reduction[3]	0%	0%	0%	87%	100%	80%
			TP	Allocation	1488	81	0	25	0	105
				% Reduction[3]	80%	80%	0%	80%	100%	80%

[1]All 14-digit HUCs are within the 8-digit HUC 05060001. The complete HUC identifier is the 8-digit stem followed by the 14-digit extension.
[2]Allocated loads are expressed in cfu $\bullet 10^{13}$ $\bullet$ season^{-1} for fecal coliform and lbs $\bullet$ year $^{-1}$ for total phosphorus.
[3]Percent reduction needed to achieve allocated load.

The fecal coliform TMDLs and allocations presented above are the core of the pathogen TMDL. It should be noted, however, that the acute fecal coliform criterion of 2000 cfu must be maintained to ensure complete attainment of recreational designated use. The load duration curve presented in Figure 6 is a visual depiction of the allowable daily fecal coliform as specified by OAC. To achieve full attainment, no more than ten percent of fecal coliform samples collected may be plotted above the line on the graph. To plot a sample it must be converted to a load by multiplying by daily flow volume. The daily load is then plotted with percentile flow as the independent variable.

Figure 6: Allowable daily fecal coliform load



5.3.5 Habitat and Sediment TMDLs

QHEI assessment results for habitat and flow limited streams are presented in Table 5.3.C. Both the observed and target condition for individual variables (e.g. substrate, cover, etc.) and the aggregate score are provided. The presence of modified habitat attributes, and their relative magnitude (high vs. moderate), is also noted for each assessment site.

Habitat and sediment TMDL scores and targets are also presented in Table 5.3.C. Sediment scores are the sum of the substrate, channel, and riparian categories. The target sediment score of ≥33 is analogous to a loading capacity, and the target scores for substrate, channel, and riparian are the rough equivalent of allocations. The habitat score is the sum of the high and moderate influence attribute scores, and the QHEI to target ratio score. See Section 4.1.1 for more information.

Table 5.3.H Existing and Target Habitat and Sediment Conditions

Habitat Limited Stream	River Mile	Assessment Results										TMDL Scores	
		QHEI Categories							QHEI	Modified Attributes		Sediment	Habitat
		Substrate	Cover	Channel	Riparian	Pool	Riffle	Gradient		High Influence	Moderate Influence		
Targets		*≥14*	*≥12*	*≥14*	*≥5*	*Sum ≥15*			*≥60*	*<2*	*Total Modified Attributes <5*	*≥33*	*3*
Alum Creek	56.3	12.0	9.0	5.5	2.5	8.0	0.5	10	47.5	①③④	③④⑦⑧⑨	20.0	0
	55.3	14.0	16.0	12.0	6.5	7.0	1.0	6	62.5		①③④⑦⑧⑨	32.5	2
W. Branch Alum Creek	12.3	15.5	10.0	9.5	4.0	3.0	0.0	8	50.0	③⑤	①③④⑦⑧	29.0	0
	9.9	10.0	14.0	8.0	3.5	6.0	0.0	6	47.5	③	①③④⑦⑧⑨	21.5	1
	8.7	15.5	12.0	6.5	3.0	4.5	1.0	6	48.5	①③④	①③④⑦⑧⑨	25.0	0
Turkey Run	3.7	10.0	17.0	12.0	7.0	5.0	0.0	6	57.0		③④⑥⑦	29.0	2
Big Run	4.8	14.0	13.0	13.5	5.0	3.0	1.0	8	57.5	③⑤	③④⑦⑧⑨	32.5	0

Key to High-Influence Modified Attributes:

① Channelized with no recovery
② Silt or muck substrates
③ Low sinuosity
④ Sparse or no cover
⑤ Max. pool depth less than 40 cm

Key to Moderate Influence Modified Attributes:

① Channelized, but recovering
② Sand substrate
③ Hardpan substrate origin
④ Fair or poor channel development
⑤ Only one or two cover types
⑥ Intermittent or poor pool quality
⑦ No fast current
⑧ High to moderate substrate embeddedness
⑨ Extensive to moderate riffle embeddedness
⑩ No riffle

5.4 Lower Alum Creek (Assessment Unit 05060001-160)

This assessment unit covers the Alum Creek mainstem from Alum Creek Dam south to "Three Creeks" (the confluence of Blacklick Creek, Alum Creek, and Big Walnut Creek).

5.4.1 Assessment Results

Alum Creek Mainstem

The biological communities in Alum Creek 4.3 miles downstream from Alum Creek Lake fully met WWH expectations for the IBI and ICI biocriteria but only marginally met for the MIwb. At Schrock Rd. (RM 19.8) the macroinvertebrate community declined into the fair range. Heavy siltation noted at the station, presumably from upstream construction, may have been a major cause of this decline. Communities continued to be impacted downstream to Refugee Rd. (RM 3.8). Much of this stretch flows through highly urbanized parts of Columbus. The stream channel in several places is channelized and impounded which slows down stream flow, reducing reaeration of the stream and creating monotonous habitat that is unsuitable for many stream organisms. Additional stressors present within this reach include urban runoff, the Alum Creek storm tank discharge, and numerous minor SSOs. Indications of water quality impairments in this area were elevated nutrients throughout this area, and contaminated sediments (PAHs, cadmium) at Refugee Rd. The biological communities were fully meeting the WWH expectations at Williams Rd. (RM 0.8/0.7). The Huber Ridge WWTP discharge was not specifically evaluated in this study, but did not appear to have an obvious impact on the biology or water chemistry in Alum Creek.

