LOADING ANALYSIS INFORMATION SCIOTO RIVER (UPPER) WATERSHED

Table of Contents

D1 BACKGROUND

Table D1-1 provides a background of the aquatic life and recreation uses determined throughout the upper Scioto River watershed. Assessments were carried out during the 2009 field season, with additional data collected in 2010 and 2011.

Table D1-1 Summary of impairment causes and actions taken for aquatic life and recreation uses for the upper Scioto River watershed.

Assessment Unit[1]	Narrative Description	Causes of Impairment	Method to Address
05060001 01 01 *Priority points (3)*	Cottonwood Ditch	Bacteria (recreation use)	*E. coli* LDC
05060001 01 02 *Priority points: 3 (3)*	Headwaters Scioto River	Sedimentation/siltation	QHEI Analysis
		Direct habitat alterations	
		Bacteria (recreation use)	*E. coli* LDC
05060001 01 03 *Priority points: (4)*	Taylor Creek	Bacteria (recreation use)	*E. coli* LDC
05060001 01 04 *Priority points: 3 (3)*	Silver Creek- Scioto River	Natural conditions (flow or habitat)	No action
		Organic enrichment, McCoy	GWLF nutrient
		Bacteria (recreation use)	*E. coli* LDC
05060001 02 01 *Priority points: 4 (3)*	Headwaters Rush Creek	Sedimentation/siltation	QHEI Analysis
		Dissolved oxygen from natural source	No action
		Bacteria (recreation use)	*E. coli* LDC
05060001 02 02 *Priority points: 1 (4)*	McDonald Creek	Nutrient/eutrophication biological indicators	GWLF nutrient
		Organic enrichment	
		Dissolved oxygen	
		Direct habitat alterations	QHEI Analysis
		Bacteria (recreation use)	*E. coli* LDC
05060001 02 03 *Priority points: 1 (4)*	Dudley Run- Rush Creek	Other flow regime alterations	QHEI Analysis
		Direct habitat alterations	
		Natural conditions (flow or habitat)	No action
		Bacteria (recreation use)	*E. coli* LDC

Assessment Unit[1]	Narrative Description	Causes of Impairment	Method to Address
05060001 03 01 *Priority points: 1 (4)*	Rock Fork	Direct habitat alterations	QHEI Analysis
		Fish kills	(This was a 2008 manure spill that the biologists decided to leave on.) No action
		Nutrient/eutrophication biological indicators	GWLF nutrient
		Bacteria (recreation use)	*E. coli* LDC
05060001 03 02 *Priority points: 1 (5)*	Headwaters Little Scioto River	Direct habitat alterations	QHEI Analysis
		Sedimentation/siltation	
		Bacteria (recreation use)	*E. coli* LDC
05060001 03 03 *Priority points: 1 (5)*	City of Marion – Little Scioto River	Sedimentation/siltation	QHEI Analysis
		Direct habitat alterations	
		Dissolved oxygen	City of Marion Combined Sewer Overflow 4B
		Organic enrichment (sewage) biological indicators	
		Metals	
		Abnormal fish deformities	
		PAHs	
		Bacteria (recreation use)	*E. coli* LDC
05060001 03 04 *Priority points: 1 (5)*	Honey Creek – Little Scioto River	Creosote	US EPA Cleanup project
		Ammonia (from CSOs)	City of Marion Combined Sewer Overflow 4B
		Metals	
		Abnormal fish deformities	
		PAHs	
		Organic enrichment	
		Direct habitat alterations	QHEI Analysis
		Nutrient/eutrophication biological indicators (Honey Creek only)	GWLF nutrient
		Bacteria (recreation use)	*E. coli* LDC
05060001 04 01 *Priority points: (6)*	Gander Run – Scioto River		
		Bacteria (recreation use)	*E. coli* LDC
05060001 04 02 *Priority points: 1*	Panther Creek	Nutrient/eutrophication biological indicators	GWLF nutrient

Assessment Unit[1]	Narrative Description	Causes of Impairment	Method to Address
05060001 04 03 *Priority points: (4)*	Wolf Creek-Scioto River	Natural Conditions (Flow or Habitat)	No action
		Bacteria (recreation use)	*E. coli* LDC
05060001 04 04 *Priority points: 1 (1)*	Wildcat Creek	Nutrient/eutrophication biological indicators	GWLF nutrient
		Dissolved oxygen	
		Direct habitat alterations	QHEI Analysis
		Bacteria (recreation use)	*E. coli* LDC
05060001 04 05 *Priority points: (6)*	Town of La Rue – Scioto River	Bacteria (recreation use)	*E. coli* LDC
05060001 04 06 *Priority points: 3 (6)*	Glade Run – Scioto River	Sedimentation/siltation	QHEI Analysis
		Bacteria (recreation use)	*E. coli* LDC
05060001 05 01 *Priority points: 1 (3)*	Patton Run	Sedimentation/siltation	QHEI Analysis
		Bacteria (recreation use)	*E. coli* LDC
05060001 05 02 *Priority points: n/a*	Davids Run-Scioto River	***Insufficient data***	
05060001 05 03 *Priority points: (4)*	Kebler Run	Bacteria (recreation use)	*E. coli* LDC
05060001 05 04 *Priority points: 1 (4)*	Fulton Creek	Direct habitat alterations	QHEI Analysis
		Total phosphorus	GWLF nutrient
		Nutrient/eutrophication biological indicators	
		Dissolved oxygen	
		Organic enrichment	
		Bacteria (recreation use)	*E. coli* LDC
05060001 05 05 *Priority points: n/a*	Ottawa Creek-Scioto River	***No impairment***	

[1] Priority points in parentheses refer to recreation uses.

