State of Ohio
Environmental Protection Agency

Division of Surface Water

Total Maximum Daily Loads for the Walnut Creek Watershed

Final Report
February 2, 2010

Ted Strickland, Governor
Chris Korleski, Director

Walnut Creek at Pontius Road in Franklin County

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List of Acronyms and Abbreviations

BIT	Bacteria Indicator Tool
BMP	best management practice
cm	centimeter
CNMP	Comprehensive Nutrient Management Plan
cnt/seas	counts per season
CO	consent agreement
Corps	U.S. Army Corps of Engineers
CREP	Conservation Reserve Enhancement Program
CRP	Conservation Reserve Program
CSO	combined sewer overflow
CSS	combined sewer system
CWA	Clean Water Act
CWH	Cold Water Habitat
DA	drainage area
DEFA	Division of Environmental and Financial Assistance
DFFOs	Directors Final Findings and Orders
DNAP	Division of Natural Areas and Preserves
DSW	Division of Surface Water
DSWC	Division of Soil and Water Conservation
ECBP	Eastern Corn Belt Plains
EQIP	Environmental Quality Incentives Program
EWH	Exceptional Warmwater Habitat
FC	Fecal Coliform
FSA	Farm Service Agency
gpd	gallons per day
GPS	geographic positioning system
GW	ground water
HSTS	household sewage treatment system
HUC	hydrologic unit code
IBI	Index of Biotic Integrity
ICI	Invertebrate Community Index
LA	load allocations
lb/yr	pounds per year
LEAP	Livestock Environmental Assurance Program
LID	low impact development
LTCP	Long term Control Plan
mg/L	milligrams per liter
MGD	million gallons per day
MHP	Mobile Home Park
MIWB	Modified Index of Well-Being
mi^2	square mile
ml	milliliter
MOR	monthly operating reports
MORPC	Mid-Ohio Regional Planning Commission
MOS	margin of safety
MS4	municipal separate storm sewer system
MWH	Modified Warmwater Habitat
NACD	National Association of Conservation Districts
NEMO	Nonpoint Education for Municipal Official

NLCD	National Land Cover Dataset
NPDES	National Pollutant Discharge Elimination System
NPS	nonpoint source
NRCS	Natural Resource Conservation Service
OAC	Ohio Administrative Code
OAEA	Ohio Agricultural Environmental Assurance
ODNR	Ohio Department of Natural Resources
ODOT	Ohio Department of Transportation
OFAER	On Farm Assessment and Environmental Review
OFBF	Ohio Farm Bureau Federation
OLC	Ohio Livestock Coalition
ORC	Ohio Revised Code
PCR	Primary Contact Recreation
PIR	Pollution Investigation Report
PTI	Permit to Install
QHEI	Qualitative Habitat Evaluative Index
RC&D	Resource Conservation and Development
RI	return interval
RM	river mile
SCR	Secondary Contact Recreation
SCS	Soil Conservation Service
SSO	sanitary sewer overflow
SSO	separate sewer overflow
SSS	sanitary sewer system
SWCD	Soil and Water Conservation District
TMDL	total maximum daily load
tn/yr	tons per year
TP	total phosphorus
TSS	total suspended solids
U.S. EPA	U.S. Environmental Protection Agency
USDA-ARS	United States Department of Agriculture-Agricultural Research Service
USGS	U.S. Geologic Survey
WHC	Wildlife Habitat Council
WLA	wasteload allocations
WPCLF	Water Pollution Control Loan Fund
WQC	Water Quality Certification
WQMP	Water Quality Management Plan
WQS	water quality standards
WRP	Wetland Reserve Program
WRRSP	Water Resource Restoration Sponsor Program
WTP	water treatment plant
WWH	Warmwater Habitat
WWTP	wastewater treatment plant

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- Team Leader – Jan Rice

Other full- and part-time staff also participated in field monitoring.

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

Our gratitude extends to all of the groups and individuals who have participated in this TMDL. The following are particularly noteworthy:

County Soil and Water Conservation Districts
County Health departments

EXECUTIVE SUMMARY

The Walnut Creek watershed is located in Central Ohio between the cities of Columbus and Lancaster. This 286 square mile watershed area is home to more than 65,000 people and encompasses all or part of 15 municipalities in Fairfield, Franklin Licking, Perry, and Pickaway counties.

In 2005, Ohio EPA staff sampled 55 sites on streams in this watershed. Through this survey, the usability of the stream resources for recreation and suitability for aquatic wildlife were evaluated. This evaluation was based on whether data collected were consistent with minimum criteria established in Ohio's Water Quality Standards (WQS) to protect those stream uses.

Details regarding this water quality survey were published in December 2006 in the *Biological and Water Quality Study of Walnut Creek and Tributaries* (available at http://www.epa.ohio.gov/portals/35/documents/WalnutCreek2005TSD.pdf). An interactive map showing sampling site locations in this watershed is available at http://wwwapp.epa.ohio.gov/dsw/gis/bio/index.php.

The survey results show Walnut Creek to be an exceptional water resource, particularly in its ability to support unique and pollution sensitive aquatic species. The spotted, Tippecanoe, and state endangered bluebreast darters were recorded for the first time in Walnut Creek. The variegate darter was also found which is, like these others, particularly sensitive to poor water quality. The darters' presence indicates that Walnut Creek is healthy. However, 22 percent of the sites, all of which were on tributary streams, did not fully attain WQS for aquatic life while 45 percent failed to meet quality criteria for recreation.

Degraded water quality was due to an excess of fine sediment such as silts and clays in the streams, unnatural channel shape due either to the ditching of small drainageways or channel erosion, and impacts of urban/suburban land uses that increase runoff and export pollutants. These stresses result in adverse impacts on the aquatic wildlife community as shown by low species diversity and an absence of native fishes that are sensitive to stress. Additionally, high concentrations of dissolved solids from Pickerington's waste water treatment facility adversely impacted stream insects. (The City of Pickerington disputes these results has retained a consultant to resample the area; results of the study have not been submitted to Ohio EPA for review as of February 1, 2010).

Recreational uses were impaired due to the elevated risk for water-borne illness from pathogen contamination. This is evidenced by high concentrations of bacteria associated with fecal matter. Reasons for these failures include poorly treated human waste coming from home septic systems and livestock wastes, particularly where they have substantial access to stream or riparian areas.

Total maximum daily loads (TMDLs) were calculated for fecal coliform bacteria, sediment, and habitat quality. Watershed hydrology and estimates of fecal coliform loading from all sources were approximated using simple modeling methods based on mathematical equations and watershed characteristics. The sediment and habitat TMDLs were generated through a direct comparison of scores from a habitat evaluation index to target scores for that index.

The calculated amount of total load reductions needed for fecal coliform bacteria ranged from 30 percent to 95 percent. The portion of the watershed upstream from and including Sycamore Creek (corresponding to the 11-digit HUC of 05060001-170) was more widely impacted and generally required larger reductions than the lower portion (corresponding to the 11-digit HUC of

05060001-180). Sediment load reductions and habitat improvements were needed in both the upper (170) and lower (180) HUCs although not widely distributed and deviations from the targets were generally modest.

Addressing the nonpoint sources of these water quality stressors can be accomplished through system upgrades or better management of home septic systems. Restricting access to streams and riparian areas for livestock will drastically improve the conditions in some localized areas. Sediment loading is most likely originating from the cropland surrounding these problem areas. Cover crops, conservation crop rotation, improvements in tillage methods, and sediment capture areas such as filter areas or wetlands would alleviate a large proportion of the problem. Riparian planting and a more naturalized approach to drainage infrastructure would improve habitat and also increase the stability and sustainability of these channels. Storm water impacts from existing urbanized areas should be minimized by retrofitting storm water infrastructure as opportunities arise, and using a proactive storm water management approach for new development. In particular, impervious surfaces should be minimized, sensitive or critical areas protected, and localized storm water management (as opposed to larger centralized systems) could be used to better mimic a natural hydrology.

1 INTRODUCTION

The Walnut Creek watershed is located in Central Ohio between the cities of Columbus and Lancaster. This 286 square mile watershed area is home to more than 65,000 people and encompasses all or part of 15 municipalities in Fairfield, Franklin Licking, Perry, and Pickaway Counties.

Ohio EPA conducted a comprehensive physical, chemical and biological survey in the Walnut Creek watershed in 2005. The water quality survey included monitoring of Walnut Creek and several tributary streams. There were stream segments not meeting the Ohio water quality standards identified during the survey. These findings and other information regarding water quality and habitat conditions are summarized in this report.

Total Maximum Daily Loads (TMDL) have been developed for pollutants and stressors that have impaired water uses and precluded attainment of applicable water quality standards. This report summarizes the approach taken and results for these TMDL analyses. This report also includes a discussion about actions and land management that can abate the identified water resource problems.

Specific TMDLs that have been developed and are described in this report include:

- Pathogens (using fecal coliform as an indicator of contamination)
- Sediment (using a qualitative index to assess the degree of in-stream sedimentation)
- Habitat (using a qualitative index to assess the quality of habitat features)

Section 8 in this report provides strategies for restoring the full uses of surface waters in the Walnut Creek watershed. Strategies for control of point sources and some non point sources involve use of regulatory wastewater and storm water permits to control pollutant discharge in the watershed. Corrective measures have already been initiated to address use impairment caused by regulated entities.

1.1 The Clean Water Act requirement to address impaired waters

The Clean Water Act (CWA) Section 303(d) requires States, Territories, and authorized Tribes to list and prioritize waters for which technology-based limits alone do not ensure attainment of water quality standards. Lists of these impaired waters (the Section 303(d) lists) are made available to the public for comment, then submitted to the U.S. Environmental Protection Agency (U.S. EPA) for approval in even-numbered years. Further, the CWA and U.S. EPA regulations require that Total Maximum Daily Loads (TMDLs) be developed for all waters on the Section 303(d) lists. The Ohio EPA identified several subwatersheds (11-digit Hydrologic Unit Code) as impaired on the 2008 303(d) list (contained in the 2008 Integrated Report (Ohio EPA, 2008), available at
http://www.epa.ohio.gov/dsw/tmdl/2008IntReport/2008OhioIntegratedReport.aspx).

Not only does the 303(d) list account for the waterbodies that are not meeting water quality standards, but also lists the environmental stressors that are responsible for the substandard water quality. These stressors are often a specific pollutant or suite of pollutants; however, the physical condition of the stream systems (e.g., poor habitat quality) may also stress the system. Additionally the sources from which these stressors originate are identified and listed. These listed parameters are then addressed through the TMDL development process.

In the simplest terms, a TMDL can be thought of as a cleanup plan for a watershed that is not meeting water quality standards. A TMDL is defined as a calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards and an allocation of that quantity among the sources of the pollutant. Ultimately, the goal of Ohio's TMDL process is full attainment of Water Quality Standards (WQS), which would subsequently lead to the removal of the waterbodies from the 303(d) list. Table 1.1 summarizes how the impairments identified in the Walnut Creek watershed are addressed in this TMDL report.

Table 1.1 A summary of the 2008 303(d) listed impairments in the Walnut Creek TMDL study area.

Assessment Unit (HUC–11) 05030204 -	**Drainage area (sq mi)**	**Aquatic Life Use Impairment**	**Recreational Use Impairment**	**Drinking Water Use Impairment**	**Priority Points**
170	138.0	Yes	Yes	Not applicable	8
180	147.5	Yes	Yes	Not applicable	7

Table 1.2 Summary of causes of impairment to aquatic life and recreational uses for the Walnut Creek watershed and actions taken to address them.

Assessment Unit[A]	**Narrative Description**	**Causes of Impairment**	**Action Taken**
05060001 170	Walnut Creek (headwaters to downstream Sycamore Creek)	Organic enrichment (sewage) Biological indicators	Addessed by activities aimed at abating habitat and fecal coliform bacteria problems (TMDLs are developed for these parameters)
		Oxygen, dissolved	Addessed by activities aimed at abating habitat and fecal coliform bacteria problems (TMDLs are developed for these parameters)
		Solids (suspended/bedload)	Addessed by activities aimed at abating habitat and fecal coliform bacteria problems (TMDLs are developed for these parameters)
		Total dissolved solids	Category 4B used
		Natural conditions	Not addressed
		Sedimentation/siltation	TMDL for sediment
		Ammonia (un-ionized)	Addessed by activities aimed at abating habitat and fecal coliform bacteria problems (TMDLs are developed for these parameters)
Priority points: 8		Bacteria (recreation use)	TMDL for fecal coliform
05060001 180	Walnut Creek (downstream Sycamore Creek to mouth)	Direct habitat alterations	TMDL for habitat
		Low flow alterations	TMDL for habitat
		Organic enrichment (sewage) Biological indicators	Addessed by activities aimed at abating habitat and fecal coliform bacteria problems (TMDLs are developed for these parameters)
		Sedimentation/siltation	TMDL for sediment
		Other (unknown toxicity)	Addessed by activities aimed at abating habitat and fecal coliform bacteria problems (TMDLs are developed for these parameters)
Priority points: 7		Bacteria (recreation use)	TMDL for fecal coliform

[A] Priority points as assigned in Ohio EPA, 2008.

1.2 Public involvement

Public involvement is key to the success of water restoration projects, including TMDL efforts. From the beginning, Ohio EPA has invited participation in all aspects of the TMDL program. The Ohio EPA convened an external advisory group in 1998 to assist the Agency with the development of the TMDL program in Ohio. The advisory group issued a report in July 2000 to the Director of Ohio EPA on their findings and recommendations. The Walnut Creek watershed TMDL project has been completed using the process endorsed by the advisory group.

Consistent with Ohio's current Continuous Planning Process (CPP), the draft TMDL report will be available for public review from November 12 through December 14, 2009. A copy of the draft report will be posted on Ohio EPA's web page (http://www.epa.ohio.gov/dsw/tmdl/index.aspx). A summary of the comments received and the associated responses will be completed after the public comment period and included in Appendix C in the final report.

Ohio EPA has been in communication with representatives from local agencies and organizations regarding the findings of the watershed assessments and preliminary TMDL results. These include: regional planning, soil and water conservation districts, county Natural Resource Conservation Service offices, and a watershed group, the Walnut Action Group, which has significant participation from local officials. Meetings were held in which results of the watershed assessment and preliminary TMDL analyses were shared and approaches towards water quality restoration were discussed.

Continued public involvement is critical to the success of any TMDL project. Ohio EPA will continue to support the implementation process and will facilitate, to the fullest extent possible, restoration actions that are acceptable to the communities and stakeholders in the study area and to Ohio EPA. Ohio EPA is reluctant to rely solely on regulatory actions and strongly advocates voluntary actions facilitated by the local stakeholders, watershed organization, and agency partners to restore the Walnut Creek watershed.

2 DESCRIPTION OF THE PROJECT AREA

2.1 Project delineation

In Ohio, TMDL projects are primarily watershed based. Watersheds are assigned identifying numbers based on the U.S. Geological Survey's (USGS) hydrologic unit codes (HUCs). These HUCs are uniquely assigned to a specific watershed area. The codes are based on a nested system where fewer digits in the HUC correspond to larger watershed areas while HUCs with those same and more digits correspond to unique subdivisions of that larger watershed area. At the time of the development of this TMDL Ohio EPA was using 11-digit HUCs (also referred as HUC11s) as the equivalent of a water quality assessment unit.

The Walnut Creek watershed is comprised of two 11-digit HUCs, the upper Walnut (05060001-170) and the lower Walnut (05060001-180). For the purpose of achieving higher resolution in the watershed analyses, 14-digit HUCs (also referred as HUC14s), and in some cases sub-divisions of these, were analyzed individually and results presented accordingly.

Table 2.1 lists the 14-digit HUCs in the Walnut Creek watershed as well as the respective 11-digit HUC (and assessment unit) to which they belong (i.e., the first 11 of the 14 digits). Figure 2.1 is a map of the entire Walnut Creek watershed with the respective 14-digit HUCs labeled with the last six of the 14 digits and identified by color.

2.2 Water resources

Walnut Creek flows almost 58 miles from headwaters in northwest Perry County to the mouth at the Scioto River. Walnut Creek joins the Scioto River approximately five miles upstream from the confluence of Big Darby Creek and the Scioto River in Circleville, Ohio. The nearness of the exceptionally diverse aquatic ecosystem of the Big Darby Creek watershed in conjunction with improved water quality in the Scioto mainstem has allowed rare and sensitive species to recolonize historic ranges, including Walnut Creek, from the Big Darby.

Principle tributaries to Walnut Creek include Sycamore, Little Walnut, Georges, Poplar, and Pawpaw creeks. Figure 2.2 is a map showing these and other named tributaries in the watershed, while Table 2.2 is a list of tributaries along with their respective lengths, average gradient, and drainage areas. Many tributaries in the watershed drain coarse glacial material, and consequently receive ground water that sustains ample baseflow even during drier times of the year. Aided by the stabilizing effect of ground water, habitat quality is generally good and capable of sustaining healthy biological communities.

There are no surface water intakes for public drinking water supplies, sizeable lakes for recreation, or any other type of resource that stands out from typical river and stream uses. Satellite imagery shows that wetlands account for less than one percent of the watershed area, amounting to about 1,000 acres.

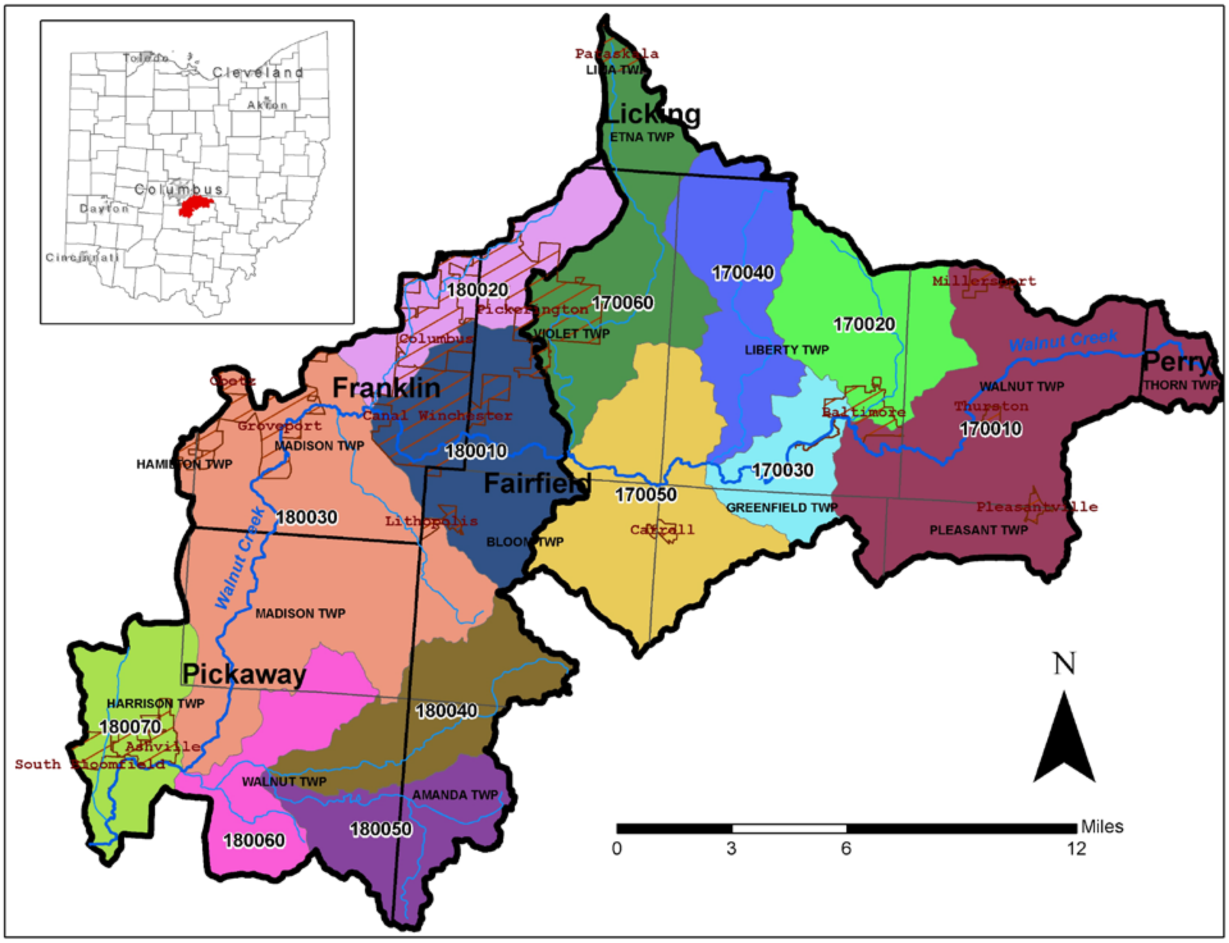


Figure 2.1 Walnut Creek's14-digit HUCs and various political boundaries.

Table 2.1 14-digit HUC watersheds within the Walnut Creek watershed.

HUC14		TMDL Watershed or Assessment Unit	Narrative Description	Area (square miles)
05060001-170	010	Upper Walnut	Walnut Creek above Pawpaw Creek	42.5
	020	Upper Walnut	Pawpaw Creek	17.5
	030	Upper Walnut	Walnut Creek below Pawpaw Creek to above Poplar Creek	9.6
	040	Upper Walnut	Poplar Creek	17.4
	050	Upper Walnut	Walnut Creek below Sycamore Creek to above George Creek	27.4
	060	Upper Walnut	Sycamore Creek	23.6
05060001-180	010	Lower Walnut	Walnut Creek Below Sycamore Creek to above George Creek	23.0
	020	Lower Walnut	George Creek	14.6
	030	Lower Walnut	Walnut Creek Below George Creek to above Little Walnut Creek	52.1
	040	Lower Walnut	Little Walnut Creek Headwaters to above Turkey Run	17.0
	050	Lower Walnut	Turkey Run	14.3
	060	Lower Walnut	Little Walnut Creek Below Turkey Run to Walnut Creek	12.7
	070	Lower Walnut	Walnut Creek Below Little Walnut Creek to Scioto River	13.9

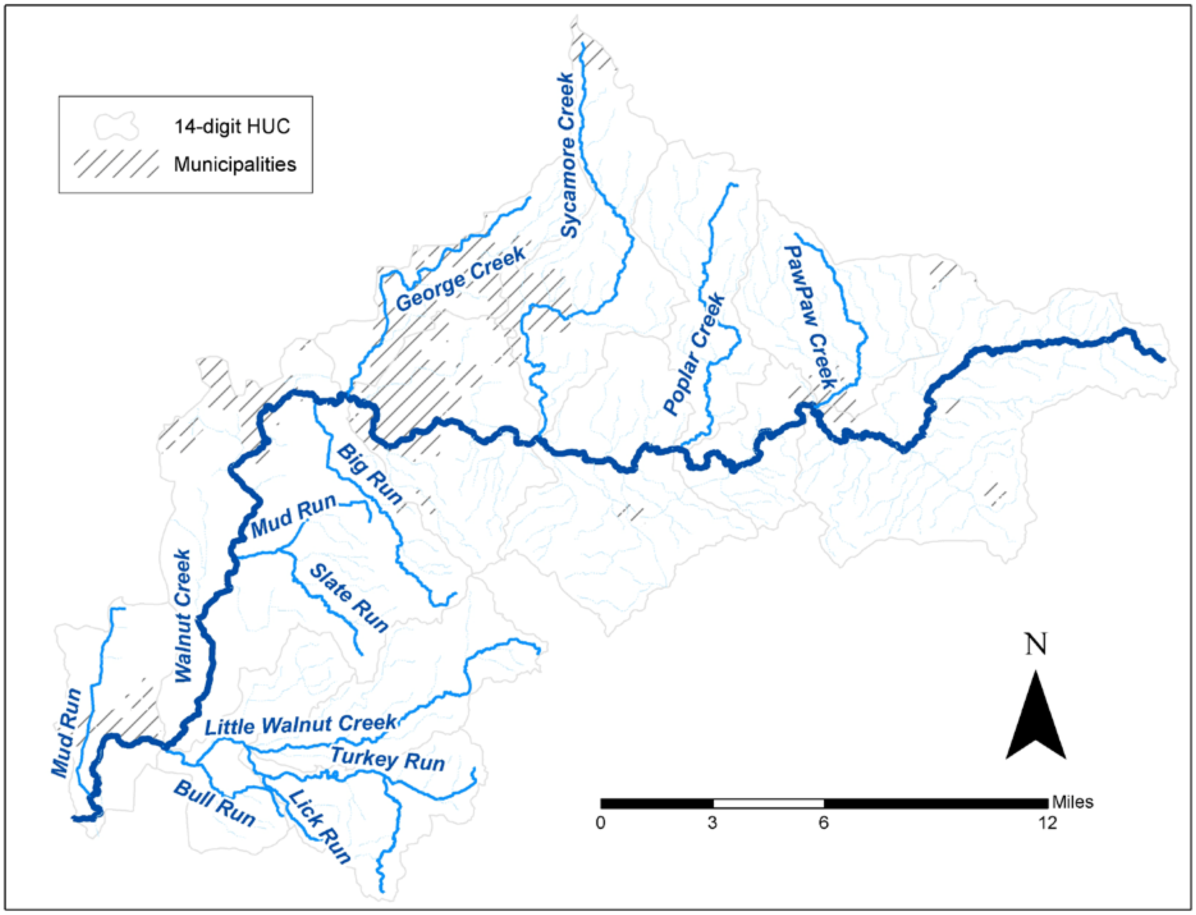


Figure 2.2 Map of named streams in the Walnut Creek watershed.

Table 2.2 Named streams in the Walnut Creek watershed.

11-digit HUC	Stream Name	Length[1] (miles)	Average gradient[2] (feet / mile)	Drainage area[2] (square mile)
N/A	Walnut Creek	57.9	9.4	286
170	Sycamore Creek	16.5	22.6	23.6
180	Little Walnut Creek	14.3	27.7	44.0
180	Mud Run	11.2	na[3]	na[3]
170	PawPaw Creek	7.7	30.0	17.5
170	Poplar Creek	10.8	29.5	17.4
180	Turkey Run	10.2	27.9	14.3
180	George Creek	10.1	10.9	14.6
180	Big Run	9.0	20.8	8.1
180	Slate Run	5.0	na[3]	na[3]
180	Bull Run	3.6	na[3]	na[3]
180	Cherry Run	3.4	25.4	5.7
180	Lick Run	2.8	45.6	2.14
170	Deep Cut	1.6	na[3]	na[3]
N/A	All unnamed tributary streams	394.8	na[3]	na[3]
	GRAND TOTAL	**559**		

1 Based on National Hydrography Dataset
2 Based on information from the Gazeteer of Ohio Streams (Ohio DNR, 2001)
3 "na" indicates these data are not available in the Gazeteer of Ohio Streams

2.3 Land cover

Land use within the basin is dominated by row-crop agriculture and residential development as portrayed in Figure 2.3. Urban/suburban land use is concentrated in the northwest third of the catchment with the highest densities in southeastern Franklin County and in Violet Township in Fairfield County. Current land use trends have increased the potential for nonpoint source pollution of the stream system. Increased frequency in the number of construction sites, large lot development, horse and novelty livestock operations, and on-site home sewage treatment systems (HSTS) contribute to this potential.

Areas protected from land development include Slate Run in Pickaway County, Pickerington Ponds in Franklin and Fairfield Counties, and Chestnut Ridge in Fairfield County. These areas encompass approximately 5 square miles; a relatively insignificant area compared to Walnut Creek's 286 square mile drainage area. Although thinned out in areas, a well defined riparian zone can be seen along the lower Walnut Creek channel. Other forested lands are located on ridges and areas that are marginal for crop production or pasturing. The percent of each land use type is given in Figure 2.3.

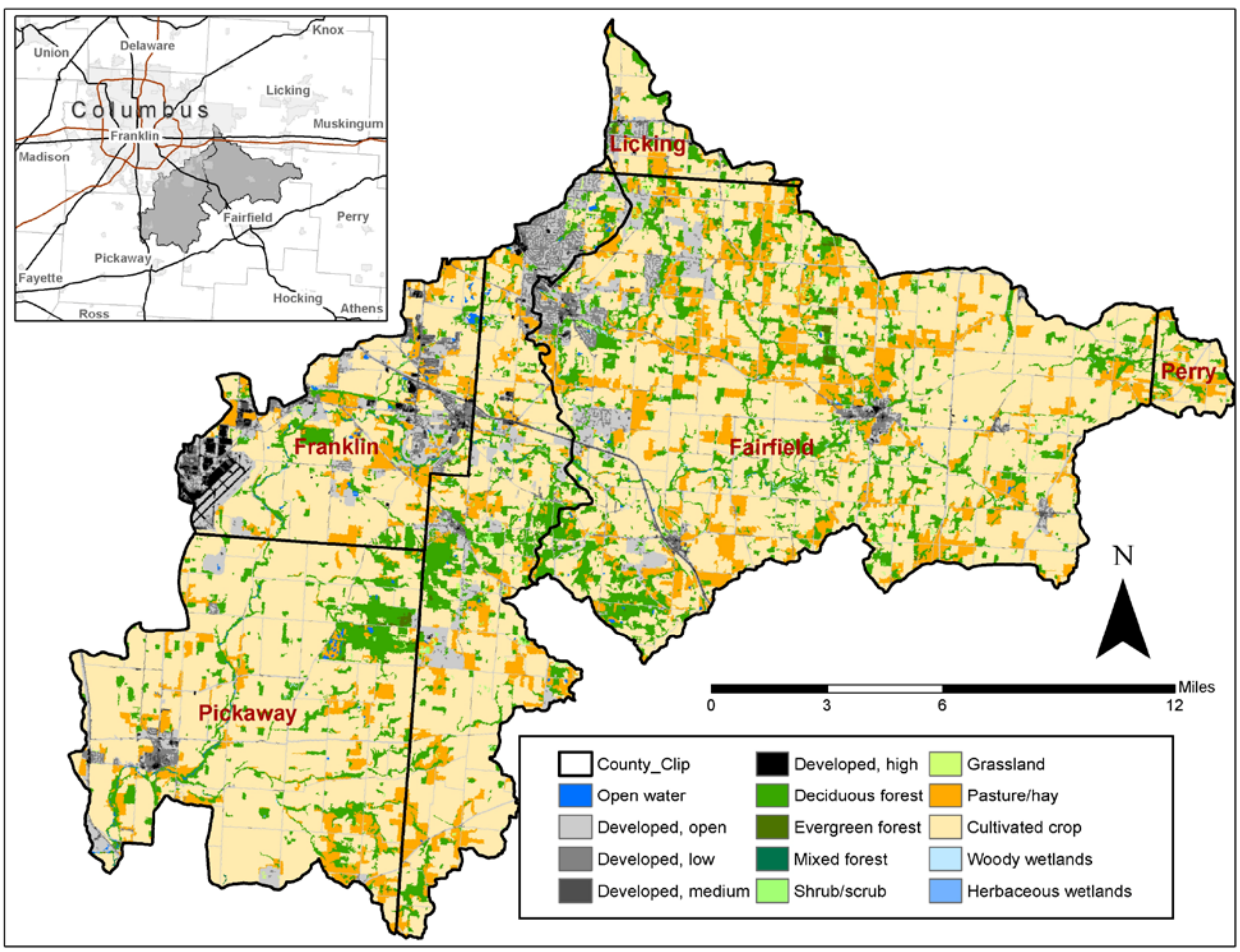


Figure 2.3 Map of land cover classes. Land cover is based on Landsat 7 imagery taken around 2001 and compiled in 2006 by the Multi-Resolution Land Characteristics (MRLC) consortium.

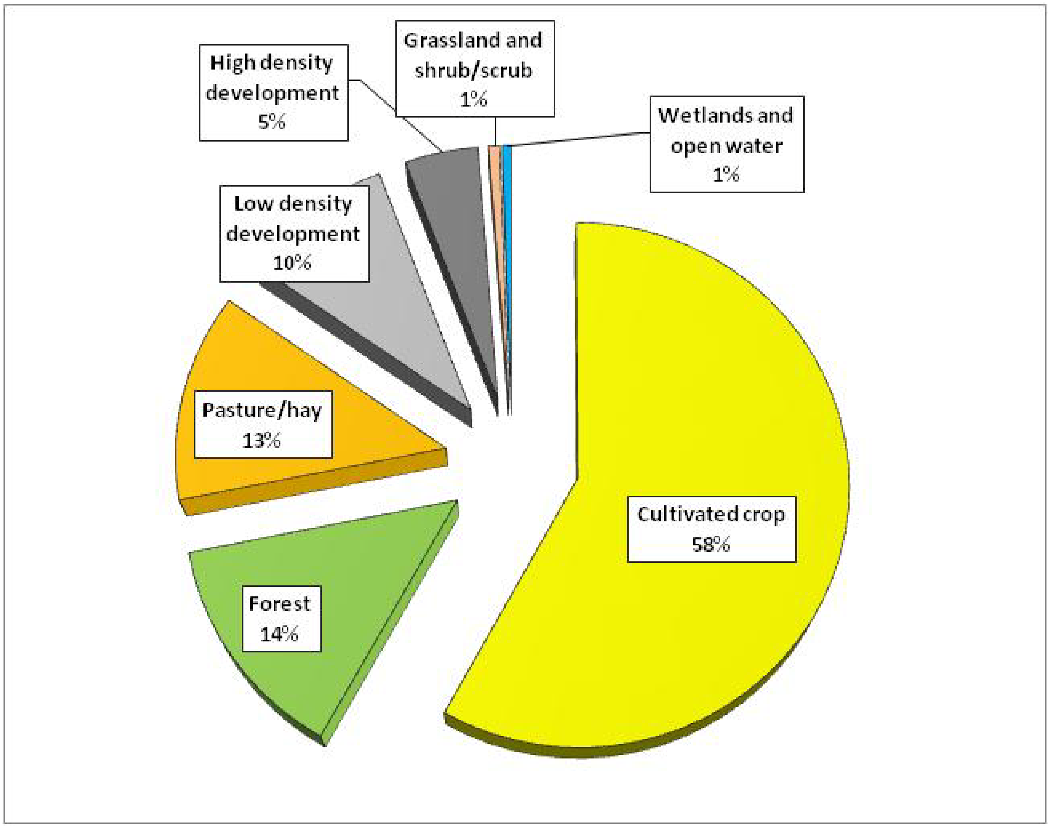


Figure 2.4 Pie chart of the distribution of land cover types.

Table 2.3 Cumulative acres of various land cover types.

Land cover	Acres	Percent
Cultivated crop	106,138	58.1%
Forest	25,120	13.7%
Pasture/hay	23,586	12.9%
Low density development	17,419	9.5%
High density development	8,241	4.5%
Grassland and shrub/scrub	1,255	0.7%
Wetlands and open water	985	0.5%
TOTAL	182,745	100%

2.4 Soils, geology and topography

The Walnut Creek watershed lies within the Central Lowland physiographic region exhibiting an undulating topography intermixed with extensive flat areas. The bedrock underlying the Walnut Creek watershed is acidic sandstone or shale. The Cuyahoga fine grained sandstone interbedded with shale is found west of the Perry county line to approximately Pickerington Road, where Berea sandstone bedrock appears. Though sandstone and shale comprise the bedrock of the watershed, the stream itself flows over a mix of relatively deep, fine-grained calcareous till and outwash deposits of Wisconsinan origin overlaying lacustrine clays of Illinoisan origin. The clay acts as an occluding layer directing ground water to move laterally to stream channels that have eroded down to the clay. The major associations, all formed in till, outwash and or alluvium, are Bennington-Cardington, Brookston-Crosby, and Cardington-Bennington-Marengo.

Surface soil deposits in the Walnut Creek basin are primarily Wisconsinan ground and end moraines overlying hardpan of Illinoisan origin. The former supplies gravel and cobble substrates to the streambed, and the later acts as a confining layer that supplies numerous ground water seeps to the stream. This combination of gravel-cobble substrates and sustained baseflow ameliorates the embedding silt and sand that tend to pervade intensively cropped drainages, Walnut Creek included.

2.5 Population and growth trends and economic development

As is noted in the preceding figures, development is projected to continue for many areas in this watershed. One of these areas which will likely see rapid economic development is along the Rt. 33 corridor in the Fairfield County portion of this watershed. Additional information regarding this corridor can be viewed at http://fairfield33.com/.

A second area likely to experience rapid growth is in the northeast quadrant of Pickaway County where the Rickenbacker Intermodal is located. Additional information regarding this facility can be found at http://www.rickenbacker.org/intermodal/.

A third area expected to see rapid economic development is located in Etna Township, Licking County, in the Sycamore Creek headwaters. Etna Township and the City of Pataskala are involved in development projects in this area.

This trend, if not managed appropriately, may result in continued riparian corridor loss along streams. This loss will be detrimental for water quality. Counties, municipalities, townships and individual landowners must work to protect and, when possible, restore riparian corridors. Riparian corridors provide benefits ranging from water quality enhancement to flood protection as well as open space for parks and trails.

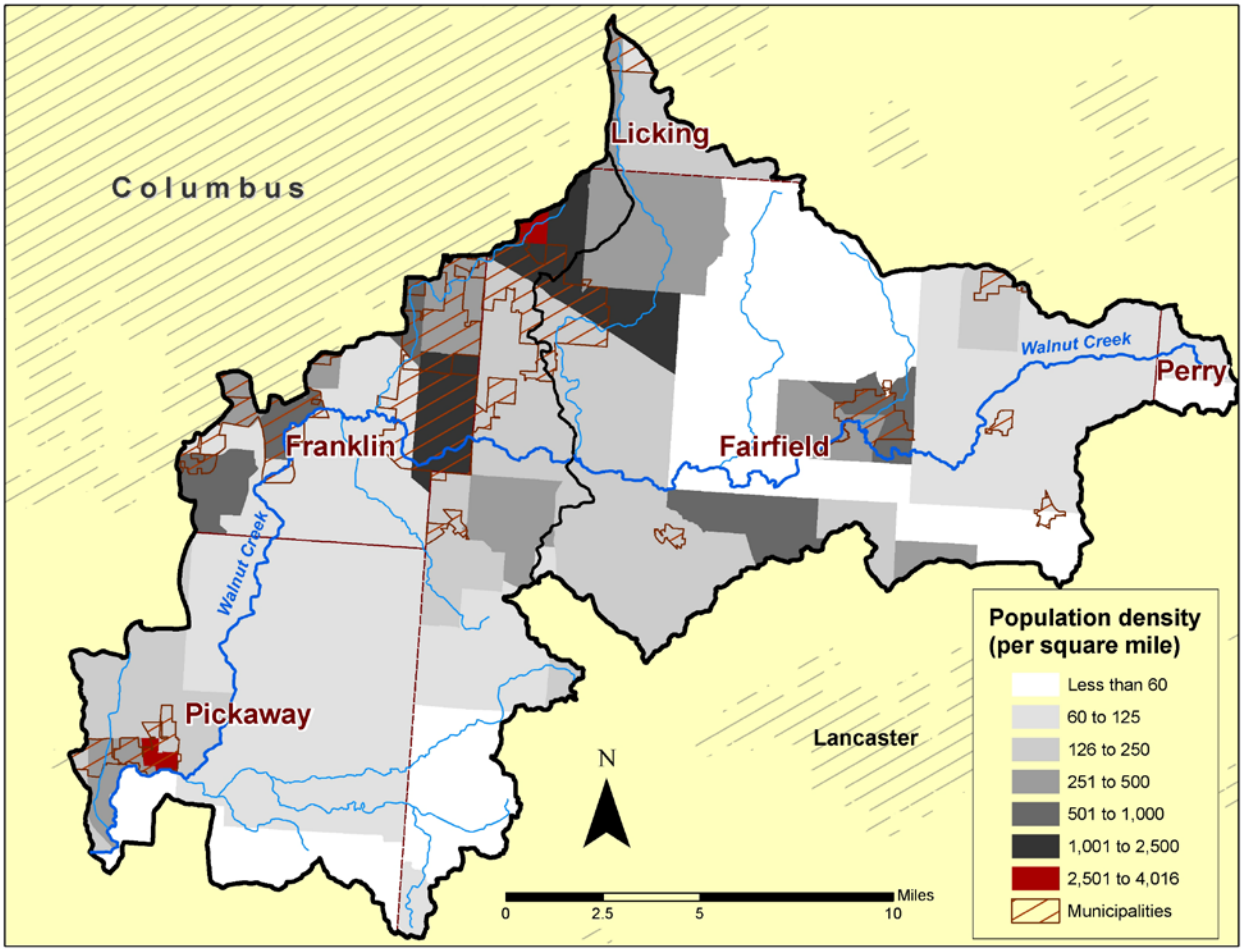


Figure 2.5 Map of population density. Based on the 2000 census provided by the Ohio Department of Development in a spatially referenced database.