The biological results from 2000 show a similar trend to the 1996 survey (Ohio EPA 1999a) with the exception of lower macroinvertebrate performance downstream from Westerville and the Huber Ridge WWTP. Water sampling results from the current study documented decreases in mean fecal coliform counts and 5-day biochemical oxygen demand in the lower Alum Creek compared to 1996.

Biosurvey results for the lower Alum Creek mainstem are presented in Table 5.4.A.

The recreational use of lower Alum Creek is impaired for both geometric mean and for frequency and magnitude of peak values for fecal coliform bacteria.

Tributaries to Alum Creek

Biosurvey sampling was conducted at seven stations in five streams that were tributaries to Alum Creek downstream from Alum Creek Lake. Of these, two stations were in FULL attainment of their existing or recommended aquatic life use designation, one was PARTIAL, and four were NON.

Biological communities in Spring Run, "West Spring Run", and Kilbourne Run were impacted to varying degrees by channel modifications, organic enrichment, high

bacterial counts, low flow, and siltation from urbanization of the surrounding watershed. The tributary to Alum Creek at RM 25.50 was supporting an exceptional headwater fish community; however, very high bacterial counts and water quality impairments (BOD_5, Total Suspended Solids, Ammonia, Total Kjeldahl Nitrogen) indicated this stream is threatened by unrestricted livestock access to the stream upstream from the collection site. Bliss Run was contaminated with very high bacterial counts; however, since aquatic communities were not sampled, it was not possible to assess its aquatic life use attainment status.

Biosurvey results are presented in Table 5.4.A.

Results of bacterial sampling indicate recreational use impairment for Spring Run, West Spring Run, the unnamed tributary to Alum Creek at Woodhaven Road, the unnamed tributaries to Alum Creek on Africa Road at RM 25.50 and at RM 23.47, Kilbourne Run and Bliss Run since all exceed targets for geometric mean fecal coliform , and frequency and magnitude of peak values for fecal coliform. Some of these bacterial exceedences are very high.

Table 5.4.A Aquatic life use attainment status of the Big Walnut Creek basin, June-October, 2000. The Index of Biotic Integrity (IBI), Modified Index of Well Being (MIwb), and Invertebrate Community Index (ICI) scores are based on the performance of fish (IBI, MIwb) and macroinvertebrate communities (ICI). The Qualitative Habitat Evaluation Index (QHEI) is a measure of the ability of the physical habitat to support biological communities. **Bolded sites are 1996 data.**

River Mile Fish[a]	Invert.	IBI	MIwb	ICI[b]	QHEI	Attainment Status	Comment
Alum Creek (02-110) *WWH Use Designation (Existing)*							
22.1[D]	22.4	43	8.0[ns]	46	70.5	FULL	Adj. Cleveland Ave.
19.8[D]		42	8.2[ns]	28*	79.5	PARTIAL	Schrock Rd.
13.4[D]	13.5	38[ns]	7.6*	32[ns]	79	PARTIAL	Innis Park
9.2	-	**28***	**8.0[ns]**		**52**	**(PARTIAL)**	**Dst. American Ditch**
-	**8.6**	-	-	**10***	-	**(NON)**	**Dst. American Ditch**
-	7.6	-	-	24*	**56.5**	**(NON)**	Wolf Park
6.6	**6.2**	**35***	**8.7**	**30***	**52.5**	**PARTIAL**	**Livingston Ave.**
2.7[A]	3.8	39[ns]	9.2	28*	86.5	PARTIAL	Ust. Watkins Rd./Refugee Rd.
0.8[A]	0.7	42	8.9	46	73	FULL	Williams Rd.
Tributary to Alum Creek (RM 25.50) (02-338) *WWH Use Designation (Recommended)*							
0.2E	-	52	NA	-	63	(FULL)	Africa Rd.
Tributary to Alum Creek (RM 23.47) (02-337) *WWH Use Designation (Recommended)*							
0.8E	-	40	NA	-	64	(FULL)	Africa Rd.
Spring Run (Trib. to Alum Creek (RM 17.22)) (02-276) *WWH Use Designation (Recommended)*							
6.0[E]	5.4	24*	NA	VP*	26	**NON**	Maxtown Rd./Blue Heron Rd.
3.7[E]		28*	NA	P*	59	**NON**	Walnut St.
0.2[E]		44	NA	F*	58	PARTIAL	Buenos Aires Rd.
"West Spring Run" (Trib. to Alum Creek (RM 17.15)) (02-240) *WWH Use Designation (Recommended)*							
0.4[E]	-	20*	NA	-	60	(NON)	SR 3
Kilbourne Run (Trib. to Alum Cr. (RM 16.34)) (02-297) *WWH Use Designation (Recommended)*							
0.4[E]	-	28*	NA	-	66	**(NON)**	Westerville Rd.