D2 LINKAGE DISCUSSION

Nutrient enrichment

Nutrients rarely approach concentrations in the ambient environment that are toxic to aquatic life and, in small amounts, are essential to the functioning of healthy aquatic ecosystems. However, excess nutrients can manifest as numerous problems that affect the biological attainment of a stream, including causes of impairment such as:

- Nutrient enrichment (biological indicators)
- Nutrient eutrophication
- Excess primary production
- Dissolved oxygen

These causes are identified by different signatures within the biological community; however, they are intrinsically linked to the root cause of excess nutrients. In general the linkage between the causes of impairment due to nutrients can be described as follows: Nutrients in excess of the needs of a balanced ecosystem increase algal and aquatic plant life production (Sharpley, 1999). This excess primary production causes negative effects, including large diel fluctuations of dissolved oxygen (DO) and potential for DO criterion violations caused by photosynthesis (O_2 production) and subsequent respiration (O_2 consumption). Comprehensive water quality studies in both Ohio and Minnesota have shown high diel fluctuations have strong correlations to declines in biological community performance (Miltner 2010; Heiskary and Markus 2003). Also, in systems where dead organic matter accumulates and decomposes eutrophic conditions can be observed. Such changes shift species composition away from functional assemblages comprised of intolerant species, benthic insectivores and top carnivores typical of high quality streams towards less desirable assemblages of tolerant species, niche generalists, omnivores and detritivores typical of degraded streams (Ohio EPA, 1999). Such a shift in community structure lowers the diversity of the system, thus lowering IBI and ICI scores. This shift may preclude a stream from achieving its aquatic-life use standard. Based on the observed biological indicators, nutrient enrichment occurs in the upper Scioto River watershed.

Phosphorus is selected as the nutrient to of concern for TMDLs because it is frequently the limiting nutrient to algal growth in the fresh water streams of Ohio. In a 2010 study by Miltner only 12 of 109 streams analyzed were not limited by phosphorus based on molar ratios. Miltner also suggests that the functional difficulty in limiting nitrogen makes forcing phosphorus limitation a desirable option, even in streams that are nitrogen limited (Miltner 2010). In effect, limiting the loading of phosphorus to streams reduces the impacts described above caused by excessive algal growth, thus addressing a stream’s nutrient enrichment. Statewide total phosphorus (TP) targets for various size drainage area streams have been developed by Ohio EPA (1999) in order to address excess nutrients impacting aquatic life.

Organic enrichment using total phosphorus as a surrogate

Organic enrichment is a cause of impairment to McCoy, McDonald and Fulton creeks. The source of both of these streams’ organic *and* nutrient enrichment is determined as being from agricultural practices. By limiting TP via the existing nutrient TMDL the organic enrichment is addressed.

The pollutant normally associated with organic enrichment is biochemical oxygen demand (BOD). BOD is a widely used indication of the organic quality of water; it is often defined as the measure of oxygen consuming material. Agricultural sources of BOD are the result of organic matter in livestock manure runoff and the detrital remains of algal growth propagated from subsidized nutrient supply to the stream from agricultural fertilization (Stringfellow, 2008). Agricultural fertilization practices should be modified in such a way that the nutrient TMDL targets can be met. The nutrient TMDL is meant to limit algal production which addresses the detrital component of organic enrichment. Manure is both a direct source of organic matter and a component of agricultural fertilization. If manure is applied using best practices to limit nutrient export to streams; the direct component of organic enrichment will be similarly reduced. Thus successful implementation of a nutrient TMDL will address the impacts of organic enrichment in the watershed.

Habitat alteration and sedimentation/siltation

Habitat alteration and sedimentation are causes of impairment at several assessment sites in the upper Scioto River watershed. Habitat alterations impact biological communities directly by limiting the complexity of living spaces available to aquatic organisms. This is significant to freshwater organisms because they have become specialized over millions of years of evolution to the niche habitats afforded in streams undisturbed by human management (i.e., pre-settlement). Consequently, fish and macroinvertebrate communities tend to lose diversity as stream habitat becomes less diverse. The primary functions of habitat for freshwater organisms are to provide protection from stressful environmental conditions, cover for species to species interactions (e.g., predator-prey) and support for specific food resources. Because of this the development of a load-based TMDL to address this cause of impairment is not possible.

Habitat alteration can result in flow alteration, which is a listed cause of impairment in the upper Scioto River watershed. Under certain circumstances flow alteration can be viewed as the hydrological consequences of habitat alteration. For example, in an agricultural setting, as is much of the upper Scioto River watershed, channelization of streams to facilitate drainage often exacerbates hydrological extremes; high flows get higher and low flows get lower. The high flows contribute to entrainment of excess sediment in the stream system, and the low flows exhibit low dissolved oxygen and high temperatures (US EPA, 2007). For stream assessment areas where flow alteration is identified as the cause of impairment, the habitat QHEI is carried out in this report.

The Qualitative Habitat Evaluation Index (QHEI) is a quantitative expression of a qualitative, visual assessment of habitat in free flowing streams and was developed by the Ohio EPA to assess available habitat for fish communities (Rankin, 1989, 1995). This tool provides a numeric value, which is assigned to a particular stream segment based on the quality of its habitat. The QHEI evaluates six general aspects of physical habitat that include channel substrate, instream cover, riparian characteristics, channel condition, pool/riffle quality, gradient and drainage area. Analysis of QHEI and biological response data by Ohio EPA (1999) determined the most sensitive aspects and breakpoint values for these aspects. Using these aspects/breakpoints as targets to directly address habitat impairment as a TMDL is an explicit method to mitigate impairment. This has been successfully employed by Ohio EPA (Ohio EPA, 2006, 2009).