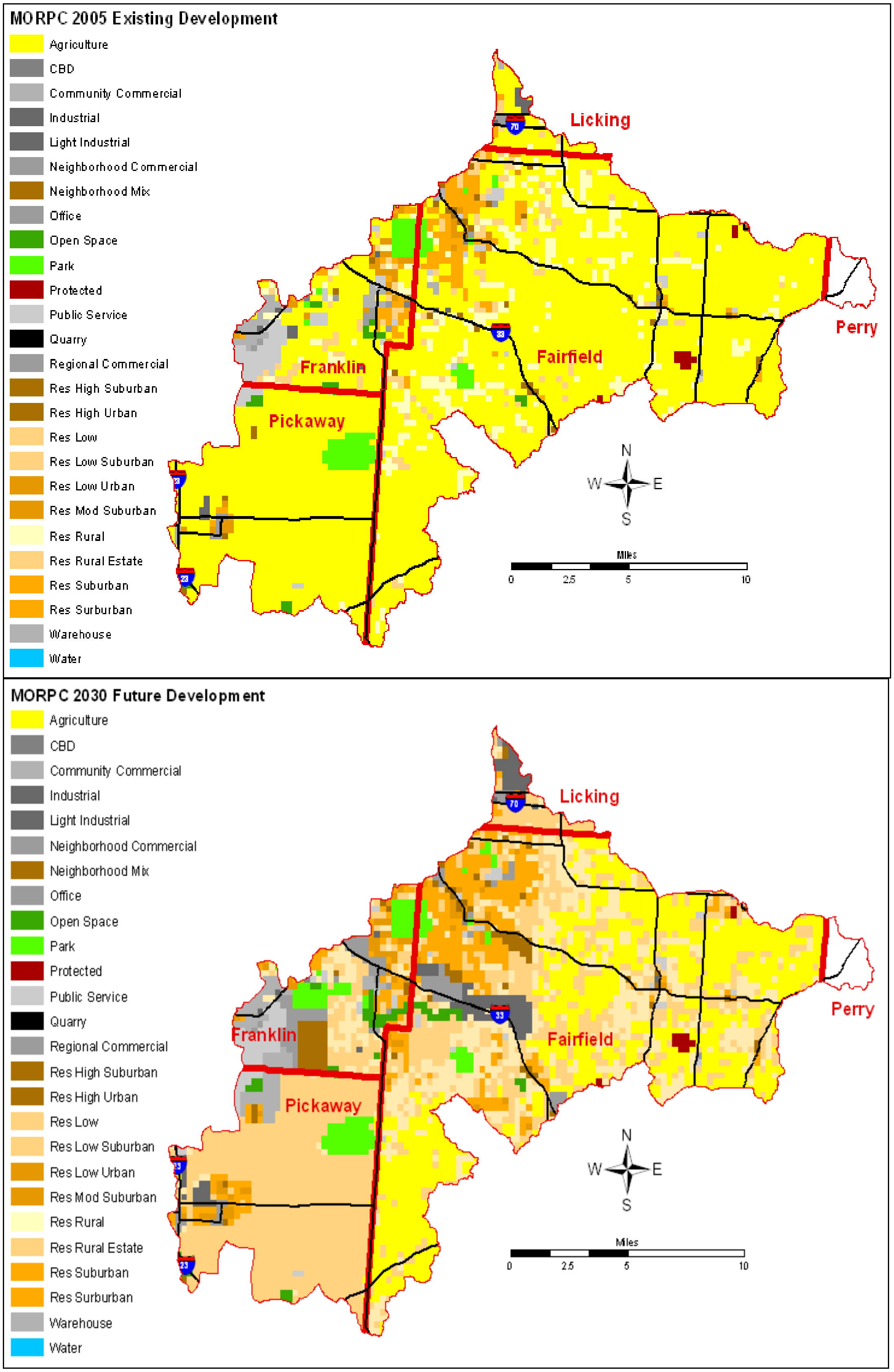


Figure 2.6 Map of recent and projected development. Spatial data from Mid Ohio Regional Planning Commission (http://www.morpc.org/info_center/dataport/gis_downloadble.asp).

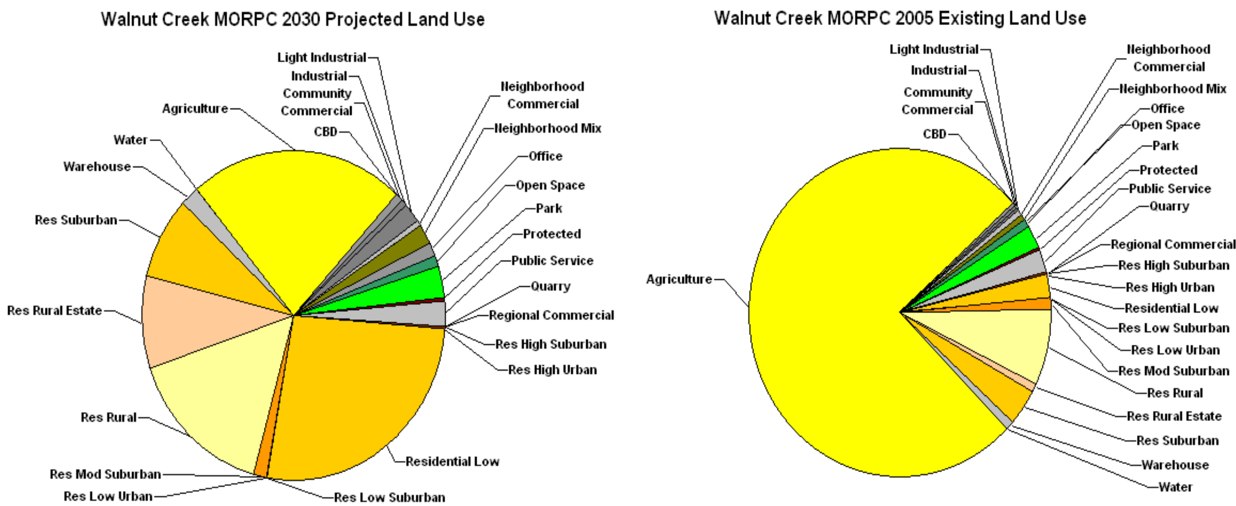


Figure 2.7 Pie charts of recent and projected development.

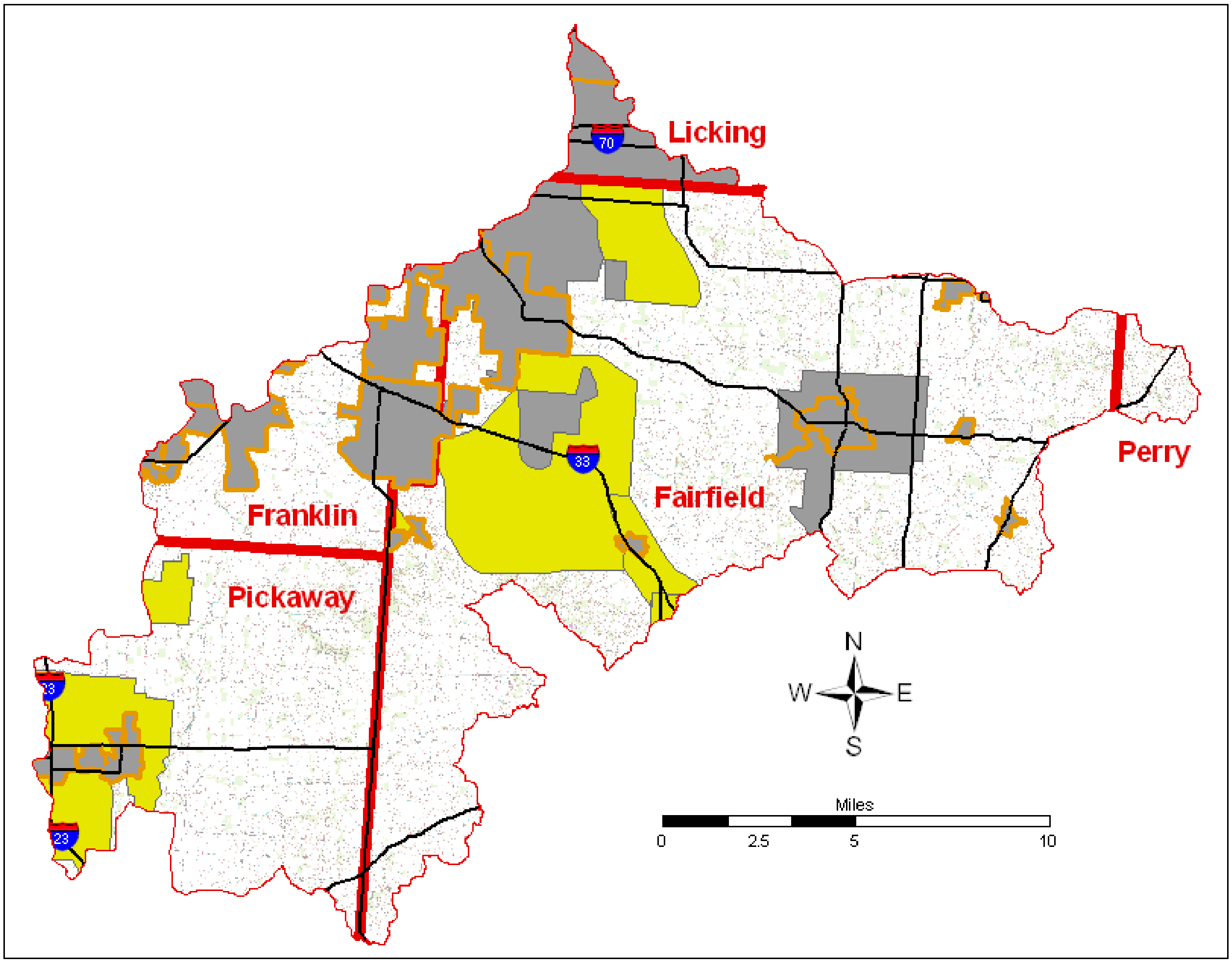


Figure 2.8 Existing and proposed sewer service. Existing sewer service is within the gray regions, while the yellow regions are areas of proposed sewer facilities. Incorporated boundaries are highlighted in orange. Spatial data from Mid Ohio Regional Planning Commission (http://www.morpc.org/info_center/dataport/gis_downloadble.asp).

3 APPLICABLE 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 Clean Water Act goal of "swimmable and fishable" waters. TMDLs are required when a waterbody fails to meet water quality standards (WQS) that have been established for a stream.

3.1 Ohio WQS

Ohio's WQS, set forth in Chapter 3745-1 of the Ohio Administrative Code (OAC), include four major components:

- Beneficial use designations
- Narrative criteria
- Numeric criteria
- Antidegradation provisions

Beneficial use designations describe the existing or potential uses of a waterbody. They consider use and value of a waterbody for public water supply; protection and propagation of aquatic life; recreation in and on the water; and agricultural, industrial or other purposes. Ohio EPA assigns beneficial use designations to each waterbody in the state. There may be more than one use designation assigned to a water body. Examples of beneficial use designations include: public water supply, primary contact recreation, and aquatic life uses (warmwater habitat, exceptional warmwater habitat, etc.) Use designations are defined in paragraph (B) of rule 3745-1-07 of the OAC and are assigned in rules 3745-1-08 to 3745-1-32. Attainment of uses is based on numeric and narrative criteria.

Numeric criteria are chemical concentrations, degree of aquatic life toxicity, and physical conditions allowable in a waterbody without adversely affecting its beneficial uses. To ensure protection of those beneficial uses, Ohio EPA determines maximum acceptable concentrations for over 100 chemicals.

Narrative criteria describe general water-quality goals that apply to all surface waters. These criteria state that all waters shall be free from sludge, floating debris, oil, scum, color and odor producing materials; substances that are harmful to human or animal health; and nutrients in concentrations that may cause nuisance algal growth.

Much of Ohio EPA's present strategy regarding water quality based permitting is based upon the narrative free from, "no toxics in toxic amounts." Ohio EPA developed its strategy based on an evaluation of the potential for significant toxic impacts within receiving waters. Other components of this evaluation are the biological survey program and the biological criteria used to judge aquatic life use attainment.

Biological criteria are based on aquatic structural and functional community characteristics. These criteria are used to evaluate attainment of aquatic life uses. Data collected in these assessments are used to characterize aquatic life impairment and to help diagnose the cause of this impairment.

The Ohio EPA Antidegradation Policy aims to keep clean waters clean. Antidegradation provisions describe conditions under which water quality may be lowered in surface waters.

Existing beneficial uses and the existing water quality, even if better than that needed to protect existing beneficial use, must be maintained and protected unless lower quality is deemed necessary to allow important economic or social development. Antidegradation provisions are in Sections 3745-1-05 and 3745-1-54 of the OAC.

3.1.1 Recreational beneficial use designations

Two recreational use designations are applicable to stream segments in the Walnut Creek watershed: Primary Contact Recreation (PCR) and Secondary Contact Recreation (SCR). PCR is applied to waters suitable for full-body contact such as swimming and canoeing. Ohio EPA assigns the PCR use designation to a stream unless it is demonstrated through use attainment analysis that the combination of remoteness, accessibility, and depth makes full-body contact recreation by adults or children unlikely. In those cases, the SCR designation is assigned.

SCR is applied to waters suitable for partial-body contact recreation such as wading. Recreational use designations are in effect for only the recreation season. The recreation season is defined as May 1st through October 15th. Recreational use designations are in Section 3745-1-07 of the OAC.

Attainment of the recreation use designation is evaluated by comparison to bacteriological numeric and narrative criteria. Ohio currently has bacteriological criteria for two parameters: fecal coliform and *E. coli*. Narrative criteria state that only one of the two criteria must be met to result in attainment. Bacteriological criteria apply outside the mixing zone of permitted discharges.

The numeric criteria for PCR state the geometric-mean fecal coliform content shall not exceed 1,000 colony forming units (cfu) per 100 milliliters (ml), and fecal coliform content shall not exceed 2,000 cfu per 100 ml in more than ten percent of samples taken. The numeric criteria for PCR also state that the geometric-mean *E. coli* content shall not exceed 126 cfu per 100 ml, and *E. coli* content shall not exceed 298 cfu per 100 ml in more than ten percent of samples takes. The numeric criteria for SCR state fecal coliform and *E. coli* content shall not exceed 5,000 cfu per 100 ml and 576 cfu per 100 ml, respectively, in more than ten percent of samples taken. Fecal coliform and *E. coli* content is to be evaluated on no less than 5 samples collected within a 30-day period for both PCR and SCR. Bacteriological criteria apply outside the mixing zone of permitted discharges.

There are 180 stream miles designated as PCR while 23 miles are SCR accounting for eleven percent of all the stream miles given a recreation use designation. There are no other recreation use designations in the Walnut Creek watershed.

The SCR designations are distributed among six different streams within five unique 14-digit HUCs. Three of these 14-digit HUCs are in the 170 11-digt HUC, while only one 14-digit HUC and three streams are located in the 180 11-digt HUC. Figure 3.1 is a map of recreation use designations.

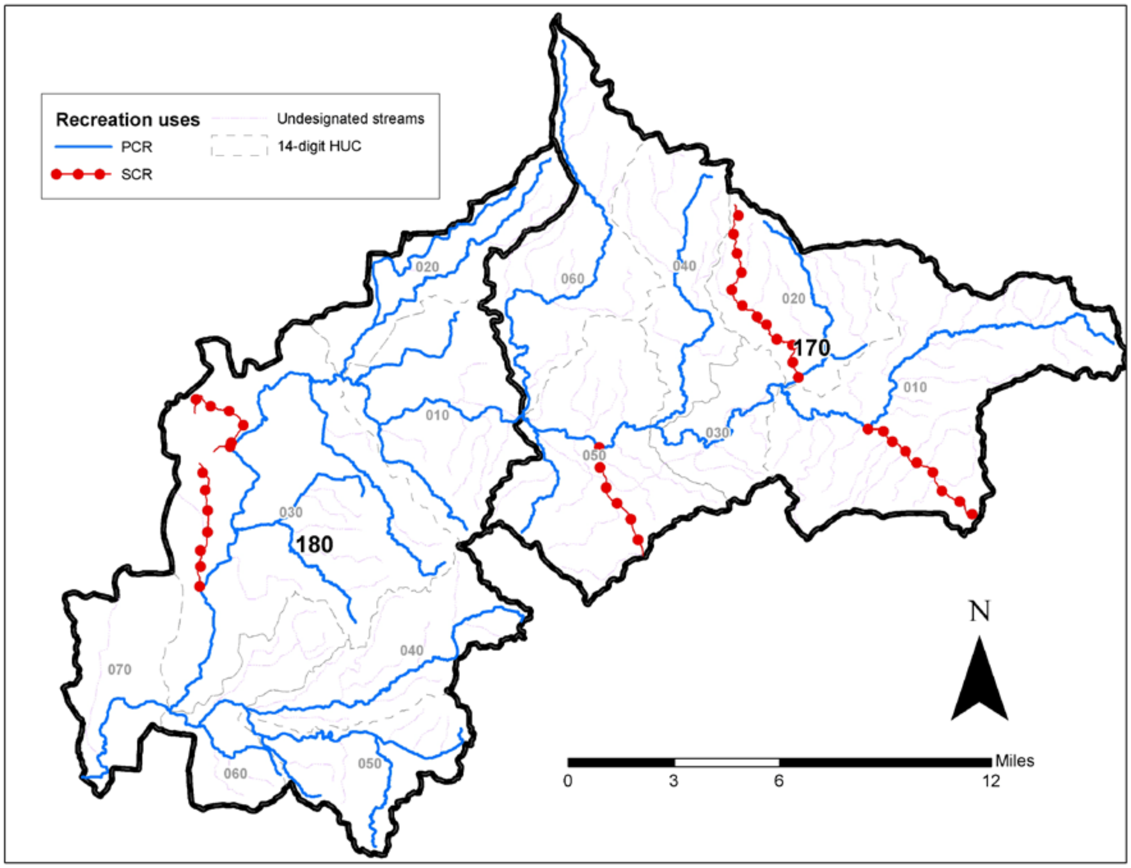


Figure 3.1 Map of recreation use designations.

3.1.2 Aquatic life beneficial use designations

Four aquatic life beneficial use designations are applicable in the Walnut Creek watershed:

- Warmwater Habitat
- Exceptional Warmwater Habitat
- Coldwater Habitat
- Modified Warmwater Habitat

The aquatic life use assigned to a waterbody is dependent upon its present or potential condition and the biological community it is capable of supporting. See http://www.dnr.state.oh.us/default/tabid/11879/Default.aspx for an overview of aquatic biological communities.

Warmwater Habitat (WWH) waters are capable of supporting and maintaining a balanced integrated community of warm water aquatic organisms. WWH represents the principal restoration target for the majority of water resource management efforts in Ohio and is in line with the Clean Water Act goal of fishable waters.

Exceptional Warmwater Habitat (EWH) represents a protection goal for the management of Ohio's best water resources. 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 (i.e., declining species).

Coldwater Habitat (CWH) is applied to waters that support native communities of cold-water organisms, and/or those that support trout stocking and management under the auspices of the Ohio Department of Natural Resources.

Modified Warmwater Habitat (MWH) is applied to waters that have been subject to maintenance, which essentially permanently modifies the stream. The MWH designation is appropriate if the modification is such that WWH criteria are unattainable. Additionally, the modification must be sanctioned by state or federal law. MWH aquatic communities are generally composed of species that are tolerant to low dissolved oxygen, silt, nutrient enrichment and poor quality habitat. Where this use designation is applied, the allowable conditions in the MWH-designated stream may be driven by the need to protect a higher downstream aquatic life use designation (e.g., WWH, EWH).

Aquatic life use attainment is dependent upon numeric biological criteria (biocriteria). Biocriteria are based on aquatic community characteristics that are measured both structurally and functionally. The rationale for using biocriteria has been extensively discussed elsewhere (Karr, 1991; Ohio EPA, 1987a,b; Yoder, 1989; Miner and Borton, 1991; Yoder, 1991; Yoder and Rankin, 1995).

Attainment of aquatic life uses is determined directly by measuring fish and aquatic macroinvertebrate populations, and comparing results to expectations derived from least impacted reference sites. Attainment benchmarks (i.e., expectations) drawn from the least impacted reference population are established in the WQS in the form of biocriteria. If measurements of an aquatic community do not achieve any one of the three biocriterion (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 aquatic communities achieve at least one of the biological criteria and none of the other criteria are rated as poor, the stream is said to be in partial attainment. A stream that is in partial attainment is not achieving its designated aquatic life use, whereas a stream that meets all of the biocriteria benchmarks is in full attainment.

Table 3.1 and Figure 3.2 show the distribution of aquatic life uses in the watershed. Table 3.2 presents biocriteria applicable in the Walnut Creek watershed. Biocriteria do not currently exist for CWH; attainment is determined on a case-by-case basis.

Table 3.1.Distribution of aquatic life use designations.

Aquatic Life Uses	Stream Length (miles)	Relative %
Warmwater habitat (WWH)	163	80.3%
Coldwater habitat (CWH)	21	10.2%
Exceptional warmwater habitat (EWH)	14	7.1%
Modified warmwater habitat (MWH)	5	2.4%
Total designated stream length	**203**	**100%**

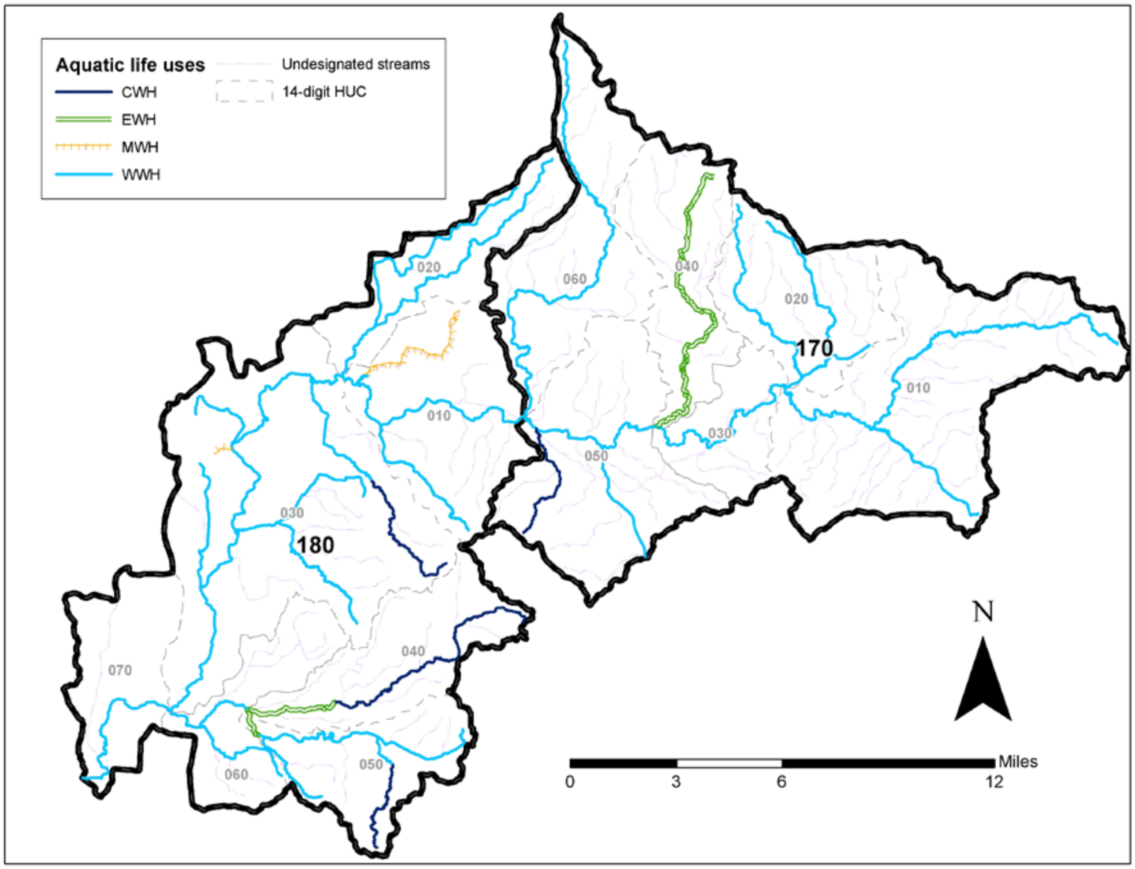


Figure 3.2 Map of aquatic life use designations .

Table 3.2 Biocriteria applicable for the Eastern Corn Belt Plains Ecoregion (ECBP)

Biological Index	Assessment Method	WWH	EWH	MWH
Index of Biotic Integrity (IBI)	Headwater	40	50	24
	Wading	40	50	24
	Boat	42	48	24
Modified Index of Well Being (MIwb)	Headwater	NA[1]	NA[1]	NA[1]
	Wading	8.3	9.4	4.0
	Boat	8.5	9.6	4.0
Invertebrate Community Index (ICI)	All[2]	36	46	22

1 Not applicable to drainage areas less than 20 mi^2
2 Limited to sites with appropriate conditions for artificial-substrate placement

4 WATERSHED ASSESSMENT RESULTS: STATUS OF WATER QUALITY RELATIVE TO THE STANDARDS

The following sub-sections discuss the results of the watershed-wide water quality survey which was conducted by the Ohio EPA between June and October of 2005. Fifty-five sites were monitored across the 286 mi^2 watershed and were evaluated as two HUC-11 watershed assessment units (AUs). Attainment status of the designated uses and accompanying statistics (e.g., percent attainment) are reported by AU in the Integrated Report.

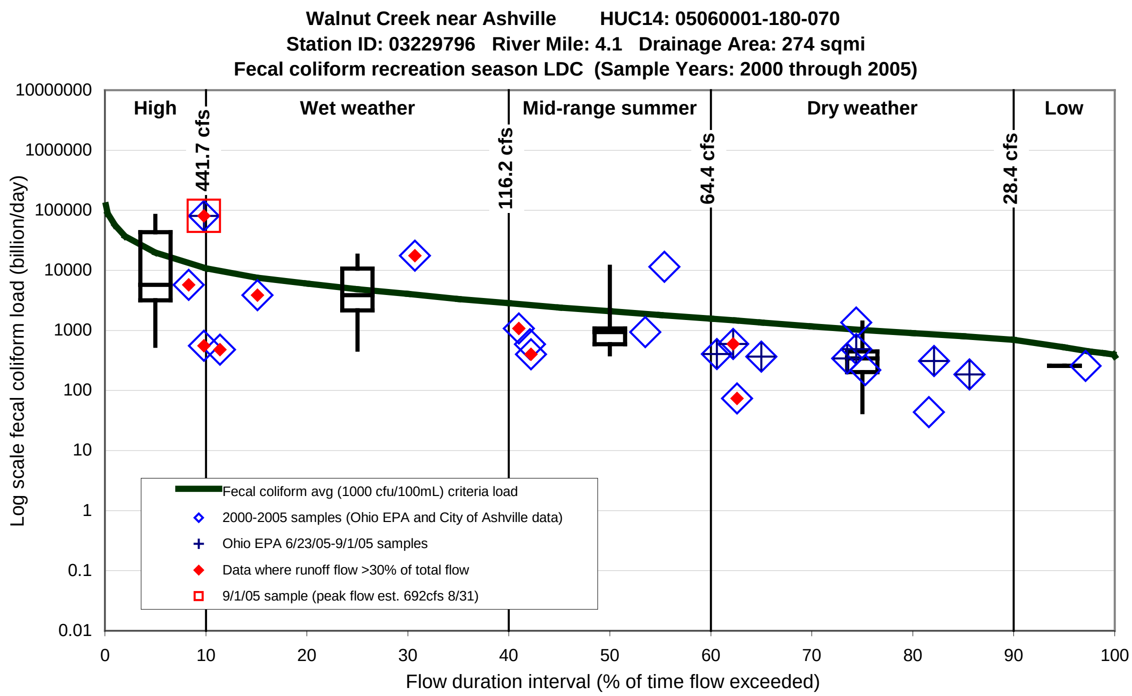
4.1 Recreation use attainment

Recreation use attainment at each sample site is based on the geometric mean and 90^{th} percentile of all samples. Data collected by the Ohio EPA during the 2005 recreation season was used to assess the status of recreation use attainment. A summary of the data is provided in Table 4.1.

Twenty-five of the 55 sites sampled failed to the meet criteria for recreation use amounting to 45 percent of all sites. Fifteen sites (27 percent) did not meet the geometric mean criterion, and each of these also failed to meet the 90^{th} percentile criterion. Ten other sites only failed in meeting the 90^{th} percentile criterion. The upper 11-digit HUC (170) had substantially more recreation use impairment with 18 sites not meeting standards compared to only seven in the lower HUC (180). The impairment in the 170 HUC was distributed among five of the six 14-digit HUCs amounting to an area of 118 out of 135 square miles (83 percent). Only three of seven were impaired in the 180 HUC accounting for 50 out of 148 square miles (34 percent).

Data collected during heavy rainfall related to Hurricane Katrina between 8/29/05 and 9/1/05 at various sites was not used for attainment calculations because it was ultimately determined to be an atypical occurrence. The excessive pulse loading of fecal coliform, which occurred after a dry spell of below normal flows, was analyzed and not considered appropriate for representing water quality. The average daily flow on 8/31/05 ranked near the recreation season's seven percent flow exceedence, where the flow before the storm was below 90 percent exceedence. The load duration curve in Figure 4.1 was developed from data collected at the USGS flow gage 03229796 near Ashville. The USGS gage site was sampled the morning of 9/1/05 after the previous day's peak flow, resulting in a 7300cfu/100ml fecal coliform concentration. The instantaneous flow was conservatively estimated at 450cfs at the time of this site's sample, but somewhat missed the full magnitude of the event. If an 8/31/05 sample would have been taken at the gage, it would likely have a much higher load due to the washoff and peak flow timing. The 9/1/05 sample captured the residual concentration of the main washoff along with post washoff effects. The other Walnut Creek subwatershed sites sampled between 8/29/05 and 9/1/05 all responded in the same manner, though at different times through the hydrograph. It was decided to exclude all samples during this time to ensure the remaining datasets are evenly weighted.

Figure 4.1 depicts fecal coliform loads (shown as a diamond) derived from samples taken between 2000 and 2005. Ohio EPA samples taken in 2005 are denoted with a plus sign, and the remaining data was all sampled by the City of Ashville WWTP as part of their NPDES permit requirements. Data highlighted with a red dot are samples taken on days where greater than 30% of the total stream flow is from runoff (or less than 70% of the flow is base flow from groundwater and point sources). The Ohio EPA atypical 9/1/05 sample at this site is highlighted with a red square. The remainder of the Ohio EPA samples was taken in the dry weather flow



Flow regime load analysis fecal coliform (billion organisms/day)	High	Wet weather	Mid-range summer	Dry weather	Low
Flow duration regime interval	0-10%	10-40%	40-60%	60-90%	90-100%
Samples per regime	3	3	5	11	1
Median sample load	5,771	3,849	944	341.9	256.4
Target criteria load (mid regime)	19,822	4,875	2,099	1,012.8	523.5
Median % sample load above criteria	None	None	None	None	None

Figure 4.1 Fecal coliform load duration curve using 2005 Ohio EPA data and 2000-2005 City of Ashville data

range. The City of Ashville stream monitoring data fills in all the flow regimes, providing a reliable dataset to review various fecal coliform loadings to the criteria. With the 9/1/05 sample included, the data compiled between 2000 and 2005 show that the chronic (i.e., based on a geometric mean) recreation use criteria is met across a reasonably wide range of flow conditions. There is not enough City of Ashville data per recreation season to determine if the acute (i.e., based on a ninetieth percentile) criteria is met within each subset of flow ranges or overall. However, the grouped data demonstrates that this section of Walnut Creek is in attainment for the recreation season, and no reductions would be needed at any flow regime. The Ashville site's attainment based on Ohio EPA data geometric mean criteria is met with (474cfu/100mL) or without (321cuf/100mL) the 9/1/05 sample. The maximum criteria based on Ohio EPA data using a 90th percentile of a recreation season's site sample dataset as an attainment metric is not met with (2519cfu/100mL) the 9/1/05 sample, but demonstrates full attainment without (428cfu/100mL). Based on the Ashville gage site analysis, the 8/29/05-9/1/05 fecal coliform data was removed from all site datasets to avoid false positive maximum criteria nonattainment issues.

Table 4.1 Sample results for fecal coliform bacteria during the 2005 recreation season.

Sample site location					Data statistics[1,2]			Attainment status[3]	
14-digit HUC (last 6 digits)		Stream	River mile	Drainage area (sq mile)	Geo[4]	Single max	90th[5]	Geo[4]	90th[5]
170	010	Pleasantville Creek	3.40	1.6	1,428	3,100	2,980	NON	NON
170	010	Pleasantville Creek	2.40	5.1	1,036	2,300	2,120	NON	NON
170	010	Pleasantville Creek	0.40	11.2	2,789	20,000	12,500	NON	NON
170	010	Walnut Creek	54.20	4.0	2,062	3,800	3,560	NON	NON
170	010	Walnut Creek	53.00	7.6	924	3,300	2,640		NON
170	010	Walnut Creek	47.00	21.1	559	1,900	1,234		
170	010	Walnut Creek	45.40	34.0	1,022	2,100	2,100	NON	NON
170	020	Trib. to Pawpaw Cr. @ RM 1.79	0.30	4.2	277	2,800	2,260		NON
170	020	W. Br. Paw Paw Creek	1.30	5.1	324	3,900	1,998		
170	020	W. Br. Paw Paw Creek	0.10	5.5	291	700	640		
170	020	Pawpaw Creek	0.80	10.5	1,692	60,000	26,520	NON	NON
170	020	Pawpaw Creek	0.60	14.0	2,014	27,000	18,600	NON	NON
170	020	Pawpaw Creek	0.30	17.5	1,190	3,000	2,580	NON	NON
170	030	Walnut Creek	41.20	60.0	600	1,500	1,500		
170	030	Walnut Creek	36.90	66.0	207	590	434		
170	040	Poplar Creek	8.00	5.2	655	4,300	4,180		NON
170	040	Poplar Creek	6.60	8.1	706	10,000	4,780		NON
170	040	Poplar Creek	0.70	17.2	603	1,700	1,142		
170	050	Gillette Run	0.10	6.1	1,959	6,000	5,220	NON	NON
170	050	Trib. To Walnut Cr. @ RM 29.9	1.30	2.9	617	5,100	3,420		NON
170	050	Walnut Creek	29.90	114.0	611	2,000	1,460		
170	060	Sycamore Creek	12.20	4.6	650	2,900	2,540		NON
170	060	Sycamore Creek	9.60	8.7	345	3,000	1,750		
170	060	Sycamore Creek	4.70	17.3	1,029	60,000	25,740	NON	NON
170	060	Sycamore Creek	4.18	18.6	585	20,000	8,480		NON
170	060	Sycamore Creek	2.60	21.6	807	5,900	3,620		NON
170	060	Sycamore Creek	0.13	24.3	573	1,800	1,440		
180	010	Tussing Ditch	0.40	4.0	481	900	702		
180	010	Trib. to Walnut Cr. @ RM 23.7	1.66	1.8	719	1,200	960		
180	010	Walnut Creek	24.45	151.0	451	560	560		
180	010	Walnut Creek	23.52	155.0	376	520	514		
180	020	Trib. to George Cr. @ RM 2.00	6.00	1.5	1,285	5,700	5,340	NON	NON
180	020	Trib. to George Cr. @ RM 2.00	2.40	5.3	1,017	2,100	2,040	NON	NON
180	020	George Creek	2.10	4.5	1,069	6,600	3,720	NON	NON
180	020	George Creek	0.10	14.6	702	2,200	1,900		
180	030	Big Run	3.85	4.6	576	1,700	1,226		
180	030	Big Run	1.60	6.3	1,737	15,000	10,200	NON	NON

Sample site location					Data statistics[1,2]			Attainment status[3]	
14-digit HUC (last 6 digits)		Stream	River mile	Drainage area (sq mile)	Geo[4]	Single max	90th[5]	Geo[4]	90th[5]
		S. Rickenbacker Run @ RM 2.00	0.10	0.6	727	1,600	1,228		
		Mud Run	1.50	5.2	791	2,000	1,880		
		Slate Run	0.50	5.0	416	4,300	2,920		NON
		Mud Run	0.70	11.5	444	1,400	968		
		Manns Run	0.30	4.7	257	1,500	1,380		
		Walnut Creek	16.90	188.0	219	560	482		
			14.90	196.0	286	580	538		
			11.00	215.0	332	480	462		
			9.30	212.0	173	430	298		
	040	Little Walnut Creek	6.40	8.8	587	1,000	982		
			3.40	15.5	644	1,700	1,250		
	050	Cherry Run	0.55	4.6	947	2,600	2,240		NON
		Turkey Run	6.50	2.8	298	1,000	730		
			5.30	9.3	1,233	2,900	2,480	NON	NON
			0.20	14.2	656	2,200	1,700		
	060	Bull Run	0.20	4.4	830	2,200	1,660		
		Little Walnut Creek	0.50	44.0	189	310	292		
	070	Walnut Creek	4.10	273.0	321	470	428		

1 Values presented as counts per 100 ml of sample
2 Statistics based on seven samples collected at each site with the exception of two sites which had only six samples collected
3 Empty spaces indicate full attainment of the designated recreation use, "NON" indicates that one or both criteria were not met. Recreation use criteria are discussed in Section 3.1.1.
4 "Geo" refers to the geometric mean.
5 "90th" refers to the 90th percentile

4.2 Aquatic life use attainment

The biological survey results show Walnut Creek to be an exceptional water resource, particularly in its ability to support unique and pollution sensitive aquatic species. In fact, the spotted, Tippecanoe, and state endangered bluebreast darters were recorded for the first time in Walnut Creek. The variegate darter was also found which is, like these others, particularly sensitive to poor water quality. The darters' presence indicates that Walnut Creek is healthy. However, 22 percent of the sites, all of which were on tributary streams, did not fully attain WQS for aquatic life while 45 percent failed to meet quality criteria for recreation.

Aquatic life use attainment was assessed at 55 sites in the Walnut Creek watershed that ranged in drainage area from 0.6 mi^2 to 44 mi^2. Forty-three of the sites (78%) are in full attainment of their designated or recommended aquatic life use. Six of the sites (11%) are in partial attainment, and six of the sites (11%) are in non-attainment. Table 4.2 provides a presentation of the attainment results, including biological index scores and Table 4.3 shows the causes and sources of impairment. Figure 4.2 illustrates aquatic life use attainment in the Walnut Creek watershed.

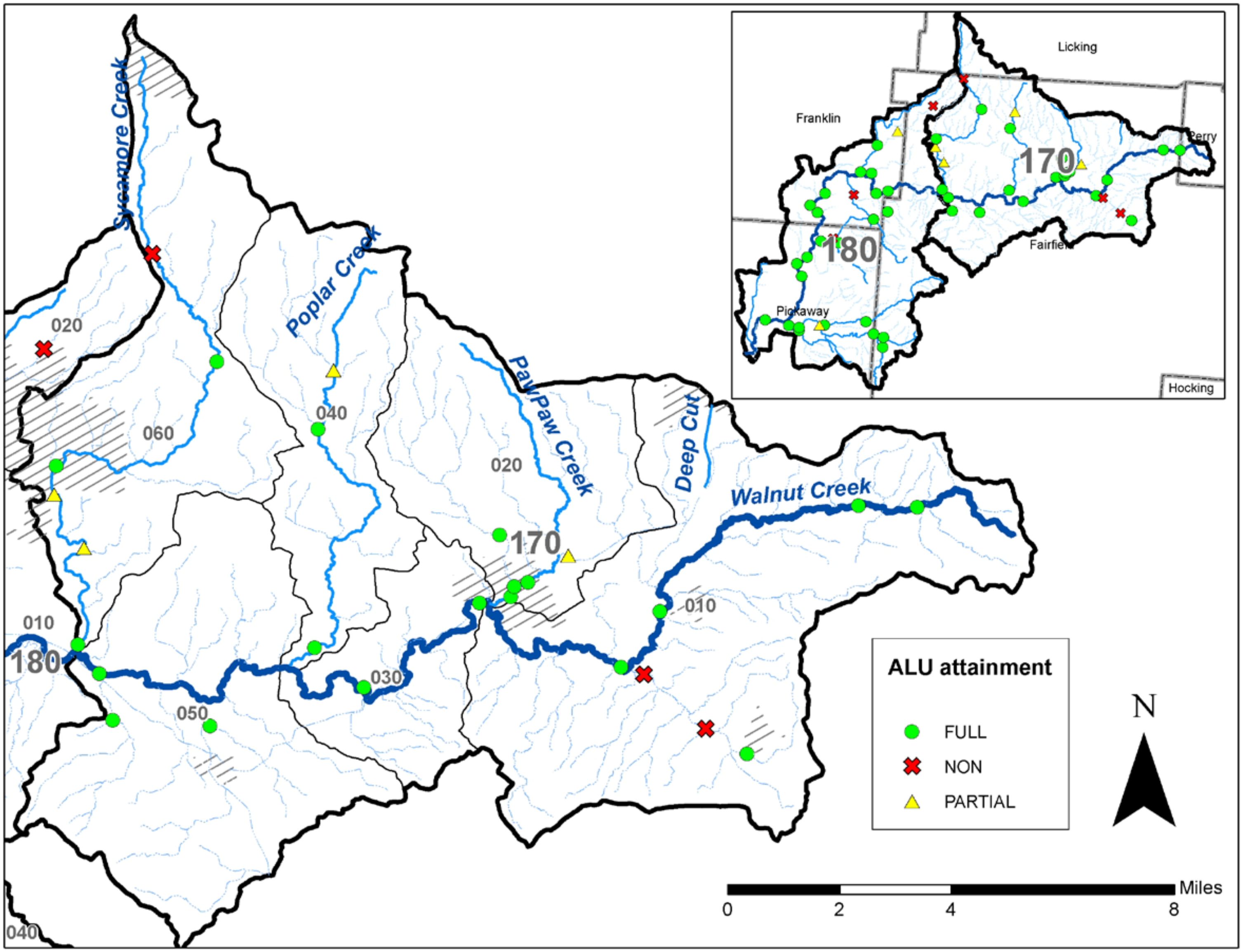


Figure 4.2 Map of the attainment status of aquatic life uses at survey sites in the 170 11-digit HUC. Two sites partially attaining their biocriteria on Sycamore Creek (RMs 4.2 and 2.6) may currently be in full attainment based on data collected in 2009.