* 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 Fish sampling methods: A=Boat, D=Wading, E=Longline.
b Narative evaluation based on qualitative macroinvertebrate sample (E=Exceptional, VG=Very Good, G=Good, F=Fair, Low F=Low Fair, P=Poor, and VP=Very Poor).
c Macroinvertebrate sample was collected in 2001 and may be replacing a 2000 sample.

5.4.2 Causes and Sources of Impairment

Alum Creek Mainstem

Causes of impairment of the aquatic life use for the lower Alum Creek mainstem are identified as siltation and habitat alteration, and the sources are identified as land development and urban runoff. Recreational use impairment is attributed to HSTS that do not adequately treat for bacteria.

Tributaries to Alum Creek

Tributary to Alum Creek at RM 25.50
The unnamed tributary to Alum Creek at RM 25.50 is fully attaining its aquatic life use. However, it is not attaining its recreational use. The recreational use of the unnamed tributary at RM 25.50 is impaired by extremely high levels of fecal coliform bacteria, the source of which is attributed to HSTS along with livestock in the creek.

Spring Run and West Spring Run
The causes of aquatic life use impairment to Spring Run and West Spring Run are habitat alteration and flow alteration, the sources of the impairment are attributed to urban runoff and direct modification of the channel through channelization. The recreational uses of Spring Run and West Spring Run are impaired by extremely high levels of fecal coliform bacteria, the source of which is attributed to urban runoff and HSTS.

Kilbourne Run
The cause of aquatic life use impairment to Kilbourne Run is organic enrichment, the source of which is attributed to urban runoff. The recreational use of Kilbourne Run is impaired by high levels of fecal coliform bacteria. The source of the recreational use impairment is HSTS.

Bliss Run
Bliss Run was not evaluated for aquatic life use attainment during the 2000 study. However, sampling of Bliss Run reveals impairment of the recreational use by extremely high levels of fecal coliform bacteria. The source of the bacteria is yet to be determined.

5.4.3 Deviation from Target

Table 5.4.B. Deviation from Target in HUC 05060001-160, Lower Alum Creek, Lower Big Walnut Creek

05060001-160: Alum Creek from below Alum Creek Dam to Scioto River					
Affected Waterbody	**Cause of Impairment**	Target Parameter *units*	Target	Observed Condition	Deviation from Target
160-010: Alum Creek from below Alum Creek Dam to near Westerville					
All within 14 digit HUC	**Pathogens**	Fecal Coliform *cfu*[1]	1000 / 2000	1248 / 18282	19.9 % / 89 %
Alum Creek	**Habitat Alteration**	QHEI	60	57.5	4.3 %
160-020: Alum Creek near Westerville to Three Creeks Park confluence					
All within 14 digit HUC	**Pathogens**	Fecal Coliform *cfu*[1]	1000 / 2000	1961 / 23908	49 % / 91.6 %
Spring Run	**Habitat Alteration**	QHEI	60	26 - 58	3.4 - 56 %
West Spring Run	**Habitat Alteration**	QHEI Metrics	<5 modified attributes	6	33 %
	Flow Alteration	QHEI Metrics	<5 modified attributes	6	33 %
Kilbourne Run	**Organic Enrichment**	Phosphorus *mg/l*	0.11	0.1 - 0.17	0 - 35.3 %
160-030: Big Walnut Creek from Three Creeks confluence to the Scioto River					
All within 14 digit HUC	-None- Full Attainment ☺				

[1] Fecal Coliform counts expressed as cfu (colony forming units) equates to the measurement of fecal coliform, number per 100ml.

5.4.4 Existing Load, TMDLs and Allocations

Existing fecal coliform loads were estimated for each 14-digit HUC in the Assessment Unit. Fecal coliform loads were calculated via the methods described in Section 4.3.2 and Appendix B. Fecal coliform loads are expressed in cfu per recreation season. For modeling purposes the recreation season is defined as May 1st to October 31st.

Existing point source loads are presented in Table 5.4.C, and existing non-point source loads are given in Table 5.4.D. Non-point sources considered in this assessment unit are surface runoff, cattle instream, sanitary sewer overflow, home septic systems, home aerator systems, and upstream flow.

Total existing loads, TMDLs, WLAs, and LAs for the assessment unit are presented in Table 5.4.E. Also included in the table is the percent existing load reduction needed to achieve the TMDL. WLAs and LAs are 14-digit HUC totals; individual allocations for point source entities are presented in Table 5.4.F, and allocations for each non-point source are given in Table 5.4.G. Wasteload allocations for surface runoff from MS4 areas are and load allocations from surface runoff from non-MS4 areas are presented in Table 5.4.H.