In terms of TMDLs for sediment, the QHEI characterizes sediment problems with the substrate metric, which has several sub-metrics that deal with fine material (sediment). Despite not providing an absolute quantity (or load) of fine material, it does deal with the relative quantity expressed as a percent of embeddedness of the channel and the percent of silt cover. Likewise the dominant substrate particle size (e.g., sands or silts) is to be scored and finer sized material score fewer points than coarser substrates. These connections are believed to be strong enough and the fact that they can reflect what is adversely impacting the biological community makes the QHEI suitable for developing sediment TMDLs. Also, other methods for developing sediment TMDLs are problematic. An example is using total suspended solids (TSS) as a surrogate for sedimentation (which is commonly done). Data gathered for modeling TSS (e.g., using GWLF, LSPC, or SWAT models) is often unreliable for calibration and validation TSS demonstrates a high degree of variability both over space and time and is very sensitive to local disturbances which could significantly inflate the concentration well above what is representative of the system. Additionally, there are few models that adequately account for in-stream sediment dynamics (e.g., erosion and deposition processes) or they require very high resource expenditures that are often not feasible (e.g., CONCEPTS).

Pathogens (bacteria) recreational use impairments
Elevated bacteria loading is the cause of recreational use impairment for most streams in the upper Scioto River watershed. The proportion of pathogenic organisms present in assessed waters is generally small compared to non-pathogenic organisms. For this reason most pathogenic organisms are difficult to isolate and identify. Additionally, pathogenic organisms are highly varied in their characteristics and type which also makes them difficult to measure. Nonpathogenic bacteria that are associated with pathogens transmitted by fecal contamination are more abundant and are, therefore, monitored as surrogates because of the greater ease in sampling and measuring. These bacteria are called indicator organisms. Ohio has promulgated water quality standards for the geometric mean concentration for *E. coli* fecal coliform bacteria (3745-1-07). These values serve as the targets used in the development of the TMDLs that address recreation use impairments. Therefore the use of *E. coli* to address recreational use impairment is adequate as it is dictated by state law.

D3 ANALYSIS METHODS

Tables D3-1 through D3-3 indicate how the applicable causes of impairment are addressed in each of the assessment units.

Table D3-1 Summary of causes of impairment and actions taken to address them in assessment units within the 05060001 01 and 05060001 02 ten-digit hydrologic units.

Causes of Impairment	Watershed Assessment Units						
	05060001 01				05060001 02		
	01	02	03	04	01	02	03
Aquatic Life Use							
Nutrient enrichment				D		D	D
Habitat alterations		D				D	D
Other flow alterations							S
Sedimentation/siltation		D			D		
Dissolved oxygen/organic enrichment				S	N	S	
Natural conditions				N			N
Recreation Use							
E. coli	D	D	D	D	D	D	D

D – direct: Means that TMDLs are calculated for this parameter
S – surrogate: Means that TMDLs are calculated for a closely related cause and actions to reduce the impact of that cause should be sufficient to address this cause.
N – not addressed: Means that the impairment is not addressed in this report.
Blank: Indicates that the assessment unit is not impaired for this cause.

Table D3-2 Summary of causes of impairment and actions taken to address them in assessment units within the 05060001 03 and 05060001 04 ten-digit hydrologic units.

Causes of Impairment	Watershed Assessment Units									
	05060001 03				05060001 04					
	01	02	03	04	01	02	03	04	05	06
Aquatic Life Use										
Nutrient enrichment	D			D		D		D		
Habitat alterations	D	D	D	D				D		
Sedimentation/siltation		D	D							D
Dissolved oxygen/organic enrichment			4B					S		
Creosote				N						
Ammonia				4B						
Fish kills	N									
Natural conditions							N			
Recreation Use										
E. coli	D	D	D	D	D		D	D	D	D

D – direct: Means that TMDLs are calculated for this parameter
S – surrogate: Means that TMDLs are calculated for a closely related cause and actions to reduce the impact of that cause should be sufficient to address this cause.
N – not addressed: Means that the impairment is not addressed in this report.
Blank: Indicates that the assessment unit is not impaired for this cause.
4B: Means that the 4B option is being used to address impairment.

Table D3-3 Summary of causes of impairment and actions taken to address them in assessment units within the 05060001 05 ten-digit hydrologic unit.

Causes of Impairment	Watershed Assessment Units 05060001 05				
	01	02	03	04	05
Aquatic Life Use					
Nutrient enrichment				D	
Total phosphorus				D	
Dissolved oxygen				S	
Organic enrichment				S	
Habitat alterations				D	
Sedimentation/siltation	D			S	
Recreation Use					
E. coli	D		D	D	

D – direct	Means that TMDLs are calculated for this parameter
S – surrogate	Means that TMDLs are calculated for a closely related cause and actions to reduce the impact of that cause should be sufficient to address this cause.
N – not addressed	Means that the impairment is not addressed in this report.
Blank	Indicates that the assessment unit is not impaired for this cause.

D3.1 Nutrient modeling method (Generalized Watershed Loading Function)

Targets

While the Ohio EPA does not currently have statewide numeric criteria for phosphorus, potential targets have been identified in a technical report titled *Association Between Nutrients, Habitat, and the Aquatic Biota in Ohio Rivers and Streams* (Ohio EPA, 1999). This document provides the results of a study analyzing the effects of nutrients and other parameters on the biological communities of Ohio streams. It recommends statewide total phosphorus (TP) target concentrations based on observed concentrations associated with acceptable ranges of biological community performance. The targets applicable to the upper Scioto River watershed are shown in Table D3-4. It is important to note that these nutrient targets are not codified in Ohio's water quality standards; however, the legal use of these targets in TMDLs has been justified by Ohio EPA (2000).

Table D3-4 Total phosphorus targets applicable to the upper Scioto River watershed

Watershed size	WWH
Headwaters (drainage area < 20 mi^2)	0.08
Wadable (drainage area ≥ 20 mi^2 < 200 mi^2)	0.10

Hydrology method (GWLF)

The hydrologic cycle for the subwatersheds receiving nutrient TMDLs is simulated using the Generalized Watershed Loading Function or GWLF model (Haith, 1992) through the desktop simulation called BasinSim 1.0 (Dai, 2000). The model predicts stream flow based on precipitation, evapotranspiration, land uses and soil characteristics. It is appropriate for the upper Scioto River subwatersheds because it simulates rural and urbanized land use at a mid-level of complexity. Figure D3-1 characterizes the hydrologic model of GWLF.