Table 4.2 Results of the biological assessment.

Hydrologic unit code (last 3 digits)		Stream name	River mile	Drainage area (sq. mile)	QHEI	Indices for biocriteria[1]				Attainment status
						IBI		MIWB[3]	ICI[4]	
HUC 11	HUC 14					Actual	Dev.[2]			
170	010	Walnut Creek	45.4	34	56.5	48	8	9.2	34	FULL
		Walnut Creek	47.0	21	67.5	48	8	9.3	MG	FULL
		Walnut Creek	51.6	9	63.0	48	8	-	VG	FULL
		Walnut Creek	54.2	4	74.5	52	12	-	E	FULL
		Pleasantville Creek	0.5	11	67.0	28	-12	-	F	***NON***
		Pleasantville Creek	2.4	5	37.5	28	-12	-	F	***NON***
		Pleasantville Creek	3.4	2	42.0	40	0	-	MG	FULL
	020	Pawpaw Creek	0.3	18	56.0	40	0	-	G	FULL
		Pawpaw Creek	0.8	11	69.0	46	6	-	G	FULL
		Trib to Pawpaw 1.79	0.3	4	50.0	40	0	-	F	***PARTIAL***
		W. Br. Pawpaw Creek	0.1	7	65.5	36	-4	-	G	FULL
		W. Br. Pawpaw Creek	1.3	6	66.5	44	4	-	G	FULL
	030	Walnut Creek	36.9	67	73.5	51	11	9.8	52	FULL
		Walnut Creek	41.2	60	73.5	47	7	8.7	42	FULL
	040	Poplar Creek[5]	0.7	17	71.0	48	-2	-	48	FULL
		Poplar Creek[5]	6.6	8	69.0	52	2	-	VG	FULL
		Poplar Creek[5]	8.0	5	67.0	48	-2	-	G	***PARTIAL***
	050	Walnut Creek	29.9	110	81.0	49	9	9.5	50	FULL
		Gillette Run	0.1	6	50.0	40	0	-	F	FULL
		Trib to Walnut 29.83[5]	1.3	3	55.5	44	4	-	E	FULL
	060	Sycamore Creek	0.2	24	74.0	49	9	9.3	50	FULL
		Sycamore Creek	2.6**	21	79.0	51	11	7.3	36	***PARTIAL*****
		Sycamore Creek	4.2**	19	75.0	48	8	-	LF	***PARTIAL*****
		Sycamore Creek	4.7	17	76.0	54	14	-	MG	FULL
		Sycamore Creek	9.6	9	68.5	40	0	-	MG	FULL
		Sycamore Creek	12.2	5	69.5	34	-6	-	F	***NON***
180	010	Walnut Creek	23.6	155	78.5	53	13	9.6	52	FULL
		Walnut Creek	24.4	151	82.5	53	13	10.0	56	FULL
		Tussing Ditch[5]	0.4	4	48.5	40	16	-	F	FULL
		Trib to Walnut 23.70	1.7	2	70.5	48	8	-	VG	FULL

Hydrologic unit code (last 3 digits)		Stream name	River mile	Drainage area (sq. mile)	QHEI	Indices for biocriteria[1]				Attainment status
						IBI		MIWB[3]	ICI[4]	
HUC 11	HUC 14					Actual	Dev. [2]			
	020	George Creek	0.1	15	62.5	38	-2	-	G	FULL
		George Creek	2.0	11	66.5	38	-2	-	MG	FULL
		Trib to George Creek	2.4	5	66.0	34	-6	-	MG	***PARTIAL***
		Trib to George Creek	6.0	2	57.0	32	-8	-	28	***NON***
	030	Slate Run	0.5	5	65.0	50	10	-	G	FULL
		Walnut Creek	9.3	222	84.5	53	11	9.0	52	FULL
		Walnut Creek	11.0	215	80.5	52	10	9.4	E	FULL
		Walnut Creek	13.8	198	79.5	48	8	8.7	E	FULL
		Walnut Creek	16.9	192	67.5	51	11	9.6	54	FULL
		Big Run	1.6	6	40.0	30	-10	-	F	***NON***
		Big Run[5]	3.9	5	71.0	50	10	-	VG	FULL
		Mud Run	0.7	12	65.0	42	2	-	VG	FULL
		Mud Run	1.5	5	43.0	34	-6	-	F	***NON***
		Trib to Walnut 15.54[5]	0.1	1	38.0	38	-2	-	F	FULL
		Manns Run	0.3	5	47.0	44	4	-	MG	FULL
	040	Little Walnut Creek[5]	3.5	16	70.0	54	4	-	VG	FULL
		Little Walnut Creek[5]	6.4	9	63.0	44	-6	-	VG	FULL
	050	Turkey Run[5]	0.2	14	47.0	48	-2	-	F	***PARTIAL***
		Turkey Run[5]	5.3	9	67.5	42	-8	-	VG	FULL
		Turkey Run[5]	6.5	3	70.0	46	-4	-	VG	FULL
		Cherry Run	0.6	4	70.0	50	10	-	VG	FULL
	060	Bull Run	0.2	4	0.0	--	--	-	MG	FULL
		Little Walnut Creek	0.5	44	68.5	50	10	9.3	48	FULL
		Little Walnut Creek	1.5	39	77.5	42	2	8.2		FULL
	070	Walnut Creek	4.1	274	68.0	48	6	9.5	46	FULL

1 Abbreviations for the indices are as follows: IBI = Index of Biotic Integrity; MIWB = Modified Index of Well-Being; ICI = Invertebrate Community index
2 "Dev." Refers to deviation of the observed IBI score to the minimum criterion for the given use designation and stream size (based on drainage area). Some scores substantially exceed the minimum criteria and reflect attainment while others fall below the criterion leading to impaired status or a non-significant departure from the criterion meaning that status in considered in attainment.
3 MiWB criteria are not applicable to streams with a drainage area less than 20 square miles (headwater streams).
4 Where number scores are not provided only a narrative evaluation is available (and have accompanying criteria thresholds). Abbreviations mean the following : E = exceptional; VG = very good; G = good; MG = marginally good; F = fair.

5 Blue highlight indicates exceptional warmwater habitat (EWH) designation, orange indicates modified warmwater habitat (MWH) and green indicates coldwater habitat (CWH). No color is used for sites designated as warm water habitat (WWH). Aquatic life use attainment for CWH is determined on a case-by-case basis since there are no criteria established specifically for this use.

** The City of Pickerington disputes these results and has retained a consultant to resample the area; results of the study have not been submitted to Ohio EPA for review as of February 1, 2010.

Table 4.3 Reasons for biological use impairments.

Hydrologic unit code (last 3 digits)		Stream name	River mile	Attainment status	Causes of impairment (stressors)	Sources of impairment (sources of the stressors)
HUC 11	HUC 14					
170	010	Pleasantville Creek	0.5	NON	Sediment, low dissolved oxygen	Unfenced pasture
		Pleasantville Creek	2.4	NON	Sediment, low dissolved oxygen	Sanitary sewer overflows, cropland
	020	Trib to Pawpaw 1.79	0.3	PARTIAL	Sediment	Channelization
	040	Poplar Creek[1]	8.0	PARTIAL	Natural conditions	Not applicable
	060	Sycamore Creek	2.6**	PARTIAL	Total dissolved solids	Pickerington wastewater treatment plant
		Sycamore Creek	4.2**	PARTIAL	Total dissolved solids, solids, total toxicity	Pickerington wastewater treatment plant
		Sycamore Creek	12.2	NON	Organic enrichment, low dissolved oxygen	Urban storm water and septic systems
180	020	Trib to George Creek	2.4	PARTIAL	Toxicity	Urban land use
		Trib to George Creek	6.0	NON	Toxicity	Urban land use
	030	Big Run	1.6	NON	Flow alterations, organic enrichment	Unknown, unverified water withdrawal, minor wastewater treatment plant
		Mud Run	1.5	NON	Sediment/poor habitat	Hydromodification-Ag, unfenced livestock
	050	Turkey Run[1]	0.2	PARTIAL	Habitat alterations	Hydromodification-Ag, channelization

1 Blue shading indicates exceptional warmwater habitat (EWH) while no shading refers to warm water habitat (WWH).

** The City of Pickerington disputes these results and has retained a consultant to resample the area; results of the study have not been submitted to Ohio EPA for review as of February 1, 2010.

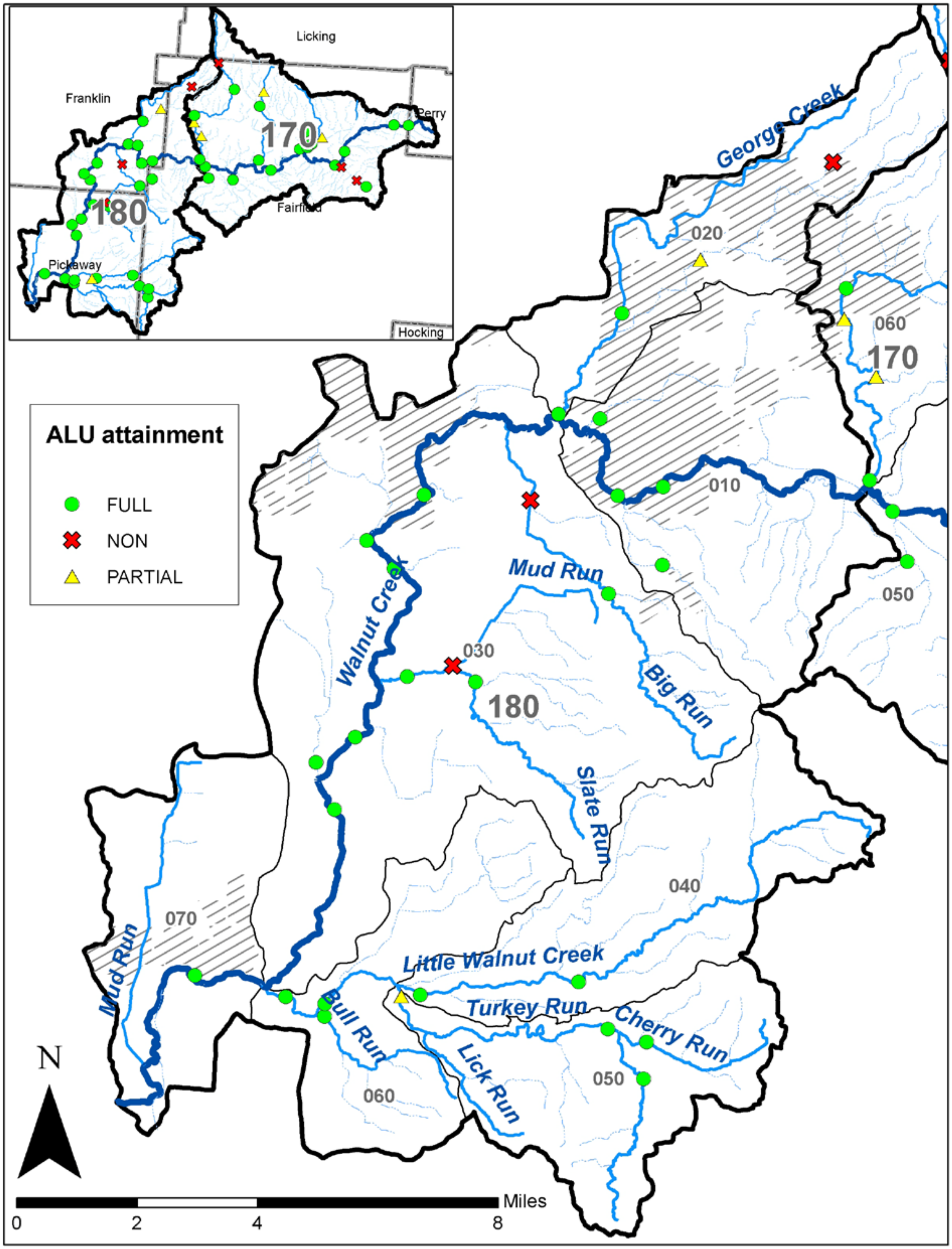


Figure 4.3 Map of the attainment status of aquatic life uses at survey sites in the 180 11-digit HUC.

4.3 Public drinking water use attainment

There are no known entities within this watershed that are using surface water as a source of drinking water. Communities within this watershed obtain their drinking water supply from ground water wells.

4.4 Human health use (fish tissue)

Walnut Creek has been sampled for fish tissue contamination by Ohio EPA twice in the past ten years, in 1999 and again in 2005.

In 1999, some of the fish sampled had levels of PCBs that were both above the threshold for a one meal per month advisory and above the threshold used in listing waters as impaired in Ohio's Integrated Report to U.S. EPA (303(d) list). Therefore, Walnut Creek is listed in Ohio's Integrated Report as impaired for PCBs in fish tissue and has a one meal per month fish consumption advisory for channel catfish due to PCBs.

Sampling conducted in 2005 resulted in no PCBs detected in eighteen samples of fish tissue. According to Ohio EPA's methodologies for determining advisories and impairments for fish tissue, another round of sampling is required to remove the current consumption advisory, or to delist Walnut Creek from the Integrated Report impairment list.

PCBs are currently banned from use in the U.S. and are expected to decrease in streams over time. Therefore, no further action other than continued monitoring for PCBs in fish in Walnut Creek will be taken.

The only other contaminant found in fish in Walnut Creek in quantities of concern to human health was mercury. The concentrations of mercury were found in the two meals per week to one meal per month advisory range, depending on the species. The concentrations were below the listing threshold for mercury impairment for Ohio's Integrated Report.

Mercury is a ubiquitous contaminant in streams throughout the U.S. and its primary source is thought to be mercury deposited from the atmosphere. Mercury as a surface water pollutant is being addressed in a variety of ways outside of the traditional TMDL process, including limits on mercury emissions from air sources, mercury take-back programs, and legislation prohibiting the sale of most mercury-containing products. Unless there are known or suspected local surface water sources of mercury, mercury is best addressed outside of the individual watershed TMDL framework.

Additional information regarding fish consumption can be found at: http://www.epa.ohio.gov/dsw/fishadvisory/index.aspx.

5 LINKAGE ANALYSES

A linkage analysis evaluates the most likely connection between the observed water quality and the source of concern.

In Ohio, biocriteria are used for aquatic life use designations, so when results show that the biological community fails to satisfy minimum criteria, the stressors that impair the biological community must be identified. Stressor identification uses both current scientific understanding and professional judgment acquired over years of biological survey work. Results from the data collection in conjunction with the observations made in the field are measured against this knowledge. The causes of impairment are ultimately submitted to the U.S. Environmental Protection Agency as a part of biennial reporting required through Sections 305(b) and 303(d) of the Clean Water Act.

For nutrients and habitat there are no water quality criteria established for the stressors identified as causing impairment, therefore reliable target conditions are needed. These targets have been established through robust statistical analyses comparing biological performance (as evidenced through scores for the biocriteria indices) and various water quality stressors. The results of these analyses are published in the *Association Between Nutrients, Habitat, and the Aquatic Biota in Ohio Rivers and Streams* (Ohio EPA, 1999).

All water quality criteria for recreation uses are based on concentrations of pollutants, which are measured as a part of the water quality survey. Without the concentration data impairment cannot be determined. In this case the link between the impairment and the stressor causing impairment is direct.

5.1 Stressors causing impaired uses

The following sub-sections discuss how stressors impair water uses and focus on ***pathogens***, ***habitat*** and ***sediment*** for which TMDLs are developed as well as ***flow alterations*** and ***lack of floodplain connection***, which is also detrimental to water quality.

5.1.1 Pathogens

The WQS for fecal coliform bacteria are meant to protect recreational water uses by limiting risk for human illness due to exposure to pathogenic microorganisms. Pathogenic organisms include bacteria, viruses, and protozoa. Contamination by pathogens is a human health issue, as skin contact or accidental ingestion can lead to various conditions such as skin irritation, gastroenteritis, or other more serious illnesses.

Fecal coliform is a measure of the number of organisms within the fecal coliform sub-group of bacteria. Fecal coliform reside in the intestinal tracts of warm blooded animals and are excreted in their wastes. Generally speaking, fecal coliform bacteria are not pathogenic organisms. However, if their numbers exceed a threshold value it becomes increasingly probable that pathogenic organisms are present in sufficient numbers to threaten public health.

The reason for measuring fecal coliform bacteria instead of other pathogenic organisms is that they are much easier to detect and identify than the many individual pathogenic organisms that may be present. Since the majority of pathogens that enter waterbodies do so in association with human or animal wastes, fecal coliform are appropriate surrogates for pathogenic organisms. Figure 5.1 shows an illicit discharge, which is a common source of pathogens.

Figure 5.1 Photo of an illicit discharge from a storm sewer outlet.

5.1.2 Habitat

In order for an aquatic community to be healthy it must have adequate habitat. The absence or low quality of stream habitat hampers the ability of aquatic organisms to successfully reproduce, acquire food, or find protection from other species and stressful environmental conditions leading to reduced or absent populations of aquatic species. A compounding effect of wide-spread degraded habitat is that source populations of sensitive aquatic species dwindle and migrate to areas that do have suitable habitat quality. Figure 5.2 shows a section for Walnut Creek with high quality habitat as evidenced by sinuosity, good substrate, and structure provided by streamside trees in the intact riparian zone.

Figure 5.2 Photo of Walnut Creek at RM 14.9 in Franklin County.

5.1.3 Sediment (siltation)

Although sediment alone can be damaging to the aquatic community, its negative impact is typically restricted to the fact that it degrades stream habitat. Specifically, sediment fills in void spaces that occur between larger substrates such as cobbles and gravels rendering those spaces inaccessible to organisms. The function of the substrate also decreases because flow of water through these spaces is limited, and with it dissolved oxygen and nutrition sources.

Figure 5.3 Photo showing fine sediment that has covered the bottom of Mann's Run (RM 0.3 end of Miller Road) in Pickaway County.

5.1.4 Flow alteration and disrupted floodplain function

Although floodplains and stream flow are not directly addressed with TMDLs for the Walnut Creek watershed, they are very important aspects of the stream system and have a critical influence over its health and stability. In particular, it is important to avoid urban or commercial development in floodplains in the Walnut Creek watershed. The following paragraphs provide an explanation of the importance of floodplains.

Importance of floodplains

The flow of water is a primary factor in shaping the stream channel and therefore influencing stream habitat. Flowing water moves sand, gravel, cobble and other substrates, as well as erodes banks and the stream bed. Higher flows associated with storm events do the vast majority of the work of shaping the stream channel. In particular, flows that have a return frequency of about 1 to 2 years are the most influential. The shape of stream channels is the result of flow patterns that have occurred over long periods of time, where a variety of naturally occurring channel adjustments has resulted in a stable configuration.

A major shift in flow patterns can have a profound effect on the shape and stability of the channel and on habitat quality. An increase in the intensity as well as frequency of high flows can lead to more severe erosion of bed and bank material. Such changes in flow patterns follow major changes in land cover such as a change from cropland to urban or commercial lands.

Adequate floodplains have a dampening effect on the rate of flow pattern change because of their ability to diffuse the energy of high flows. In particular, water depth increases more slowly in relation to increases in flow volume because water is spread out horizontally across a much wider area rather than be confined in the stream channel itself. This is important because depth of flowing water is directly related to the capacity to erode and transport sediment. Floodplains also temporarily store flood waters, which reduces the potential for severe erosion and downstream flooding.

Figure 5.4 Photo of Walnut Creek overflowing its banks in Canal Winchester during a spring 2008 rain event. Such events occur several times each year in this basin.

Floodplains also foster the separation of fine sediment from coarser, more functional bed substrates. This happens because finer grained material such as sands, silts and clays more readily fall out of suspension in the slower waters of the floodplain as opposed to the heavier gravels and cobbles that are less likely to leave the main channel. Floodplain soils are also especially well suited to assimilate other pollutants such as nutrients and organic based pollutants.

In order to maintain a healthy aquatic community that is able to meet the WQS, the stream system should have a stable channel form that includes floodplains. Rapid changes in land use from agricultural to residential and commercial are reducing available floodplains in the Walnut Creek watershed. Figure 5.4 is a photo chronic flooding on Walnut Creek which may be due in part to reduction in available floodplain storage in the watershed.

Additional information regarding floodplains is available at http://www.dnr.state.oh.us/water/floodpln/default/tabid/3511/Default.aspx.

5.2 Sources of the stressors

The preceding discussed water quality stressors that are causing designated use impairment. This section discusses the sources of these stressors.

Primary stressor sources identified in the Walnut Creek watershed are:

Point sources
- permitted wastewater discharges
- sanitary sewer overflows
- home sewerage treatment systems
- storm sewers

Nonpoint sources
- livestock wastes and stream use
- cropland runoff
- ditch maintenance
- land development and
- urban/suburban land uses

In several instances an individual source may contribute multiple stressors to the water resource.

5.2.1 Permitted wastewater discharges

All wastewater discharges to waters of the state must be permitted through the National Pollutant Discharge Elimination System (NPDES). NPDES permits limit the quantity of pollutants, such as fecal coliform and suspended solids discharged and impose monitoring requirements. NPDES permits are designed to protect both public health and the aquatic environment by helping to ensure compliance with state and federal regulations.

Because point sources generally discharge wastewater continuously under all flow conditions, their impact on water quality tends to be greatest under average to low flow conditions, because the potential for dilution is lower. NPDES dischargers located near the origin of a stream or on a small tributary have a much greater influence over water quality and the potential to violate water quality standards.

This TMDL classifies NPDES dischargers as major, minor, or miscellaneous. Majors are those that discharge more than one-million gallons per day (MGD). Minors are small- or medium-sized wastewater treatment plants (WWTPs), such as those serving small municipalities, schools, private businesses, and developments. Miscellaneous facilities are those discharging process, cooling, or storm water, such as industrial complexes, water treatment plants (WTPs), and quarries. A listing of wastewater discharge permit holders in this watershed is included in Appendix A of this report.

In the Sycamore Creek subwatershed, data from Ohio EPA's 2005 survey shows that the discharge from the Pickerington WWTP is precluding WQS attainment. This facility discharges elevated amounts of total dissolved solids (TDS), which has had an adverse impact on several important macroinvertebrate species. Pickerington WWTP receives waste from the Pickerington water treatment plant, which has elevated TDS. This issue is being addressed in the NPDES permit; therefore a TMDL is not needed. Instead a category 4B option is used (see Appendix B). The City of Pickerington disputes Ohio EPA's 2005 results and has retained a consultant to resample the area; results of the study have not been submitted to Ohio EPA for review as of February 1, 2010.

5.2.2 Sanitary sewer overflows

A sanitary sewer overflow (SSO) results when the hydraulic capacity of a sanitary sewer collection system designed to collect and transport only wastewater is exceeded. Ground water infiltration and storm water inflow into a sanitary sewer system may contribute to an SSO. Ground water infiltration results when the integrity of sanitary sewer pipes is compromised. Inflow of storm water into a sanitary sewer collection system results from the illegal connection of roof and /or building foundation drains or from poorly-sealed man holes.

Wastewater from a SSO is untreated and may discharge directly to a stream, storm sewer or city street. Such events are illegal and must be reported to Ohio EPA. A plan for SSO elimination is then required.


Figure 5.5 Photo of a sanitary sewer overflow pipe in the Walnut Creek Sewer District Leitnaker Road Pump Station. When the pump station becomes hydraulically overloaded, untreated wastewater discharges through the pipe to an unnamed tributary of Pleasantville Creek.

SSO discharges, when occurring, increase bacteria concentrations in a receiving stream and may result in organic solids deposits on the stream bottom. SSO discharges can contribute to stream and habitat degradation and to the total watershed pollutant load.

The SSO shown in Figure 5.5 is within the Walnut Creek Sewer District (WCSD) sanitary sewer collection system and is impairing designated uses in Pleasantville Creek. Currently actions are being taken by WCSD to rectify this source of impairment.

5.2.3 Home sewage treatment systems

Household Sewage Treatment Systems (HSTSs) are small wastewater treatment units serving individual homes or businesses. HSTSs are typically located on the property of the home or business from which they treat waste. Depending on site conditions, such systems may or may not have been designed to discharge wastewater to a stream.

There are many types of HSTSs, but those most common in the Walnut Creek watershed are septic tanks with soil-adsorption fields, septic tanks with sand filters, and aeration systems. The efficiency of each treatment system is dependent upon its age, the manner in which it is maintained, and characteristics of the site where it is located. Important site characteristics include soil drainage, water-table depth, bedrock depth, land slope, and parcel-lot size.

HSTSs affect water quality under multiple conditions. HSTSs discharging directly to a stream or river, such as many aeration or illicit systems, behave similarly to a point source. These types of systems primarily affect water quality under dry, low-flow conditions. HSTSs discharging indirectly to a stream via a tile drain or intermittent ditch may exhibit effects similar to a nonpoint source.

Figure 5.6 Photos of failed home septic treatment. The top picture is an example of a home sewage treatment system discharge pipe outlet. The grayish discoloration of the discharge in this photograph and in picture below is typical for a system that is discharging inadequately treated wastewater. Failing systems such as this contribute to elevated bacteria counts noted in watersheds.

Wastewater discharged to a dry tile or ditch may be of insufficient volume to sustain flow to the stream. Additional pollutant delivery pathways associated with HSTSs exist, but those discussed above are believed the most significant in the Walnut Creek watershed.

HSTSs are regulated by permits issued by local health authorities. Pollution from HSTSs contributes to the total wasteload if it is directly discharging, such as an aeration system, or the total load if it is non-discharging such as leach field system.

There is a large proportion of the Walnut Creek watershed in which HSTSs are used for sewage treatment. Improperly functioning systems are resulting in high bacteria loading and WQS nonattainment in some areas.

5.2.4 Livestock wastes and stream use

Livestock with stream access contribute large pollutant loads to the stream. Of particular concern is bacterial contamination because unrestricted livestock can deposit waste directly into the stream. This results in very high localized bacterial counts, and can impair downstream use attainment as well.

Figure 5.7 Photo of livestock with access to Mud Run on the west side of Goodman Road north of Perrill Road in Pickaway County.

Livestock with stream access can also contribute to habitat and channel degradation. Livestock often graze to the stream edge, eliminating riparian vegetation which, among other benefits, protects against bank erosion. Further, livestock may trample, collapse, and de-stabilize stream banks as can be seen in Figures 5.7 and 5.8. This can result in an increase in sediment discharge to a stream and lead to downstream siltation. Grazing livestock with stream access is a source of impairment in the Walnut Creek watershed where specific locations have been noted as having obvious impact. These areas, such as that along an unnamed tributary located near Pleasantville, should be of higher priority when addressing these specific water quality issues in the watershed.

5.2.5 Cropland runoff

Crop production requires intense land management and there are several unintended consequences that can negatively affect water quality. Practices that pose the greatest threats are tillage and the application of agro-chemicals, especially fertilizers. Although different from runoff, sub-surface drainage, which is extensively used in Ohio, also provides a means for land applied substances to reach surface waters.

Tillage is used for seedbed preparation and weed-control and is often carried out in the spring before planting or in the fall after harvest. After tillage, soil is vulnerable to sheet erosion and can be transported to surface waters during a rain event or as snow melts. Cropland topography has a strong influence on the degree to which this type of erosion occurs where steeper slopes yield higher soil losses. Other means for soil erosion result in the formation of rills and gullies where runoff is concentrated and has more power to erode soil. Management to minimize soil losses include conservation tillage, cover cropping and grassed waterways.

Figure 5.8 Photo of a livestock operation north of the Village of Carroll on the west side of Carroll Northern Road. This photograph shows dry weather feedlot drainage and unrestricted stream access within the pasture. Note the high potential for manure washoff from the pasture during wet weather events. The stream at this location is Gillette Run.

Agro-chemicals are transported with soil particles especially those that readily bind to soil. Phosphorus and a number of herbicides are often associated with sediment as these chemicals readily bind with soil. More soluble agro-chemicals are transported in runoff or through sub-surface drainage tiles. Nitrate loading is most strongly associated with water from sub-surface drainage tiles. A number of areas in the Walnut Creek watershed have been adversely affected by fine sediment originating from cropland runoff.

5.2.6 Ditch maintenance

Ditch maintenance refers to work that is done to an open channel to sustain some minimum level of water conveyance. The increase in conveyance can support more efficient surface drainage and/or shallow ground water being drained through field tiles. Ditch maintenance often entails removal of woody material in the channel, suppression of woody vegetation along the banks and riparian zone, and periodic dredging and/or restructuring the shape of the channel with excavation equipment. Figure 5.9 illustrates a ditch in Fairfield County that is likely having routine ditch maintenance performed.

The benefits of ditch maintenance include reduction in surface ponding or flooding in urban and residential areas which protects against property damage and/or nuisance conditions, but its application is far more widely used to increase trafficability of crop fields during wetter times of the year and improve crop yields. Ditch projects are often supported by local assessment fees where a county agency is then responsible for managing and/or carry out the necessary work. Such arrangements follow a petition process that is decided upon by local officials; however, private ditch maintenance is not at all uncommon.

Water quality problems associated with ditch maintenance include the diminished capacity of the drainage way to assimilate nutrients and organic pollutants, to sort and store fine sediment, and to dampen the intensity of high flow events. Additionally, the channels are maintained in ways that reduce habitat diversity and quality an often lead to erosion within the channel that exacerbates water quality problems associated with fine sediment.

Alternatives to the type of ditch maintenance typically performed are believed to be less damaging to water quality. These include a greater toleration of woody vegetation and trees along the banks and riparian areas and wider excavation of the ditch to provide limited floodplain function during smaller more frequent flow events. Additionally, fewer out of the ditch flood events occur due to increased capacity of the wider configuration. Fewer out of ditch floods benefit both water quality and crop production.

The Ohio State University Extension Service and Ohio Department of Natural Resources (ODNR) are developing updated ditch design guidance, which intends to provide sufficient drainage capacity while reducing the transport of pollutants and floodwaters as compared with the typical trapezoidal ditch designs. See the following link for an explanation of these efforts http://www.dnr.state.oh.us/Portals/12/programs/rural_drainage/docs/Drainage%20Report.pdf.

Figure 5.9 Photo of highly maintained ditch used for agricultural drainage in the Hocking River watershed in Fairfield County. Although not within the Walnut Creek watershed, this ditch typifies many small drainageways in intensely farmed areas.

5.2.7 Land development and urban and residential land uses

Land cover has an important role in terms of watershed hydrology as well as water quality. The rate at which precipitation that falls on the landscape reaches streams and rivers is strongly influenced by land cover, specifically whether or not the type of cover slows or diverts the flow of water. This affects flooding issues, in-stream erosion, and the transport of pollutants from the landscape to streams and rivers. Additionally, land cover influences water quality because certain cover types are larger sources of pollutants and/or have a diminished capacity to keep those pollutants from washing off the landscape and into surface waters.

Impervious surfaces, such as those associated with urban, residential, commercial, or industrial land uses, offer the lowest capacity to slow or divert surface runoff. These surfaces have negligible infiltration and storage capacity and their relative smoothness does not effectively slow runoff. This results in more frequent and intense flooding; increases the potential for channel erosion, and leads to an overall decline in water quality. For this reason most storm water infrastructure subject to regulatory authority must include storage components such as detention ponds. As the amount of impervious surface increases, the amount of precipitation that infiltrates to ground water is lessened leading to less stream flow during the dry months and less ground water.

Due to the intensity of land use and land management associated with impervious surfaces (e.g., roads and parking lots, lawn care), they are among the most substantial sources for water pollutants. Among those pollutants that act as stressors are organic-based chemicals such as oils, toxic substances and metals, and an increase in temperature of runoff that reaches surface waters.

The Sycamore Creek, Georges Creek and East Fork of Georges Creek sub-watersheds are among the most rapidly developing in the Walnut Creek watershed, and the negative effects of this land conversion are detected in the water quality survey. Figure 5.10 is an aerial photo showing recent development in this area of the watershed.

Figure 5.10 Development in the Pickerington area near Pickerington Ponds Metropolitan Park.

Municipal Separate Storm Sewer Systems (MS4s)
A Municipal Separate Storm Sewer System (MS4) is a sewer system constructed to only receive storm water runoff which is subsequently discharged to surface waters. Since storm water runoff from urban areas can have significant impacts on water quality, many MS4s must obtain NPDES coverage for their discharges. This requirement is predicated on the size of the population serviced by the MS4, where municipalities with a population greater than 100,000 fall under Phase I of these storm water rules and MS4s in urbanizing areas (as defined by the U.S. Census Bureau) fall under Phase II of the rules. A list of the MS4s and a map showing their locations in the Walnut Creek watershed is found in Appendix A of this report.

MS4s must comply with the specifications in their NPDES permits. See the following web link for more information: http://www.epa.state.oh.us/dsw/storm/ms4_index.aspx

6 METHODS OF TMDL DEVELOPMENT

This section describes how TMDLs were developed for the Walnut Creek watershed. A TMDL is the total amount of a pollutant that a receiving waterbody can assimilate while still achieving water quality standards. TMDLs can be expressed in terms of mass per time or by other appropriate measures. TMDLs are composed of the sum of individual WLAs for point sources and load allocations (LAs) for nonpoint sources and natural background levels. In addition, the TMDL must include a margin of safety (MOS), either implicitly or explicitly, that accounts for the uncertainty in the relationship between pollutant loads and the quality of the receiving waterbody. When future growth (FG) is a concern and can be quantified, it is also included. Conceptually, this is defined by the following equation:

TMDL = WLA + LA + MOS + FG

Where:
TMDL = total maximum daily load
WLA = waste load allocation
LA = load allocation
MOS = margin of safety
AFG = allowance for future growth

6.1 Selection of bacteria water quality target values

Numeric targets for fecal coliform are derived from bacteriological water quality standards (see 3.1.1). As such all primary contact waters are expected to remain below a fecal coliform average concentration of 1,000 cfu per 100 ml of sample during the recreation season.

6.2 Selection of habitat and sediment target values

The Qualitative Habitat Evaluation Index (QHEI) is a tool developed and used by Ohio EPA to assess stream habitat quality (Rankin 1989, 1995). This index is designed to provide an empirical evaluation of general habitat characteristics that are essential to fish communities and generally important to other aquatic life.

The empirical nature of the QHEI and the data that underlie it provide measurable targets that are analogous 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. The QHEI 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.

The QHEI is composed of six principal habitat categories: substrate quality, in-stream cover (physical structure), stream channel morphology and condition, riparian quality and bank erosion, pool and run-riffle quality, and gradient. Total QHEI score equals the sum of habitat category scores, with a maximum possible QHEI score of one-hundred (100). The QHEI score of a stream segment is established in the field by a trained evaluator.

QHEI scores have demonstrated a strong direct correlation to measures of biological community health (Ohio EPA, 1999). Analysis of an extensive dataset of paired QHEI and IBI scores led to the development of target QHEI scores generally shown to be supportive of the biological - assemblages typical of WWH and EWH (Ohio EPA, 1999). For the aquatic life use designation of warmwater habitat (WWH) an overall QHEI score of 60 has been shown to provide reasonable certainty that habitat is not deficient to the point of precluding attainment of the biocriteria. An overall QHEI score of 75 is targeted for streams designated as exceptional warm water habitat (EWH).

Comparisons between the QHEI attributes within each component and the IBI resulted in a list of specific habitat attributes that are particularly associated with degraded communities (referred to as modified attributes). These attributes were then grouped as either high influence or moderate influence modified attributes based on the statistical relationship of the presence of an attribute and the IBI score at each site. For streams designated WWH, there should be no more than four modified attributes of which no more than one should be a high influence attribute. Table 6.1 lists modified and high influence modified attributes and provides the QHEI targets used for this habitat TMDL. For simplicity, a pass/fail distinction is made telling whether each of the three targets are being met. Targets are set for: 1) the total QHEI score, 2) maximum number of all modified attributes, and 3) maximum number of high influence modified attributes only. If the minimum target is satisfied, then that category is assigned a “1”, if not, it is assigned a “0”. To satisfy the habitat TMDL, the stream segment in questions should achieve a score of three.

Table 6.1 Habitat TMDL targets

	Overall QHEI Score	**All Modified Attributes**	
		High Influence Modified Attributes	**All Other Modified Attributes**
Range of Possibilities	12 to 100 points	- Channelized or No Recovery - Silt/Muck Substrate - Low Sinuosity - Sparse/No Cover - Max Pool Depth < 40 cm (wadeable streams only)	- Recovering Channel - Sand Substrate (boat sites) - Hardpan Substrate Origin - Fair/Poor Development - Only 1-2 Cover Types - No Fast Current - High/Moderate Embeddedness - Ext/Mod Riffle Embeddedness - No Riffle
Target	Overall score ≥ 60	Total number < 2	Total number < 5[a]
TMDL Points Assigned if Target is Satisfied	+ 1	+ 1	+ 1

[a] Total number of modified attributes includes those counted towards the high influence modified attributes.

Sediment TMDL targets and QHEI

The QHEI is also used to develop the sediment TMDL for this project. Numeric targets for sediment are based on the metrics of the QHEI. Although QHEI evaluates the overall quality of stream habitat, some of the component metrics consider particular aspects of stream habitat that are closely related to and/or impacted by the sediment delivery and transport processes occurring in the system

The QHEI metrics used in the sediment (bedload) TMDL are the substrate, riparian, and channel metrics. All of these evaluate stream attributes related to substrate quality and the amount of fines in the sediment. Substrate is a QHEI category that measures the type, origin, quality, and degree of embeddedness of stream substrates. Degree of embeddedness refers to the extent to which gravel, cobble, and boulders are surrounded, buried by, or covered by fine materials such as sand or silt. The riparian QHEI category evaluates riparian width, quality, and bank erosion. The channel QHEI category 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 targets were established based on a paired analysis of IBI scores with corresponding values of these QHEI metrics. The targets are set at the fiftieth percentile of the site that achieve a minimum IBI score of 40, which is meant to reflect a warmwater habitat fish community. Table 6.1 summarizes the sediment TMDL targets that are used to address sedimentation.

Table 6.2 Sediment (bedload) TMDL targets

Sediment TMDL =	**Substrate**	**+**	**Channel Morphology**	**+**	**Riparian Zone/Bank Erosion**	
For WWH >=	13	+	14	+	5	>= 32

The sedimentation scores can be thought of as a “concentration”, as they measure the current amount of sediment in the stream. This means that the load allocations (LAs) and wasteload allocations (WLAs) are the same as the loading capacity (e.g., score = 32).

6.3 Methods of quantifying existing loads

Analysis methods selected address the major impairing factors in the Walnut Creek watershed; each individual method addresses one or more of the following areas listed by section number:

- Section 6.3.1: Determine the hydrologic response by quantifying the recreation season baseflow and runoff distribution per subwatershed.
- Section 6.3.2: Determine the load contributions to the stream from nonpoint source activities originating on the watershed landscape, municipal and industrial facilities and activities, and septic system inputs.
- Section 6.3.3: Establish current habitat conditions and quantify desired habitat goals per site.

The techniques selected are the most appropriate, applicable, and available methods for the goals and constraints of this project.

6.3.1 Hydrologic response

Pollutant concentration is an important metric for water quality assessment, and many regulated pollutant limits are based entirely on concentration. The mass per volume approach allows for a representation of a fecal coliform contact level a swimmer would experience, which is a useful metric across various level of stream flow. However, concentration alone does not give an indication of the extent of pollutant source loading to a stream, or how much is transported downstream. The loading analysis of a stream allows for an understanding of the extent of various source loads being transported downstream to possibly sensitive areas.

A stream's daily load of fecal coliform can be highly variable depending on the particular flow level of the day and the types of sources that contribute during different weather patterns. The total load of a recreation season load can also vary across years due to patterns of drought and excess. One of the first steps in assessing how representative a single season's fecal coliform dataset is to observe the hydrologic conditions under which the samples were taken. This is done by reviewing cyclical data from a long term flow gage that is characteristic of the study area. The most representative long term gage in the region monitors the drainage of the southern half of Fairfield County. The Hocking River gage station 03157500 at Enterprise has been operated by USGS for over seven decades. While the Walnut Creek watershed is not connected to the Hocking river, it is an adjacent watershed and has similar drainage patterns and mixed land use characteristics.