Table 5.4.C: Existing Point Source Loads for HUC 0506001-160

14-Digit HUC[1]	**Facility Name** *NPDES Permit #*	**Median Q** *MDG*	**[FC][2]** *cfu*	**Facility FC Load** *count/season*	**HUC FC Load** *count/season*
160-020	Delaware Co. Alum Creek WWTP *4PK00003*	2.24	2.64	4.12E+10	6.69E+14
	Ohio-American Water Co. Huber Ridge WWTP *4PU00000*	0.777	112.9	6.11E+11	
	Alum Creek Storm Tanks (CS0) *4PF00001-006*	27.16[3]	650,000[4]	6.68E+14	

[1]All presented 14-digit HUCs are within the 8-digit HUC 05060001. The complete HUC identifier is the 8-digit stem followed by the 14-digit extension.

[2]Values in this column represent the historical fecal coliform effluent concentration for each facility. For information regarding the source and period of record for each value, see Table B-18 in Appendix B.
[3]Value represents the average seasonal (May to October) overflow volume. The stated volume is in million gallons (MG).
[4]Concentration is a literature value for combined sewage (Metcalf & Eddie 1991).

Table 5.4.D: Existing Non-Point Source Loads for HUC 05060001-160

14-Digit HUC[1]	**Sub-Watershed**	**Sub-Watershed Extent** (Upper RM-Lower RM)	**Parameter** (units)	**Existing Non-Point Source Loads**							
				Runoff	Cattle	SSO	Septic	Aerator	GW	Upstream	**Total**
160-010	Alum Cr.	26.7 - 19.8	FC (cfu •10^{13} •season^{-1})	46.3	28.7	0.0	2.28	2.44	0.0	40.1	**120**
160-020	Alum Cr.	19.8 to Big Walnut	FC (cfu •10^{13} •season^{-1})	47.0	0.0	854	0.0929	1.86	0.0	54.9	**958**

[1]All presented 14-digit HUCs are within the 8-digit HUC 05060001. The complete HUC identifier is the 8-digit stem followed by the 14-digit extension.

Table 5.4.E: Total Existing Load, TMDL, and Allocations for HUC 05060001-160

14-Digit HUC[1]	**Sub-Watershed**	**Sub-Watershed Extent** (Upper RM-Lower RM)	**Parameter** (units)	**Existing Loads**			**%Reduction**	**TMDL**	**Allocations**		
				PS	NPS	Total			WLA	LA	MOS
160-010	Alum Cr.	26.7 - 19.8	FC (count •10^{13} •season^{-1})	0.0	120	120	54%	54.9	9.14	45.8	0
160-020	Alum Cr.	19.8 to Mouth	FC (count •10^{13} •season^{-1})	66.9	958	1025	91%	94.4	39.3	55.2	0

[1]All presented 14-digit HUCs are within the 8-digit HUC 05060001. The complete HUC identifier is the 8-digit stem followed by the 14-digit extension.

Table 5.4.F: Point Source Allocations for HUC 05060001-160

Facility Name *NPDES Permit #*	**Design Q** *MGD*	**FC Permit Limit** *cfu*	**FC WLA** *count/season*
Delaware Co. Alum Creek WWTP *4PK00003*	10	1000	6.36E+13
Ohio-American Water Co. Huber Ridge WWTP *4PU00000*	1.03	1000	6.55E+12
Alum Creek Storm Tanks (CS0) *4PF00001-006*	NA	NA	6.01E+13

Table 5.4.G: Non-Point Source Allocations for HUC 05060001-160

14-Digit HUC[1]	**Sub-Watershed** (Upper RM-Lower RM)	**Parameter** (units)		**Non-Point Source Allocations**					
				Cattle	CSO	Septic	Aerator	GW	Upstream
160-010	Alum Cr. (26.7 - 19.8)	FC (count •10^{13} •season^{-1})	Allocation:	0	0	0	1.12	0	40.1
			%Reduction:	100%	100%	100%	54%	0%	0%
160-020	Alum Cr. (19.8 - Mouth)	FC (count •10^{13} •season^{-1})	Allocation:	0	0	0	0.171	0	54.9
			%Reduction:	100%	0%	100%	91%	0%	0%