GWLF simulates runoff, groundwater recharge and stream flow by a water-balance method using measurements of daily precipitation and average daily temperature. These are the only two daily inputs that drive this model. Runoff is calculated using the Natural Resources Conservation Service's Runoff Curve Number method (USDA, 1986). This method determines the amount of precipitation that runs off the surface and is adjusted for antecedent soil moisture before the precipitation event, growing or dormant season, detention potential and soil characteristics. Curve numbers vary by land cover, use and soil type; the higher the curve number the more runoff produced. The predicted surface runoff flow is the quick response flow including interflow and drainage from tiles.

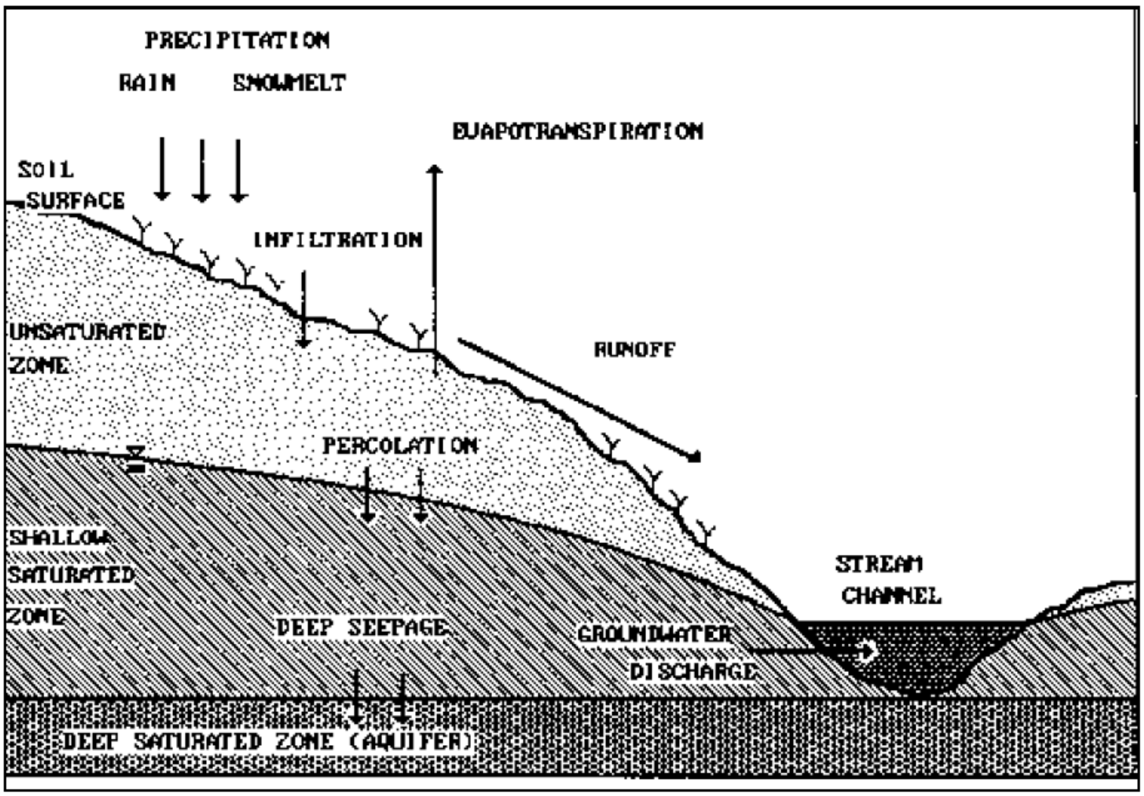

Figure D3-1 GWLF Model hydrology component interaction

Groundwater recharge is determined by tracking daily water balances in the unsaturated and shallow saturated zones. These zones act as reservoirs and have inputs and outputs. The input to the unsaturated zone is the infiltrated water calculated as the amount of the precipitation received less the surface runoff. Water leaves this zone to the atmosphere via plant root uptake through transpiration and down to the shallow saturated zone through percolation. Transpiration is grouped with evaporation to make an evapotranspiration function. GWLF determines a daily potential evapotranspiration based on day light length, temperature and a cover coefficient of plant or crop in the area of interest. If there is enough available moisture in the unsaturated zone, the potential evapotranspiration will be lost to the atmosphere. If the available moisture in the unsaturated zone is less than that day’s potential evapotranspiration, all water in that zone will go to the atmosphere. When the temperature is less than or equal to zero degrees C., there is no evapotranspiration. Percolation occurs daily when the unsaturated zone moisture volume exceeds the storage capacity after any evapotranspiration occurs. The shallow saturated zone receives the percolated water. This zone is treated as a linear reservoir; it can discharge water to the stream as baseflow or lose moisture to deep seepage. Each of these losses is determined by the product of the zone's moisture storage and a specific constant rate coefficient (one for baseflow and one for seepage).

Stream flow is computed as the sum of the groundwater discharge from the shallow saturated zone (baseflow) and the surface runoff. The model computes daily water balance and resulting stream flow, but its output is intended to be used on a monthly temporal scale.

GWLF hydrology is calibrated for the upper Scioto River watershed using the records from the Scioto River near Prospect USGS gage, number 03219500. This gage measures the stream discharge of most of the area covered in this TMDL study, 567 square miles.

The model simulates the USGS gage's watershed using weather stations applicable to the watershed based on geography. This hydrology calibration is carried out for a 30-year period. GWLF predicts stream hydrology on a monthly time step. Initial model simulation hydrology results are compared to the sum of the mean daily flows of the gage.