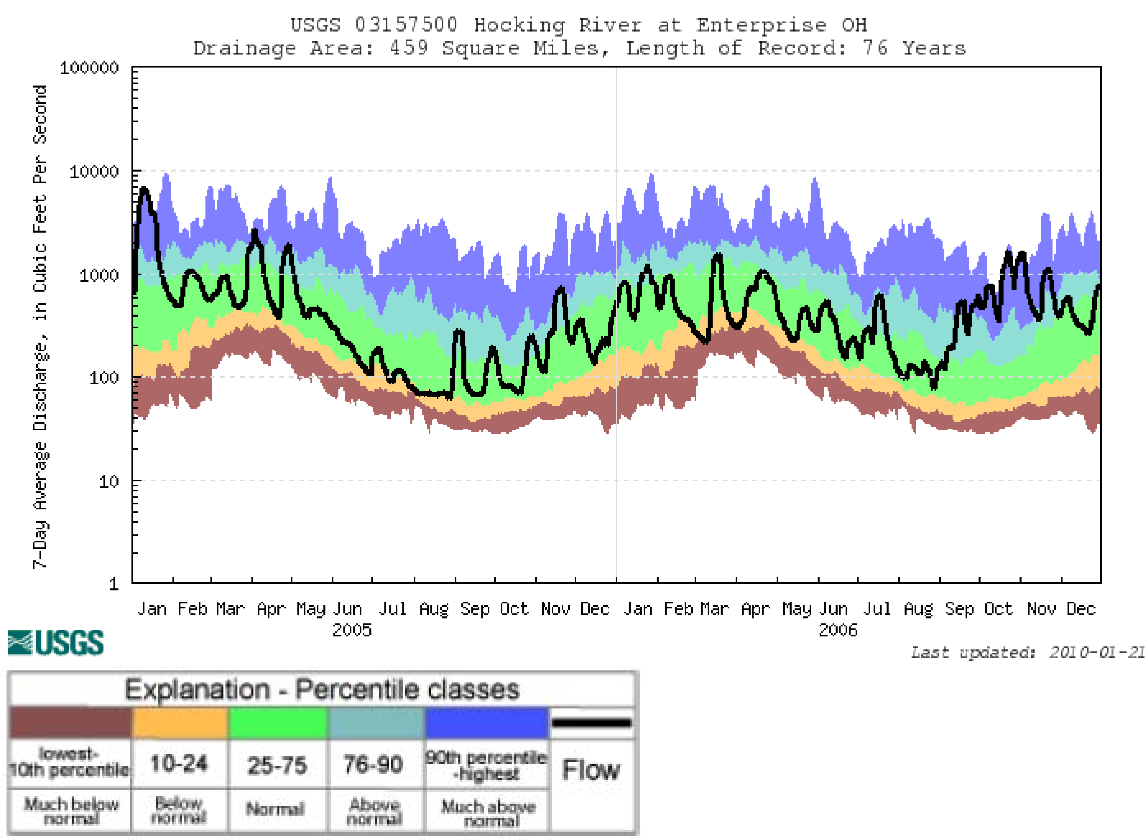


Figure 6.1. Comparison of average daily flow values from January 2005 to December 2006 to the historic flows record at the USGS gage on the Hockign River at Enterprise..

USGS provides analysis of flow condition for long term gages as shown in Figure 6.1. Historic flow range is tracked on a daily basis and percentiles of flow are assigned for a day's record. A year's 7 day average flows can be reviewed against this daily percentile range, as provided by USGS. Using a 7 day average dampens short term extremes and provides a more stable flow trend for analysis. Walnut Creek fecal coliform samples in 2005 were focused at the months of July and August. The flow pattern for these months borders on the below normal flow regime. This indicates that the 7 day average flow pattern was stable and somewhat low for the particular time of year in this region. Storm runoff would have much less direct contribution in this flow regime, indicating that the 2005 sample's geometric mean and maximum violations are indeed indicating a chronic issue in the non-attaining Walnut subwatersheds.

Another method of analyzing the flow conditions under which samples were taken is by use of a load duration curve. A load duration curve provides a means to review loading characteristics of different flow regimes for a particular sample site. The target curve, for example fecal coliform's 1000cfu/100mL geometric mean criteria, is created by multiplying the flow and a conversion factor to the concentration target. Load duration curves are better suited for sites where a long term flow record has been established. The use of a long term record provides an averaging effect for cyclical flow patterns, and allows both high and low extremes to be better represented. This thorough definition of a load duration curve makes it useful for review against a particular year's samples, revealing a site's seasonal flow trend and sample flow variability. For pollutants with seasonal criteria, it may be more intuitive to deviate from using the full annual record in order to eliminate trends not seen during the period of interest. In the case of fecal coliform, the recreation season flows from May 1st to October 15th are of interest.

USGS established a gage on Walnut Creek for the Ohio EPA study, which was used to develop the load duration curve shown in Figure 4.1. USGS gage 03229796 at Ashville near Walnut Creek's mouth has a 274 square mile drainage area. At the time of this analysis, USGS had released a provisional record set of daily flows beginning 10/1/2005. Since this record began after the Ohio EPA fecal coliform sample dates, a method was needed to establish a representative flow record both for the sample dates and for a long term record. The watershed of the Hocking River Enterprise gage has comparable drainage area and hydrology characteristics of the Walnut Creek gage's watershed, and is used to construct a representative flow record. Since the Ashville gage captured the complete 2006 Walnut Creek recreation season daily flow dataset, this period was used to build a correlation between the two gages. As seen in Figure 6.1, the 2006 season was found to be suitable for correlation due to a varying range of typical summer flows followed by above normal flows at the end of the season.

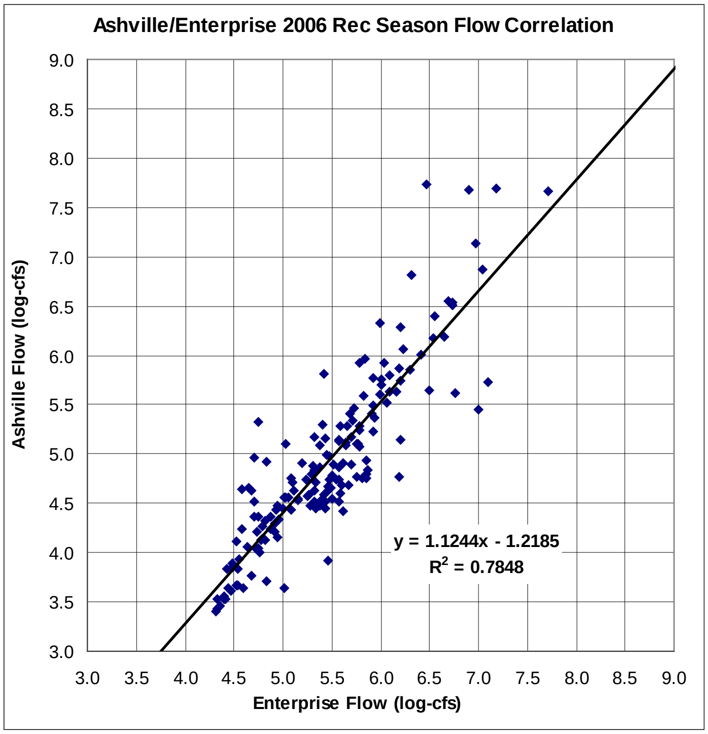


Figure 6.2 Ashville and Enterprise Flow Correlation

The regression equation shown in Figure 6.2 was developed based on the daily comparison of the 2006 recreation season data from the two gages. The coefficient of determination (the R^2 value) is a statistic that can indicate the relationship between two data sets and is a unitless measure ranging from 0 to 1. Higher values indicate the curve representing the model results is closer to observed data curve with 1 being a perfect fit. The gage correlation results in a R^2 value equal to 0.78. The 2006 correlated Walnut Creek data compared to the USGS gage's Walnut Creek data is shown in Figure 6.3. The comparison confirms that both base flow and peak flow representation are agreeable by the flow data correlated data from the Hocking River.

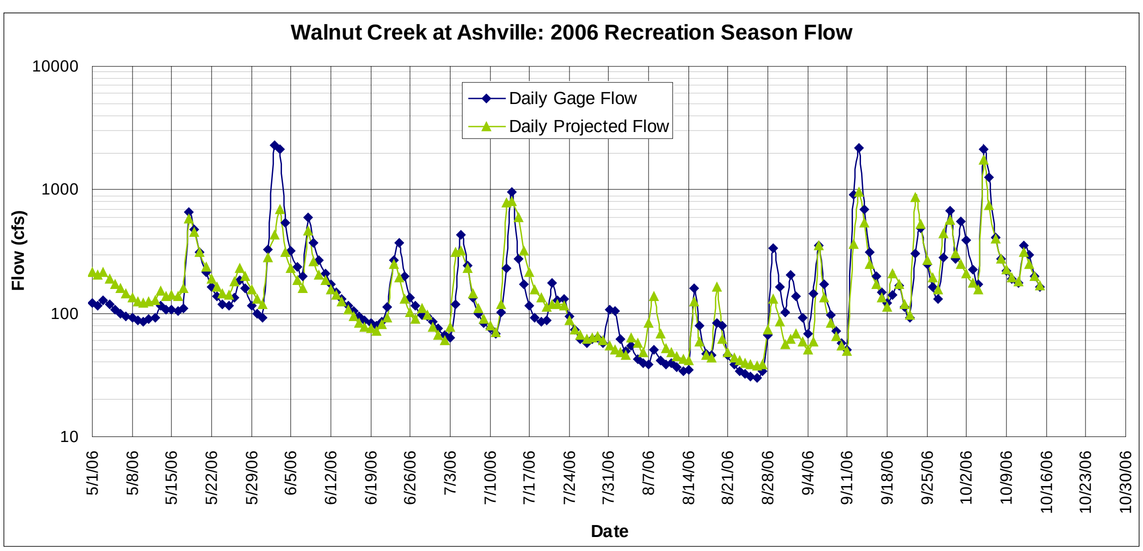


Figure 6.3 Corresponding values between the values for average daily flow at the USGS gage on Walnut Creek in Ashville and the projected flows based on the USGS gage on the Hocking River at Enterprise.

With a method established to estimate daily recreation season flow for the Walnut Creek at Ashville site, a ten year record was calculated from 1997 to 2006. These ten years in this region of Ohio have a range of flow trends from drought to above normal flow, which makes the period of record representative of seasonal variation. The flow duration curve depicted in figure 6.4 demonstrates the nature of Walnut Creek's recreation season flow range for the ten year period.

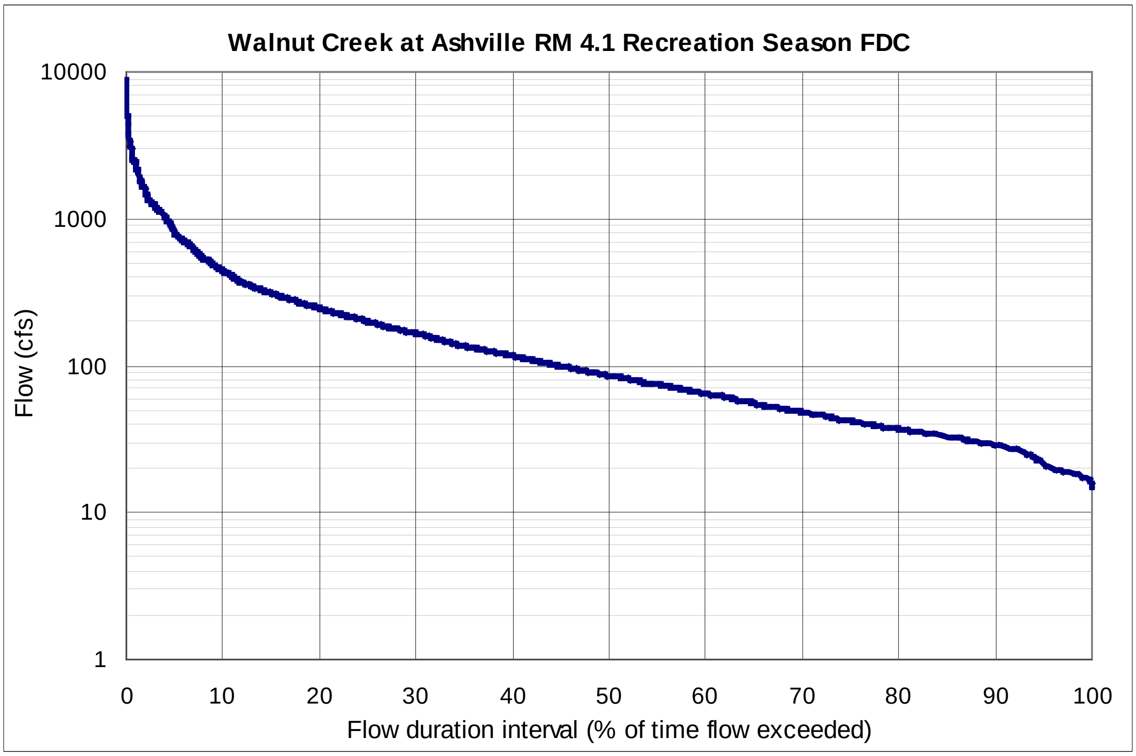
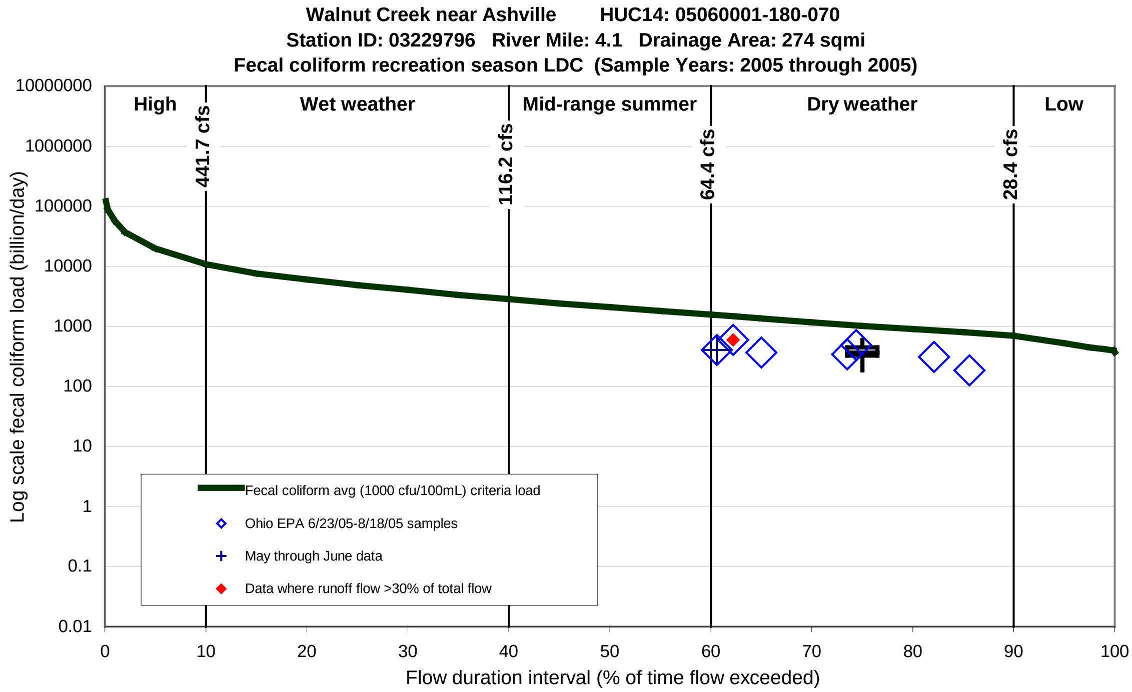


Figure 6.4 Flow duration curve for the USGS gage on Walnut Creek at river mile 4.1.

The Walnut Creek flow duration curve for the Ashville site is the basis for the development of the fecal coliform load duration curve in Figure 4.1, and shown only with representative Ohio EPA data in Figure 6.5. Referring to the representative 2005 Ohio EPA dataset isolated in Figure 6.5, and understanding that all subwatershed sites follow a similar flow pattern on their sample days, each site has a few representative samples taken within the dry weather flow regime (between 60-90% flows exceeding). The sample sets at various subwatersheds reveal a chronic issue during a dry weather flow regime, but do not provide information on other flow regimes where other contributing source loads could be better estimated. The full attainment Ashville site's combined Ohio EPA and Ashville WWTP monitoring data shown in Figure 4.1 provide a comprehensive loading estimate for multiple flow regimes. Unfortunately, there is no direct way to estimate the loading of other non attaining subwatershed sites at the other normal recreation flow regimes (mid-range and wet weather).



Flow regime load analysis fecal coliform (billion organisms/day)	High	Wet weather	Mid-range summer	Dry weather	Low
Flow duration regime interval	0-10%	10-40%	40-60%	60-90%	90-100%
Samples per regime				7	
Median sample load				365.9	
Target criteria load (mid regime)	19,822	4,875	2,099	1,012.8	523.5
Median % sample load above criteria	**No Data**	**No Data**	**No Data**	**None**	**No Data**

Figure 6.5 Representative 2005 Ohio EPA dataset used for fecal coliform attainment analysis at the Ashville gage site

Fecal coliform washoff from various non-point sources may have a significant load contribution not observed in 2005, which impacts the accuracy of TMDL derivation of load allocations to sources. Two methods of determining fecal coliform loadings from varying flow regimes are to resample at non-attaining sites through another season across a range of flows, or determining the fecal coliform loading through modeling, which is what was done.

6.3.2 Fecal coliform loads to the stream

Model selection is a key part of the TMDL development process. The type of model used is dependent on site attainment issues, spatial variability of non-attaining sites, sample representation, hydrology, land usage, available source data, time allocated for modeling, staff model experience, management goals, and other issues. The simplest model can use field samples directly to derive load allocations for the site in question. Load duration curves have already been excluded from consideration due to the small range of flows under which the representative Ohio EPA 2005 samples were collected. There are also other issues with load duration curves, such as sites with no flow data, and sites that may not represent the intended sub-watershed due to substantial in-stream decay of fecal coliform, or proximity to a local source. The other extreme is using a high level model such as HSPF. HSPF can simulate daily flow at multiple points within a watershed and determine the fecal coliform loadings and needed reductions from multiple sources with a higher level of certainty. However, HSPF is data intensive for calibration and can take considerably more time to develop a representative model.

Walnut Creek's non-attaining sites are mostly isolated to HUC-14 level tributaries, and most of Walnut Creek does not need load allocations defined. The sites that do not meet recreation criteria are only represented by fecal coliform samples during the dry weather flow regime and little site flow measurement data exists. There is not an appropriate dataset to directly calculate the tributary loadings for a representative flow range, and the percentage of non-attaining sub-watersheds is not enough to justify the expense of modeling the entire watershed with HSPF. A compromise in modeling approach was needed.

The Ohio EPA modeling section's in-house fecal coliform model SLAPIT (Stream Load Allocating Pathogen Indicator Tool) was used for load modeling. It is a series of algorithms written in an Excel spreadsheet that computes point source loading, non-point source in-stream loading, and non-point source wash-off loading from runoff events. It is suitable for calculating fecal coliform loading of small ungaged sub-watersheds where in-stream decay is negligible. Flow calibration is not possible since there is little to no flow measurement data at the individual sub-watersheds, but daily precipitation records from nearby sources and estimates from an encompassing flow gage provide a sufficient flow estimate. The model utilizes readily available data through various GIS coverages and County based data such as septic systems, livestock, and wildlife. While the county averaged data is somewhat coarse, it gives a conservative estimate of available loadings and the data mining process is less time consuming. Since the uncalibrated loadings are based on having all land based loads entirely available for wash-off and does not consider current BMPs, the approach provides an implicit margin of safety within the TMDL calculations. SLAPIT integrates in stream sources such as NPDES permitted point sources, wildlife, and cattle with stream access. The model can also differentiate between a point source MS4 storm water permit region as opposed to storm water wash-off from a nonpoint source developed area. This approach addresses loadings from multiple flow regimes where 2005 data load duration curves can not, and does not have the cost investment of a higher level modeling approach.

Sources of Data

Land use, soil, and weather data are critical components of a watershed model. The land use data is taken from the National Land Cover Dataset (NLCD). The NLCD was compiled from satellite imagery circa 2001 and includes fifteen classes of land use as 30x30 meter rasterized units. These fifteen classes are aggregated through GIS into 6 classes: built-up, cropland, pastureland, forest, water, other (typically barren land). Soil properties and distribution is documented by the National Resources Conservation Service (NRCS) through county level soil surveys. This data is tabularized and is available in a newer version through the National Soil Information System (NASIS) or the original format the Map Unit Interpretation Record (MUIR). These tables are linked with a digitized mapping system into the Soil Survey Geographic Database (SSURGO). SSURGO is the most detailed soil information available through NRCS and is available on a county basis. The soil hydrologic group is assigned a letter A through D which indicates the extent of a soil's infiltration capacity. The selected weather stations are located close to the Walnut Creek watershed. Daily precipitation data was supplied by NOAA weather stations at Buckeye Lake and the Port Columbus airport. The three modeled sub-watersheds in the northeast corner of Fairfield County are modeled using the Buckeye Lake gage, while the remaining sub-watershed models reference the Port Columbus airport gage.

Point source data is available through the NPDES permitting program. Average design flows listed in a permit is used to model flow in the model. Unless no fecal coliform source is discharged by a point source, the allowable load is set to the permit concentration limit (fecal coliform 1000cfu/100ml) multiplied by the design flow. Combined sewer overflows (CSO) are not noted in the watershed. However, there are some known sanitary sewer overflows, which are illegal and are assigned a zero load without further modeling (See Figure 5.5). Regions with existing and proposed sewer service are mapped by the Mid Ohio Regional Planning Commission (MORPC) and are shown in Figure 2.8. The region is experiencing considerable growth due to improving infrastructure and the population increase of the Columbus metropolitan region. Fairfield County and Pickaway County have targeted key growth areas that will need sewer service in order to protect human health and water quality. The sewer service mapping is imported into GIS and used primarily to determine areas that should not have septic systems in use. Future development could have negative aquatic impacts on stream quality which could be minimized by best management practices. However, future development could have a positive recreation attainment impact for controlling septic system discharge as they are replaced with centralized treatment systems.

The population on septic systems was estimated using US 2000 Census block map data. The number of conventional septic systems is assigned a 20% failure rate. The number and location of mechanical (aerator) systems was obtained from the Fairfield County Health Department. While Fairfield County has required a leach field with any new mechanical system for a number of years, there are still many that have no secondary treatment and may have direct influences on nearby streams or wells. The quantity of mechanical systems of the bordering counties is assumed to be similar, and is estimated for each impaired sub-watershed. USEPA considers mechanical HSTS systems to have a 100% failure rate. The septic system mapping is imported into GIS for spatial analysis. An example of septic system model input is provided in Table 6.2 for sub-watershed 170-010PV. While SLAPIT is capable of modeling direct stream septic flow from straight pipe or failing septic systems, no localized evidence was collected and the direct stream simulation was turned off. Septic system load reduction is a special case of the model in that the percent reduction is determined before washoff simulation. The percent reduction is based on the number of existing failures and a calculated acceptable failure level which is based on a 1% failure rate for a septic system with a 20 year design life. After the wash-off simulation, this percent reduction is used on the load that reaches the stream to determine a stream load allocation. The percent reduction based on system design life is intended to ensure correction of failing septic systems polluting State waters with organics and pathogens, and will also help protect against such systems contaminating nearby private drinking water wells.

Table 6.3 Watershed 170-010PV septic system data and % reduction calculation

Septic System and Failure Rate Determination for 2005	
Estimated Households	407
Estimated Population	1140
Reported Aerators	116
Additional Potential Aerators	0
Percent Of Aerator Systems	28.5
Estimated Household Failure Rate % of other HSTS's	20
Estimated other HSTS Failures as Households	58.2
Total Failures as Households	174.2
Estimated Total Failure Rate%	42.8
Portion Estimated Failure% Represented as Ponding	100
Portion Estimated Failure% Represented as Direct	0

Target a 1% failure rate for septics (20 year design)	
Seasonal Load	2.17E+14
Target Load	**5.07E+12**
Direct Load	0.00E+00
Direct % Reduction	**100**
Remaining Load	2.17E+14
%Reduction	**97.66**

Livestock numbers are obtained from the 2002 USDA NASS agricultural census at the County level. The County data was proportioned to a sub-watershed by a ratio of County pasture to sub-watershed pasture. The livestock numbers were further refined by "windshield survey" recons and review of high resolution aerial photography. Some livestock data was adjusted to reflect manure spreading within the sub-watershed instead of direct deposition, depending on species and housing practices. Table 6.4 provides an example of livestock estimation for the 170-010PV watershed. The model only considers cattle as being able to enter a stream. Direct stream input by cattle is limited only to those streams with evidence of cattle access as determined by Ohio EPA field staff (see Figure 5.7).

Table 6.4 Watershed 170-010PV livestock data

Livestock	County Farms	Est SubWS Farms	County Number	Est SubWS Number	LvStk/Farm Est	Acre/LvStk Est	BPJ Est
Grazed Cattle	238	8.2	10941	374.7	46.0	4.3	250
Swine	69	2.4	13865	474.9	200.9	3.4	50
Confined Cattle	185	6.3	5495	188.2	29.7	8.5	175
Poultry	196	6.7	7734	264.9	39.5	6.0	275
Horses	42	1.4	2033	69.6	48.4	23.0	75
Sheep	75	2.6	1616	55.3	21.5	28.9	75
Other	88	3.0	747	25.6	8.5	62.6	25

Wildlife numbers are obtained from the Ohio Department of Natural Resources census data at County level. The total number of animals within the County was divided by the total number of acres of relevant land use in the watershed. The resulting animal densities (animals per acre) were used to estimate the animal populations within each sub-watershed. Direct stream deposition by wildlife was estimated using a percent of time that each animal type typically spends in or next to a stream. Table 6.5 provides a breakdown of wildlife load contribution to the 170-010PV watershed.

Table 6.5 Watershed 170-010PV wildlife data

Wildlife Populations	Crop	Pasture	Forest	Distribution	Direct Stream	Direct Stream	Wildlife
Animals	An/SqMi	An/SqMi	An/SqMi		Animal-Equiv	Daily Load	Total Daily
Ducks	0.31	0.31	0.77	Near Stream	1.75	4.25E+09	Stream Load
Geese	0.40	0.40	0.34	Near Stream	0.30	1.47E+10	2.07E+10
Deer	9.25	9.25	17.46	Watershed	1.50	7.50E+08	
Beaver	0.03	0.03	1.98	Near Stream	1.25	3.13E+08	Total Rec Season
Raccoons	25.00	25.00	25.00	Watershed	2.50	3.13E+08	Stream Load
Other	10.00	10.00	10.00	Watershed	0.10	4.09E+08	3.48E+12

Description of Method

SLAPIT stream flow is simulated using a combination of two methods to estimate daily storm runoff and groundwater base flow, resulting in a daily stream flow record. The method does not include all of the mechanisms shown in Figure 6.6, but does represent the major hydrologic functions for a small stream's watershed. Runoff is calculated as a percent of daily precipitation that does not route to deep infiltration. Base flow is calculated separately by estimation from a gaged watershed. The model predicts ten years of recreation season (May 1st through October 15th) stream flow based on precipitation, land uses, soil characteristics, and base flow estimate.

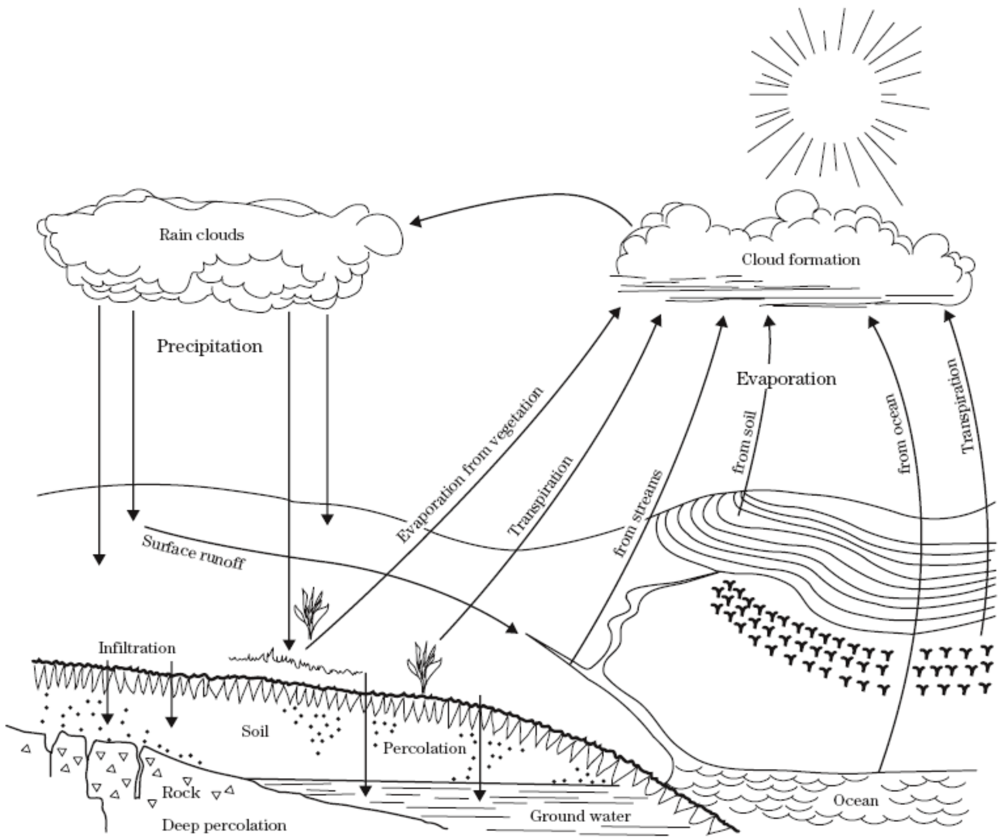


Figure 6.6 Diagram of the hydrologic cycle (National Engineering Handbook Part 630 Chapter 10, USDA/NRCS 210-VI-NEH July 2004)

Runoff is calculated using a form of the Natural Resources Conservation Service's Curve Number method (See chapter 10 "Estimation of Direct Runoff from Storm Rainfall" of NEH Part 630 for calculation methods). The curve number (CN) represents the amount of precipitation that runs off a particular land-use surface and is adjusted for detention potential and for soil characteristics. The characteristics needed to determine a CN are combined in GIS as 30x30 meter individual hydrologic response units (HRU). Table 6.14 lists developed HRUs and corresponding CNs for the 170-010PV sub-watershed. The CN's mathematical representation is the percent of runoff from a particular HRU, the higher the curve number the more runoff produced. Each HRU group is simulated separately and the individual runoff quantities from all HRUs are summed for the modeled watershed. The calculated flow of this method defines runoff as a combination of overland flow, shallow interflow, and drainage from field drainage tiles. The method does not incorporate hydrologic routing, so a day's total precipitation converted to runoff is assumed to contribute to the stream and leave the same day. This approach likely overestimates a storm day's stream flow and underestimates the following day's flow, but the total flow for a recreation season is all accounted. The model is designed to provide seasonal average output, and not daily output due to this and other limitations. That being said, a high percentage of the runoff will be through the system within one day for a small drainage area as targeted for these modeled sub-watersheds.

A sub-watershed stream's base flow is determined by estimation from the constructed ten year Ashville flow gage record, which was previously discussed. First, a sub-watershed is assigned a temporary ten year flow record by assigning a percent of the Ashville gage flow based on a linear drainage area ratio. Then the sliding interval base flow separation method developed by Pettyjohn and Henning is used to remove flow derived from runoff. The sliding interval method assigns base flow as the minimum flow from a determined range of days before and after the day in question. The range of days assessed is based on the size of the drainage area of the reference gage. For these small sub-watersheds, base flow is predicted using the minimum of the three days before and after the target day.

SLAPIT borrows the core of the land based fecal coliform load estimating methodology as used in US EPA's Bacteria Indicator Tool (BIT). The BIT loading model requires three types of values: user-defined, default, and literature. User-defined values are specific to the study area. User-defined values required by the tool are land use distribution, numbers of livestock, and wildlife densities. Default values are supplied by the tool, but it is suggested that they be 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 livestock. 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 most default values were unchanged because limited watershed-specific information was available.

Some modifications and additions were made to BIT within the SLAPIT model to better represent the Walnut Creek watershed, as discussed in the following descriptions. Load buildup is routed through direct deposition, manure spreading, accumulation in urban environments, and septic system hydraulic failure. Septic systems are not modeled as a direct stream source as they are in BIT, which was discussed in the data sources section. SLAPIT estimates a seasonally changing accumulation rate of fecal coliform on four land-use categories: built up, cropland, pastureland, and forest. Buildup is not assigned to the relatively small acreage of the "other" or "water" land uses, but they are integrated for flow calculation. The changing accumulation rate is controlled with 24 to 30 day time periods instead of months in order to better fit the recreation season. It is recognized that runoff from unmanaged feedlots can be a major source of a stream's fecal coliform load, but this source is lumped into the modeled pasture load for simplicity. All direct stream loads are estimated by SLAPIT, while BIT only estimates land accumulation. SLAPIT integrates NPDES point sources, CSOs, cattle with stream access, and wildlife.

Manure spreading is based on a storage approach, applying manure to crop and pasture lands in times of normal practice. The annual amount of stored manure is allocated for spreading over several time periods as a percent of the total available. The manure is assumed to be incorporated into the soil to a certain percent which limits the amount of fecal coliform available for wash-off. The different percents incorporated into the soil based on agricultural practices are for hog manure 80%, cattle manure 75%, horse manure 75%, and poultry litter 96%. Table 6.6 provides the distribution of manure application timing for all the modeled sub-watersheds. The approach allows for periods of different loading characteristics, such as pronounced application and planting in May. Any manure applied outside of the recreation season does not contribute to the modeled loadings. Since manure spreading between October 16th and April 30th, no attempt was made to make the time period representative for the Walnut Creek basin. Unlike BIT, SLAPIT assumes there is no manure spreading on full season croplands typically established toward the end of May (i.e. corn and soybeans), and routes the excess to multi-harvest grain croplands and pastureland. The percent of full season cropland is based on County level USDA NASS crop statistics, and sized down to the sub-watershed crop percentages. The bulk of harvesting picks up in mid October, and fall manure spreading is assumed to pick up late October.

Table 6.6 SLAPIT manure application percent timing assignment for the Walnut Creek sub-watersheds (total year per animal type = 1)

Manure Application	Jan	Feb	Mar	Apr	May1-May24	May25-Jun23	Jun24-Jul23	Jul24-Aug22	Aug23-Sep21	Sep22-Oct15	Oct16-Nov30	Dec
%Hog Manure	0	0	0	0.1	0.1	0	0	0	0	0	0.8	0
%Cattle Manure	0.0375	0.0375	0.0375	0.05	0.05	0.0375	0.0375	0.0375	0.0375	0.03	0.57	0.0375
%Horse Manure	0.1067	0.1067	0.1067	0.1067	0.0600	0.0600	0.0600	0.0600	0.0600	0.0480	0.1187	0.1067
%Poultry Litter	0	0	0	0.1	0.1	0	0	0	0	0	0.8	0

All of the land based loading characteristics are processed and condensed into a daily buildup table distinguished by land-use and time period. See Table 6.7 for an example daily buildup table. The buildup of fecal coliform is asymptotically limited due to fecal coliform's attenuation rate, and the buildup limit is reached if no wash-off occurs over a period of days. The default limit values used are 1.5 times the maximum buildup for cropland and pastureland, and 1.8 times the daily buildup for forest and developed land. The Built-Up (developed) land-use is further broken down into nonpoint source Built-Up, entity point source MS4 Built-Up, and a special Built-Up to tie in septic systems for wash-off simulation. The septic system 210 HRU coding overlaps both point and non-point Built-Up, treating the wash-off derived from failing septic systems as a separate allocation from other fecal coliform sources within developed regions.

Table 6.7 Watershed 170-010PV fecal coliform land based buildup table

MONTH	CODE	May1-May24	May25-Jun23	Jun24-Jul23	Jul24-Aug22	Aug23-Sep21	Sep22-Oct15
BUILT-UP	110	1.46E+07	1.46E+07	1.46E+07	1.46E+07	1.46E+07	1.46E+07
CROP	120	2.14E+09	1.55E+08	1.55E+08	1.55E+08	1.55E+08	1.55E+08
PASTURE	130	1.51E+10	1.97E+10	1.97E+10	1.97E+10	1.97E+10	1.97E+10
FOREST	140	1.12E+08	1.12E+08	1.12E+08	1.12E+08	1.12E+08	1.12E+08
WATER	150	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
OTHER	160	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SEPTIC	210	2.40E+10	2.40E+10	2.40E+10	2.40E+10	2.40E+10	2.40E+10
BUILT-UP MS4-1	50110	1.46E+07	1.46E+07	1.46E+07	1.46E+07	1.46E+07	1.46E+07
BUILT-UP MS4-2	110110	1.46E+07	1.46E+07	1.46E+07	1.46E+07	1.46E+07	1.46E+07
BUILT-UP MS4-3	120110	1.46E+07	1.46E+07	1.46E+07	1.46E+07	1.46E+07	1.46E+07

SLAPIT uses the land based fecal coliform buildup data in combination with the hydrology simulation to provide a discrete daily wash-off load. The amount of wash-off of accumulated fecal coliform is based on relationships proposed by Amy et al. (1974) and Sartor and Boyd (1972). The wash-off function was originally used in the SWMM model and is also used in GWLF. The first-order wash-off equation suggested by Amy et al. is based on the assumption that 1/2" of runoff in one hour will remove 90% of the accumulated load in an urban setting. The equation is bound by zero washoff and an asymptotic limit of 100% wash-off. Figure 6.7 illustrates the graphical depiction of the first order wash-off equation for various 1/2" wash-off efficiencies. In order to keep SLAPIT's fecal coliform wash-off methodology consistent across land-uses, the first order wash-off equation is applied to the non-urban land-uses with different assumed percent removal efficiencies at the1/2" runoff point. The four accumulation model land uses are assigned wash-off curves based on estimation of what percent accumulation would wash-off under 1/2" runoff conditions. The land uses' wash-off curves are assigned as the 90% to urban land, the 80% to cropland, the 70% to pastureland, and the 50% to forested land.

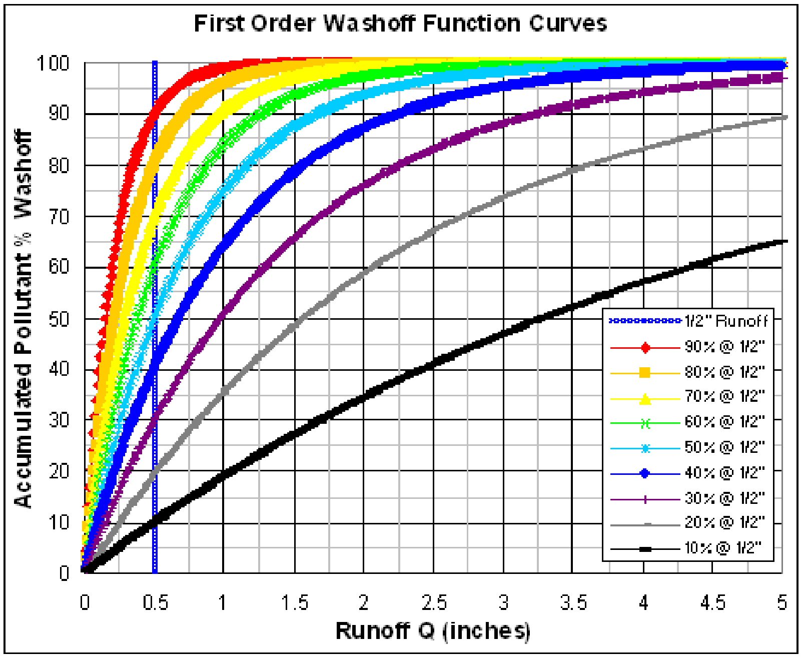


Figure 6.7 First-order wash-off function curves. Equation and curve fitting assumption of 90% of accumulation washes off of an urban land use in response to 1/2" runoff are as cited in the SWMMS and GWLF literature.

Each HRU group is modeled separately for the ten year simulation and the resulting totals summarized by each year's recreation season and land-use type. An example of the daily sub-watershed 170-010PV simulation for the Built-Up 110 land-use for May of 1997 is provided in Table 6.15. The analysis keeps track of daily runoff, base flow, land based daily fecal coliform buildup, fecal coliform wash-off, and amount left for future wash-off for each HRU in a sub-watershed. A loss function was built into SLAPIT to account for accumulations prevented from washing off, but this method is not used for the Walnut Creek sub-watersheds. While this model provides a streamlined TMDL procedure, the user should be aware that this model assumes all runoff and all wash-off fecal coliform are designed to contribute in entirety on the same day of the precipitation driven event. Not incorporating lag time creates a discrete daily pulse load representation, which does not capture the continuous time frame and loading flux of fecal coliform in response to a storm hydrograph. Since the model is intended to be used as a means to estimate a total season's fecal coliform load for a small drainage area, the daily lag time issue becomes insignificant. The longer the stream reach modeled, the more significant the issue becomes. SLAPIT is best used to represent headwater HUC-14 sub-watersheds due to this limited capability, but can be used for an internal sub-watershed analysis if only the sub-watershed's water contributions are simulated.

There are two modeled sub-watersheds that receive flow upstream of their modeled boundary. Lower Sycamore Creek (170-070LS) and Walnut Creek between Poplar and Sycamore Creeks both (170-050) have upstream watershed contributions. The issue is handled by the assumption that the upstream waters meeting recreation criteria or are to be managed through a TMDL to have an average seasonal fecal coliform load that meets the fecal coliform 1000cfu/100mL target. This assumption allows the upstream flow and load to essentially be added to the lower basin's flow and load, and then subtracted out of the analysis since upstream waters are allocated to the target. The dry weather sample results from these two sub-watersheds indicate that fecal coliform sources are internal loading issues, and non-attaining upstream sub-watersheds are being allocated their own TMDLs.

The resulting totals for the ten year simulation summarized in Excel pivot table format are presented in Table 6.8 for the 170-010PV watershed. The ten recreation season quantities for each landuse type are averaged to get values representative of a several seasons. These values are added to the seasonal base flow, direct stream source flow, and fecal coliform load tracked by SLAPIT. As shown in upper left sub-table in Table 6.9 for sub-watershed 170-010PV, the data aggregation provides a total representative recreation season flow and load for a sub-watershed.