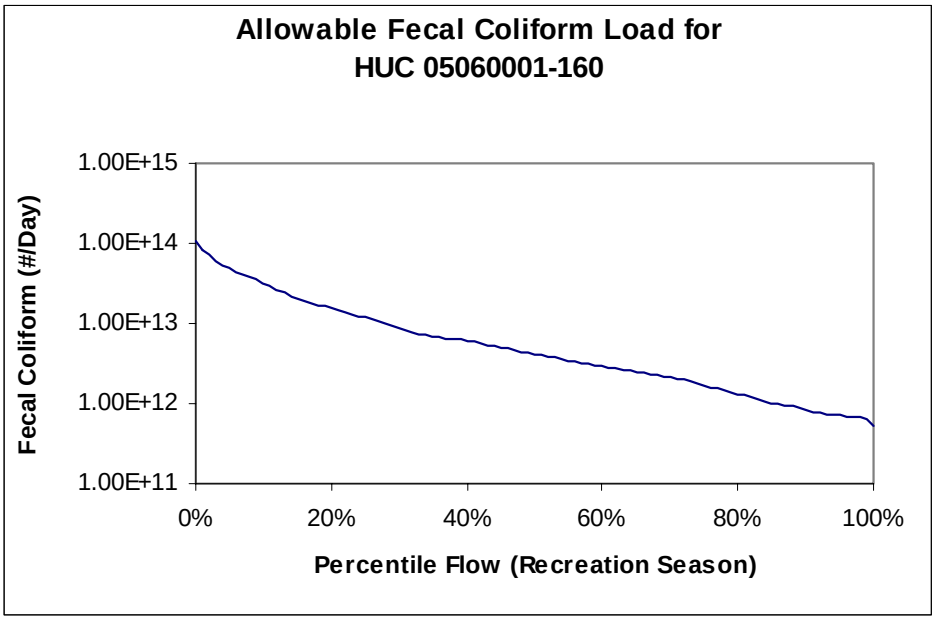
[1]All 14-digit HUCs are within the 8-digit HUC 05060001. The complete HUC identifier is the 8-digit stem followed by the 14-digit extension.

Table 5.4.H: MS4 wasteload allocations and surface runoff load allocations HUC 05060001-160

14-Digit HUC[1]	**Sub-Watershed**	**Sub-Watershed Extent** (Upper RM-Lower RM)	**MS4 Entities**	**Parameter** (units)	**Remaining Loading Capacity**	**%of Watershed that is MS4**	**MS4 Wasteload Allocation**	**Surface Runoff Load Allocation**
160-010	Alum Cr.	26.7 - 19.8	-City of Columbus -City of Westerville -Orange Twp. -Genoa Twp.	FC (count $\bullet 10^{13} \bullet$season^{-1})	13.7	66.8%	9.14	4.54
160-020	Alum Cr.	19.8 to Mouth	-City of Columbus -City of Westerville -City of Worthington -Huber Ridge CDP -City of Bexley	FC (count $\bullet 10^{13} \bullet$season^{-1})	26.3	99.7%	26.2	0.0789

The fecal coliform TMDLs and allocations presented above are the core of the pathogen TMDL. It should be noted, however, that the acute fecal coliform criterion of 2000 cfu must be maintained to ensure complete attainment of recreational designated use. The load duration curve presented in Figure 7 is a visual depiction of the allowable daily fecal coliform as specified by OAC. To achieve full attainment, no more than ten percent of fecal coliform samples collected may be plotted above the line on the graph. To plot a sample it must be converted to a load by multiplying by daily flow volume. The daily load is then plotted with percentile flow as the independent variable.

Figure 7: Allowable daily fecal coliform load



5.4.5 Habitat and Sediment TMDLs

QHEI assessment results for habitat and flow limited streams are presented in Table 5.4.I. Both the observed and target condition for individual variables (e.g. substrate, cover, etc.) and the aggregate score are provided. The presence of modified habitat attributes, and their relative magnitude (high vs. moderate), is also noted for each assessment site.

Habitat and sediment TMDL scores and targets are also presented in Table 5.4.I. Sediment scores are the sum of the substrate, channel, and riparian categories. The target sediment score of ≥33 is analogous to a loading capacity, and the target scores for substrate, channel, and riparian are the rough equivalent of allocations. The habitat score is the sum of the high and moderate influence attribute scores, and the QHEI to target ratio score. See Section 4.1.1 for more information.

Table 5.4.I Existing and Target Habitat and Sediment Conditions

Habitat Limited Stream	River Mile	Assessment Results										TMDL Scores	
		QHEI Categories							QHEI	Modified Attributes		Sediment	Habitat
		Substrate	Cover	Channel	Riparian	Pool	Riffle	Gradient		High Influence	Moderate Influence		
Targets		*≥14*	*≥12*	*≥14*	*≥5*	*Sum ≥15*			*≥60*	*<2*	*Total Modified Attributes <5*	*≥33*	*3*
Alum Creek	23.8	13	11	8.5	5	9.5	3	8	58	③④	①⑦⑨	26.5	0
	22.6	11	11	9	4.5	9	5	8	57.5	③④	⑦⑨	24.5	1
	9.2	12.5	9	9	5.5	8	0	8	52	③④	⑦⑧	27.0	1
	7.5	14.5	7	11	6	8	0	10	56.5	④	①⑦⑧	31.5	2
	6.6	8.5	13	9	4	8	0	10	52.5	②	⑦⑧	21.5	2
	3.9	14	8	8.5	6.5	8	2.5	8	55.5		⑦	29.5	2
Spring Run	6.0	2.0	5.0	6.0	4.0	3.0	0.0	6	26.0	①②③④⑤	①③④⑤⑦⑧	12.0	0
	3.7	12.5	13.0	13.5	4.0	7.0	1.0	8	59.0		③④⑦⑧⑨	30.0	1
	0.2	13.0	8.0	15.0	6.0	5.5	2.5	8	58.0	④	④⑦⑨	34.0	2
W. Spring Run	0.4	15.5	14.0	12.0	4.0	5.0	1.5	8	60.0	③	①③④⑦⑧⑨	31.5	2