Hydrology calibration efforts to improve fit agreement with observed cumulative monthly gage flow have been carried out. This is accomplished first through an analysis of model to gage total flows, model to baseflow and model to runoff. Gage baseflow and runoff are estimated for these efforts using a hydrologic stream flow separation algorithm (Sloto, 1996). After analysis, reasonable changes to GWLF transport functions and curve numbers are made whereupon the flow analysis would be repeated. Several calibration simulations have been carried out determining the best fit model setup. Figure D3-2 shows the monthly modeled stream flow versus the monthly gage streamflow of the calibrated hydrology as points on a scatterplot. This figure shows a one to one line that can be used to judge fit. Also a linear regression for the data is plotted. Figures D3-3 and D3-4 show the model to gage baseflow and runoff respectively. These plots additionally have a one to one line and a linear regression noted. Figure D3-5 shows an example of average monthly modeled and gage streamflow being compared. This plot also contains the average monthly precipitation.

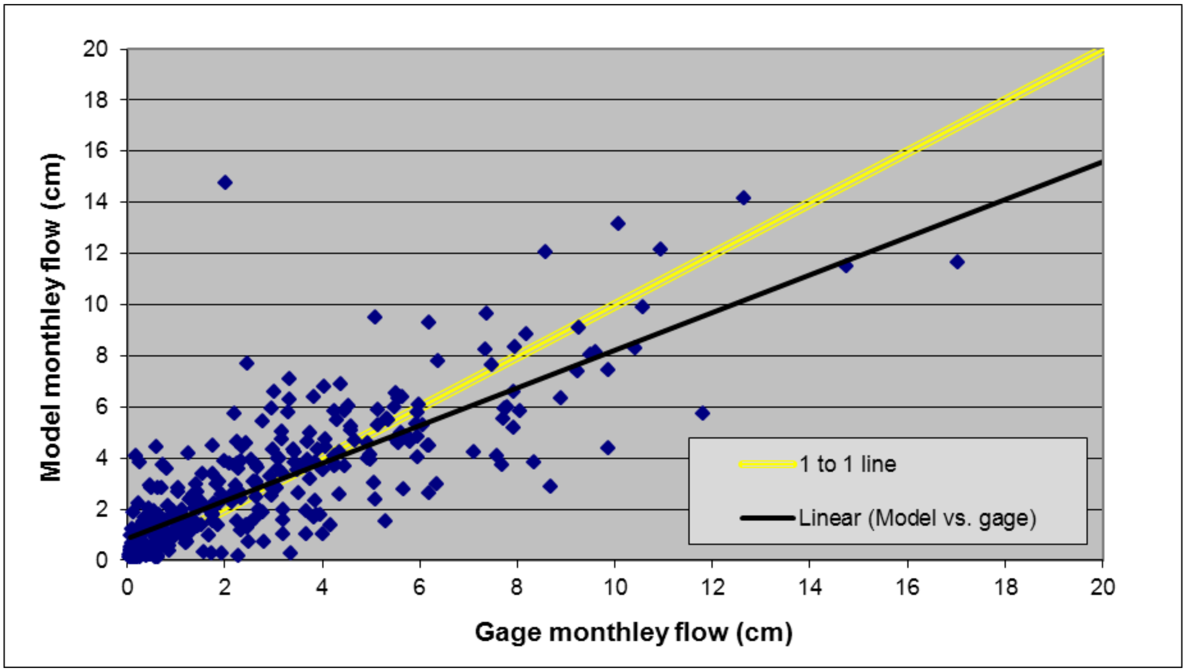

Figure D3-2 Hydrology calibration to the Scioto River at Prospect gage site, total streamflow model versus gage

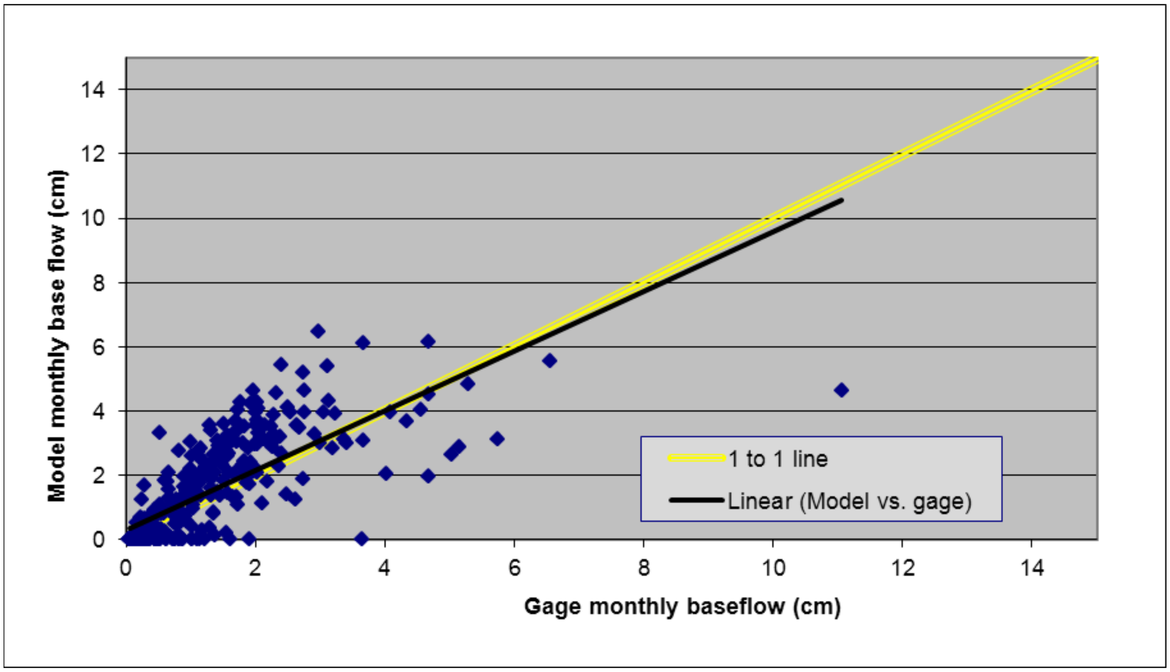

Figure D3-3 Hydrology calibration to the Scioto River at Prospect gage site, baseflow model versus gage