Table 6.8 Sub-watershed 070-010PV SLAPIT seasonal runoff and load outputs aggregated by year and land-use

Sum of Runoff (cf)		YEAR										
MS4	INDEX	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Average
0	110	7.65E+05	5.41E+05	1.80E+05	3.30E+05	3.52E+05	4.90E+05	5.14E+05	5.27E+05	5.54E+05	4.24E+05	4.68E+05
	120	1.08E+08	5.67E+07	1.36E+07	2.88E+07	3.04E+07	5.85E+07	5.21E+07	5.94E+07	8.06E+07	3.51E+07	5.24E+07
	130	1.03E+07	2.85E+06	2.51E+05	9.96E+05	1.05E+06	3.63E+06	2.27E+06	3.02E+06	7.36E+06	1.15E+06	3.28E+06
	140	4.90E+06	1.05E+06	2.29E+04	2.27E+05	3.04E+05	1.38E+06	6.26E+05	9.76E+05	3.36E+06	3.17E+05	1.31E+06
	150	2.76E+06	2.27E+06	1.13E+06	1.80E+06	1.88E+06	1.98E+06	2.56E+06	2.20E+06	2.09E+06	2.32E+06	2.10E+06
	160	4.06E+07	3.25E+07	1.32E+07	2.31E+07	2.43E+07	2.82E+07	3.37E+07	3.08E+07	2.93E+07	3.00E+07	2.86E+07
	210	1.96E+06	1.39E+06	4.64E+05	8.50E+05	9.07E+05	1.26E+06	1.32E+06	1.35E+06	1.42E+06	1.09E+06	1.20E+06
50000	50110	1.19E+06	8.49E+05	2.84E+05	5.20E+05	5.55E+05	7.67E+05	8.08E+05	8.26E+05	8.63E+05	6.69E+05	7.33E+05
110000	110110	2.30E+06	1.67E+06	5.69E+05	1.04E+06	1.10E+06	1.49E+06	1.59E+06	1.61E+06	1.66E+06	1.34E+06	1.44E+06
120000	120110	3.27E+06	2.33E+06	7.78E+05	1.42E+06	1.52E+06	2.10E+06	2.21E+06	2.26E+06	2.37E+06	1.83E+06	2.01E+06

Sum of Base (cf)		YEAR										
MS4	INDEX	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Average
0	STREAM	9.92E+07	9.99E+07	3.02E+07	5.64E+07	8.65E+07	9.56E+07	1.13E+08	1.58E+08	6.61E+07	7.80E+07	8.83E+07

Sum of LOAD		YEAR										
MS4	INDEX	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Average
0	110	7.19E+09	7.24E+09	3.12E+09	5.35E+09	5.65E+09	5.75E+09	7.09E+09	6.45E+09	5.30E+09	6.98E+09	6.01E+09
	120	1.27E+13	1.65E+13	6.12E+12	1.69E+13	3.10E+13	1.65E+13	1.75E+13	2.29E+13	2.49E+13	6.53E+12	1.71E+13
	130	8.52E+13	4.01E+13	4.63E+12	1.74E+13	1.43E+13	5.22E+13	3.82E+13	4.79E+13	7.46E+13	1.91E+13	3.94E+13
	140	2.21E+11	6.88E+10	1.73E+09	1.69E+10	2.19E+10	9.31E+10	4.58E+10	7.01E+10	1.84E+11	2.28E+10	7.45E+10
	150	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
	160	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
	210	2.58E+13	2.56E+13	1.08E+13	1.86E+13	1.96E+13	2.06E+13	2.52E+13	2.33E+13	1.92E+13	2.40E+13	2.13E+13
50000	50110	1.12E+10	1.13E+10	4.88E+09	8.36E+09	8.82E+09	8.95E+09	1.11E+10	1.00E+10	8.24E+09	1.09E+10	9.37E+09
110000	110110	2.15E+10	2.16E+10	9.47E+09	1.63E+10	1.71E+10	1.72E+10	2.15E+10	1.91E+10	1.58E+10	2.13E+10	1.81E+10
120000	120110	3.07E+10	3.09E+10	1.34E+10	2.29E+10	2.42E+10	2.46E+10	3.03E+10	2.75E+10	2.26E+10	2.99E+10	2.57E+10

TMDL Calculation and Allocation

A total maximum daily load is calculated as a waterbody's waste load allocation for point sources added to a load allocation for non-point sources with an additional added margin of safety load. For Walnut Creek's fecal coliform TMDLs, the margin of safety is implicitly built into the load allocations based on the modeling strategy as discussed throughout this section and in Section 6.5.

The total seasonal averaged flow provided by the SLAPIT model is multiplied by the 1000cfu/100mL fecal coliform target to determine a sub-watershed's TMDL. Table 6.9 provides the seasonal TMDL calculation for the 170-010PV sub-watershed in the lower left sub-table. The percent reduction required is determined by comparing the total seasonal averaged load with the seasonal target load. The required reduction is further broken down into the source components tracked by the model. NPDES point sources are assigned a load based on their design flow and fecal coliform permitted concentration limit. Livestock with direct stream access are all expected to be fenced out and are assigned a 100% load reduction. No load reduction from direct stream deposits of wildlife is necessary. Septic system loading is assigned a percent reduction as demonstrated in Table 6.3. After the previous reductions are allocated, the wash-off from land-uses are allocated individual load reductions based on requiring that all types are met the same percent load reduction. These allocated land uses include point source MS4 developed regions, nonpoint source developed regions, pastureland and cropland. Forest lands are not assigned a percent reduction, as the loading is considered to be at background levels. The right sub-table of Table 6.9 is the SLAPIT seasonal source breakout TMDLs based on the tracked sources for the 170-010PV sub-watershed.

Table 6.9 Sub-watershed 170-010PV SLAPIT recreation season fecal coliform TMDL allocation output

Calculate TMDL

Recreation Season Load and Volume	
Load	5.19E+14
Volume cf	1.87E+08
Concentration	9827.08
TMDL (Rec Season) Calculation	
Allowed	1000
TMDL (Rec Season)	5.28E+13
Exceedence	4.66E+14
% Reduction Required	89.82

HUC 14:	05060001170010						
Sub-Basin:	Walnut Creek Creek Below Unnamed Tributary at RM 47.60 to Below Pleasantville Creek						
TMDL (Rec Season)	Existing Load	WLA	LA	TMDL Balance	% Reduction	Load Reduction	Exceedence Balance
Point				0.00E+00			4.66E+14
Walnut Creek SD	1.15E+12	1.15E+12		1.15E+12	0.00	0.00E+00	4.66E+14
CSO	0.00E+00	0.00E+00		1.15E+12	100.00	0.00E+00	4.66E+14
Nonpoint				1.15E+12			4.66E+14
Direct Septics	0.00E+00		0.00E+00	1.15E+12	100.00	0.00E+00	4.66E+14
Washoff Septics	2.13E+13		4.97E+11	1.65E+12	97.66	2.08E+13	4.46E+14
Direct Livestock	4.37E+14		0.00E+00	1.65E+12	100.00	4.37E+14	8.92E+12
Direct Wildlife	3.48E+12		3.48E+12	5.13E+12	0.00	0.00E+00	8.92E+12
Forest	7.45E+10		7.45E+10	5.21E+12	0.00	0.00E+00	8.92E+12
MS4	5.32E+10	4.48E+10		5.25E+12	15.77	8.38E+09	8.91E+12
Built Up	6.01E+09		5.06E+09	5.26E+12	15.77	9.48E+08	8.91E+12
Pasture	3.94E+13		3.32E+13	3.84E+13	15.77	6.21E+12	2.70E+12
Crop	1.71E+13		1.44E+13	5.28E+13	15.77	2.70E+12	0.00E+00

Some pollutants with average concentration derived load reduction targets are more meaningful to watershed management if based on larger time scales other than a daily load. However, recent rulings have dictated that all TMDLs must have an actual daily load allocation. The derived seasonal fecal coliform load allocations for the Walnut Creek sub-watersheds are divided by the 168 days of the recreation season in order to provide the daily TMDLs presented in Tables 7.1 through 7.6. Tables 6.10 through 6.13 are taken from the 170-010PV SLAPIT seasonal TMDL module. The first table shows both seasonal and daily TMDLs for comparison. Walnut Creek's allocated fecal coliform TMDLs will ensure that watershed management will meet the geometric mean chronic recreation season criteria, as well as control acute washoff events.

Table 6.10 Sub-watershed 170-010PV lumped seasonal TMDL allocation, and reference daily TMDL allocations

Fecal Coliform	Total SubWS Load	NonP Septic Systems	Point Sources NPDES WWTP	Point Sources NPDES MS4	Nonpoint Sources Direct Livestock	Nonpoint Sources Washoff & Wildlife	Margin of Safety
Seasonal Allocated Load (May 1st through October 15th) cfu*10^{10}/season							
Allowable	5284.67	49.67	115.11	4.48	0.00	5115.42	Implicit
Existing	51932.86	2125.80	115.11	5.32	43680.00	6006.63	-
% Reduction	90%	98%	0%	16%	100%	15%	-
Reference Daily Allocated Load cfu*10^{8}/day							
Allowable	3145.64	29.56	68.52	2.67	0.00	3044.89	Implicit
Existing	30912.41	1265.36	68.52	3.16	26000.00	3575.38	-
% Reduction	90%	98%	0%	16%	100%	15%	-

Table 6.11 Sub-watershed 170-010PV seasonal TMDL allocation breakout of non-point source wash-off and direct stream sources

Fecal Coliform	Washoff Source				Direct Stream Source	
(cfu*10^{10}/season)	Developed	Crop	Pasture	Forest	Livestock	Wildlife
Allowable	0.51	1443.91	3315.18	7.45	0.00	348.37
Existing	0.60	1714.27	3935.94	7.45	43680.00	348.37
% Reduction	16%	16%	16%	0%	100%	0%

Table 6.12 Sub-watershed 170-010PV seasonal TMDL allocation breakout of point source MS4 wash-off

MS4 Acres (Inhabited/Infrastructure/Open Urban):			532
Fecal Coliform MS4 Allocation (cfu*10^{10}/season)			4.48
MS4 Jurisdiction	% MS4 Total Area	% FC Source	Load Allocation
Walnut Township	57.0%	18.0%	0.81
Thurston	15.7%	32.4%	1.45
Pleasantville	27.3%	49.6%	2.22

Table 6.13 Sub-watershed 170-010PV seasonal TMDL allocations breakout of NPDES permitted point.

Fecal Coliform (cfu*10^{10}/season) Wasteload Allocations			
Permit#	Facility	WLA	Notes
4PA00005	Walnut Creek Sewer District WWTP	115.11	SSO issues are being resolved

Table 6.14 Hydrologic Response Unit control module of SLAPIT model, populated with sub-watershed 170-010PV data

MS4	MS4 Name
50000	Walnut Twp
110000	Thurston
120000	Pleasantville
0	None

LOC	Location Name
100	Watershed
200	Septic

LU	Name
10	Built-Up
20	Cropland
30	Pastureland
40	Forest
50	Water
60	Other

SSURGO	Soil Group
1	A
2	A/D
3	B
4	B/D
5	C
6	C/D
7	D

Washoff	1/2" %Removal
110	90
120	80
130	70
140	50
150	0
160	0
210	80
220	0
230	0
240	0
250	0
260	0
50110	90
110110	90
120110	90

HRU	VALUE	COUNT	HYDRO	INDEX	LU	SUBWS	MS4 REGION	Use for Septic	WS/LU	LU	MS4	CN	COUNT	ACRES	CN_W	%OnSoilType
1	113	2	3	110	10	100	0	10	110	Built-Up	None	85.00	2	0.45	37.89	2.08
2	115	94	5	110	10	100	0	10	110	Built-Up	None	93.00	94	20.95	1948.60	97.92
3	121	10	1	120	20	100	0	0	120	Cropland	None	67.00	10	2.23	149.53	0.09
4	123	419	3	120	20	100	0	0	120	Cropland	None	78.00	419	93.51	7294.12	3.58
5	125	11234	5	120	20	100	0	0	120	Cropland	None	85.00	11234	2507.26	213116.75	95.85
6	127	57	7	120	20	100	0	0	120	Cropland	None	89.00	57	12.72	1132.22	0.49
7	133	18	3	130	30	100	0	0	130	Pastureland	None	61.00	18	4.03	245.57	0.50
8	135	3585	5	130	30	100	0	0	130	Pastureland	None	74.00	3585	801.80	59333.24	99.42
9	137	3	7	130	30	100	0	0	130	Pastureland	None	80.00	3	0.67	53.68	0.08
10	143	22	3	140	40	100	0	0	140	Forest	None	55.00	22	4.91	269.95	1.29
11	145	1600	5	140	40	100	0	0	140	Forest	None	70.00	1600	356.95	24986.70	93.84
12	147	83	7	140	40	100	0	0	140	Forest	None	77.00	83	18.52	1425.80	4.87
13	153	2	3	150	50	100	0	0	150	Water	None	100.00	2	0.44	44.48	10.00
14	155	18	5	150	50	100	0	0	150	Water	None	100.00	18	4.00	400.34	90.00
15	163	47	3	160	60	100	0	0	160	Other	None	98.00	47	10.56	1034.83	4.69
16	165	955	5	160	60	100	0	0	160	Other	None	98.00	955	214.56	21026.77	95.31
17	50115	144	5	50110	10	100	50000	10	110	Built-Up	Walnut Twp	93.00	144	32.10	2985.09	98.63
18	50117	2	7	50110	10	100	50000	10	110	Built-Up	Walnut Twp	97.00	2	0.45	43.24	1.37
19	50123	1447	3	50120	20	100	50000	0	120	Cropland	Walnut Twp	78.00	1447	322.95	25189.95	8.22
20	50125	15995	5	50120	20	100	50000	0	120	Cropland	Walnut Twp	85.00	15995	3569.84	303436.21	90.90
21	50127	155	7	50120	20	100	50000	0	120	Cropland	Walnut Twp	89.00	155	34.59	3078.83	0.88
22	50133	532	3	50130	30	100	50000	0	130	Pastureland	Walnut Twp	61.00	532	118.98	7258.03	15.41
23	50135	2881	5	50130	30	100	50000	0	130	Pastureland	Walnut Twp	74.00	2881	644.35	47681.74	83.43
24	50137	40	7	50130	30	100	50000	0	130	Pastureland	Walnut Twp	80.00	40	8.95	715.69	1.16
25	50143	499	3	50140	40	100	50000	0	140	Forest	Walnut Twp	55.00	499	111.32	6122.86	16.12
26	50145	2577	5	50140	40	100	50000	0	140	Forest	Walnut Twp	70.00	2577	574.92	40244.20	83.26
27	50147	19	7	50140	40	100	50000	0	140	Forest	Walnut Twp	77.00	19	4.24	326.39	0.61
28	50153	24	3	50150	50	100	50000	0	150	Water	Walnut Twp	100.00	24	5.34	533.79	25.81
29	50155	40	5	50150	50	100	50000	0	150	Water	Walnut Twp	100.00	40	8.90	889.65	43.01
30	50157	29	7	50150	50	100	50000	0	150	Water	Walnut Twp	100.00	29	6.45	644.99	31.18
31	50163	70	3	50160	60	100	50000	0	160	Other	Walnut Twp	98.00	70	15.73	1541.23	5.82
32	50165	1127	5	50160	60	100	50000	0	160	Other	Walnut Twp	98.00	1127	253.20	24813.79	93.68
33	50167	6	7	50160	60	100	50000	0	160	Other	Walnut Twp	98.00	6	1.35	132.11	0.50
34	110115	222	5	110110	10	100	110000	0	110	Built-Up	Thurston	93.00	222	49.48	4602.02	84.09
35	110117	42	7	110110	10	100	110000	0	110	Built-Up	Thurston	97.00	42	9.36	908.10	15.91
36	110125	244	5	110120	20	100	110000	0	120	Cropland	Thurston	85.00	244	54.46	4628.85	98.79
37	110127	3	7	110120	20	100	110000	0	120	Cropland	Thurston	89.00	3	0.67	59.59	1.21
38	110135	73	5	110130	30	100	110000	0	130	Pastureland	Thurston	74.00	73	16.33	1208.18	100.00
39	110145	27	5	110140	40	100	110000	0	140	Forest	Thurston	70.00	27	6.02	421.65	57.45
40	110147	20	7	110140	40	100	110000	0	140	Forest	Thurston	77.00	20	4.46	343.57	42.55
41	110165	70	5	110160	60	100	110000	0	160	Other	Thurston	98.00	70	15.73	1541.23	63.06
42	110167	41	7	110160	60	100	110000	0	160	Other	Thurston	98.00	41	9.21	902.72	36.94
43	120115	403	5	120110	10	100	120000	0	110	Built-Up	Pleasantville	93.00	403	89.83	8354.12	100.00
44	120123	2	3	120120	20	100	120000	0	120	Cropland	Pleasantville	78.00	2	0.45	34.82	2.41
45	120125	81	5	120120	20	100	120000	0	120	Cropland	Pleasantville	85.00	81	18.08	1536.63	97.59
46	120135	29	5	120130	30	100	120000	0	130	Pastureland	Pleasantville	74.00	29	6.49	479.96	100.00
47	120145	33	5	120140	40	100	120000	0	140	Forest	Pleasantville	70.00	33	7.36	515.35	100.00
48	120165	246	5	120160	60	100	120000	0	160	Other	Pleasantville	98.00	246	55.27	5416.32	100.00

Table 6.15 Sub-watershed 170-010PV abbreviated SLAPIT daily simulation example

STEP	DATE	MONTH	YEAR	Base Flow (cfs)	PRECIP(in)	INDEX	LU	MS4	Q(in)	BUILD/ACRE	Loss	Available	WASH/ACRE	Acres	LOAD	Runoff (cf)	Base (cf)
1	5/1/1997	5	1997	8.7	0.055	110	10	0	**0.000**	1.46E+07	0.00E+00	1.46E+07	0.00E+00	21.40	0.00E+00	0.00E+00	7.55E+05
2	5/2/1997	5	1997	8.7	0.588	110	10	0	**0.156**	2.09E+07	0.00E+00	2.09E+07	1.07E+07	21.40	2.29E+08	1.21E+04	7.55E+05
3	5/3/1997	5	1997	8.7	0.561	110	10	0	**0.140**	1.90E+07	0.00E+00	1.90E+07	9.04E+06	21.40	1.93E+08	1.09E+04	7.55E+05
4	5/4/1997	5	1997	8.7	0.131	110	10	0	**0.000**	1.89E+07	0.00E+00	1.89E+07	0.00E+00	21.40	0.00E+00	0.00E+00	7.55E+05
5	5/5/1997	5	1997	13.1	0.085	110	10	0	**0.000**	2.28E+07	0.00E+00	2.28E+07	0.00E+00	21.40	0.00E+00	0.00E+00	1.13E+06
6	5/6/1997	5	1997	13.7	0.035	110	10	0	**0.000**	2.45E+07	0.00E+00	2.45E+07	0.00E+00	21.40	0.00E+00	0.00E+00	1.19E+06
7	5/7/1997	5	1997	13.7	0.000	110	10	0	**0.000**	2.53E+07	0.00E+00	2.53E+07	0.00E+00	21.40	0.00E+00	0.00E+00	1.19E+06
8	5/8/1997	5	1997	13.7	0.411	110	10	0	**0.064**	2.56E+07	0.00E+00	2.56E+07	6.52E+06	21.40	1.40E+08	4.97E+03	1.19E+06
9	5/9/1997	5	1997	13.7	0.190	110	10	0	**0.002**	2.29E+07	0.00E+00	2.29E+07	1.68E+05	21.40	3.61E+06	1.25E+02	1.19E+06
10	5/10/1997	5	1997	14.1	0.009	110	10	0	**0.000**	2.45E+07	0.00E+00	2.45E+07	0.00E+00	21.40	0.00E+00	0.00E+00	1.22E+06
11	5/11/1997	5	1997	12.9	0.000	110	10	0	**0.000**	2.52E+07	0.00E+00	2.52E+07	0.00E+00	21.40	0.00E+00	0.00E+00	1.11E+06
12	5/12/1997	5	1997	12.2	0.000	110	10	0	**0.000**	2.56E+07	0.00E+00	2.56E+07	0.00E+00	21.40	0.00E+00	0.00E+00	1.06E+06
13	5/13/1997	5	1997	12.2	0.000	110	10	0	**0.000**	2.57E+07	0.00E+00	2.57E+07	0.00E+00	21.40	0.00E+00	0.00E+00	1.06E+06
14	5/14/1997	5	1997	10.4	0.375	110	10	0	**0.049**	2.58E+07	0.00E+00	2.58E+07	5.23E+06	21.40	1.12E+08	3.82E+03	9.02E+05
15	5/15/1997	5	1997	9.5	0.155	110	10	0	**0.000**	2.35E+07	0.00E+00	2.35E+07	4.79E+00	21.40	1.02E+02	3.43E-03	8.23E+05
16	5/16/1997	5	1997	9.0	0.071	110	10	0	**0.000**	2.48E+07	0.00E+00	2.48E+07	0.00E+00	21.40	0.00E+00	0.00E+00	7.78E+05
17	5/17/1997	5	1997	8.8	0.235	110	10	0	**0.008**	2.54E+07	0.00E+00	2.54E+07	8.67E+05	21.40	1.86E+07	5.86E+02	7.58E+05
18	5/18/1997	5	1997	8.8	0.141	110	10	0	**0.000**	2.53E+07	0.00E+00	2.53E+07	0.00E+00	21.40	0.00E+00	0.00E+00	7.58E+05
19	5/19/1997	5	1997	7.6	0.640	110	10	0	**0.187**	2.56E+07	0.00E+00	2.56E+07	1.48E+07	21.40	3.16E+08	1.45E+04	6.55E+05
20	5/20/1997	5	1997	6.8	0.254	110	10	0	**0.011**	1.93E+07	0.00E+00	1.93E+07	9.79E+05	21.40	2.10E+07	8.80E+02	5.87E+05
21	5/21/1997	5	1997	6.4	0.000	110	10	0	**0.000**	2.25E+07	0.00E+00	2.25E+07	0.00E+00	21.40	0.00E+00	0.00E+00	5.50E+05
22	5/22/1997	5	1997	6.2	0.000	110	10	0	**0.000**	2.44E+07	0.00E+00	2.44E+07	0.00E+00	21.40	0.00E+00	0.00E+00	5.38E+05
23	5/23/1997	5	1997	6.2	0.000	110	10	0	**0.000**	2.52E+07	0.00E+00	2.52E+07	0.00E+00	21.40	0.00E+00	0.00E+00	5.38E+05
24	5/24/1997	5	1997	6.2	0.347	110	10	0	**0.038**	2.56E+07	0.00E+00	2.56E+07	4.15E+06	21.40	8.88E+07	2.99E+03	5.38E+05
25	5/25/1997	6	1997	6.2	0.384	110	10	0	**0.053**	2.39E+07	0.00E+00	2.39E+07	5.13E+06	21.40	1.10E+08	4.08E+03	5.38E+05
26	5/26/1997	6	1997	6.2	0.099	110	10	0	**0.000**	2.27E+07	0.00E+00	2.27E+07	0.00E+00	21.40	0.00E+00	0.00E+00	5.38E+05
27	5/27/1997	6	1997	7.4	0.000	110	10	0	**0.000**	2.45E+07	0.00E+00	2.45E+07	0.00E+00	21.40	0.00E+00	0.00E+00	6.36E+05
28	5/28/1997	6	1997	8.1	0.014	110	10	0	**0.000**	2.52E+07	0.00E+00	2.52E+07	0.00E+00	21.40	0.00E+00	0.00E+00	7.02E+05
29	5/29/1997	6	1997	8.1	0.155	110	10	0	**0.000**	2.56E+07	0.00E+00	2.56E+07	5.21E+00	21.40	1.11E+02	3.43E-03	7.02E+05
30	5/30/1997	6	1997	8.1	0.146	110	10	0	**0.000**	2.57E+07	0.00E+00	2.57E+07	0.00E+00	21.40	0.00E+00	0.00E+00	7.02E+05
31	5/31/1997	6	1997	8.1	0.935	110	10	0	**0.392**	2.58E+07	0.00E+00	2.58E+07	2.15E+07	21.40	4.61E+08	3.05E+04	7.02E+05

6.3.3 Habitat quality and sediment analysis

The habitat and sediment (bedload) TMDLs are based upon the QHEI. Since no processes are being simulated and source and transport mechanisms are not applicable, the TMDLs are generated strictly based on comparison of observed conditions (i.e., QHEI scores) to target conditions. (Section 6.2 lists the target values and provides information regarding the QHEI). For the sediment TMDLs, the target is based on the sum total of the substrate, channel, and riparian metric scores, and the deviation is calculated as the proportion of the difference between actual and target values to the target value. No percent deviation is calculated for the results of the habitat analysis and only the sum of each pass/fail score (i.e., one indicates “pass” while zero indicates “fail”), which ranges from zero and three, is used to convey the degree of habitat improvement needed. Specifically, the score shows how many of the aspects of habitat quality are in need of improvement.

6.4 Critical conditions and seasonality

Aquatic Life
The critical condition for aquatic organisms is the summer when the aquatic life activity and biomass production are at their highest levels and the organisms are most sensitive to environmental conditions. Summer is also when excessive algal growth, high in-stream temperatures, and reduced stream flows occur leading to the lowest dissolved oxygen concentrations. Ohio EPA biological and habitat targets are protective of the critical period as they are based on data collected only during the summer months. Further, assessing the biology during the summer months evaluates the biological performance during its most critical time of the year.

Seasonality is accounted for in the aquatic life indices. Biological and habitat indices are measures of aggregate annual conditions reflecting compounding factors over time. Such factors include episodic flow events and pollutant loads that are more extreme in nature and have long-term impact on the ecosystem. Other compounding factors might involve chronic stress such as high water temperatures and swings in dissolved oxygen. The use of these indices reflects the collective seasonal effects on the biota. The measurement of these indices during the summer period reflects the biotic performance during critical conditions.

Pathogens
The recreation season from May 1st to October 15th establishes a critical period when protection of the public from waterborne illness is most important. The recreation season's weather pattern is characterized by long periods of relatively stable warm weather with intermittent frontal storms. The recreation season's hydrology is characterized by beginning with stream flows of average span and continuing down to the lowest flow span observed throughout the year.

Chronic elevated pathogen levels present a critical condition for public safety. Though days of runoff from storms are a small fraction of the total recreation season, pathogens washed off as pulsed loads from various land uses during such events can contribute to a stream's chronic pathogen problems. Excessive wash-off of pathogens pose a critical condition to the extent of increasing a stream's chronic pathogen levels, and delivering significant pathogen loads to downstream waters.

Habitat and Sediment

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

6.5 Margin of safety

A TMDL must include a margin of safety to account for any lack of knowledge concerning the relationship between load and wasteload allocations and water quality (CWA § 303(d)(1)(C), 40 C.F.R. § 130.7(c)(1)). U.S. EPA guidance explains that the margin of safety may be implicit (i.e., incorporated into the TMDL through conservative assumptions) in the analysis, or explicit (i.e., expressed in the TMDL as a loading set aside). The implicit and explicit margin of safety factors used in the analyses are described below.

The List of Impaired Waters (the 303(d) List)
Ohio's integrated monitoring ensures that Ohio's water quality problems are being properly and thoroughly identified. Likewise, delisting requires attainment of the aquatic life use determined by the direct measurement of the aquatic biological community. This provides a high level of assurance (and an implicit margin of safety) that if the TMDL allocations do not lead to sufficiently improved water quality then the segments remain on the list until true attainment is achieved.

Pathogens
A margin of safety was implicitly incorporated into the pathogen TMDL. The targeted fecal coliform concentration of 1000 cfu/100mL represents the Ohio EPA 30 day geometric mean standard, but is used for the allowable daily maximum load calculation. Using this target also provides a substantial implicit margin of safety by not basing maximum load calculations on the Ohio EPA maximum daily standard concentration of 2000 cfu/100mL.

The fecal coliform load to the streams in each sub-watershed was quantified, as was the fecal coliform loading capacity at the outlet of each sub-watershed. Loading capacity was calculated as the product of the seasonal flow volume and the fecal coliform target concentration. 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 (see *EPA's Protocol for Developing Pathogen TMDLs* (EPA 841-R-00-002)). Also, no attempt was made to link landuse buffering capacity efficiency with upstream loading via best management practices. The assumption that 100% of all fecal coliform sources are available for washoff considers a watershed with no pollutant reduction from containment or entrapment. While there are likely some washoff management strategies being practiced, not considering any landuse controls is also represented as the implicit margin of safety.

Habitat and sediment
A MOS was implicitly incorporated into the habitat and sediment 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 (OEPA, 1999). 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.

7 RESULTS OF TMDL DEVELOPMENT

This section of the report provides the results of the TMDL analyses. These results indicate the needed pollution and/or stressor abatement needed in the watershed in order to meet the applicable water quality standards. Section 8.0 of the report focuses on strategies that might best achieve the needed water quality improvements.

Figure 7.1 is a map of the watershed illustrating the areas that were analyzed for the various TMDL parameters. Tables 7.1 through 7.4 present results for the fecal coliform TMDLs and Table 7.5 presents results for both the sediment and habitat TMDLs. Table 7.1 shows the overall TMDL and the major allocations for each assessed area (based on 14-digt HUCs or some smaller watershed sub-division). Table 7.2 focuses on the nonpoint source load allocations (LAs) in greater detail providing allocation to each of the applicable types of land cover. Table 7.3 shows the wasteload allocations for the applicable municipal separate storm sewer systems (MS4s) and identifies each entity associated with each (MS4). Table 7.4 shows the wasteload allocations to the appropriate wastewater dischargers (i.e., NPDES permittees) in the watershed.

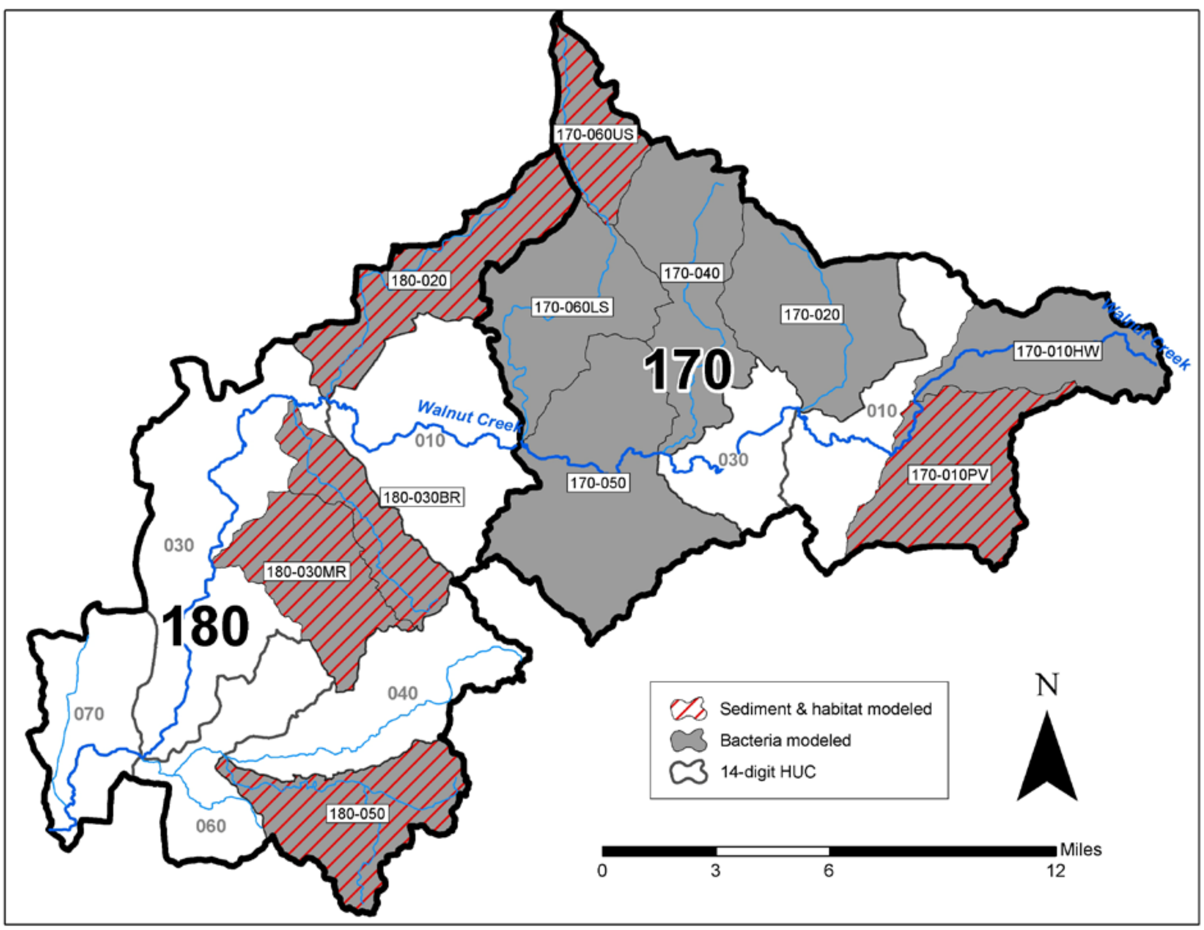


Figure 7.1 Areas analyzed for TMDL development. Areas without shading or diagonal lines were not subject to TMDL analysis.

Table 7.1 Results of the TMDL analyses for fecal coliform bacteria.

HUC - 11	HUC - 14	Sub-watershed	Existing loads (cfu * 10^8 / day) Point sources	Existing loads (cfu * 10^8 / day) Nonpoint sources	Margin of safety	Allowable loads (cfu * 10^8 / day) Total WLA	Percent reduction[1]	Total LA	Percent reduction[1]	TMDL	Percent reduction[1]
		Walnut Cr. Headwaters to upstream Buckeye Trib									
		170-010HW	0.25	45343.1	implicit	0.21	17%	2419.56	95%	2419.77	95%
		Walnut Cr. below Buckeye Tr to below Pleasant									
	010	170-010PV	71.68	30840.73	implicit	71.18	70%	3074.45	90%	3145.63	90%
		Pawpaw Creek									
	020	170-020	5.41	35294.98	implicit	3.56	34%	3671.15	90%	3674.71	90%
		Poplar Cr.									
	040	170-040	2.01	22858.72	implicit	1.08	46%	4053.88	82%	4054.96	82%
		Walnut Cr. below Poplar Cr. to above Sycamore									
	050	170-050	29.91	35922.75	implicit	28.26	6%	6503.35	82%	6531.61	82%
		Upper Sycamore Creek									
		170-060US	7.05	3394.63	implicit	6.06	14%	2228.21	34%	2234.27	34%
		Lower Sycamore Creek									
170	060	170-060LS	927.42	8293.84	implicit	923.06	0.5%	4784.6	42%	5707.66	38%
		Georges Creek									
	020	180-020	31.96	7181.45	implicit	28.14	12%	4987.98	31%	5016.12	30%
		Big Run									
		180-030BR	10.7	4685.14	implicit	10.35	32%	2292.19	51%	2302.54	51%
		Mud Run									
	030	180-030MR	0.19	11713.84	implicit	0.12	36%	2850.46	76%	2850.58	76%
		Turkey Run									
180	050	180-050	0	5884.35	implicit	0	0%	2918.48	50%	2918.48	50%

1 Percent reduction refers to reduction necessary to meet the allocation (allowable loading) based on the estimated existing loads.

Table 7.2 Existing loads and load allocations for nonpoint sources for fecal coliform bacteria.

HUC - 11	HUC - 14	Sub-watershed	Land cover type for washoff (cfu * 10^8/ day)								Direct stream source (cfu * 10^8/ day)			
			Developed[1]		Cropland		Pasture		Forest		Livestock		Wildlife	
			Existing	LA	Existing	LA	Existing	LA	Existing	LA	Existing	LA	Existing	LA
		Walnut Cr. Headwaters to upstream Buckeye Trib												
		170-010HW	*0.04*	*0.03*	*823.8*	*683.48*	*1868.86*	*1550.53*	*4.76*	*4.76*	*41600*	*0*	*146.21*	*146.21*
		Walnut Cr. below Buckeye Tr to below Pleasant												
	010	170-010PV	*0.36*	*0.3*	*1020.4*	*859.47*	*2342.82*	*1973.32*	*4.44*	*4.44*	*26000*	*0*	*207.36*	*207.36*
		Pawpaw Creek												
	020	170-020	****	****	*1487.46*	*978.54*	*3662.41*	*2409.34*	*7.74*	*7.74*	*28080*	*0*	*240.59*	*240.59*
		Poplar Cr.												
	040	170-040	****	****	*1373.38*	*734.95*	*5601.51*	*2997.6*	*16.06*	*16.06*	*12480*	*0*	*238.96*	*238.96*
		Walnut Cr. below Poplar Cr. to above Sycamore												
	050	170-050	*7*	*3.62*	*1911.03*	*988.32*	*8809.47*	*4555.94*	*34.17*	*34.17*	*20800*	*0*	*833.21*	*833.21*
		Upper Sycamore Creek												
		170-060US	****	****	*712.27*	*611.65*	*1471.45*	*1263.58*	*13.58*	*13.58*	*0*	*0*	*321.46*	*321.46*
		Lower Sycamore Creek												
170	**060**	170-060LS	****	****	*1157.04*	*891.37*	*4334.29*	*3339.07*	*15.75*	*15.75*	*0*	*0*	*502.19*	*502.19*
		Georges Creek												
	020	180-020	****	****	*1625.55*	*1431.22*	*2511.39*	*2211.16*	*25.44*	*25.44*	*0*	*0*	*1282.74*	*1282.74*
		Big Run												
		180-030BR	*0.99*	*0.71*	*706*	*508.8*	*1996.62*	*1438.93*	*14.2*	*14.2*	*0*	*0*	*271.26*	*271.26*
		Mud Run												
	030	180-030MR	*0.85*	*0.54*	*734.76*	*467*	*3147.92*	*2000.78*	*22.42*	*22.42*	*6240*	*0*	*314.54*	*314.54*
		Turkey Run												
180	**050**	180-050	*0.51*	*0.29*	*1058.44*	*603.02*	*3907.39*	*2226.15*	*5.82*	*5.82*	*0*	*0*	*49.54*	*49.54*

Table 7.3 Existing loads and load allocations for point sources for fecal coliform bacteria.

HUC-11	HUC-14	Sub-watershed	Non point source: Septic Systems (cfu * 10^8 / day) Existing	Non point source: Septic Systems (cfu * 10^8 / day) Allocated	Point sources (cfu * 10^8/ day) NPDES WWTP Existing	NPDES WWTP Allocated	NPDES MS4 Existing	NPDES MS4 Allocated
		Walnut Cr. Headwaters to upstream Buckeye Trib						
		170-010HW	899.17	34.55	0	0	0.25	0.21
		Walnut Cr. below Buckeye Tr to below Pleasant						
	010	170-010PV	1265.36	29.56	68.52	68.52	3.16	2.66
		Pawpaw Creek						
	020	170-020	1816.78	34.94	0	0	5.41	3.56
		Poplar Cr.						
	040	170-040	3148.81	66.31	0	0	2.01	1.08
		Walnut Cr. below Poplar Cr. to above Sycamore						
	050	170-050	3527.85	88.09	26.5	26.5	3.41	1.76
		Upper Sycamore Creek						
		170-060US	875.86	17.94	0	0	7.05	6.06
		Lower Sycamore Creek						
170	060	170-060LS	2284.58	36.22	908.5	908.5	18.92	14.56
		Georges Creek						
	020	180-020	1736.33	37.42	0	0	31.96	28.14
		Big Run						
		180-030BR	1696.06	58.29	9.46	9.46	1.23	0.89
		Mud Run						
	030	180-030MR	1253.36	45.18	0	0	0.19	0.12
		Turkey Run						
180	050	180-050	862.65	33.66	0	0	0	0

Table 7.4 Wasteload allocations for Municipal Separate Storm Sewer Areas (MS4s) for fecal coliform bacteria.

HUC - 11	HUC - 14	Sub-watershed	MS4 area (acres)	MS4 allocation (cfu * 10^8/day)	MS4 Permittees	Proportion of area	Proportion of loading	Wasteload allocation (cfu * 10^8/day)
		Walnut Cr. Headwaters to upstream Buckeye Trib						
		170-010HW	194	0.21	Walnut Township	100%	100%	0.21
		Walnut Cr. below Buckeye Tr to below Pleasant						
					Walnut Township	57%	18%	0.48
					Thurston	16%	32%	0.86
	010	170-010PV	532	2.66	Pleasantville	27%	50%	1.32
		Pawpaw Creek						
					Walnut Township	17%	5%	0.18
					Liberty Township	41%	12%	0.42
	020	170-020	921	3.56	Baltimore	43%	83%	2.96
		Poplar Cr.						
					Violet Township	4%	90%	0.01
					Liberty Township	91%	81%	0.87
	040	170-040	1,016	1.08	Etna Township	5%	18%	0.2
		Walnut Cr. below Poplar Cr. to above Sycamore						
					Violet Township	85%	92%	1.61
	050	170-050	738	1.76	Liberty Township	16%	9%	0.15
		Upper Sycamore Creek						
					Violet Township	28%	15%	0.91
					Etna Township	70%	83%	5
		170-060US	1,015	6.06	Pataskala	2%	2%	0.15
		Lower Sycamore Creek						
					Violet Township	48%	30%	4.34
					Liberty Township	7%	2%	0.23
170	060	170-060LS	2,835	14.56	Pickerington	45%	69%	9.99
		Georges Creek						
					Madison Township	11%	8%	2.36
					Violet Township	46%	41%	11.4
					Etna Township	50%	50%	0.14
					Pickerington	24%	24%	6.81
					Columbus	17%	22%	6.25
	020	180-020	3,510	28.14	Canal Winchester	3%	4%	1.18
		Big Run						
		180-030BR	349	0.89	Madison Township	100%	100%	0.89
		Mud Run						
	030	180-030MR	30	0.12	Madison Township	100%	100%	0.12
		Turkey Run						
180	050	180-050	NO MS4 PRESENT					

Table 7.5 Wasteload allocations for NPDES dischargers for fecal coliform bacteria.