Key to High-Influence Modified Attributes:

① Channelized with no recovery
② Silt or muck substrates
③ Low sinuosity
④ Sparse or no cover
⑤ Max. pool depth less than 40 cm

Key to Moderate Influence Modified Attributes:

① Channelized, but recovering
② Sand substrate
③ Hardpan substrate origin
④ Fair or poor channel development
⑤ Only one or two cover types
⑥ Intermittent or poor pool quality
⑦ No fast current
⑧ High to moderate substrate embeddedness
⑨ Extensive to moderate riffle embeddedness
⑩ No riffle

6.0 Public Participation

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

Local Implementation

The Big Walnut Creek watershed is inhabited by many citizens committed to its well-being. There are no less than 5 local watershed groups in this watershed with a wide range of activities and planning efforts. This Big Walnut Creek TMDL will aid these groups by identifying measurable targets to achieve and identifying areas for future focus. A brief synopsis of each of these groups follows.

Rocky Fork Task Force

The Rocky Fork Task Force is the oldest of the watershed groups in the basin. Formed in the early 1990s with a focus on protecting Rocky Fork in the face of extensive development in the basin, the group has been active in assisting Ohio EPA with storm water compliance related to construction site storm water runoff.

Friends of Blacklick Creek

The Friends of Blacklick Creek was formed in the spring of 1998 with the goal of protecting Blacklick Creek. The group has been successful in raising awareness regarding issues of construction runoff in the watershed, and has been successful at eliminating destructive aspects of some projects, and/or creating positive mitigation in the form of wetlands or stream naturalization. A presentation on the on-going Big Walnut TMDL process was given by Ohio EPA staff in June of 2003.

Upper Big Walnut Creek Water Quality Partnership

Source water protection issues concerning atrazine in the City of Columbus water supply was the driving force for the formation of the Upper Big Walnut Water Quality Partnership. This group has completed a watershed action plan, and is well into implementation of the plan. Significant accomplishments include obtaining priority status for the watershed in the USDA Environmental Quality Incentives Program (EQIP), garnering $1.3 million towards contracts for watershed farmers between 1998 and 2002. In addition, the Partnership has been active in securing a Conservation Reserve Enhancement Program (CREP) in the upper watershed, which provides cost share and incentive payments to producers for creating and maintaining vegetated buffer strips and wetlands (15 year contracts). A voluntary perpetual easement program is associated with this CREP, which is funded through the City of Columbus. The Upper

Big Walnut Creek Water Quality Partnership has been so successful that the Agricultural Research Service (ARS) has selected the upper watershed as a location to evaluate and quantify the effectiveness of conservation practices in improving water quality.

Friends of Alum Creek and Tributaries

FACT (Friends of Alum Creek and Tributaries) was formed in 1998 as a group of citizens concerned about the welfare of lower Alum Creek. Since then FACT has developed programs in education and outreach, advocacy and stewardship. FACT has completed the Lower Alum Creek Watershed Action Plan, with support and participation from local stakeholders. Priority projects outlined in the plan are:

- Dam removal,
- Reduction of Sediment Loads,
- Education and Outreach in targeted areas, such as Spring Run, and
- Collaboration with community partners.

Ohio EPA staff were actively involved in the meetings that lead up to the development of the watershed action plan, through 2003 and 2004.

Friends of Big Walnut Creek

The Friends of Big Walnut Creek (FoBWC) has formed relatively recently, with assistance from the Mid Ohio Regional Planning Commission (MORPC). Since that time they have applied for a 319 grant to fund a watershed coordinator, who was subsequently started in July, 2004. The groups objectives are to collaborate with local officials on watershed issues and events such as stream clean-ups, storm drain marking events, educational events, and to develop ability to act as a resource for communities as the storm water Phase 2 plans are developed.

Consistent with Ohio's current Continuous Planning Process (CPP), the draft TMDL report was made available for public review from December 15, 2004 to January 21, 2005. A copy of the Draft Big Walnut Creek TMDL will be posted on Ohio EPA's web page (www.epa.state.oh.us/dsw/tmdl/index.html). A summary of the comments received and the associated responses is in the final report as Appendix E.