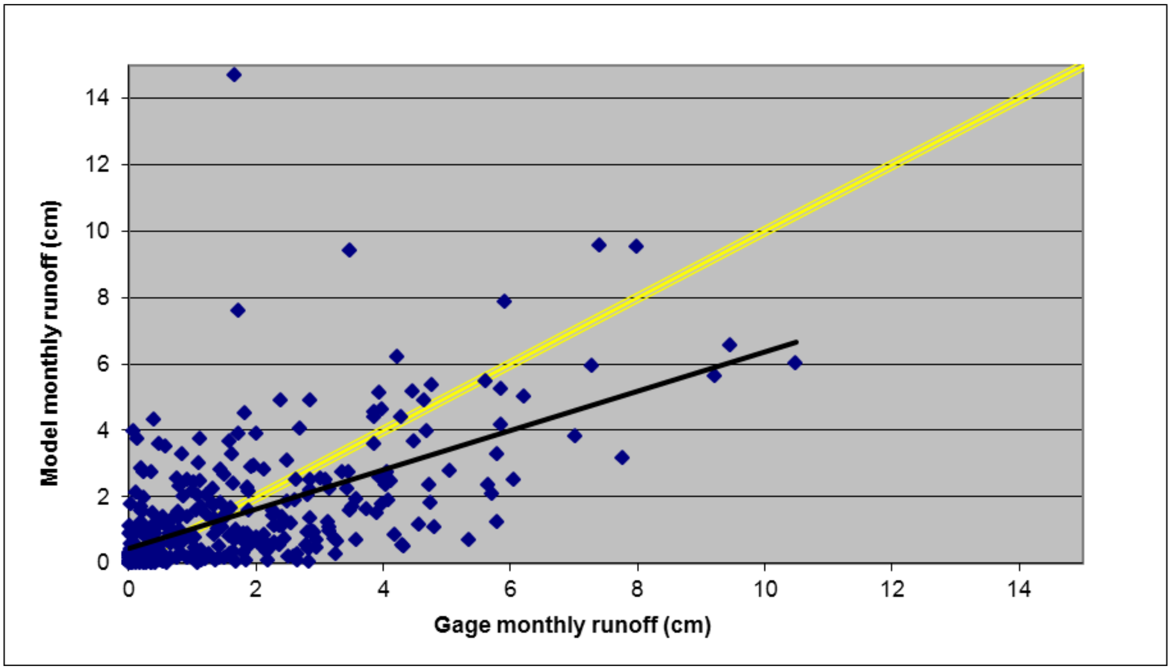

Figure D3-4 Hydrology calibration to the Scioto River at Prospect gage site, runoff model versus gage

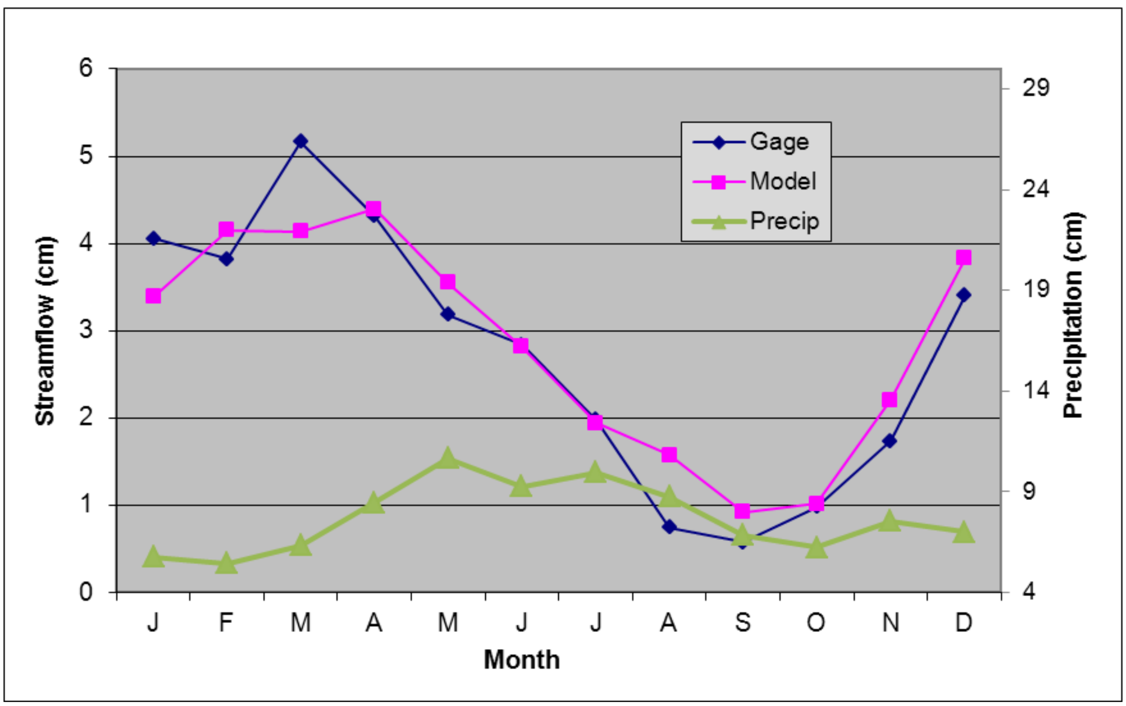

Figure D3-5 Gage and modeled average monthly streamflow for the Scioto River at Prospect. Average precipitation is also shown on a different scale

Tests and statistics are used to determine how well the model predicts various aspects of the gage data. For instance, seasonal and monthly values are examined in addition to runoff versus groundwater baseflow. Two final values are used to determine how well the predicted calibrated model total flow results compare to the observed total flow. 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 that the curve representing the model results is closer to the observed data curve, with 1 being a perfect fit. The predicted to observed ratio indicates if the model is under or over predicting the stream flow, and also indicates how well the two data sets compare. Again, the closer to 1 the better the model match apples to this statistic. An R^2 value of 0.66 and predicted to observed ratio of 0.74 are determined for hydrology of the calibrated upper Scioto GWLF model.