HUC - 11	HUC - 14	Sub-watershed	Permit number (Ohio EPA)	Facility Name	Design Flow (MGD)	Wasteload allocation (cfu * 10^8/day)	Comments
		Walnut Cr. below Buckeye Tr to below Pleasant					
	010	170-010PV	4PA00005	Walnut Creek Sewer District WWTP	0.181	68.52	SSO issues are being resolved
		Pawpaw Creek					
	20	170-020	4IA00001	Ohio Paperboard Corp. WWTP	1.08	0	Industrial effluent only
		Walnut Cr. below Poplar Cr. to above Sycamore					
	50	170-050	4PS00015	Village of Carroll WWTP	0.07	26.5	Controlled discharge lagoon
		Lower Sycamore Creek					
			4PG00027	Sycamore Creek WRF	0.8	302.83	Operated by Fairfield County
170	**60**	170-060LS	4PB00017	City of Pickerington WWTP	1.60	605.67	No known overflows
		Big Run					
180	**30**	180-030BR	4GS00011	Century Acres WWTP	0.025	9.46	Operated by Franklin County

Table 7.6 Results of the TMDL analyses for sediment (bedload) and habitat.

TMDL Targets	SEDIMENT (BEDLOAD) TMDL				HABITAT TMDL			
Use	Allocations			TMDL	Allocations			TMDL
EWH	>15	>15	>5	35	>75=1	0=1	<3=1	3 pts
WWH	>13	>14	>5	32	>60=1	<2=1	<5=1	3 pts

Stream name (aquatic life use)	SEDIMENT (BEDLOAD) TMDL							HABITAT TMDL						
		QHEI Categories									Subscore			
	River mile	Substrate	Channel	Riparian	Total Sediment Score	% Deviation from Target	Main Impaired Category	QHEI Score	# High influence Attributes	Total # Modified Attributes	QHEI	High Influence	# Modified Attributes	Total Habitat Score
Walnut Cr. below Buckeye Tr to below Pleasant (170-010PV)														
Pleasantville Creek (WWH)	2.4	5	7	4.5	16.5	48%	Substrate	39	4	11	0	0	0	0
	0.4	11	15	5	31	3%	Substrate	67	0	6	1	1	0	2
Pawpaw Creek (170-020)														
Trib to Pawpaw 1.79	0.3	20	9.5[1]	8	37.5	0%[1]	Channel[1]							
Upper Sycamore Creek (170-060US)														
Sycamore Creek (WWH)	12.2	10	16	3.5	29.5	8%	riparian							
Georges Creek (180-020)														
East Fork Georges Creek (WWH)								56	2	6	0	0	0	0
								65	0	5	1	1	0	2
Big Run (180-030BR)														
Big Run (WWH)	1.6	10.5	11	4.5	26	19%	channel	40	2	9	0	0	0	0
Mud Run (180-030MR)														
Mud Run (WWH)	1.5	12.5	9	3.5	25	22%	channel	51	1	7	0	1	0	1
Turkey Run (180-050)														
Turkey Run (EWH)								47	2	7	0	0	0	0

1 Sediment has been identified as a cause of impairment despite meeting the overall sediment TMDL target. However, one component of the sediment score, the channel metric, is significantly deficient (deviation = 32%) and should be noted.

8 STRATEGY FOR ACHIEVING WATER QUALITY GOALS

The purpose of this section of the report is to outline a strategy to improve water quality in the Walnut Creek watershed. Areas that are not meeting water quality standards and areas for which TMDLs were developed are the primary focus. However, water quality in the watershed is threatened by ongoing land development, which is known to substantially degrade water quality. Thus, a general strategy to minimize this impact is also included.

Ohio EPA provides an restoration strategy in its TMDL reports out of commitment to achieving water quality goals. The agency, along with the Ohio Department of Natural Resources (ODNR), the Ohio Department of Health (ODH), Ohio Department of Agriculture (ODA) and other state agencies is directed to manage, protect, and improve water quality throughout Ohio. This plan therefore will reflect the actions that Ohio EPA intends to take as well as its recommendations for other agencies including federal and local agencies and governments that are also charged with protecting water quality.

8.1 Sources to prioritize

This section interprets the TMDL results to highlight the sources of pollution that most need to be addressed to protect and restore the streams.

8.1.1 Recreational use impairments

Recreational uses are impaired due to contamination by fecal matter. All relevant sources have been accounted for in the watershed loading analysis and include: wastewater treatment plants (WWTPs), municipal separate storm sewer systems (MS4s), home sewage treatment systems, livestock with stream access, and various nonpoint sources. Figures 8.1 through 8.4 illustrate the distribution of bacteria loading from the various sources, while Section 5.2 provides background regarding these types of sources. Each bar in Figure 8.1 represents the ratio of the loads from all non-NPDES-regulated sources to the NPDES sources. The higher the ratio (i.e., the longer the bar in the graph in Figure 8.1) bar, the more extreme the load from non-NPDES-regulated sources. For example, in sub-watershed 170-020 (Pawpaw Creek), the sum of the loads from livestock, HSTS, and NPS is 353 cfu x 10^{10} per day, while the NPDES –regulated load is 0.05 cfu x 10^{10} per day. Thus, the ratio is: 353 cfu x 10^{10} per day / 0.05 cfu x 10^{10} per day or 7,059 as shown in Figure 8.1.

It is clear through the TMDL analyses that NPDES permitted entities (MS4s and WWTPs) are very small sources of bacteria in comparison to other sources. Figure 8.1 shows that NPDES sources contribute about nine times to over 11,000 times <u>less</u> fecal coliform than other sources within each of the sub-watersheds. Effective wastewater treatment and permit compliance by WWTPs and the fact that MS4 areas account for ten percent or less of the areas analyzed are reasons for the very small proportion of the loading from those sources. However, this also reflects higher loading intensity from the other sources.

Among the other sources, manure directly deposited in the stream by livestock is the most significant (see Table 8.1 for the estimated distribution of livestock across the subwatersheds). Areas where livestock have direct access to streams, loading rates are from about four to nearly fifty times higher than that from failed home septic systems (i.e., HSTSs) and from about an equal contribution to about twelve times greater than other nonpoint sources (i.e, this varies by subwatershed). The combinations of other nonpoint sources such as pastures, cropland, developed lands and forested areas (i.e., wildlife contributions) contribute more than failed

HSTS, specifically, from just over one to about six times as much. Figure 8.2 shows the loading comparisons between livestock, nonpoint, and HSTS sources. Figures 8.3 and 8.4 show existing and allocated loading, respectively, for these three categories of sources.

Table 8.1 Estimated distributions of livestock across the impaired sub-watersheds. Estimates are based on multiple lines of evidence including the National Agricultural Statistics Service's database and field observations.

Modeled area			**Estimated livestock count**						
HUC 11 (last 3 digits)	**HUC 14 (last 3 digits)**	**Modeled sub-watershed**	**Grazed Cattle**	**Confined Cattle**	**Swine**	**Poultry**	**Horses**	**Sheep**	**Other**
170	010	170010HW	200	125	50	175	45	35	20
		170010PV	250	175	50	275	75	75	25
	020	170020	450	275	250	400	100	80	40
	040	170040	300	225	50	350	90	70	30
	050	170050	500	250	50	450	125	100	50
	060	170060HW	50	75	50	100	100	25	25
		170060PK	250	150	50	275	75	50	25
180	020	180020	100	200	50	150	40	25	10
	030	180030BR	100	75	50	100	30	20	10
		180030MR	150	50	1	100	50	20	10
	050	180050	200	250	50	325	100	70	25

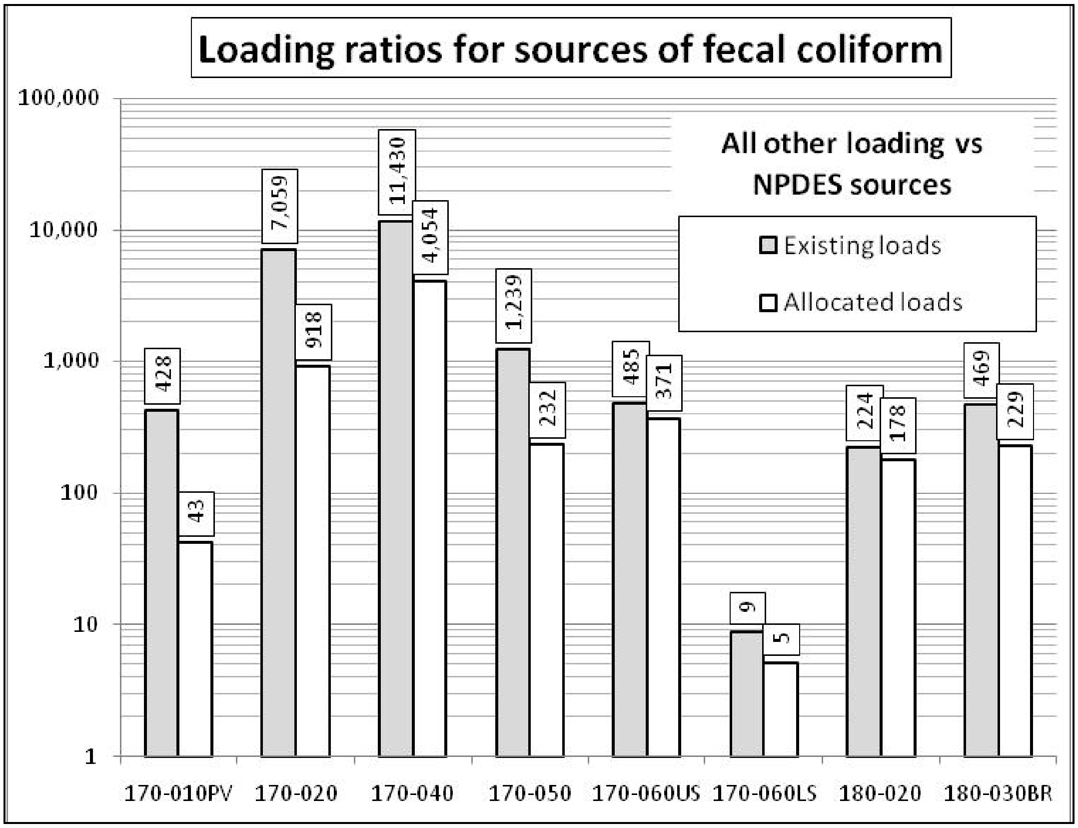


Figure 8.1 Graph showing the loading ratios between sources of fecal coliform loading that are required to obtain NPDES permits and sources that have no such requirements.

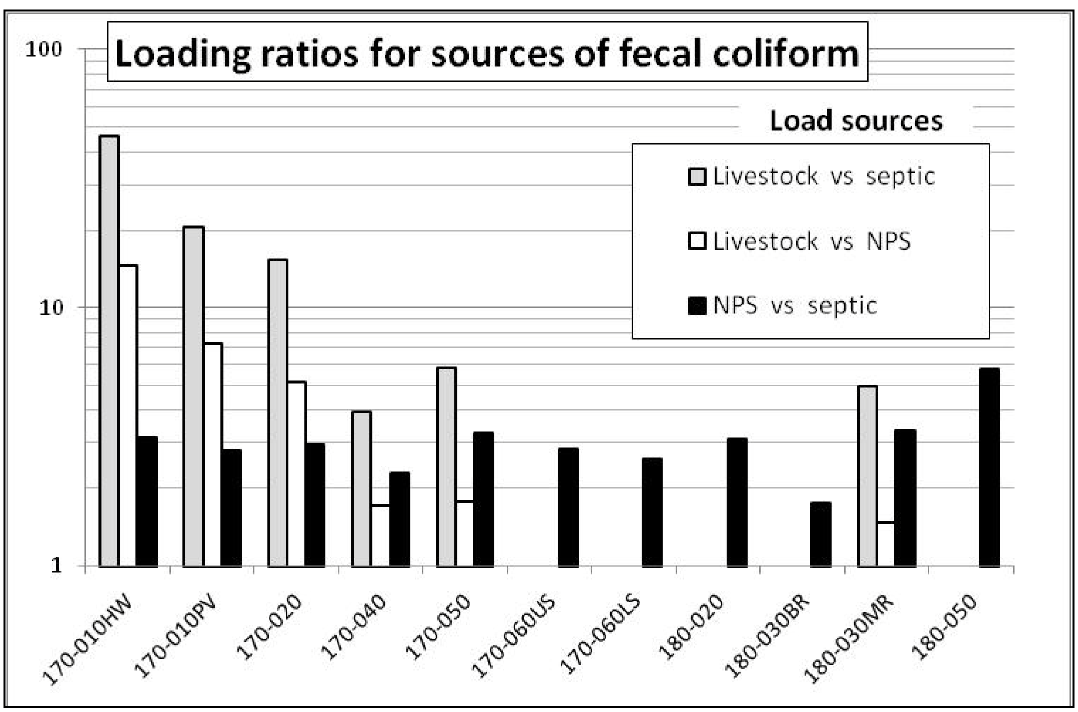


Figure 8.2 Graph showing the loading ratios between sources of fecal coliform loading that are not required to obtain NPDES permits.

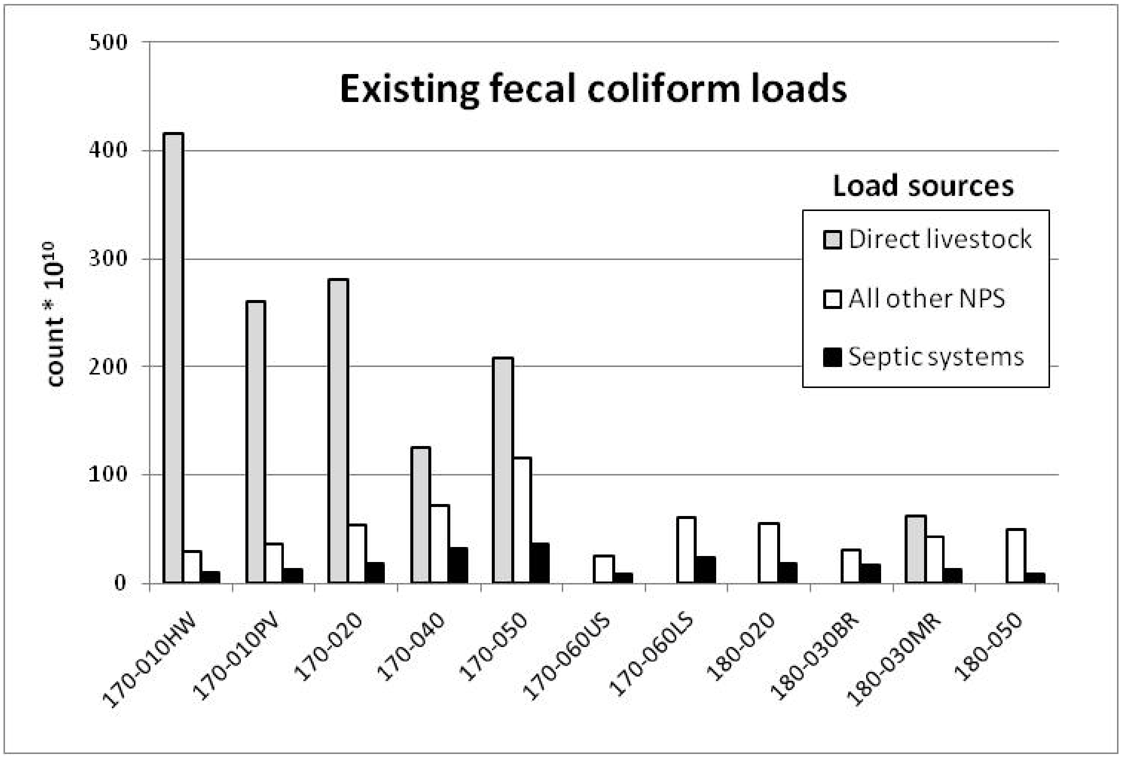
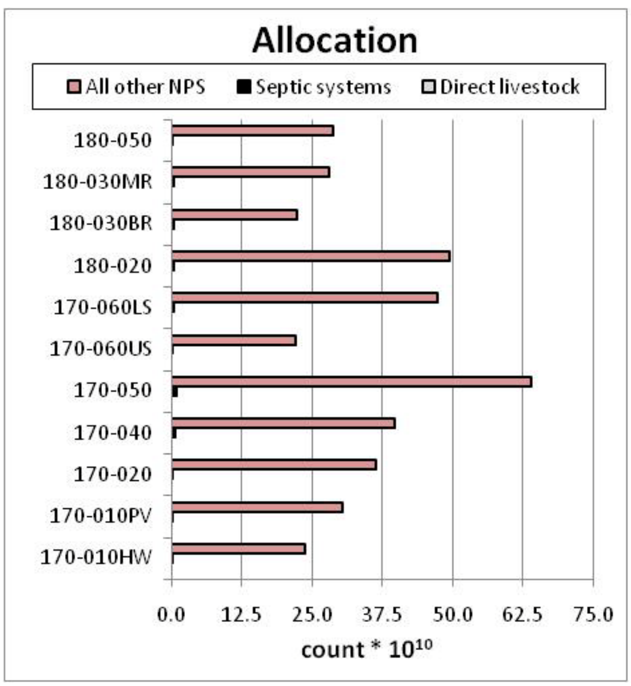


Figure 8.3 Graph showing existing fecal coliform loading from three unregulated sources.



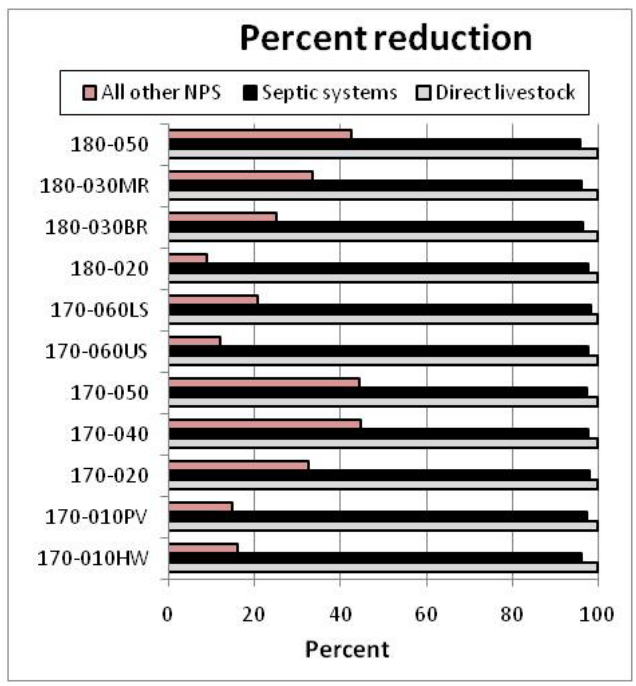


Figure 8.4 Graph showing allocations for fecal coliform loading from three unregulated sources.

8.1.2 Aquatic life use impairments

Aquatic life uses are impacted by excessive fine sediment on the streambed, poor habitat quality, organic enrichment and low concentrations of dissolved oxygen, various toxins in runoff, dissolved solids, and low flow conditions (see Table 4.3). Based on recently submitted data, Ohio EPA must determine if dissolved solids are currently impairing aquatic life uses. If it is determined that these impairments continue then these problems should be abated through better treatment of wastewater. The cause of the low flow conditions on Big Run is uncertain and the suspected water withdrawal remains unverified.

Sources of these stressors include stream use by livestock which leads to trampled banks and substantial sediment erosion, ditching of streams which contributes to sediment problems and degrades the structural habitat of the stream, cropland contributing sediment, and urban land uses contributing various toxins and altering stream flow conditions. The sanitary sewer overflow located near Pleasantville (Leitnaker Rd Pump Station) which belongs to the Walnut Creek Sewer District (WCSD) is not expected to discharge because a second sewer line has already been installed to better accommodate the sewage volume and infiltration and inflow (I & I) problems should be completely remedied by the end of 2011. WCSD is also improving its treatment at the plant which should eliminate sewage problems associated with centralized collection and treatment in this area of the watershed. Section 5.2 provides information about each of the sources discussed above.

Figures 8.5 and 8.6 are maps of the two HUC 11 watersheds, 170 and 180, respectively, showing aquatic life use attainment status. One of the two maps included in each figure lists the causes of impairment at sites not fully meeting the biocriteria while the second map lists the sources ascribed to those stressors (i.e., the “causes”). These maps are instrumental in showing where each of the abatement strategies to address these specific stressors and stressor sources should be applied.

Sediment degrading streambed substrate habitats coupled with damaged larger structural habitats such as woody debris, boulders, and pools is responsible for more impairment than any of the other causes. The sources for this include livestock use of the streams, ditching of channels, and cropland runoff.

The next most significant problem is cumulative toxic effects from polluted runoff from urban and other similarly intensive land uses (e.g., commercial, residential). Abatement of these impacts centers on effectively managing storm water for both quality and quantity (see Section 5.1 and also later discussion in the report). In addition, although currently slowed due to circumstances with the economy, commercial and residential land development is very rapid in portions of the watershed closest to the City of Columbus. With the expectation that continued growth is inevitable, recommendations are given on how new development should proceed with regard to storm water management and the protection of sensitive natural resources.

Figures 8.5 and 8.6 show that sediment and habitat related problems are grouped in two general areas. A tributary to Pawpaw Creek (see aerial photo in Figure 8.8) and the Pleasantville tributary are thus impacted and located in the upper portion of the watershed (HUC 14s 170-020 and 170-010) near the towns of Baltimore, Thurston, and Pleasantville in the Fairfield County (Walnut, Pleasant and Liberty townships). In particular, restricting cattle access on the Pleasantville tributary and using alternatives to common cropland drainage techniques around the tributary to Pawpaw Creek would provide substantial relief. The other area is located on tributaries entering the lower sections of Walnut Creek

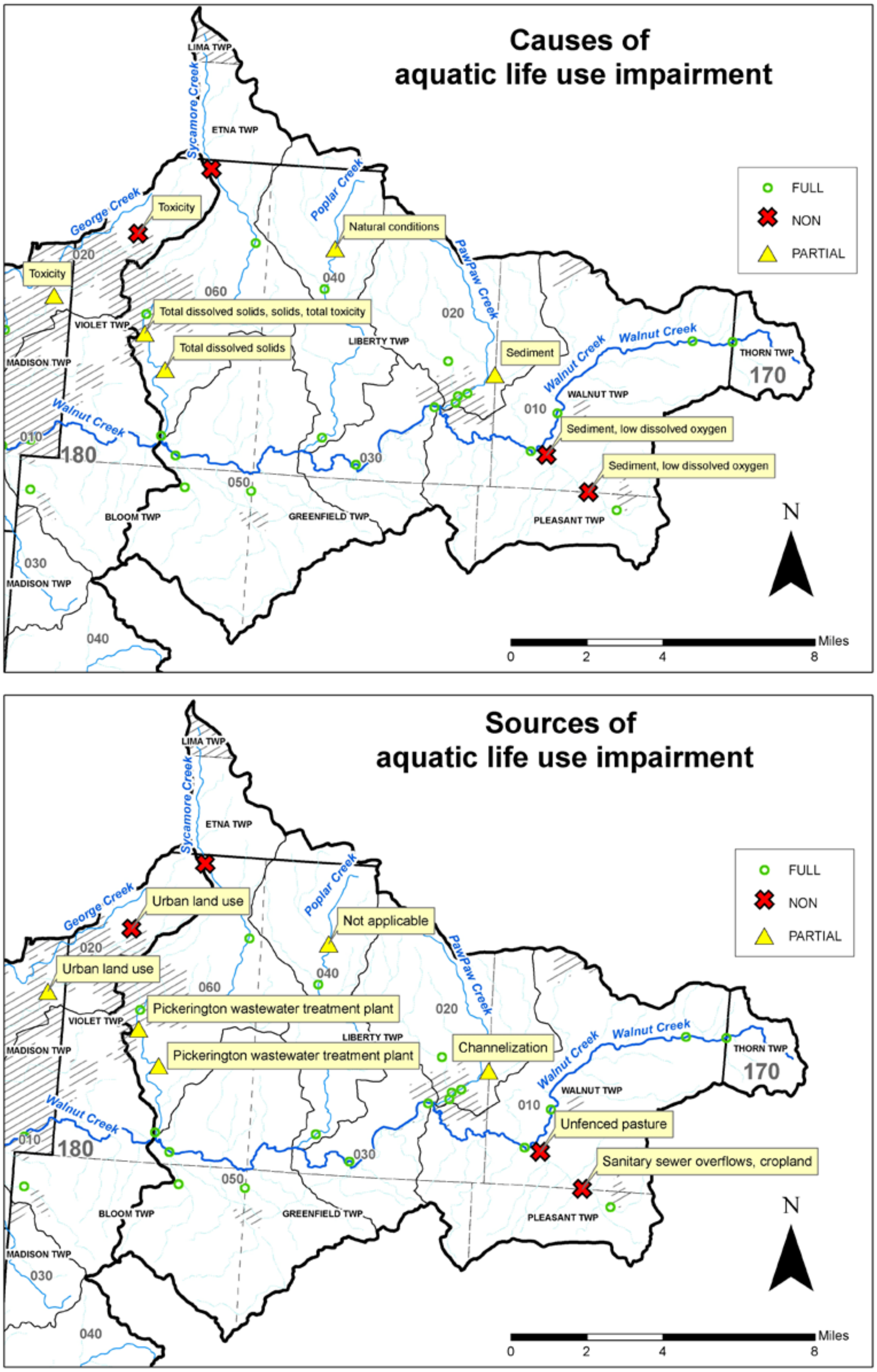
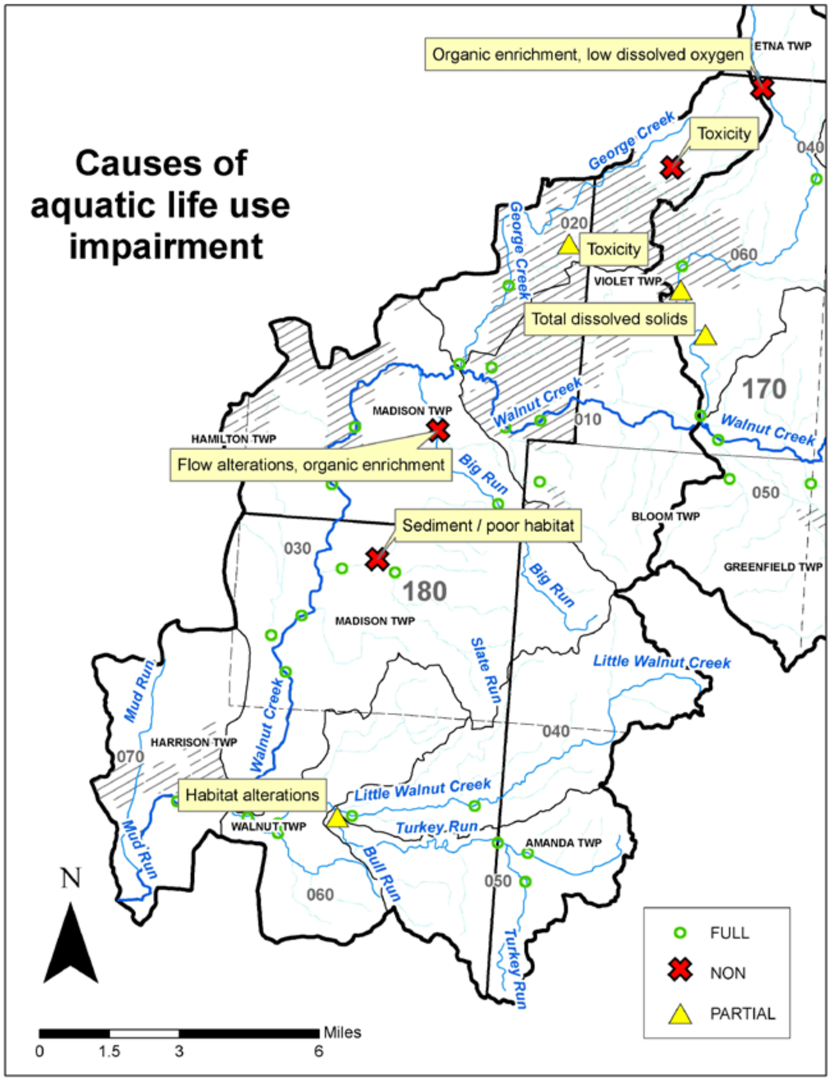


Figure 8.5 Maps showing status of aquatic life use attainment and causes (above) and sources (below) at sites not fully attaining their use designation in the 170 HUC 11 watershed.
Two sites partially attaining their bio-criteria on Sycamore Creek (RMs 4.2 and 2.6) may currently be in full attainment based on data collected in 2009. In such case the Pickerington WWTP would not be considered a source of impairment.


Causes of aquatic life use impairment
Organic enrichment, low dissolved oxygen
Toxicity
Toxicity
Total dissolved solids
Flow alterations, organic enrichment
Sediment / poor habitat
Habitat alterations
ETNA TWP
VIOLET TWP
MADISON TWP
HAMILTON TWP
BLOOM TWP
GREENFIELD TWP
HARRISON TWP
WALNUT TWP
AMANDA TWP
George Creek
Walnut Creek
Big Run
Slate Run
Little Walnut Creek
Mud Run
Turkey Run
Bull Run
170
180
010
020
030
040
050
060
070
FULL
NON
PARTIAL
N
Miles
0
1.5
3
6

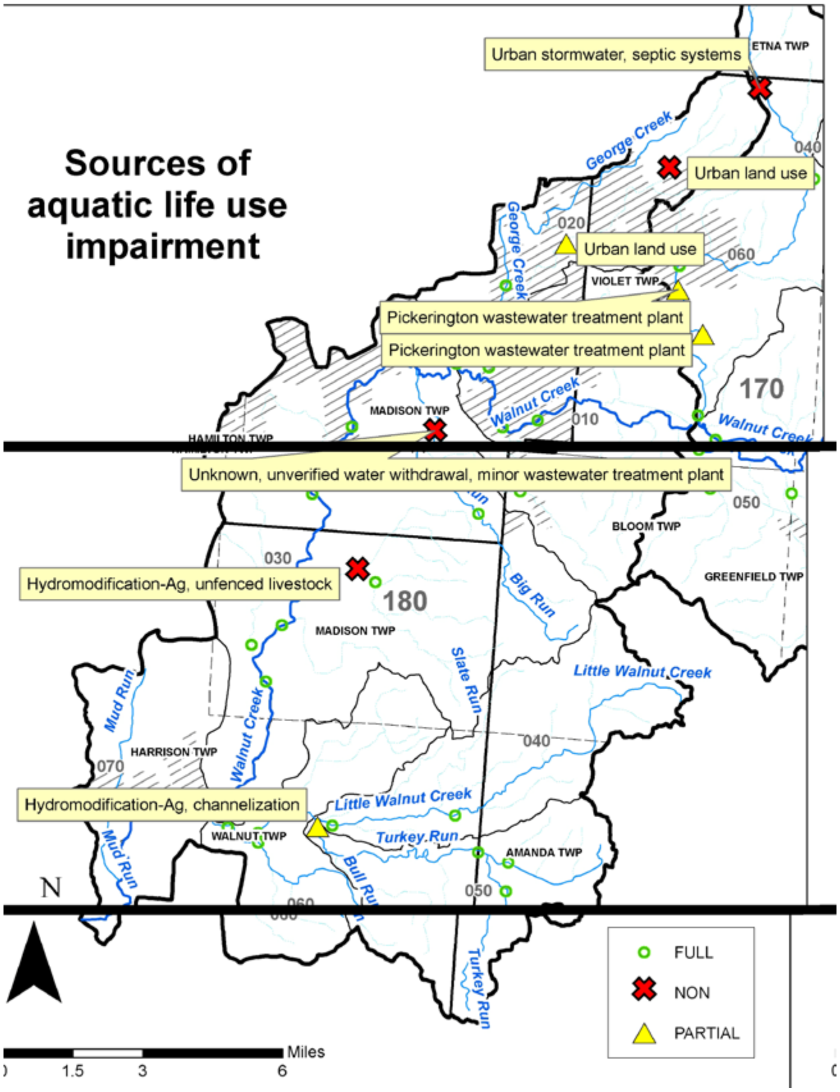


Figure 8.6 Maps showing status of aquatic life use attainment and causes (left) and sources (right) at sites not fully attaining their use designation in the 180 HUC 11 watershed.

roughly between Ashville and Groveport in Walnut and Madison townships in Pickaway County. The site on Turkey Run in Walnut Township showed evidence of recent channelization at the time of the 2005 biological survey (see photo in Figure 8.7). Although not verified, it is likely that ditch maintenance is occurring on this stream which is designated as exceptional warmwater habitat (EWH). Mud Run is also impacted by upstream ditch maintenance (see aerial photo in Figure 8.8).

Figure 8.7 Photos of livestock with access to Mud Run (left) and bank erosion on a ditched section of Turkey Run (right).

Figure 8.8 Aerial photos showing sources of stress to a tributary to Pawpaw Creek (left) in Fairfield County and Mud Run (right) in Pickaway County. The left photo shows the partially impaired site (yellow triangle) as well as a clear illustration of the level of intensity of subsurface drainage use (evidenced by the drier, lighter colored soil above the drainage tiles). Soil map units are also included to illustrate the dominance of loamy soils in the area which, when drained, leads to higher peak discharge . The right photo illustrates drainage ditch maintenance approximately 0.6 miles upstream of a biological survey site that failed to meet any of the biocriteria.

The maps in Figures 8.5 and 8.6 also show where polluted runoff and likely changes to the hydrology of the area, both due to urban land uses, occur. Violet Township in Fairfield County and Madison Township in Franklin County are currently the most developed and have the highest population density (see Figure 2.5) in the entire watershed. As discussed earlier, future development is also likely to occur in this area and to the adjacent townships.

Two sites of particular concern are in the East Branch George Creek at RM 2.4 (Wright Rd., Franklin County) and RM 6.0 (Refugee Rd., Fairfield County). Storm water retrofit opportunities should be given first priority in a management plan that includes aggressive construction site and storm water management, low-impact development designs for future subdivisions, and comprehensive landuse planning.

Figure 8.9 Aerial photo and graphical depiction showing recently urbanized areas (formerly rural) having an adverse impact on water quality on Georges and Sycamore Creeks. The red Xs in both images indicate survey sites that are in non attainment of their aquatic life uses where the X on the left is located on Georges Creek and the right is on Sycamore Creek. The picture on the left is an aerial photo from 2006 and the image on the right is a land classification based on the degree (percent) of imperviousness associated with the respective type of land cover (based on LANDSAT satellite imagery taken in 2001)

8.2 Water quality improvement strategy

This section describes actions to eliminate or minimize causes of the beneficial use impairments. The primary focus is technical feasibility and sufficiency of the actions to eliminate the cause. However, economic considerations are made to provide for a viable and realistic strategy. Section 8.3 will discuss already initiated programs and activities consistent with the recommendations proposed here as well as suggest programs that are best suited to address the various types of nonpoint sources. This section is organized by source of the pollution.

8.2.1 Point sources

Effluent from the Pickerington wastewater treatment plant has had relatively high concentrations of total dissolved solids (TDS) and has impaired aquatic life uses on Sycamore Creek. (The City of Pickerington disputes these results and has retained a consultant to resample the area; results of the study have not been submitted to Ohio EPA for review as of February 1, 2010). After review of the study, if it is determined that these impairments continue then these problems should be abated through better treatment of wastewater through a legally enforceable compliance schedule contained in the city's NPDES wastewater discharge permit. Additionally, in response to development pressure in the area and discussions with Ohio EPA the city is progressing with work necessary to upgrade its WWTP to 3.2 MGD.

Other point sources such as sanitary sewer overflows are caused by inadequate capacity of the sewer lines. The remedy is to increase this capacity by replacing existing lines with ones with greater capacity or simply adding sewer lines. Director's Final Findings and Orders (DFFOs) issued to the Walnut Creek Sewer District (WCSD) became effective January 30, 2008, and contain a schedule of compliance for WWTP and sewerage system improvements necessary to eliminate sanitary sewer overflows and sludge loss from the plant. Per these orders SSO events must be eliminated no later than December 31, 2011 and the sewer district must complete the final phase of I/I removal by December 31, 2011. Completion of work necessary in the sewer district's WWTP and sanitary sewer collection system will eliminate the SSO and unpermitted sludge discharge portion of the problem noted in this stream segment. To date, WCSD has installed an additional sewer line which results in greater capacity.

Pollutants such as fecal coliform bacteria and various toxins emanating from municipal separate storm sewers systems (MS4s) would be abated using the similar management and infrastructure as other urban areas with separate sewers but not designated as MS4 entities. The MS4 designation means that those entities must apply for and secure coverage under a NPDES permit (i.e., individual or general) and adhere to the requirements of that permit. See the following web link for information on these permits:
http://www.epa.state.oh.us/dsw/storm/index.aspx

Table 7.4 shows the wasteload allocations for the MS4s in the watershed and lists each entity associated with each of the MS4s in the watershed (see Appendix A for MS4 areas).

8.2.2 Livestock access to streams

Livestock with direct access to streams causes pollution problems associated with manure, bank erosion, and loss of habitat; overall this situation has little compatibility with good water quality. For this reason, abatement options are restricted to substantially limiting or, altogether eliminating this access. Livestock with stream access have been allocated a zero load in the TMDL analysis because excluding livestock is necessary to meet standards and can be reasonably accomplished.
Basic requirements are to use fencing as a barrier to streams or to confine livestock (the latter is not being advocated here). However, from a production standpoint maintaining stream access for livestock is attractive since it provides a water source and means for livestock to cool in the

summer heat. Installing fencing and finding alternative watering sources is an added operational expense.

Livestock producers have options available for assistance. The Environmental Quality Incentives Program (EQIP) is possibly the best, or at least the most widely available, program that producers can use for financial assistance. EQIP offsets actual costs of installation through cost sharing and also provides additional financial incentives for a set timeframe. Applicable practices that are eligible for compensation (based on the Natural Resource Conservation Service's (NRCS) conservation practices (CPs)) are listed in Table 8.1.

Table 8.2 Natural Resource Conservation Service's (NRCS) conservation practices (CPs) eligible for full cost share assistance to eliminate livestock access to streams.

Conservation practice (CP)	CP number	Cost per unit	Unit type	Comments
Fence	382	range from $0.51 to $7.60	linear foot	Types of fence include barbed wire, confinement, 4,5, and 6 strand electric, woven wire, livestock use exclusion
Pond	378	$30,438	acre	
Stream crossing	578	$3.26	square foot	
Watering facility	614	range from $680 to $2290	per item	Items include auto waterer, trough, frost free tank, portable plastic tank, storage tank

8.2.3 Ditch maintenance

Ditching drastically simplifies inherently complex stream systems which, diminishes the ability to process pollutants, moderate flow extremes, and support diverse and healthy wildlife communities. Dipping out streambed material, removing and suppressing woody riparian vegetation, and deepening the channel which limits floodplain access are typically done in creating and maintaining drainage ditches. Each of these practices has consequences that degrade the quality of the stream resource.

There are alternatives to these practices that are more expensive to initially construct but yield superior outcomes for water quality, drainage capacity, and possibly ongoing maintenance. Providing additional floodplain function in a channel that is otherwise dug too deeply to access adjacent floodplain areas may be one of the more practical ways of meeting drainage and water quality objectives on small streams (i.e., those that drain less than two to three square miles of watershed).

Ditches excavated to be extra-wide (i.e., wider than needed to accommodate what would otherwise be the minimally acceptable flood event such as a one in two year storm flow) tend to develop small floodplain features. These small floodplain features are believed to reduce the susceptibility of bank erosion and restore some of the stream's natural capacity to process pollutants. There may also be habitat improvements; however, these are believed to be less significant. Obstacles to this approach center on expense. The additional earth work needed to make a wider ditch may increase the total cost by a factor of two or more. Also, some cropland acreage may need to come out of production to accommodate the wider ditch; however, this is estimated to be a fairly small proportion (perhaps less than two percent).

8.2.4 Crop production and field drainage

Crop production is affecting water quality due to sediment delivered to streams from erosion on exposed fields. Subsurface drainage can also be a conduit for sediment delivery if the pipes are compromised (cracked or have a blow-out connection to the soil surface) but more significant are its impacts on the hydrology of the area. Ultimately, subsurface drainage along with the land smoothing and soil compaction, which accompanies years of crop production, leads to more efficient land drainage that increases peak stream discharge. This also reduces storage of water in the soil profile, which causes streams to dry out more frequently and for longer durations.

The impact of sediment on habitat has been discussed earlier in the report; however, stream desiccation also impacts habitat (water is required for aquatic life) as well as the capacity to dilute or otherwise process pollutants. One of the best known and readily available means to offset the impacts of subsurface drainage is to add the ability to control flows coming from the subsurface drainage system. Controlled drainage, also called water table management, accomplishes this when one or more control structures are installed within the drainage system.