7.0 Big Walnut Creek TMDL Implementation Strategy

Ohio EPA is taking an iterative, adaptive approach to implementation for this TMDL project. Point source reductions will be achieved through effluent limitations, compliance schedules, and special conditions in existing dischargers' NPDES permits. A schedule will be developed for issuance of NPDES permits consistent with implementing the TMDL recommendations. Permits will be issued such that:

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

Implementation of nonpoint source reduction measures will be achieved through a locally adopted implementation strategy built around non-regulatory and voluntary incentive programs. The existence of the local watershed groups in the basin ensures that local input will be gained in a planning and decision making process that leads to reasonable and sustainable actions that will be most effective in restoring water resources in the watershed. A two tiered approach that prescribes land management practices and promotes natural channel stability will be the most effective in obtaining nutrient and sediment load reductions. Traditional BMPs and barriers should be targeted at the stream segments most vulnerable to erosion during high flow events. Restoring stream habitat and maintaining channel stability will increase the nutrient and sediment assimilative capacity of streams during normal and lower flow conditions.

Currently FACT is seeking a 319 grant to implement stream restoration activities that are consistent with the goals of the Big Walnut Creek TMDL. In the upper watershed UBWCWQP is promoting ongoing successful programs for riparian easements, CREP and EQIP programs will ensure that pollutant loadings are reduced from that portion of the watershed. Upon approval of the TMDL by USEPA, the local watershed groups will be in a position to utilize the TMDL in their watershed action planning processes to promote activities which will have an influence on the measurable goals of the TMDL.

7.1 Reasonable Assurances

As part of an implementation strategy, reasonable assurances provide a level of confidence that the wasteload allocations and load allocations in a TMDL will be implemented by the Federal, State, or local authorities and/or by voluntary action. Reasonable assurances for planned point source controls, such as wastewater treatment plant upgrades and changes to NPDES permits, will be scheduled for implementation upon approval of the TMDL by USEPA. Reasonable assurances for non-regulatory activities, such as certain nonpoint source improvements lie in the

existing, extensive local infrastructure represented by the watershed groups. This provides a local coordination and implementation structure for the TMDL project. In addition, these watershed groups are supported by local government structure, such as the county soil and water conservation offices, county health departments, and local Natural Resource Conservation Service offices of the U.S. Department of Agriculture, as well as by local municipalities.

7.1.1 Reasonable Assurances Summary

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

7.1.2 Point Source Controls

Implementation of the TMDL for Big Walnut Creek watershed NPDES permit holders is expected to consist of language in the NPDES permits including Long Term Control Plan (LTCP) for CSOs (City of Columbus) and compliance schedules to meet the Total Phosphorus loads for the affected facilities.

Phosphorus effluent limitations will be required in upcoming NPDES permit actions as shown in Table7.1.A.

Table 7.1.A. Recommended NPDES Permit Limits In the Big Walnut Creek TMDL

Facility Name	NPDES Permit #	Receiving Stream	Total Phosphorus Limit mg/l		Allocated Load (lbs/year)
			Existing	Recommended	
Taylor Estates	4PA00001	Rocky Fork	none	1.0	76
Westerville Estates MHP	4PA00011	Rocky Fork	none	1.0	213
Fairfield County Tussing Rd WWTP	4PU00004	Blacklick Cr	none	0.5	4,569
Modern MHP	4PV00114	Blacklick Cr	none	1.0	12
Ohio American Water Co. Blacklick Estates WWTP	4PU00002	Blacklick Cr	none	0.5	1,828
Sunbury	4PB00010	Big Walnut Cr	none	0.5	1,715
Galena	4PB00106	Big Walnut Cr	none	0.5	2,591

7.1.3 Nonpoint Source Controls

Nonpoint source controls in the basin will be focused on preservation or enhancement of instream habitat, reduction of phosphorus and bacterial loads to the watershed. Some local watershed groups have already established watershed action plans that are, or soon will be achieving these some of these objectives (FACT, UBWCWQP). Other groups will be developing watershed action plans in the future (FoBWC).

Habitat
Habitat rehabilitation is important to consider for the restoration of aquatic life uses in the upper areas of the watershed. In many cases, establishing riparian buffers and putting a stop to active channel alteration activities will suffice to let these waters recover. In other places, a more direct intervention, such as dam removal, will be necessary for habitat and aquatic life use recovery to occur (such as in lower Alum Creek). The TMDL has included allocations for habitat that will allow watershed planners to assess the effectiveness of riparian buffer establishment, and also a way to assess the effectiveness of erosion control BMPs. Habitat improvement and riparian buffer establishment is one of the most effective BMPs due to the fact that it directly improves the habitat for aquatic life, and additionally can act as a filter for sediment, and phosphorus loads that may be coming from upland sources.

Tables 5.1.G, 5.2.G, 5.3.G, and 5.4.G list habitat attributes that result in lower QHEI scores, and thus contribute to impairment of the biological . The tables list the habitat attributes that can become areas of focus for improvement by local watershed groups. If for example, a sediment TMDL shows that QHEI metrics for embeddedness are not scoring high enough, Best Management Practices (BMPs) can be implemented in order to reduce sediment loading to the stream. In this way, the tables can become guides to allow local groups to take effective action to improve aquatic habitat. Although there are other stream habitat and morphology evaluation systems, the QHEI has the benefit of being directly correlated with aquatic life performance. This makes improvement in QHEI scores by improving aquatic habitat one of the most effective BMPs available to allow recovery of impaired streams.