Sources of Data

Land use and weather data are critical components of hydrology functions of GWLF. The National Land Cover Dataset (NLCD) is used as the land cover resource for this study (Homer, 2004). This program distributes weather data measured by the National Climatic Data Center which is part of the National Oceanic and Atmospheric Administration. Daily precipitation and air temperature data acquired from the Midwestern Regional Climate Center are used. The two weather stations used for the upper Scioto River modeling watershed are located in Marion (ID 334937) and Kenton (ID 334189). Whichever station is closest to each watershed's centroid is what is used.

Surface runoff

The GWLF model's BasinSim software application is used to determine the TP load from runoff and groundwater. Table D3-5 shows the runoff TP values for various land uses in this modeling. These values are fixed within a modeling simulation, and are determined from the BasinSim user's manual. GWLF inputs of TP sediment runoff concentrations for various land uses are determined using reference values from the model's user's guide augmented by any known values available. Since the model requires one groundwater phosphorus concentration per watershed, data from Ohio EPA's ambient groundwater sampling program are used. An average value of average TP concentrations from five wells examined yields 0.056 mg/l (standard deviation of 0.019). This value is used for all of the modeled watersheds.

Table D3-5 TP model input values (in mg/l)

Rural land uses	Concentration (mg/l)	Urban land uses	Concentration (mg/l)
Pasture/Hay	0.2500	Transitional	0.1500
Row Crops	0.2000	Urban/Recreational Grasses	0.1500
Deciduous Forest	0.0080	Woody Wetlands	0
Emergent Herbaceous Wetlands	0	Commercial/Industrial/ Transportation	0.0112
Evergreen Forest	0.0080	High-Density Residential	0.0112
Mixed Forest	0.0080	Low-Density Residential	0.0030
Open Water	0	Quarries/Strip Mines/ Gravel Pits	0

Effort is made to further breakdown managed agricultural land uses for GWLF phosphorus modeling. Based on an examination of Ohio EPA's Animal Feeding Operation's Unit, two subwatersheds receiving nutrient TMDLs receive proportionally more land applied livestock manure than the rest of the watershed. Because of this those subwatersheds, the McDonald Creek and lower Rush Creek watersheds (05060001 02 02 and 05060001 02 03 respectively), are modeled with a higher concentration of runoff TP. Table D3-6 below shows the breakdown of pasture and row crop land as modeling for existing conditions.

Table D3-6 Management area breakdown of pasture and row crop

12-dig HUC (05060001)	Name	Total area (acres)	Pasture		Row crop	
			Acre	% of watershed	Acre	% of watershed
01 04 (partial)	McCoy Run	5,228	189.3	3.6	4,386.3	83.9
02 01	Headwaters Rush Creek	38,869	3,557.7	9.2	28,182.9	72.5
02 02	McDonald Creek	9,433	449.6	4.8	8,191.4	86.8
02 03	Dudley Run- Rush Creek (low. Rush Ck)	19,110	344.9	1.8	16,634.1	87.0
03 01	Rock Fork	15,367	145.3	0.9	11,889.6	77.4
03 04 (partial)	Honey Creek	5,058	390.2	7.7	3,587.4	70.9
04 02	Panther Creek	14,815	937.5	6.3	11,485.7	77.5
04 04	Wildcat Creek	14,354	628.2	4.4	11,807.3	82.3
05 04	Fulton Creek	29,868	3,186.9	10.6	25,060.6	83.4

Point sources

The concentration of phosphorus effluent from conventional point source discharges is largely based on discharge monitoring records collected by the individual discharging entities. In the case of several smaller package plants, however, no phosphorus monitoring data is available to characterize the quality of their effluent. For these instances, effluent phosphorus concentrations are based upon historical data from similar sized WWTPs across the state that have effluent data (Metcalf & Eddy, 1991). While the estimated effluent concentrations may result in under or over prediction of the contributed loads, the size of the loads are relatively small when compared to the major dischargers in the sub-basin. To calculate the existing load of TP discharged from these facilities each facility's current effluent flow rates are used. It should be noted that most discharger's effluent flow is well below their facility design flow.

Home Sewage Treatment Systems (HSTSs)

The number of HSTSs and the percentage of those which are failing are determined via GIS analysis and Ohio Department of Health resources. The number of HSTSs in each subwatershed is estimated based upon 1990 and 2000 census demographic geospatial information by the use of GIS analysis. The percentage of failing HSTSs is set at 23% a failure rate. This general value is based on a statewide survey of HSTS and their failure rates (ODH, 2008). HSTS pollutant loads are estimated as the product of 1) the number of persons served by failing systems in each subwatershed, again using census data broken down by GIS, 2) a per capita wastewater flow-rate and 3) representative wastewater-quality pollutant concentrations (Metcalf & Eddy, 1991).

This method of calculating HSTS loads does not discriminate between HSTS systems that are designed to be discharging (i.e., aeration tanks) or non-discharging (i.e., leach fields). Since the TP load delivered to streams is expected to be zero, knowing this breakdown is unnecessary. This is further explained below.

Existing load and water quality calibration

The GWLF model was simulated for two nutrient TMDL subwatersheds, Rock Fork and Fulton Creek to facilitate water quality calibration. These model simulations examined what is considered to be each watershed's existing condition. To simulate this condition the point sources are set at the current average daily flows. Modeling results mirrored differences in the watershed's TP water quality data, in most flows. The model does not properly predict TP in low flows, and in these circumstances the TP concentration becomes much higher than ever observed. This is in large part due to this model's conservative nature; it is unable to incorporate instream assimilating processes that result in a seeming decay of TP concentration. In order to calibrate for the models lack of in-stream processing, a 15% reduction in output model loads was found to best fit observed data. This across the board reduction on output data was required because GWLF does not have the functionality to simulate this type of nutrient sink. Due to the limited nature of observed water quality data available, the decision to not use low flow water quality model results has been made. This is appropriate given the critical condition being used for the TMDLs (see next sub-section). More robust data do not exist to substantiate further adjustments to the water quality inputs of the model.