Like the conservation practices for excluding livestock from streams, conservation practices to abate sediment delivery from cropland and problems with drainage are eligible for financial and technical assistance through EQIP. The Conservation Reserve Program (CRP), administered under the Farm Service Agency (FSA), also provides cost share and incentive payments to landowners who convert cropland to temporary vegetated buffer areas. Table 8.2 lists practices that are recommended to abate sediment delivery to streams as well as mitigate impacts to watershed hydrology.

Table 8.3 Natural Resource Conservation Service's (NRCS) conservation practices eligible for full (100%) cost share assistance to address impacts from crop production and drainage.

Conservation practice (CP)	CP number	Cost per unit	Unit type	Benefit	Comments
Conservation cover	327	range from $285 to $394	acre	Reduces surface erosion potential	Various options for the types of grasses used
Cover crop	340	range from $29.02 to $42.41	acre	Reduces surface erosion potential	Various options for the types of grasses used
Residue management (no-till/strip-till)	329	range from $15.02 to $49.34	acre	Reduces surface erosion potential	Various options for management approach
Residue management (mulch-till)	345	$11.01	acre	Reduces surface erosion potential	
Residue management (ridge-till)	346	range from $15.02 to $49.37	acre	Reduces surface erosion potential	Various options for management approach
Grassed waterway	412	range from $4,307 to $6,100	acre	Reduces gulley erosion potential	Various options for types of materials/structures installed

Conservation practice (CP)	CP number	Cost per unit	Unit type	Benefit	Comments
Riparian hebaceous cover	390	range from $315 to $419	acre	"filters" sediment in sheet flow runoff	Various options for the types of installation methods used
Riparian forest cover	391	range from $337 to $650	acre	"filters" sediment in sheet flow runoff	Various options for the types of trees and installation methods used
Filter strip	393	range from $307 to $411	acre	"filters" sediment in sheet flow runoff	Various options for the types of grasses and installation methods used
Sediment basin	350	$3,566	per item	removes sediment carried in concentrated flow	
Water and sediment control basin	638	range from $2,215 to $2,702	per item	removes sediment carried in concentrated flow	Varies based on type of slope it is installed on
Wetland creation	658	range from $108 to $193	acre	Treats runoff and improves hydrology	Done on site not formerly a wetland; varies based on whether tiled cropland or depressional area
Wetland restoration	657	range from $108 to $193	acre	Treats runoff and improves hydrology	Done on site that was formerly a wetland; varies based on whether tiled cropland or depressional area
Wetland enhancement	659	range from $108 to $194	acre	Treats runoff and improves hydrology	Done on site that was formerly a wetland; varies based on whether tiled cropland or depressional area
Wetland restoration and wetland enhancement	657 and 659	$2.17	cubic yard	Treats runoff and improves hydrology	Done on site that was formerly a wetland; requires earthwork
Drainage water managment	554	$101	per item	Improves hydrology	

8.2.5 Home septic treatment systems

Ohio Department of Health (ODH) recommends proper siting, design and installation of sewage treatment systems to help ensure the protection of public health and the environment, and protection of the investment a property owner makes in a sewage treatment system. This will also reduce the need for public dollars to provide sewage treatment through public facilities in the future. System designs need to account for site and soil conditions, site limitations, reasonable expected design flows and waste strength to ensure proper system performance.

Proactive and preventive approaches to managing sewage treatment systems that combines public education, local health district involvement, local planning and management factors, and consideration of area risks to sensitive water or ecological resources are needed. Improved coordination and training for local watershed groups and other grass roots organizations (green and community initiatives) will help promote an understanding of the importance of proper sewage system operation and maintenance to the system owner, and the impact to a community when systems are not maintained.

Local health districts need legal and enforcement tools to ensure that service contracts for mechanical systems are maintained, and that routine inspection and maintenance occurs for all systems. Decentralized management of systems should be supported and encouraged as a public and private sector tool that provides assistance and support to system owners, offers a cost structure that is affordable, and helps ensure that systems in a wide range of density configurations are properly managed.

Implementation of these recommendations and the use of the new Ohio EPA Household Sewage System wastewater discharge permit (see: http://www.epa.state.oh.us/dsw/permits/GP_HouseholdSewageTreatmentPlants.html) will help to control bacterial discharge from these small systems in this watershed.

8.2.6 Conversion to urban land use

Storm water management

The most serious threat to water quality and biological integrity, in the Walnut Creek watershed is the rapid conversion to residential, commercial, and industrial uses. Numerous scientific studies show that increasing impervious cover in a watershed (i.e., through development) is commensurate with the degradation of water quality and biological communities (Booth, 2005; Brabec et al., 2002; Roy et al., 2003; Roy et al., 2006; Morgan and Cushman, 2005).

Controlling run off associated with development typically consists of end-of-pipe measures such as storm water detention and retention. These controls abate flooding and reduce erosion, thus providing some water quality protection. However, studies show that water quality degradation occurs in developing watershed despite these controls due to the altered hydrologic regime (Brabec et al., 2002; Booth, 2005).

Onsite storm water retention and infiltration is a way to approximate a more natural watershed hydrology. With this approach, storm water is managed near the area generating the runoff and infiltration is maximized. This contrasts centralized systems that collect runoff over a broad area and provide relatively little opportunity for infiltration and consequently must manage very large volumes. Individual onsite controls operate on a small scale but are distributed to act collectively in managing runoff across a large area. Incentives, utilities and/or market based programs should be explored as a means to achieve more effective and ecologically meaningful storm water management. Parikh et al. (2005) provide an analysis of options for addressing storm water management in an environmentally and economically sustainable manner.

Onsite, or decentralized, storm water management increases infiltration and reduces runoff by decreasing imperviousness through planning, such as that used for Low Impact Development (LID). Low Impact Development is based on maximizing contiguous open space, protecting sensitive areas, namely floodplains and wetlands, and preserving existing vegetation (especially trees). Web based resources for LID include: www.lowimpactdevelopment.org/ . In a Low Impact Development, houses are located closer to one another, roadways are narrower, and bio-retention and infiltration techniques are used. Since LID reduces runoff it can provide cost savings in storm water infrastructure. Other benefits of LID may include a greater than average increase in property values due to improve aesthetics and more contiguous open space.

Watersheds that retain relatively large areas of forest are able to better mitigate the impacts of increasing imperviousness than those with little forest cover (Brabec et al., 2002, Booth, 2005).

The procurement of conservation easements, and the establishment of parkland and nature preserves can help retain some of the existing forest cover as well as facilitate the conversion from open land to forest. Although land preservation alone is not likely to occur at a level necessary to mitigate development impacts, it will augment other measures that are taken (e.g., LID and/or discrete onsite storm water management).

At the smaller, more discrete level of individual residences or businesses, storm water abatement techniques can be used that include diverting drainage from rooftops, driveways, and other impervious surfaces away from a centralized collection system (e.g., outlets to either curb-and-gutter drains or storm water sewer lines) and to permeable areas that can provide infiltration and/or temporary storage. Minimizing the extent of impervious surfaces by limiting their size or substituting them with permeable surfaces will also increase infiltration and detention for a given property. Outreach and education activities are likely to result in some increase in this type of voluntary action taken by watershed residents, however to what extent would be very difficult to predict. Outreach efforts that include landscape design and construction companies may also be beneficial as they can present options for enhanced storm water management to their prospective clients.

The current draft of the Rainwater and Development Guide that is posted on the ODNR website at ftp://ftp.dnr.state.oh.us/Soil_&_Water_Conservation/rainwater/ provides a great deal of information regarding storm water management. This resource highlights the goals, effectiveness, and limiting conditions for both planning and structural controls. The following topics are discussed:

- Reduction in impervious area
- Low Impact Development
- Conservation Development (similar to LID)
- Setbacks
- Water quality ponds
- Infiltration trenches
- Sand and organic filters
- Grass filters
- Bioretention area

Floodplains
Floodplains abate the impacts of development on stream systems (see Section 5.4). The reduction of the erosive power of storm flows, temporary flood storage, and sediment assimilation all act to mitigate the damage caused by increased runoff volume during flood events. Wetlands also provide storm water retention, increase infiltration and reduce the energy of surface flows (i.e., reduces erosion potential). These important environmental areas must be protected and preserved to the greatest reasonable extent.

Provisions for floodplain filling vary across the Walnut Creekwatershed under county, township and municipality ordinances and zoning codes. Timely and adequate public notification of fill requests (permitting process) and opportunity for public hearings are recommended to ensure that permitting decisions are based on an adequate array of information, scientific as well as socio-economic.

Riparian buffers
Allowing wooded riparian corridors to remain intact as an area develops reduces the impact of development in many ways. Soil and pollutants are filtered out as water flows through the corridor, tree roots stabilize stream banks, the canopy shades the stream regulating in-stream

temperature and reducing algal production, and woody material provides food and habitat for both aquatic and terrestrial life.

Twenty-five feet is a minimum recommended width for riparian buffers. The more width in a buffer; however, the more buffering it can do. The Ohio EPA recommends use of additional minimum stream corridor protection zones similar to those shown in Figure 8.10. Zone widths may vary depending on use of the corridor from one stream segment to the next.

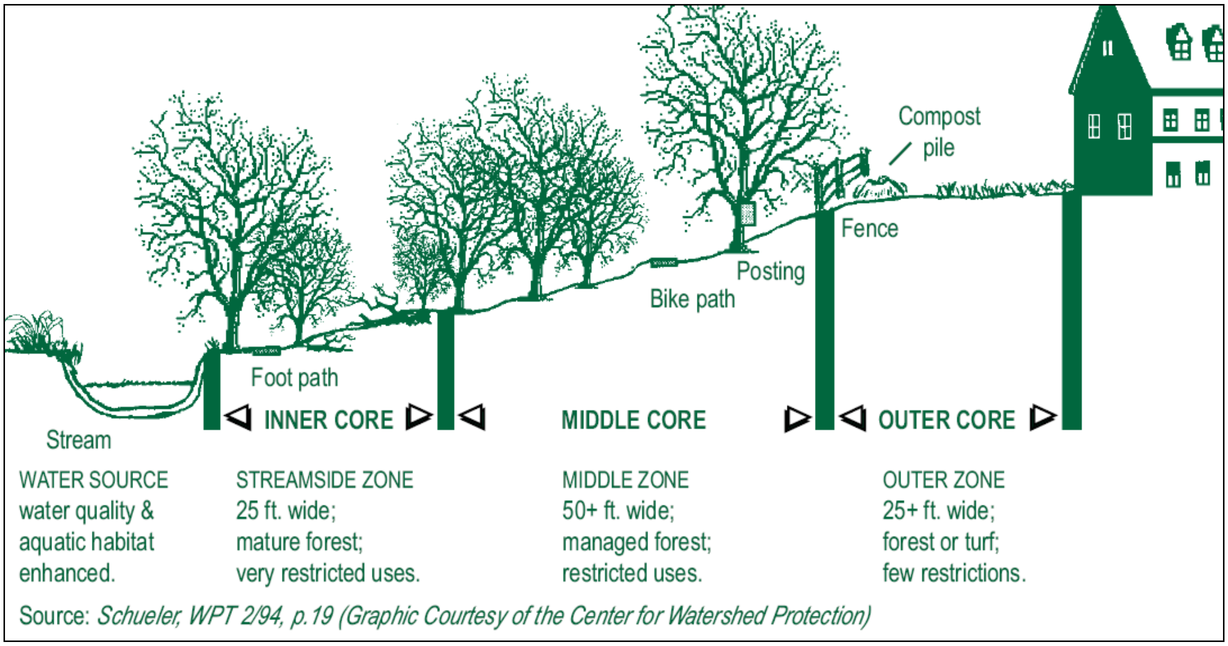


Figure 8.10 Graphic showing recommended management for three designated zones within a hypothetical riparian buffer.

It is very important to maintain and, when possible, restore riparian corridor continuity in a watershed to maximize benefits that such corridors provide. Such protection becomes even more critical for the smaller headwater streams in a watershed. Information regarding the importance of riparian corridors can be found at: http://ohiodnr.gov/water/Home/pubs/fs_st/stfs01/tabid/4157/Default.aspx Information regarding the importance of headwater streams can be found at: http://www.epa.ohio.gov/dsw/wqs/headwaters/index.aspx.

Research suggests that the effective use of greenways for the protection of surface water quality depends not only on the physical characteristics of the buffer zones and on the diversity of pollutants encountered, but also on the coordinated arrangement of buffer zones across a catchment area." Buffers along small tributary stream have disproportionately greater benefits than buffers along wider stream carry much larger flow volumes. In essence, the potential to impact stream quality in the immediate vicinity of the buffer decreases as stream size increases.

8.3 Programs for implementing abatement strategy

This section discusses organizations, programs and other means of assistance that could be instrumental in implementing the abatement strategy described in Section 8.2. Also discussed are past and current activities or programs that facilitate abatement of water quality stressors in the watershed. This section is organized based on the sources of impairment.

8.3.1 Point sources

National Pollutant Discharge Elimination System (NPDES)
The NPDES permits program manages pathogens and other pollutants found in discharge from wastewater treatment systems, sanitary sewer overflows and production of biosolids. The City of Pickerington and the Walnut Creek Sewer District WWTPs are working to resolve problems associated with their collection and treatment systems. The Villages of Ashville and Baltimore are also involved with upgrading their WWTPs and sanitary sewer collection systems to eliminate sanitary sewer overflows.

A listing of NPDES permittees in the Walnut Creek watershed is provided in Appendix B of this report. Additional information regarding the permits program is available at: http://www.epa.ohio.gov/dsw/permits/permits.aspx. The Ohio EPA will perform audits of MS4 permit holders in this watershed to ensure compliance with MS4 permit conditions.

Compliance Assistance Unit
This unit, established by Section 104(g) (1) of the Federal Clean Water Act, helps bring wastewater treatment plant (WWTP) facilities into compliance and/or to maintain compliance. The goal is to improve the water quality of streams, rivers, and lakes by assisting WWTPs that need help in meeting their NPDES permit. This unit has provided assistance as necessary to operators at several WWTPs within this watershed. Additional information is available at: http://www.epa.ohio.gov/dsw/compl_assist/compasst.aspx.

House Bill 110 Program for small WWTPs
This program outlines an agreement between county health departments and the Ohio EPA allowing participating health departments to inspect smaller wastewater treatment plants (0 – 25,000 gallons per day). Fairfield, Franklin, Licking and Pickaway counties currently participate in this program. Additional information is available at: http://www.epa.ohio.gov/dsw/compl_assist/hb110.aspx.

8.3.2 Nonpoint sources

This section discusses programs that are poised to deal stressors coming from home septic system failures, livestock and crop production and ditch maintenance. Table 8.3 provides a summary of such programs or organizations.

Ohio Department of Health (ODH) and county health departments
The Ohio Department of Health has legal authority for implementation of a regulatory program for pathogen control in streams within this watershed. That program focuses on standards for the siting, design, installation, operation, monitoring, maintenance and abandonment of household sewage treatment systems and small flow on-site sewage treatment systems. Under OAC 3701-29, local health departments are responsible for code enforcement, operational inspections, and nuisance investigations of household sewage treatment systems serving one, two, or three family dwellings. The Ohio Department of Health works with local health departments and provides technical assistance and training.

The county health departments should endeavor to make information regarding home owner's onsite treatment systems as user friendly as possible. Several health department websites provide easily accessible information regarding various wastewater treatment systems available for use in varying situations.

Additional information regarding this program in the Ohio Department of Health is available at: http://www.odh.ohio.gov/odhPrograms/eh/sewage/sewage1.aspx

Changes to the sewage treatment systems law and rules
Amended Substitute House Bill 119 (Am. Sub. HB 119) suspended operation of most portions of ORC Chapter 3718, the sewage law, until July 1, 2009. Programs in use by health departments in this watershed now allow, only as a last resort, use of household sewage treatment systems which discharge wastewater to a stream. In such cases an Ohio EPA NPDES wastewater discharge permit is required. In addition, more attention is now being given to soil characteristics which might limit use of a site for wastewater treatment thus reducing possible movement of pollutants to a stream.

Restricting and, whenever possible, preventing off-lot wastewater discharges will reduce the incidence of bacterial contamination and habitat impacts associated with organic enrichment of streams in this watershed. Routine inspection by health departments of treatment systems having off-site discharges will help ensure that such systems are operating properly.

County conservation agencies
County SWCDs and NRCS staff serves the producers and landowners in their counties regarding conservation planning, technical assistance, and advisement regarding available conservation programs.

Between 2002 and 2008 Fairfield County has facilitated the installation of 45 grassed waterways, 22 water and sediment control basins (WASCOBs), three wetlands, and one stream crossing for livestock all within the Walnut Creek watershed. During a similar time interval Pickaway County staff has facilitated installation of over 20,000 feet of grassed waterway in the watershed.

The Franklin County SWCD holds conservation easements of which 13 acres of are held on Canal Winchester School District including mature riparian corridor (average width of 50') and former agricultural land which was planted with conservation cover crop and left to re-vegetate. The District plans to use grant funding (applications pending) for additional easement purchases.

Walnut Creek Watershed Restoration Project
During the 1997 through 2002 period of time a significant effort was underway in this watershed as numerous agencies collaborated on the Walnut Creek Watershed Restoration Project.

An except of the group's formal goal statement reads, "*The goal of the Walnut Creek River Restoration Project is to significantly improve the quality of the region by implementing agricultural and silvicultural Best Management Practices (BMPs) in conjunction with urban planning."*

Natural resource concerns identified by this project included:

- Stream bank erosion
- Localized flooding due to stream blockage
- Erosion from cropland and urban development
- Loss of riparian corridor
- Organic enrichment from animal waste

- Siltation of streambed habitat
- Loss of habitat due to channelization
- Excessive levels of pesticides

Ditch maintenance authorities

The majority of ditch work done in Ohio is through petition ditch laws where county engineer's or soil and water conservation district offices typically design, budget, and administer the construction/reconstruction and subsequent maintenance of ditch and other drainage infrastructure (e.g., subsurface drain tile mains and sub-mains). If alternative designs and more environmentally sensitive approaches are to be employed, such approaches must be effectively communicated with these organizations.

According to the Ohio Department of Natural Resources Division of Soil and Water Conservation (ODNR-DSWC), current drainage needs far exceed the capacity of state and county agencies to provide required technical assistance and administration. In response to this shortfall, ODNR-DSWC and the Ohio Federation of Soil and Water Conservation Districts (OFSWCDs) convened and advisory group represented by agricultural and environmental interests, as well as several government agencies or organizations that are involved in some way with drainage infrastructure in Ohio. ODNR-DSWC has posted a brochure explaining this on the following weblink:
http://www.dnr.state.oh.us/Portals/12/programs/rural_drainage/docs/Drainage%20Report.pdf

Although few tangible action items have been completed so far, the group intends to improve the efficiency of the petition process while also ensuring greater protection of water quality. ODNR-DSWC has drafted a drainage manual that is to provide the basis for implementing those objectives.

Table 8.4 Programs best suited to address nonpoint sources in the watershed but not including sources related to storm water or urban development.

Source of impairment	Organization or Program	Authority or resources available to address source of impairment	Priority areas in the watershed
Failed home septic treatment systems	County health departments	Under OAC 3701-29, county health departments must enforce codes regarding the siting, design, installation, operation, monitoring, maintenance, and abandonment of HSTSs. Codes must be no less stringent than state requirements; however, local HDs can adopt and enforce more stringent requirements.	Each area with recreational use impairments has issues with failing home septic systems. These areas widely distributed.
	Ohio Department of Health	Under OAC 3701-29, ODH must enforce codes regarding the siting, design, installation, operation, monitoring, maintenance, and abandonment of HSTSs.	
	Ohio EPA	Direct discharge home septic systems must have NPDES coverage handled by the permits program. NPS/319 and other OEPA programs also communicate with health departments regarding water quality data and the HSTS impacts and sometimes work to make funds available through the 319 grant program to address problem areas.	
Livestock with stream access	Pollution Abatement Program (Ohio DNR - DSWC and county SWCDs)	Under OAC 1501, ODNR must respond to complaints regarding pollution from agriculture including animal wastes. ODNR and/or the county SWCDs must investigate the situation and approve abatement plans that are deemed necessary. If the landowner does not carry out the plan as specified, the chief of ODNR-DSWC would issue orders, where failure to comply with these orders is a first degree misdemeanor.	14-digit HUCs: 170-010 (Pleasantville Creek) and 180-030 (Mud Run)
	NRCS and EQIP	NRCS administers EQIP which provides cost share and incentive payments for certain conservation practices that address livestock exclusion. NRCS also provides technical assistance at landowners/operators requests.	
	Ohio EPA	NPS/319 and other OEPA programs communicate with conservation professionals and/or local authorities regarding water quality data and the impacts from livestock wastes and sometimes work to make funds available through the 319 grant program to address problem areas.	
Cropland and field drainage	NRCS	NRCS administers EQIP which provides cost share and incentive payments for certain conservation practices that address cropland BMPs. NRCS is also provides technical assistance at landowners/operators requests.	14-digit HUCs: 170-010 (Pleasantville Creek) and 170-020 (Tributary to Pawpaw Creek)
	County SWCD	County SWCDs provide technical assistance at landowners/operators requests regarding resource concerns and conservation practices. SWCDs are also often involved with outreach and promotion of existing or new conservation programs and conservation practices.	

Source of impairment	Organization or Program	Authority or resources available to address source of impairment	Priority areas in the watershed
	Ohio EPA - NPS/319 Programs	NPS/319 and other OEPA programs communicate with conservation professionals and/or local authorities regarding water quality data and the impacts from livestock wastes and sometimes work to make funds available through the 319 grant program to address problem areas.	
	OSU Extension	County extension staff disseminate current science based information to the people in the county. A core mission is make the best information readily available to the public and to promote the use of technically sound and practical management practices.	
Ditch maintenance	County Engineer or SWCD office	Under ORC 6131 landowners may petition for drainage improvements in which case county engineers must submit a cost estimate to the county commissioners and make recommendations regarding the necessity of the project. Through this process the Engineer's Office is involved with the design of the drainage improvements and can pursue drainage improvements that are more amenable to protecting water quality than what has been typical in the past.	14-digit HUCs: 170-020 (Tributary to Pawpaw Creek); 180-030 (Mud Run) and 180-050 (Turkey Run)
	County Commissioners	Under ORC 6131, County Commissioners make the final decision regarding petitions for publicly administered drainage improvement projects. Commissioners can make decisions that place higher importance on protecting water quality than what has been typical in the past.	
	Ohio DNR - DSWC	Ohio DNR - DSWC employs both area engineers and ecological engineers who are involved with drainage petition projects as per assistance requests from county SWCD staff. Ohio DNR - DSWC can advise pursuing designs that are amenable to water quality.	
	Ohio EPA -	NPS/319 and other OEPA programs communicate with conservation professionals and/or local authorities regarding water quality data and the impacts from ditch maintenance and sometimes work to make funds available through the 319 grant program to address problem areas.	

8.3.3 Land conversion and storm water management

Land development occurs as permitted through zoning ordinances as well as various regional plans that focus on major infrastructure such as sewerage, roads and transportation, and utilities. Ohio EPA approves plans regarding waste water collection and treatment through its section 208 program. Storm water management is also regulated by the Ohio EPA for large construction projects and MS4 areas that fall under specific criteria.

As indicated in the 2006 208 Plan, Ohio EPA interacted with counties and municipalities regarding water quality management plans. Several of the counties in which the Walnut Creek watershed is located are referenced in the state 208 plan.

In 2010, Ohio EPA will review and update, as necessary, the water quality management plans required by Sections 303 and 208 of the Clean Water Act. These plans describe and promote efficient and comprehensive programs for controlling water pollution from point and nonpoint sources in a defined geographic area. Information regarding 208 planning as well as the 2006 208 WQM can be accessed at: http://www.epa.state.oh.us/dsw/mgmtplans/208index.aspx

County regional planning and storm water protections
Three counties in the watershed are expected to undergo substantial growth in the coming decades therefore responsible planning is important. Fairfield, Licking, and Pickaway Counties are projected for the most growth. Table 8.4 shows what the projections are.

Table 8.5 Projected population growth for three fastest growing counties in the watershed.

County	Projected population increase by 2030	
	Number	Percent
Fairfield	78,255	64
Licking	53,270	37
Pickaway	7,250	14

Several county regional planning agencies in the watershed have developed land use plans which include provisions intended to help preserve riparian corridors. Riparian corridor preservation and, when possible, restoration will help streams in this watershed maintain and return to attainment with the aquatic life use designation.

Fairfield County
The Fairfield County Development Strategy and Land Use Plan can be viewed at http://www.co.fairfield.oh.us/rpc/county_development_strategy_land_use_plan.htm. While information available at http://www.co.fairfield.oh.us/rpc/images/2008_AnnualReport.pdf indicates that the county is working to update its land use plan.

Page 119 in the Fairfield County plan discusses Natural Resource Areas and acknowledges that quality of the watershed can be preserved through planning efforts and public education. A Critical Resource Model discussed in this section of the plan calls for preservation of flood plains, wooded lands, wetlands, flood prone soils, stream buffers (150 feet from the stream centerline), and slopes greater than 25 percent. This plan encompasses various aspects of wastewater and storm water management which, if implemented, will greatly promote attainment of water quality aquatic life and recreational use designations in the county's streams.

Franklin County

In Franklin County, several documents applicable to water quality management have been developed in recent years. In 1997 the Mid Ohio Regional Planning Commission published http://www.morpc.org/pdf/greenways.pdf which contains recommendations for stream corridor protection for numerous streams in the area. The Walnut Creek Watershed (described as Little Walnut Creek in the plan) is referenced in the Greenways Plan.

In August, 2007, Franklin County published its draft Storm water Management Manual, which can be viewed at http://www.morpc.org/pdf/Final_Draft_Storm water_MANUAL_Au07.pdf . The manual requires establishment of stream corridor protection zones in areas of new development and gives specific guidance on this zone.

Licking County

The Licking County 208 Water Quality Management Plan (the Plan) can be viewed at http://www.lcounty.com/Planning/docs/Final_2006_208_Plan.pdf . The purpose and scope of the Plan is to develop a county-wide waste water treatment plan in partnership with agencies responsible for Publicly Owned Treatment Works (POTWs), townships, the Licking County Health Department and other stakeholders in the county. This Plan is seen as a mechanism to manage growth in the county and support locally controlled efforts such as Comprehensive Planning, Farmland Preservation and Conservation Preservation.

The Plan establishes what areas of the County may be developed over the next 20 years and how areas that are not served by a POTW will be developed. In addition, the Plan addresses impacts from storm water runoff and other non-point source pollutants.

Pickaway County

Pickaway County does not have, nor are there any immediate plans to create, a county or regional comprehensive plan. The Pickaway County Board of Commissioners has funded township planning initiatives since zoning authority in unincorporated Pickaway County is managed by each township. Except for economic development planning, there is presently little support for county-wide planning.

Pickaway County has reorganized its planning commission and now has a newly-formed comprehensive planning committee. Ohio EPA staff will meet with the planning committee to discuss the benefits of a county-wide plan and clean-water objectives. Ohio EPA recommends that County land use planning agencies interact with townships and municipalities in development of land use/comprehensive plans that include stream corridor protection zones. The Ohio EPA recommends that counties in this watershed continue work necessary to ensure that their comprehensive plans provide stream corridor and stream headwater protection.

Franklin SWCD storm water program

Franklin SWCD has an Illicit Discharge Detection and Elimination Program (IDDE). In cooperation with the county's health department, the district's program creates "a database of outfalls and other drainage features contributing to open drainage within the target area or municipality." The unincorporated areas of the Walnut Creek Watershed are expected to be completed by 2011.

Franklin SWCD also has an Urban Conservation Program that reviews all development plans for unincorporated portions of the county. The review is to "assure proper sediment and erosion control practices and natural resource protection."

Franklin SWCD's Backyard Conservation Program targets drainage problems, storm water quality-quantity, stream bank erosion and wildlife habitat. Madison and Canal Winchester Schools will install rain gardens in 2008. Native tree and shrub plantings were installed on London and Lancaster Road to address standing water. A rain garden is planned to manage home storm water runoff.

Township planning

Each township has a Zoning Commission. The Township Zoning Commission may develop land use/comprehensive plans for the Township and make a recommendation to the Township Board of Trustees on said plans. Such plans guide development in a township and thus help control pathogen discharge through requiring use of appropriate wastewater and storm water disposal techniques. Such plans may also guide development in a township through requiring riparian corridor protection. Planning for riparian corridors near streams will provide habitat protection, open space for possible bikeways and walking trails, and help maintain floodplains

Some townships within this watershed have a comprehensive plan of some kind. Ohio EPA is aware of the following plans:

<u>Violet Township, Fairfield County</u>

Violet Township is the fastest growing township in the watershed. Comprehensive construction site management and post-construction storm water management that preserve existing hydrology are needed to maintain the biological integrity of Sycamore Creek.

The township has developed a Land Use and Transportation Plan for use as the township works with the City of Pickerington to manage significant growth in this area. This plan can be viewed at:
http://www.violet.oh.us/documents/Violet%20Land%20Use%20Plan633100809311406250.pdf.
Section 9 Implementation Strategies in the plan indicates that the plan will be reviewed in 2009 and again in 2014 to determine if additional updates are needed or if additional issues need to be addressed. A subwatershed known as Sycamore Creek is located within Violet Township. This subwatershed is categorized by the Ohio EPA as a rapidly developing watershed (RDW).

When the township reviews its plan in 2009 it should continue measures necessary to control sediment and habitat loss within the township. Stream riparian corridor protection is an excellent technique for use in maintaining water quality and habitat in the area.
The township has taken steps to reduce sediment loss through implementation of its Drainage, Erosion and Sediment Control (DESC) Regulations developed through interaction with the Fairfield County Soil and Water Conservation District Office. The DESC Regulations can be viewed at http://www.violet.oh.us/documents/DESCregulations633100788190468750.pdf

<u>Liberty Township, Fairfield County</u>

The township is in the process of developing a land use plan but little information is available regarding plan status.

<u>Etna Township, Licking County</u>

The township created its 1996 Land Use Plan and Recommendations Addendum. This plan is now in the process of being reviewed by the township. Ohio EPA staff provided a brief overview of the Walnut Creek study to township trustees and highlighted the importance of riparian corridor protection as part of the comprehensive planning process.

Benefits of incorporating riparian corridor protection zones in land use/comprehensive plans have been cited in numerous literatures. Benefits include, but are not limited to, the following:

- Reduce flood impacts by absorbing peak flows, slowing the velocity of floodwaters and regulating base flow.
- Stabilize the banks of watercourses to reduce bank erosion and downstream
- transport of sediments eroded from watercourse banks.
- Reduce pollutants in watercourses during periods of high flows by filtering, settling and transforming pollutants in runoff before they enter watercourses.
- Provide habitat to a wide array of wildlife by maintaining diverse and connected riparian vegetation.
- Provide economic benefits by minimizing encroachment on watercourse channels and the need for costly engineering solutions, such as dams, retention basins and rip rap to protect structures and reduce property damage and threats to the safety of watershed residents. This helps to preserve the character and property values of an area.

Planning and storm water protections by municipalities
Several municipalities in this watershed have developed storm water control plans which include stream corridor protection zones. Each of these plans incorporate protections for Georges Creek and are the following:

- City of Pickerington – http://www.ci.pickerington.oh.us/sections/community/stormwater_mgmt.asp
- City of Columbus – http://utilities.columbus.gov/DOSD/PDFs/FULL%20SWDM_MARCH_06.pdf
- City of Columbus' Southeast Area Plan - http://assets.columbus.gov/development/planning/sedraft.pdf
- Southeast Area Bixby Road Economic Development Amendment - http://assets.columbus.gov/development/planning/SoutheastAreaPlanBixbyRoad.pdf

The plans dealing with the southeast area of Columbus indicate that Georges Creek will receive protection through use of a riparian buffer zone that is either the floodway width or 150 feet each side of the creek centerline (total width 300 feet) or whichever is greater. All other streams should consist of the greater width of either the floodway or 50 feet each side of the stream centerline.

The Southeast Plan indicates that a 2000-foot buffer will surround the portion of Pickerington Ponds that lies within the planning area. The Southeast Plan also proposes use of a development technique known as the hamlet or open space subdivision. See Figure 8.11 for the area covered by the Southeast Area Plan and the Bixby Road Economic Development Amendment.

Village of Canal Winchester
In 2008 this village adopted its Storm water Design Manual which includes a Stream Corridor Protection Policy that will be implemented by the village. The policy will help protect the riparian corridor in this area from future develop thus benefiting water quality.

The village recently completed a street improvement project which incorporated use of pervious pavement in portions of this project to help control storm water runoff. Use of pervious pavement allows water to pass through the pavement and is a means of reducing the storm water runoff rate in contrast with a higher runoff rate that would occur with impervious pavement. Controlling the runoff rate will help reduce flooding and further protect Walnut Creek

from higher runoff rates associated with use of impermeable surfaces. Additional information regarding this project can be found at:
http://www.canalwinchesterohio.gov/mediacenter/pressrel/071408ColumbusStreetEvent.pdf .
A photograph of this street project and close up of the pavement surface is provided below:

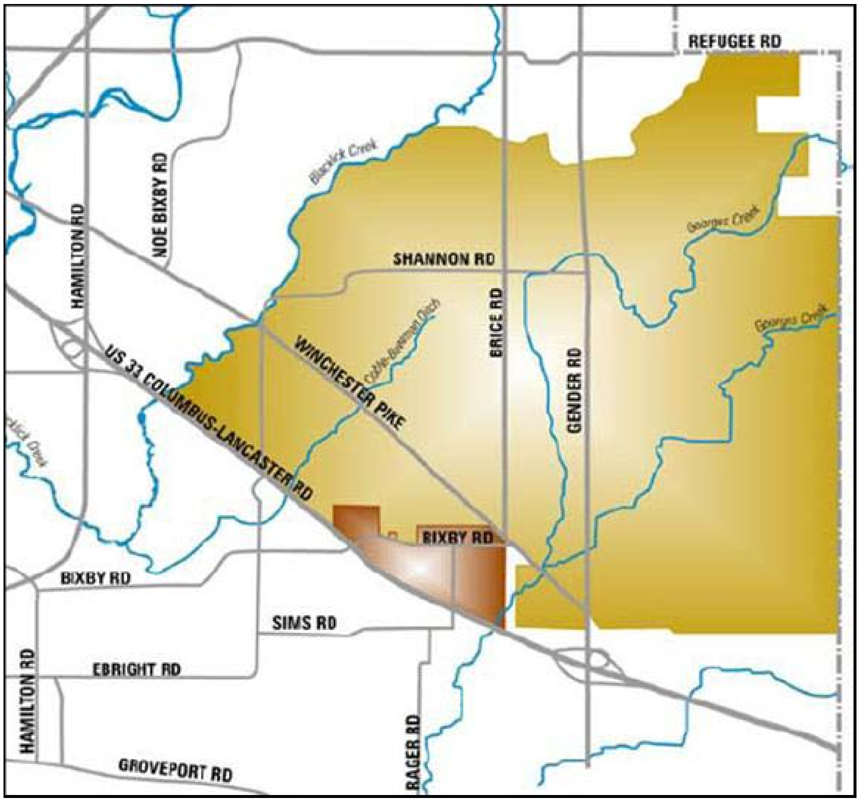


Figure 8.11 Map of the areas included in the Southeast Area Plan (olive color) and the Southeast Area Plan Bixby Road Economic Development Amendment (brown color). Note the location of portions of Georges and East Branch Georges Creek within the development area.

Figure 8.12 Photos showing the use of pervious pavement (tan color) alongside asphalt within the area of the Canal Winchester Street Project. The photo on the right is a close-up of the pervious pavement surface.

Village of Groveport
In 2008 this village adopted a Storm water Management Policy which includes Stream Corridor Protection Zones within the village. The policy will help protect the riparian corridor in this area from future develop thus benefiting water quality.

The Ohio EPA recommends that townships and municipalities in this watershed continue work necessary to ensure that their comprehensive plans and zoning provide riparian corridor protection.

Metro Parks land acquisitions
Recent land acquisition by the Metro Parks Program has provided additional riparian corridor protection in the Walnut Creek Watershed. Purchase of the 170 acre Rawn Dairy Farm in 2007 increases the size of the Pickerington Pond Metro Park. The Rawn property includes acreage through which a portion of Georges Creek flows on the west side of this park. The 486 acre Chestnut Ridge Park is located generally south east of the intersection of Winchester and Amanda Northern Roads midway between the Villages of Lithopolis and Carroll in Fairfield County. Several headwater streams are protected from development as they flow through this park. In 2008 Metro Parks announced that it purchased 485 acres of land for creation of a new metro park. The acreage is adjacent to the Walnut Creek mainstem between Groveport and Canal Winchester and will provide additional riparian corridor protection.

An excerpt from this Metro Parks website (http://www.metroparks.net/CmsData/Site/Documents/2008/LEVY%20PLANNING_RFS.pdf) indicates the possibility of additional riparian corridor protection for the Walnut Creek mainstem.

8.4 Summary of restoration strategy

Tables 8.5 through 8.7 summarize the strategy for restoring water quality in the Walnut Creek watershed.

Table 8.6 Inventory of TMDL Action Items Walnut Creek — HUC 05060001-170

Waterbody	Cause of Impairment	Primary Source	Action Item	Target & Unit	2009 Status	Likely Source of Funding	Comments
Priority Actions:							
Pleasantville Creek (RM 2.4 @ Pleasantville Rd)	Low D.O. Sediment	SSO	Eliminate Leitnaker Road pump station sanitary sewer overflow	Steps in orders	SSO work underway	Walnut Creek Sewer Dist./OWDA	Orders issued for WWTP upgrade and SSO elimination
		Agriculture	Implement agricultural BMPs to reduce sediment	Varies by BMP	To be pursued	NRCS-EQIP OEPA-319 Grants	
Pleasantville Creek (RM 0.5, downstream of WCSD WWTP)	Sediment Low D.O. Ammonia	Point Source	Upgrade Walnut Creek WWTP	Steps in orders	WWTP upgrade underway	Walnut Creek Sewer Dist./OWDA	Orders issued for WWTP upgrade and SSO elimination
		Livestock in Stream	Install fencing to restrict livestock access to creek. Alternate livestock water supply	1,600 linear feet of fencing	To be pursued	NRCS-EQIP OEPA-319 Grants	Ohio EPA/SWCD staff must discuss this issue in 2009 and then attempt resolution.
Tributary to Paw Paw Creek (RM 1.79 @ Cherry Lane Rd)	Sediment	Hydro-modification Agriculture	Stream habitat restoration	Linear feet	To be pursued	NRCS-EQIP OEPA-319 Grants	
			Agricultural BMPs to reduce sediment	Varies by BMP			
Sycamore Creek (RM 12.2 @ Fairlawn Ave.)	Organic enrichment Low D.O.	Urban storm water	NPDES storm water permit audit.	Audit	CDO-DSW to pursue	Ohio EPA	NPDES storm water permit audits to commence in 2009
		Failing HSTS	Investigation necessary to determine problem source	# of HSTS fixed	To be pursued		
Sycamore Creek ** (RM 4.2 @ Hill Rd; RM 2.6 @ Busey Rd)	TDS Solids Toxicity	Point Source	Upgrade Pickerington WWTP Implement TDS control plan	Permit compliance	WWTP upgrade underway	Pickerington Ohio EPA	NPDES permit compliance schedule

Waterbody	Cause of Impairment	Primary Source	Action Item	Target & Unit	2009 Status	Likely Source of Funding	Comments
Priority Actions:							
WATERSHED WIDE	Pathogens	Failing HSTS	Repair or replace failing HSTS systems	# of HSTS fixed	To be pursued	Local Health Departments	ODH rule revisions underway and Ohio EPA HSTS General Permits are now in use.
		Livestock in Stream	Install fencing to restrict livestock access to creek. Alternate livestock water supply	Linear feet of fencing	To be pursued	OEPA/ODNR	
Additional Areas of Concern:							
Walnut Creek	Habitat loss Sediment	Man-made modification	Habitat restoration and riparian protection	Structures and acres protected	To be pursued	OEPA-319 Grants	
Popular Creek	Fish stress	Unknown	Further investigation by Ohio EPA needed	Study completed	To be pursued	Ohio EPA	
Paw Paw Creek	Organic waste	SSO	Eliminate Mill/Monroe sanitary sewer overflow	SSO gone	In process	Village of Baltimore	Minimize I/I into sewer
		Industrial Storm water	Eliminate nuisance discharges from storm sewers	Storm and process separate	Enforce-ment under way	National Fruit and Vegetable	
West Branch Paw Paw Creek	No capacity						Assimilative capacity has been reached
Gillette Run	Bacteria Nutrients Sediment	Livestock in Stream	Install fencing to restrict livestock access to creek. Alternate livestock water supply	Linear feet of fencing	To be pursued	OEPA/ODNR	
Tributary to Walnut Creek @ RM 29.83	Sediment	Unknown	Further investigation necessary	Study completed	To be pursued	Ohio EPA	

** Additional data collected in 2009 at stream locations at river miles 4.2 and 3.8 suggests that the applicable biological criteria is now being met. These data are currently under review by the Ohio EPA and appropriate attainment status will be assigned according to the outcome of the review.