Nutrients
Nutrient loads in the watershed exceed targets established by Ohio EPA. Nutrient reduction in the form of phosphorus reduction will eliminate this stress to aquatic life. Many of the BMPs that UBWCWQP is recommending for the control of atrazine will also be beneficial for the control of total phosphorus. Local groups wishing to establish voluntary phosphorus controls can look at the UBWCWQP as a successful example of an organization implementing these types of controls.

Pathogens
Pathogen or bacteria loads are high throughout the watershed, and there is widespread impairment of recreational uses in the watershed. Much of the impairment can be correlated with the presence of discharging HSTS (home aerator systems). These systems are not designed to disinfect the discharge, and are a significant contributor of pathogens in this watershed.

In Table 7.1.B, pathogen loading reduction requirements are listed by county and subwatershed. Health Departments in the effected counties should evaluate the required loading reductions, and determine a plan to achieve these reductions. Elimination of home aerator discharges is one way to achieve targeted loading reductions. Rehabilitation of malfunctioning systems, along with the installation of filtration and effluent disinfection may be necessary for many of the existing home aerator discharges, and represent available technology to achieve these reductions. No new discharging HSTS should be permitted, as these will be a source of additional bacterial load for which there is no allocation.

Table 7.1.B. also shows the available bacterial loading for HSTS. Please note that there is no additional available pathogen loading to surface or ground water for HSTS,. In other words, 100% of the pathogen loading from HSTS must be eliminated. This means that malfunctioning, or otherwise inoperable HSTS need to be upgraded. Current standards for installation of new HSTS vary by county. A recent publication by the Ohio State University Extension, Bulletin 896 outlines the criteria necessary for installing HSTS in a fashion that will allow for no further loading of bacteria to ground water or surface water. In light of the fact that current bacterial loads in the Big Walnut Creek watershed exceed assimilative capacity, and that recreational uses are impaired, no new HSTS should be installed that do not comply with the criteria established in Bulletin 896, in the absence of site specific information showing that other standards will protect against bacterial loading to ground water or surface water.

Table 7.1.B. Required reductions in pathogen loading in the Big Walnut Creek Watershed.

County	Watershed	14-digit HUC	Pathogen Loading reductions for discharging HSTS	Other NPS Pathogen Loading Reductions
Delaware	Culver Creek[1]	130-020	81%	Cattle - 85%
	Rattlesnake Creek[2]	130-040	71%	Cattle - 85%
	Big Walnut Creek	130-050	90%	Cattle - 90%
	Little Walnut Creek	130-060	68%	Cattle - 85%
	Alum Creek	150-040	74%	Cattle - 100% Forest - 15% Pasture - 15% Cropland - 15%
	Big Run	150-050	80%	Cattle - 87%
	Alum Creek	160-010	56%	Cattle - 100% Runoff - 77%
Franklin	Big Walnut Creek	140-010	6%	Runoff - 49%
	Rocky Fork	140-020	76%	Cattle - 100% Runoff - 57%
	Big Walnut Creek	140-030	2%	Runoff - 12%
	Mason Run	140-040	45%	Runoff - 45%
	Upper Blacklick Creek[2]	140-050	78%	Runoff - 65% Cattle - 100%
	Lower Blacklick Creek[2,3]	140-060	10%	Runoff - 21%
	Alum Creek	160-010	56%	Cattle - 100% Runoff - 69%
	Alum Creek	160-020	91%	SSO - 100% CSO - 91% Runoff - 44%
Morrow	Big Walnut Creek	130-010	66%	Cattle - 96%
	Alum Creek	150-010	65%	Cattle - 99%
	West Branch Alum Creek	150-020	76%	Cattle - 98%
	Turkey Run	150-030	81%	Cattle - 98%

1. Also includes affected areas of Knox County.
2. Also includes affected areas of Licking County.
3. Also includes affected areas of Fairfield County.

Pathogen runoff from agricultural sources can be addressed through a number of BMPs, primarily fencing cattle out of streams. A number of funding sources EQIP, CREP, etc. may be evaluated for financial assistance by landowners needing to make reductions in bacterial loadings. Local SWCD personnel can assist landowners in evaluating the extent of any problems, and how best to approach reducing bacterial loadings from agricultural sources.

As noted in Table 4.3.B, SSO discharges are allocated zero load of bacteria. The City of Columbus sanitary sewer system has SSOs in the Big Walnut Creek watershed. According to the terms of a August 1, 2002 judicial consent agreement between Ohio EPA and the City, all discharges from SSOs will cease in accordance with the schedules established in the consent agreement. Therefore, the expectation that there will be no pathogen loading from this source is well founded.

7.2 Process for Monitoring and Revision

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

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

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

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