Table 8.7 Inventory of TMDL Action Items Walnut Creek — HUC 05060001-180

Waterbody	Cause of Impairment	Primary Source	Action Item	Target & Unit	2009 Status	Likely Source of Funding	Comments
Priority Actions:							
East Branch George Creek (@ Refugee Rd and Wright Rd)	Toxicity	Urban storm water	NPDES storm water permit audit.	Audit	CDO-DSW to pursue	Ohio EPA	NPDES storm water permit audits to commence in 2009
Big Run (RM 1.6 Hayes Rd.)	Flow withdrawal	Unknown	Further investigation necessary	Study completed	To be pursued	Ohio EPA	
	WWTP	Point Source	Inspect WWTP	Inspection done	CDO-DSW to pursue	Ohio EPA	Possible I/I impact on WWTP
			Fix any problems found	To be determined	To be pursued	WWTP	
Mud Run (RM 1.5 Goodman-Teegardin Rd.)	Sediment Poor Habitat	Flow alteration Agriculture	Implement agricultural BMPs to reduce sediment	Varies by BMP	To be pursued	NRCS-EQIP OEPA-319 Grants	Ohio EPA and SWCD meet to determine course of action
		Livestock in Stream	Install fencing to restrict livestock access to creek. Alternate livestock water supply	400 feet of fencing	To be pursued		
Turkey Run(RM 0.2)	Habitat alterations	Channelization Agriculture	Habitat restoration and riparian protection	Structures and acres protected	To be pursued	OEPA-319 Grants	Ohio EPA and SWCD meet to determine course of action
WATERSHED WIDE	Pathogens	Failing HSTS	Repair or replace failing HSTS systems	# of HSTS fixed	To be pursued	Local Health Departments	ODH rule revisions underway and Ohio EPA HSTS General Permits are now in use.
		Livestock in Stream	Install fencing to restrict livestock access to creek. Alternate livestock water supply	Linear feet of fencing	To be pursued	OEPA/ODNR	

Waterbody	Cause of Impairment	Primary Source	Action Item	Target & Unit	2009 Status	Likely Source of Funding	Comments
Priority Actions:							
Additional Areas of Concern:							
Walnut Creek		Rickenbacker Airport and Intermodal area storm water	Work on and implement plan to prevent water quality degradation from area storm water discharges	Plan in place and actions implemented	Ongoing	Airport Authority Intermodal facilities Ohio EPA	Airport Authority and Ohio EPA have been working on this since 2007. EMH&T doing study.
Georges Creek		Urban & suburban land use	Construction site and comprehensive storm water management needed. Low impact design, conservation development, and other elements of the storm water manuals implemented.	Local ordinances and regional planning	To be pursued	Jurisdictional division and developers	Pickerington and Columbus storm water manuals now in effect for future development. Columbus SE Plan proposed for use. Franklin County Draft storm water manual in place.
Tussing Ditch	Channelization	Urban, suburban & commercial land use	Stream restoration and storm water management	Local ordinances and regional planning	Violet Twp DES Control regulations in effect. Other TBP	Ohio EPA, jurisdictional divisions and developers	Work with appropriate stakeholders for implementation of stream protection strategies. CW storm water manual applicable to future dev.
South Rickenbacker Run		Urban & commercial land use Airport runoff	Develop plan to prevent water quality degradation from airport storm water. Periodic monitoring for signs of acutely toxic conditions	Plan in place Sampling	To be pursued	Airport Authority Ohio EPA	
Manns Run	Sediment Channelization	Channel modification	Implement agricultural BMPs to reduce sediment	Varies by BMP	To be pursued	SWCD Ohio EPA	
			Stream restoration	Linear feet			

Waterbody	Cause of Impairment	Primary Source	Action Item	Target & Unit	2009 Status	Likely Source of Funding	Comments
Priority Actions:							
Bull Run			Confirm use and attainment with fish data	IBI, MIwb	To be pursued	Ohio EPA	
			Remove from county maintenance	Feet removed	To be pursued	County	If drainage adequate for current needs

9 FUTURE EVALUATIONS OF THE PROJECT AREA AND CORRECTIVE ACTIONS

9.1 Current and ongoing monitoring

The effectiveness of actions implemented based on the TMDL recommendations should be validated through ongoing monitoring and evaluation. Information derived from water quality analyses can guide changes to the implementation strategy to more effectively reach the TMDL goals. Additionally, monitoring is required to determine if and when formerly impaired segments meet applicable water quality standards (WQS).

This section of the report provides a general strategy for continued monitoring and evaluation and lists parties who can potentially carry out such work. It highlights past efforts and those planned to be carried out in the future by the Ohio EPA and others. It also outlines a process by which changes to the implementation strategy can be made if needed.

Evaluation and analyses

Aquatic life habitat and recreational uses are impaired in the watershed, so monitoring that evaluates the stream system with respect to these uses is a priority to the Ohio EPA. The degree of impairment of aquatic life habitat is exclusively determined through the analysis of biological monitoring data. Recreational use impairment is determined through bacteria counts from water quality samples. Ambient conditions causing impairment include ***point sources (home septic treatment systems, sanitary sewer overflows, storm sewers, wastewater treatment plants), and non point sources (livestock, agricultural activity, maintenance of drainage infrastructure, urban/suburban development)***. This report sets targets values for these parameters (Chapter 7), which should also be measured through ongoing monitoring.

A serious effort should be made to determine if and to what degree the recommended implementation actions have been carried out. This should occur within an appropriate timeframe following the completion of this TMDL report and occur prior to measuring the biological community, water quality or habitat.

Past and ongoing water resource evaluation

<u>Monitoring performed by other groups</u>

Since 2003, a stream quality monitoring project has been underway at four locations in Walnut Creek in the Canal Winchester area. This work has been led by Dick Miller, the village's urban forester. This monitoring effort is based on the Ohio Department of Natural Resources Stream Quality Monitoring Assessment Form. Stream conditions and various macroinvertebrates are observed and recorded on the form for use in a visual assessment of stream quality.

Work performed by Mr. Miller is important and should continue as a means to help monitor the Walnut Creek mainstem in an area facing increasing development pressures. Mr. Miller can be reached at http://www.canalwinchesterohio.gov/departments/pubworks/UrbanFor/Default.aspx for additional information regarding this project in Canal Winchester.

Additional information regarding this Stream Quality Monitoring Project in Ohio can be found at this website: http://www.dnr.state.oh.us/tabid/980/Default.aspx .

Recommended Approach for Gathering and Using Available Data

Early communications should take place between the Ohio EPA and any potential collaborators to discuss research interests and objectives. Through this, areas of overlap should be identified and ways to make all parties research efforts more efficient should be discussed. Ultimately important questions can be addressed by working collectively and through pooling resources, knowledge, and data.

9.2 Schedule for Ohio EPA monitoring

In accordance with the Ohio 2008 Integrated Water Quality Monitoring and Assessment Report (Ohio EPA, 2008), the next scheduled Ohio EPA evaluation of this watershed is in 2020.

9.3 Approach for making needed revisions

An adaptive management approach will be taken in the Walnut Creek watershed. Adaptive management is recognized as a viable strategy for managing natural resources (Baydack et al., 1999) and this approach is applied on federally-owned lands. An adaptive management approach allows for changes in the management strategy if environmental indicators suggest that the current strategy is inadequate or ineffective.

The recommendations put forth for the Walnut Creek watershed largely center on reducing pathogen discharge into streams and preventing further habitat loss.

If chemical water quality does not show improvement and/or water bodies are still not attaining water quality standards after the implementation plan has been carried out, then a TMDL revision would be initiated. The Ohio EPA would initiate the revision if no other parties wish to do so.

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APPENDIX A

NPDES Permitted Dischargers and Municipal Separate Storm Sewer Systems in TMDL Project Area

Figure A.1 Map of the outfall locations of NPDES permitted waste water dischargers in the Walnut Creek watershed.

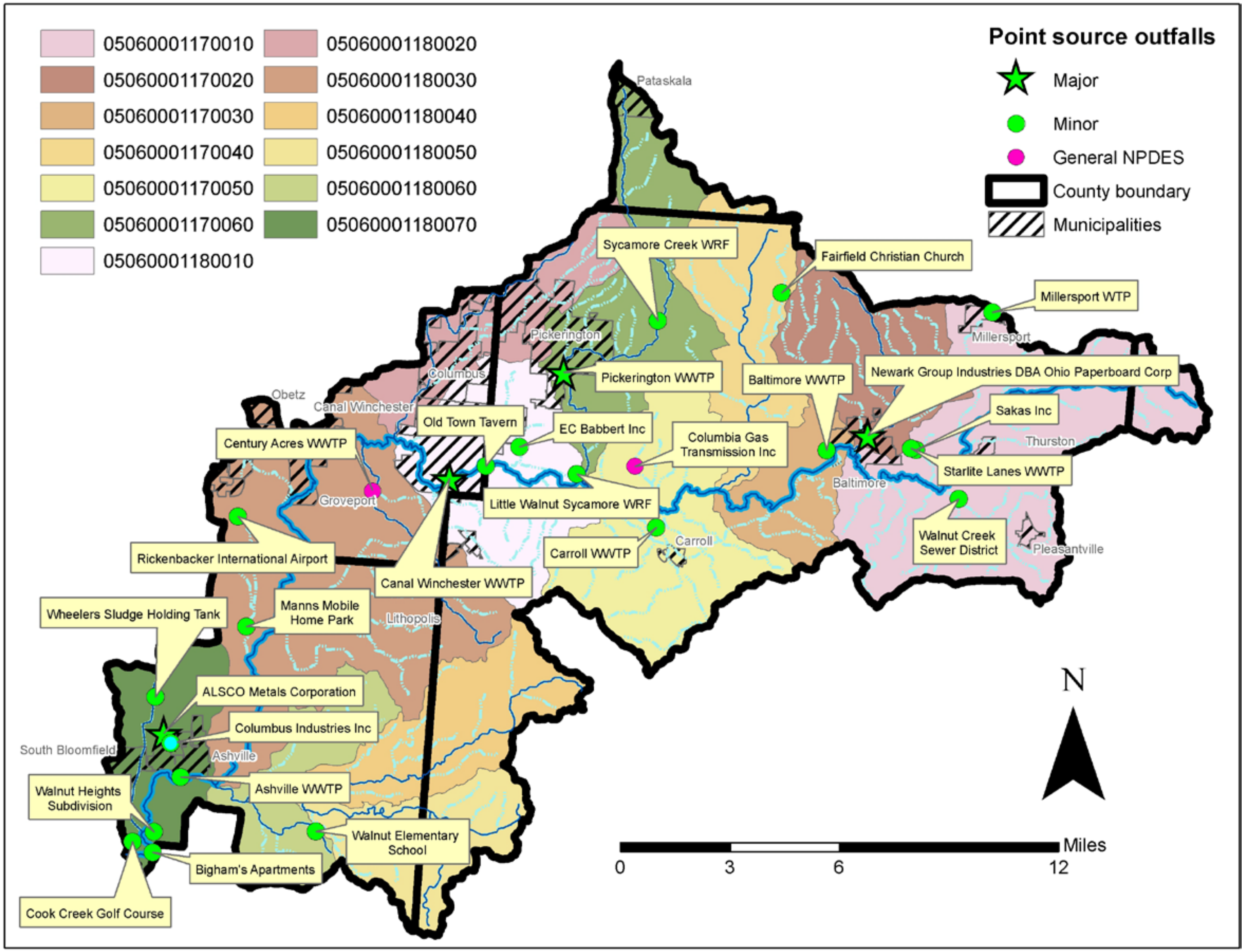

Table A.1 NPDES permitted waste water dischargers in the Walnut Creek watershed.

OEPA permit number	HUC 14 (last 6 digits)	Facility name	Receiving stream(s)	Effective date	Expiration date	Design flow discharge (million gallons per day)
4IC00002	180-070	ALSCO Metals Corporation	Unnamed trib to Mud Run	6/1/2006	1/31/2011	0.019
4PC00005	180-070	Ashville WWTP	Walnut Cr (RM 4.45)	7/1/2007	6/30/2012	0.600
4PB00011	170-030	Baltimore WWTP	Walnut Cr (RM 40.05)	8/1/2008	7/31/2013	0.500
4PW00007	180-070	Bigham's Apartments	Walnut Cr (RM 0.8)	9/1/2004	8/31/2009	0.0032
4PB00012	180-010	Canal Winchester WWTP	Walnut Cr (RM 34.15)	10/1/2008	6/30/2013	2.480
4PS00015	170-050	Carroll WWTP	Unnamed trib to unnamed trib to Walnut Cr at RM 32.09	9/1/2007	8/31/2012	controlled discharge
4GS00011	180-030	Century Acres[2]	Big Run (RM 1.75)	7/1/2005	12/31/2009	0.025
4GH00011	170-050	Columbia Gas Transmission Inc – Line B93 B111 site[2]	Unnamed tributary to Walnut Creek at river mile 32.09	5/1/2009	10/31/2012	NA
4IN00185	180-070	Columbus Industries Inc	Mud Run	7/1/2009	6/30/2014	only cooling water
4PX00021	180-070	Cook Creek Golf Course	Walnut Cr (RM 0.42)	8/1/2005	7/31/2010	0.000526
4IM00104	180-010	EC Babbert Inc	Unnamed trib to Walnut Cr at RM 26.4	8/1/2007	9/30/2012	0.002
4PR00103	170-040	Fairfield Christian Church	Unnamed trib to unnamed trib to Poplar Cr at RM 5.27	4/1/2008	3/31/2013	0.003
4PJ00101	180-010	Little Walnut Sycamore WRF	Walnut Cr (RM 29.05)	7/1/2008	6/30/2013	0.750
4PR00028	180-030	Manns MHP	Unnamed trib to Walnut Cr at RM 9.96	2/1/2005	1/31/2010	0.080
4IY00132	170-010	Millersport WTP[1]	NA	8/1/2006	7/31/2011	controlled discharge

OEPA permit number	HUC 14 (last 6 digits)	Facility name	Receiving stream(s)	Effective date	Expiration date	Design flow discharge (million gallons per day)
4IA00001	170-020	Newark Group Industries DBA Ohio Paperboard Corp	Unnamed trib to Pawpaw Cr	8/1/2004	7/31/2009	0.400
4PR00101	180-010	Old Town Tavern	Walnut Cr (RM 25.59)	10/1/2007	9/30/2012	0.001
4PB00017	170-060	Pickerington WWTP	Sycamore Creek	1/1/2008	12/31/2012	1.600 / 3.200[1]
4IN00085	180-030	Rickenbacker International Airport	Walnut Cr (RMs 15.54 and 15.64) and Unnamed Trib to walnut cr at RM 9.96	1/1/2006	12/31/2010	variable discharge
4IC00015	170-020	Sakas Inc	Unnamed trib to Walnut Cr at RM 44.95	8/1/2005	7/31/2010	0.0006
4PX00038	170-020	Starlite Lanes WWTP	Unnamed trib to Walnut Cr at RM 44.95	7/1/2009	6/30/2014	0.0025
4PG00027	170-060	Sycamore Creek WRF	Sycamore Creek	8/1/2008	7/31/2013	0.800
4PA00005	170-010	Walnut Creek SD	Pleasantville Creek	8/1/2008	7/31/2013	0.181
4PT00117	180-060	Walnut Elem Sch	Bull Run	8/1/2007	7/31/2012	0.010
4PG00018	180-070	Walnut Heights Subdiv	Unnamed trib to Walnut Cr at RM 1.8	4/1/2007	3/31/2012	0.063
4IN00199	180-070	Wheelers Sludge Holding Tank	NA	8/1/2008	7/31/2013	only sludge

1 These two numbers indicate existing and planned design flows (following plant expansion).
2 This facility is regulated under a general and not an individual NPDES permit.

Figure A.2 Map of the NPDES permitted municipal separate storm sewer system (MS4s) areas in the Walnut Creek watershed.

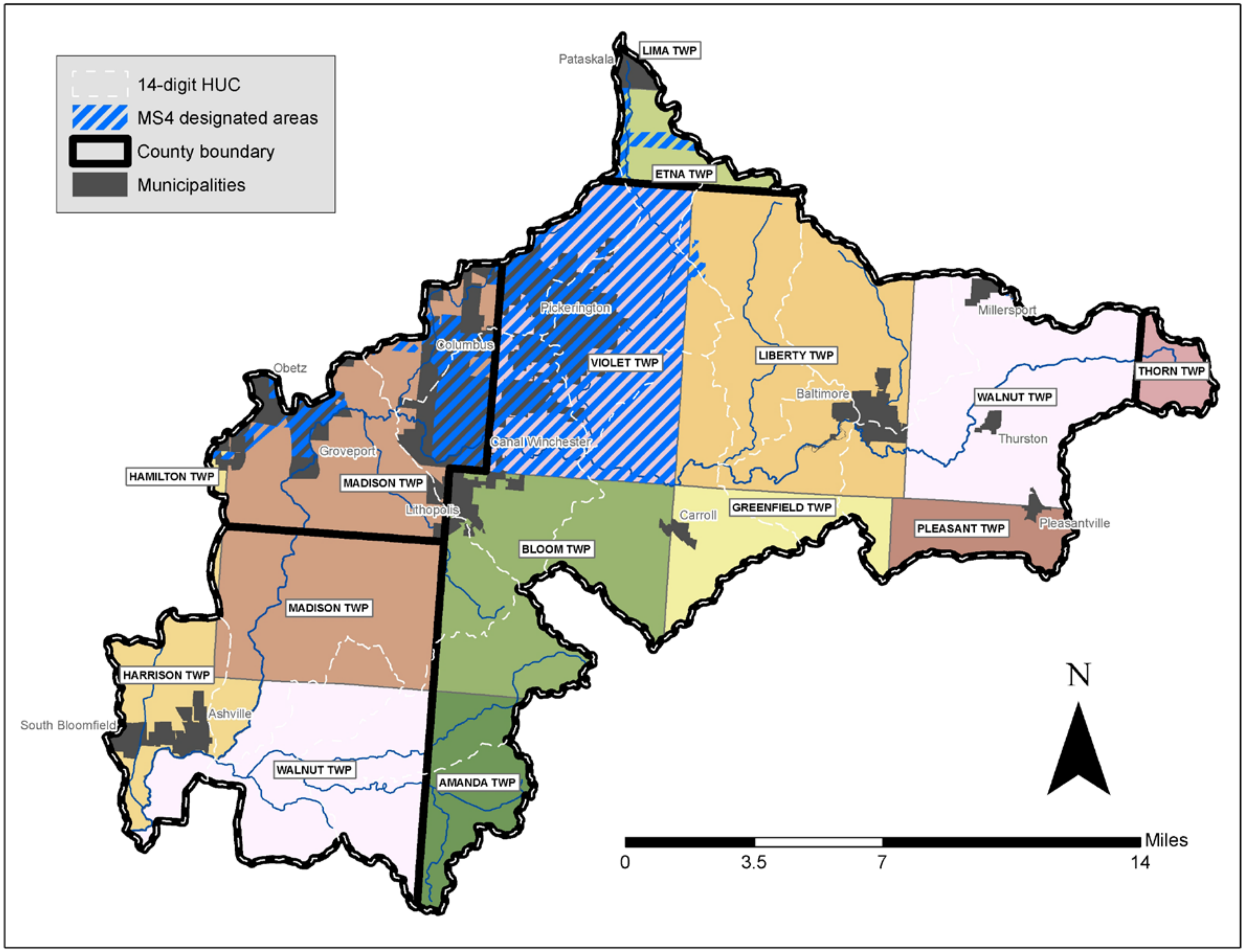

Table A.2 NPDES permitted municipal separate storm sewer system (MS4s) areas in the Walnut Creek watershed.

County	Permit No	Applicant Name	Issue Date
FAIRFIELD	4GQ10012*BG	CITY OF PICKERINGTON	5/26/2009
FAIRFIELD	4GQ10006*BG	FAIRFIELD COUNTY & OTHERS	4/1/2003
FRANKLIN	4GQ10005*AG	VILLAGE OF CANAL WINCHESTER	5/26/2009
FRANKLIN	4GQ10004*BG	VILLAGE OF GROVEPORT	5/26/2009
LICKING	4GQ10007*BG	CITY OF PATASKALA	5/26/2009

APPENDIX B

Justification for Use of Category 4b Alternative(s)
Pickerington Waste Water Treatment Plant

Problem causing the impairment.[1]

The Ohio Environmental Protection Agency (Ohio EPA) measured the water quality in the Walnut Creek watershed in 2005, collecting biological, chemical and physical data. Impairment of biological water quality standards (OAC 3745-1-07) was measured at six sites on Sycamore Creek, a tributary to Walnut Creek.

Three sites in Sycamore Creek met the biological criteria and three did not. The most upstream site (river miles (RM) 12.2) was impaired due to organic enrichment (probably due to septic systems), then two sites (RMs 9.6 and 4.7) met the criteria. The next two sites (RM 4.18 (Hill Road) and 2.6 (Busey Road) partially met the criteria. The stream recovered to fully meet the criteria at the most downstream site (RM 0.2).

The City of Pickerington wastewater treatment plant (WWTP) discharges to Sycamore Creek at RM 4.35. No impairment to Sycamore Creek immediately upstream of Pickerington or downstream of RM 2.6 was measured. The biological impairment is resulting from the Pickerington WWTP effluent discharge.

The site at RM 4.18 only partially met the WWH biological criteria. The fish community was in very good condition while qualitative invertebrate sampling revealed a low-fair community. This is likely caused by the proximity of the Pickerington WWTP to this sampling station and documented chronic toxicity of effluent to *Ceriodaphnia* (Ohio EPA, 2006, Bioassay Report 06-3447-C). Both fish and invertebrate communities improved at Sycamore Creek sites downstream of RM 4.18.

The chemical water quality criterion for total dissolved solids (1500 mg/l) was exceeded in Sycamore Creek downstream of the Pickerington WWTP (2110, 1950, 1710 mg/l).

Link between the source of the problem and the specific listed impairments

High total dissolved solids (TDS) concentrations result from the Pickerington WWTP discharge. The WWTP accepts a waste stream from the Pickerington water treatment facility which uses a Zeolite process to treat drinking water. This process creates a wastewater high in dissolved solids which the WWTP does not effectively treat. This high dissolved solids waste gets passed through the WWTP and into Sycamore Creek.

Bioassay testing results on the Pickerington effluent and mixing zone have confirmed TDS-related impairment to the invertebrate community as well by demonstrating negative effects (immotility, death) to *Ceriodaphnia*. Mayfly populations found downstream of the WWTP are impaired revealing only 2 mayfly taxa (compared with 8 found upstream of the discharge point) plus a variety of TDS tolerant and facultative invertebrates as well. The two sites upstream and the site at the mouth were in full attainment of WWH biological standards with moderately good (qualitative assessments at RM 9.6 and 4.7) to exceptional (ICI=50 at RM 0.2) communities of invertebrates.

Low fish MIWB scores found at RM 2.6 provide further evidence of a problem with excessive TDS instream contributing to reduced numbers of fish.

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[1] The City of Pickerington disputes these results and has retained a consultant to resample the area; results of the study have not been submitted to Ohio EPA for review as of February 1, 2010.

Further information regarding the 2005 findings is available in the Biological and Water Quality Study of Walnut Creek and Select Tributaries 2005, available on Ohio EPA web site (http://www.epa.ohio.gov/portals/35/documents/WalnutCreek2005TSD.pdf).

Ohio EPA included total dissolved solids for this assessment unit in the 2008 Integrated Report (303(d) list), available at (http://www.epa.ohio.gov/dsw/tmdl/2008IntReport/2008OhioIntegratedReport.aspx).

Description of pollution controls and how they will achieve water quality standards

The City of Pickerington operates a sewer collection system and a wastewater treatment facility and is regulated under a National Pollutant Discharge Elimination System (NPDES) permit (4PB00017*LD).

The existing Pickerington wastewater plant has an average daily design flow of 1.6 MGD (million gallons per day). Pickerington is expanding its wastewater plant to an average design flow of 3.2 MGD to accommodate new development within its service area. Along with other improvements, for solids handling the City will construct two new aerobic digesters and new sludge drying beds for storage.

The permit requires the development of a method to control discharges of elevated dissolved solids. Both interim and final effluent concentrations of dissolved solids are present in the permit (calculated by wasteload allocation) which should serve to ameliorate the violations of the WQS in Sycamore Creek (see NPDES permit Fact Sheet for the Pickerington WWTP, attached)

Point and nonpoint source loadings that will achieve water quality standards.

The allowable loading is based on the beneficial uses assigned to the receiving waterbody in OAC 3745-1. Dischargers are allocated pollutant loadings/concentrations based on the Ohio Water Quality Standards (OAC 3745-1). TDS was allocated using the mass-balance method, using the following general equation:

Discharger WLA = [(downstream flow x WQS) - (upstream flow x background concentration)] / discharge flow.

See the attached permit fact sheet for details.

The continuous discharge from the WWTP into Sycamore Creek at low stream flows during the summer represent the critical condition for the aquatic ecosystem. The WLA calculation accounts for the nonpoint source load in the equation. See the attached permit fact sheet for details.

All loads in kg/d	Existing WWTP Flow	Expanded WWTP Flow
TMDL	11,022	20,433
LA	666	666
WLA	10,356	19,767

An estimate or projection of the time when WQS will be met

The NPDES permit requires the City of Pickerington to meet the final effluent limitations in the permit within 25 months of the effective date of the permit (in 2010). WQS should be met soon after as macroinvertebrates can recover quickly (6 months to a year) once the stressor is removed.

Schedule for implementing pollution controls

Reference the NPDES permit for scheduling information (attached).

Monitoring plan to track effectiveness of pollution controls

The City of Pickerington WWTP is required to submit monthly Discharge Monitoring Reports for effluent quality from the WWTP and upstream and downstream of their discharge point.

The permit requires 24-hour composite sampling for TDS of the WWTP effluent, to be completed three times per week year-round. In addition, the WWTP will collect an ambient grab sample for TDS is collected at sites both upstream and downstream of the discharge into Sycamore Creek (they will use a laboratory of their choice).

The facility's monthly discharge monitoring reports are reviewed by permit staff in Ohio EPA's Central District Office. Ohio EPA staff will also conduct unannounced facility inspections until all identified operational and process changes have been completed.

Water chemistry and macroinvertebrate community health will be monitored following the construction and new plant start up. After the Pickerington WWTP improvements have been in place for at least one year, Ohio EPA will return to monitor Sycamore Creek to determine if progress toward meeting the Aquatic Life Use is being made. This work would follow Ohio EPA's protocol for sampling the aquatic biology and chemistry. If sufficient progress is not being made, Ohio EPA will evaluate the options available under NPDES authority, including operations assistance and enforcement.

Ohio EPA will report progress in its Integrated Report until the impairment has been eliminated.

Future monitoring

City of Pickerington (far field monitoring for TDS in the NPDES permit, analysis by a laboratory of their choice) and Ohio EPA DSW, CDO WQ (chemistry, with analysis by Ohio EPA DES) and EAS (macroinvertebrates).

Cost estimates

Five work days for two people to sample chemistry, 1 work day for two people to do qualitative macroinvertebrate monitoring, and the associated standard lab costs for TDS samples.

Analysis of the results and annual reporting

Ohio EPA, CDO, DSW WQ staff will examine both data from Ohio EPA sampling and that generated by Pickerington. EAS macroinvertebrate staff will analyze their own data. Ohio EPA CDO staff will all of the reporting necessary for this 4B.

Revising the implementation strategy and corresponding pollution controls

The CDO surface water manager will initiate a reexamination of the implementation strategy if significant progress is not being made by the end of the next NPDES permit cycle for Pickerington.

APPENDIX C

Response Summary to Public Comments on the

Draft Walnut Creek TMDL Report

The draft Walnut Creek Watershed Total Maximum Daily Load Report was available for public review from November 12 through December 14, 2009. This appendix contains the comments received and responses to those comments. Please note that references to page numbers in the draft report may not correspond to the same page numbers in the final report.

Four sets of comments were submitted. The comments and responses are grouped by commenter; the number in parenthesis indicates the author of the specific comment, as listed here.

#	Date Received	Name	Affiliation
1	December 14, 2009	Dr. Dave McCartney	Ohio Agricultural Research and Development Center / Ohio State University
2	December 14, 2009	Paul D. Kennedy, A.A.E.	Columbus Regional Airport Authority
3	December 14, 2009	Brenda I. VanCleave, P.E.	City of Pickerington, Engineer's office
4	December 11, 2009	Steven P. Samuels	Schottenstein Zox & Dunn Co. LPa on behalf of the City of Pickerington
5	December 14, 2009	Steven P Samuels	Schottenstein Zox & Dunn Co. LPa on behalf of the City of Pickerington

Comment (1)
1. Only a small portion of the watershed with high (>75) QHEI ratings is being evaluated according to Exceptional Warmwater Habitat (EWH) standards. Most of these sites would meet those standards and many nearby sites have nearly adequate QHEIs and biotic indicators to rate that designation. The press release for this TMDL (<file:///http://www.epa.state.oh.us/portals/47/nr/2009/november/WalnutCreek.pdf>http://www.epa.state.oh.us/portals/47/nr/2009/november/WalnutCreek.pdf) touts the return of several pollution-intolerant fish species to the watershed. This TMDL's lack of support of EWH standards for more of this watershed would prove an impediment to maintaining and building on recent gains in the face of increasing stresses from urbanization.

Response
EWH use designations are based on demonstrated conditions, not QHEI scores. The QHEI score of 75 is only a guideline, not a criterion. Given that the biological scores only narrowly met the EWH criterion at nearly every site, and partially attained at one, the certainty that we could duplicate those scores across the board in future sampling was unlikely. In other words, simply based on random chance, we could expect some of the scores to drop below the EWH criteria, and render a segment into "non-attainment." As was recommended in the total dissolved solids, if the scores are maintained across the board the next time we sample the basin, then we will re-visit an EWH use designation.

Comment (1)
2. No nutrient TMDL was developed for phosphorus (P). The TMDL asserts that this nutrient is not limiting to biotic function. This is not consistent with information included in the technical support document (TSD) (OEPA Technical Report Number EAS/2006-12-8, <file:///http://www.epa.state.oh.us/portals/35/documents/WalnutCreek2005TSD.pdf>http://www.epa.state.oh.us/portals/35/documents/WalnutCreek2005TSD.pdf). Stream P levels are documented as being elevated above that considered to be a biotic stressor to Warmwater

habitat (WWH) waters for much of the watershed where point source effluents occur (and downstream for considerable distances) and well above target levels for EWHs. In several locations the TSD suggests that elevated nutrient concentrations may be impeding biota meeting EWH standards on both the mainstem and tributaries. Several of the stream segments not meeting WWH biotic standards are below WWTPs and have elevated P levels. It is a concern that the lack of a nutrient TMDL will lead to NPDES permit renewals for WWTPs without requirements for nutrient reductions and a failure to deal with this impediment to improved watershed function.

Response
Nowhere in the attainment table are nutrients listed as a cause of impairment. Where nutrients are mentioned in the technical support document (TSD), there is typically a more proximate cause of impairment, such as organic enrichment or TDS. Addressing those causes will take care of the nutrients in most cases. Additionally, where nutrients are cited as limiting potential attainment of EWH, those passages are rather speculative, and do not form a credible basis for implementing permit limits. As for the WWTPs, where we have information that indicates an increased loading of phosphorus may cause the stream go into non-attainment, then we will consider limits if and when the plant expands.

Comment (1)
3. Appendix B stream loading allowances for the Pickerington WWTP expansion may not provide any remediation for the foreseeable future due to their calculation assumptions being based on WWTP capacity rather than actual flows. Effluent limits should be adjusted annually based on the previous year's flow plus a reasonable growth factor. Most WWTP upgrades are made with the intent of capturing several decades' growth and basing current effluent limits on future flows is not appropriate.

Response
Effluent limits are both concentration and loading based. The concentration limits, if met, are protective of the water quality total dissolved solids in-stream average criterion of 1500 mg/l up to the flows the permitted concentrations are based on. The interim limit of 1710 mg/l TDS is protective up to effluent flows of 2 MGD. The final limit of 1632 mg/l is protective of flows up to 3.2 MGD (the expanded design flow). The average discharge flow in 2009 was 1.16 MGD. At this average flow, the facility could discharge a concentration of 1863 mg/l TDS and still achieve the water quality criterion downstream. However, the permit required 1710 mg/l in 2009; therefore, the permit is designed to be protective of water quality at flows less than design.

Comment (2)
Section 8.3.3 discusses development and zoning. CRAA remains extremely interested in any zoning efforts related to storm water management surrounding our airports. As a federally-funded airport sponsor, CRAA is charge with the management and abatement of attractants to wildlife. To that end CRAA would like to be party to any proposed zoning or designs related to stormwater management practices. For detailed information on our FAA obligations please visit

http://www.faa.gov/airports/resources/advisory_circulars/media/150-5200-33B/150_5200_33b.pdf

Response
Ohio EPA will keep CRAA advised regarding proposed stormwater management practices that may affect its operation.

Comment (2)
Table 8.8 in the Report discusses "areas where water quality is threatened". It goes on to list "Rickenbacker Airport and Intermodal area stormwater" as an Additional Area of Concern. There is no cause of impairment listed, however. Can you provide clarification regarding the intent of listing Rickenbacker and the Intermodal area on this table?

Response
The title of Table 8.8 is incorrect on page 86 of the TMDL. The table on page 86 is part of Table 8.7. The table title has been revised to Table 8.7 (cont.). With this in mind, references to Table 8.8 have been deleted.

Rickenbacker and the Intermodal area were listed in Table 8.7 due to information contained in the Walnut Creek Water Quality Study which is available at http://www.epa.state.oh.us/portals/35/documents/WalnutCreek2005TSD.pdf . The first paragraph on page 98 in the study states the following: "… that localized, episodic disturbance may be influencing the fish community, in that most of the expected fish community is present, just not in high relative abundance. Runoff from the concentration of impervious surfaces in and adjacent to the airport may be responsible, and should be closely monitored."

Page 5 of the study contains a section titled "Other Recommendations and Future Monitoring Concerns" in which Rickenbacker Airport is referenced and reads as follows: "The continued growth of warehousing and other commercial buildings in the vicinity of Rickenbacker Airport warrants future monitoring at regular five-year intervals to assess potential storm water impacts to the lower Walnut mainstem. Construction and post-construction stormwater management serving this area needs to address more than drainage and detention by including treatment of first-flush pollutants."

Comment (2)
On Table 8.8 we would like to clarify the relationship between the "Intermodal area" vs. the Norfolk Southern Intermodal Facility. The storm water from the Intermodal Facility actually flows to a tributary of the Scioto River. I will assume that the intent was to describe the southern area of Rickenbacker as the Intermodal area. Perhaps a distinction between area and facility could be made in the report?

Response
Primary Source language in what is now Table 8.7 (cont.) has been revised to read as: "Rickenbacker Airport/Intermodal area storm water within the watershed".

Comment (2)
Table 8.8 describes the South Rickenbacker Run and a sampling effort "to be pursued". Can you please describe what this plan is, as CRAA is unaware of a current proposal.

Response
As mentioned in the response to comment 2 above "The continued growth of warehousing and other commercial buildings in the vicinity of Rickenbacker Airport warrants future monitoring at regular five-year intervals to assess potential storm water impacts to the lower Walnut mainstem." This monitoring will be conducted periodically by Ohio EPA staff.

Comment (2)
Appendix A of the Report lists NPDES permit holders. Figure A.1 illustrates an outfall labeled "Ohio Air National Guard 121 ARW". Was this outfall intended to be associated with CRAA?

Response
Based on further review it has been determined that the Ohio Air National Guard 121 ARW outfall does not discharge into the Walnut Creek watershed and it has been deleted from the A.1 map.

Comment (2)
I apologize for missing the references, but I did not find discussion in the 2005 data report or in the 2009 Report regarding the darter varieties found. Can you please point me to those pages?

Response
Discussion regarding darter varieties can be found in the Walnut Creek Water Quality Study on pages 2, 5-6 and 98. Darter varieties were also mentioned in the November 23, 2009 News Release available at http://www.epa.state.oh.us/portals/47/nr/2009/november/WalnutCreek.pdf .

Thank you for noticing that a reference to the darter species is missing from the TMDL. A reference to darter species is now included in the TMDL Executive Summary.

Comment (3)
Figure 3.1 - if printed in black and white, it's difficult to differentiate the different line types.

Response
The map in Figure 3.1 has been replaced with one that indicates Secondary Contact Recreation (SCR) use designated streams with a line style that is clearly visible in a black and white printout. The other streams designated as Primary Contract Recreation (PCR) remain unchanged in the map.

Comment (3)
P. 65, Section 8.2.1 - please clarify which point source is being discussed in the second paragraph.

Response
The point source being discussed is the Walnut Creek Sewer District. This paragraph will be revised as follows (revisions underlined):

> *<u>Other point sources such as</u> sanitary sewer overflows are caused by inadequate capacity of the sewer lines. The remedy is to increase this capacity by replacing existing lines with ones with greater capacity or simply adding sewer lines. Director's Final Findings and Orders (DFFOs) <u>issued to the Walnut Creek Sewer District</u> became effective January 30, 2008, and contain a schedule of compliance for WWTP and sewerage system improvements necessary to eliminate sanitary sewer overflows and sludge loss from the plant. <u>Per these orders</u> SSO events must be eliminated no later than December 31, 2011 and the sewer district must complete the final phase of I/I removal by December 31, 2011. Completion of work necessary in the sewer district's WWTP and sanitary sewer collection system will eliminate the SSO and unpermitted sludge discharge portion of the problem noted in this stream segment. <u>To date, WCSD has installed an additional sewer line which results in greater capacity.</u>*

Comment (3)
Figure A.1 on page A-2 identifies two Pickerington WWTPs. Please clarify that the northern most is the Fairfield County WWTP.

Response
The map in Figure A.1 on page A-2 has been updated to reflect current names and locations of the individual NPDES outfalls in the watershed. There are no longer two locations labeled as the Pickerington WWTP.

Comment (3)
Figure A.2 doesn't properly map Pickerington's MS4 area.

Response
The map of the MS4 areas in the Walnut Creek watershed (Figure A.2) has been updated in Appendix A . Pickerington's MS4 area is properly noted and other errors have been corrected.

Comment (4)
On behalf of the City of Pickerington, EnviroScience, Inc. performed a Level 3 biocriteria study on selected reaches of Sycamore Creek (spanning from RM 4.7 to RM 3.8) in the vicinity of the City's WWTP outfall. This study was conducted under the Ohio EPA-approved Level 3 Credible data Collectors Program project Study Plan titled Final Study Plan for 2009 Biological Survey of Sycamore Creek, Pickerington, Fairfield County, Ohio.

The Draft Walnut Creek Watershed Total Maximum Daily Load (TMDL) Report (page 33 and Appendix B) notes that, based on the findings of Ohio EPA's 2005 investigation on Sycamore Creek, elevated TDS discharged from the City's WWTP adversely effects Sycamore Creek's biological communities and results in non-attainment of WWH criteria. However, preliminary data from EnviroScience's 2009 study indicate that Sycamore Creek, downstream of the discharge, may now meet attainment criteria for WWH. These results suggest that the Draft Walnut Creek watershed Total Maximum Daily Load (TMDL) Report should be amended to reflect this more recent data, which we plan on providing to Ohio EPA in the very near future.

Comment (5)
On behalf of the City of Pickerington, EnviroScience, Inc. performed a Level 3 biocriteria study on selected reaches of Sycamore Creek (spanning from RM 4.7 to RM 3.8) in the vicinity of the City's WWTP outfall. This study was conducted under the Ohio EPA-approved Level 3 Credible data Collectors Program project Study Plan titled Final Study Plan for 2009 Biological Survey of Sycamore Creek, Pickerington, Fairfield County, Ohio.

Enclosed please find a summary of the findings of this study and a copy of the associated data. Based on this data, Sycamore Creek, downstream of the discharge, may now meet attainment criteria for WWH. Accordingly, the City of Pickerington requests that the Draft Walnut Creek Watershed Total Maximum Daily Load (TMDL) Report be amended to reflect this more recent data.

Response
The comment was accompanied by a data summary described as "preliminary." When the final data are submitted, Ohio EPA will review the information and decide if a revision of the aquatic life use (ALU) attainment status is warranted and if revisions to Pickerington's discharge permit are needed. Attainment status will ultimately reflect the most current and valid data from that reach of Sycamore Creek. However, since no TMDLs were developed for listed causes of impairment to Sycamore Creek (namely organic enrichment, low D.O., total dissolved solids, solids, and total toxics), a change in the ALU attainment status does not impact the TMDLs that were developed.

Changes were made in the TMDL report to acknowledge that the City of Pickerington questions Ohio EPA's attainment conclusions and is conducting its own study. This text has been added in captions to tables and figures in Section 4.2 as well as text in Sections 5.2.1, 8.1.2, and 8.2.1 and the captions to Figure 8.5 and Table 8.6.

The category 4B alternative referenced in the report and included as Appendix B is based on permit requirements, so if permit requirements are revised based on the new biocriteria study, the 4B will be altered to reflect the change. U.S. EPA action on 4B alternatives is part of the approval of the 303(d) list, not in individual TMDLs. Based on current circumstances, Ohio EPA would expect to include the Walnut Creek 4B as part of the 2012 303(d) report, along with an update to reflect progress between now and 2012 (including the possibility that the 4B is no longer needed).

References

Ohio EPA. 2006. Biological and Water Quality Study of **Walnut Creek and Tributaries**, Hydrologic Units 05060001 180 and 05060001 170. Fairfield, Franklin, Licking and Pickaway Counties, Ohio. Ohio EPA Biological and Water Quality Report EAS/2006-12-8.