Modeling condition, margin of safety and future growth
A single TMDL critical condition is determined to consider all sources of loading for these TP TMDLs. The average load delivered during the mid-flow periods will be this condition; specifically the 40^{th} to 60^{th} exceedance percentile flow regimes. This flow condition is used in order to create straightforward TMDLs that consider the loads from both point and non-point sources of TP as significant contributors. This is also an appropriate flow condition considering the heavy agricultural land use and relatively flat geography of this watershed. The nutrient loads that runoff from agricultural practices during higher flow regimes must flow into the myriad ditches and then larger streams. The residence time of these nutrients persist long enough in the watershed well into periods of lower flows. While these lower flow conditions occur when biologic life is most at stress due to nutrient enrichment, it is the nutrients delivered during the runoff periods that are a significant cause of the enrichment.

All of the nutrient TMDL subwatersheds are simulated using GWLF to determine the stream flow and TP load at the critical condition. These GWLF model simulations are set to predict conditions applicable for future resource management of the watershed. This includes setting the NPDES dischargers to their full permitted design flow. No NPDES dischargers are expecting any expansions or increases to their existing facilities discharge flow. The Ohio Fresh Eggs, Mt. Victory facility, is expected to receive an NPDES permit with two discharge points to McDonald Creek. With the assistance of Ohio EPA's Animal Feeding Operation Unit, flows for these discharges have been calculated for the nutrient critical condition. These discharges have also been included in the future conditions model simulations.

The TMDL loading capacity for each subwatershed is determined by taking the product of the average critical condition stream flow and phosphorus concentration target.

To account for model uncertainty an explicit margin of safety (MOS) is included in the TP nutrient TMDLs. The Modeling and Assessment Section at Ohio EPA currently applies a standard 5% explicit reserved load for this MOS when using watershed model nutrient TMDLs. There are implicit MOS included in these TMDLs, because of the numerous conservative assumptions made throughout this modeling process. These assumptions include:

- The median flows are used for the TMDL condition. This condition excludes peak flows and provides a lower flow that is used to calculate the loading capacity and ultimately a lower set of allocations.
- The mostly reference values for nutrient inputs are on the high side of recommended ranges.

Population projections for this watershed show insignificant growth in Marion and Hardin counties. Union and Delaware counties are expected to have continued growth, but not in the parts of those counties contained by this watershed. Because of this, a relatively low allowance for future growth (AFG) is reserved from the TMDL load, 2%. This AFG is adequate to incorporate load from future HSTS general permits.

Allocation of the loading

The following describes how TP loads are allocated for each nutrient TMDL: First the 5% for MOS and 2% for allowance for future growth are subtracted from the loading capacity.

Some HSTSs are discharging systems, generally these are systems with aeration tanks, and some HSTSs are considering non-discharging via the use of leech fields. Discharging HSTSs are considered point sources and any TP load resulting from a poorly performing non-discharging HSTS are considered nonpoint sources. The TP load from a properly working non-discharging system, by design should not reach surface waters. HSTSs that are brought into compliance and will be discharging are required to obtain a general NPDES permit for discharging HSTSs from Ohio EPA. No permits have been issued in the nutrient enriched subwatersheds of Upper Scioto River however, and at this time few are expected to become permitted within the next 10 years. Therefore a zero load allocation for both point and nonpoint sources of HSTS is allocated.

Point source facilities with a design flow greater than 0.025 million gallons per day (MGD) are allocated to 1.0 mg/l of TP multiplied by their design flow. For point sources with less than a 0.025 MGD design flow, two scenarios are developed for the watershed these plants discharge to. The first scenario allocates these plants to a TP concentration limit of 1 mg/l. The second scenario gives these plants no TP limits, and therefore no reduction in TP load from these sources.

The remaining loading capacity is allocated to nonpoint sources (the load allocation) and MS4 runoff sources in a manner that requires those sources to reduce by an equal proportion. Even though both are nonpoint sources, MS4 is considered a wasteload allocation because it is permitted. Table D3-7 shows this process.

Table D3-7 Summary of nutrient TMDL (total phosphorus) development

Development step	Source		Method
Existing conditions without loading reductions	Point source		Product of discharger average existing flow and current average (or estimated) P effluent concentrations.
	Nonpoint source		GWLF nutrient model simulation.
	HSTS		Population served by failing HSTS is estimated via GIS. Total P load based upon population estimate and a per capita loading rate.
Calculation of loading capacity	-		Product of the average critical condition stream flow (i.e., mean of the flows between the 40th and 60th percentiles) and the total P target concentration.
Allocation	WLA	NPDES Point Sources	Product of design flow rate and a proposed effluent limitation of 1.0 mg TP/ml for all plants with greater than 0.025 MGD design flows. Two scenarios are developed for plants with less than 0.025 MGD design flow; one with the 1.0 mg/l limit and another with no limit.
		MS4	MS4s are allocated a portion of the total LA. MS4s allocations are the product of the percentage of the sub-basin area occupied by MS4s and the surface runoff allocation (the remaining load after the other wasteload allocations, MOS and AFG).

Development step	Source		Method
		HSTS	Discharging HSTSs are allocated a total P load of zero. This load is not shown in the results section.
	LA	Nonpoint source	Sum of all WLAs, MOS, AFG and background runoff subtracted from the assimilative capacity.
		HSTS	Non-discharging HSTSs are allocated a total P load of zero. This load is not shown in the results section.
	Margin of safety		Five percent of the assimilative capacity is reserved for the margin of safety.
	Allowance for future growth		Two percent of the assimilative capacity is reserved for potential future growth.

D3.2 Habitat and sediment method (Qualitative Habitat Evaluation Index)

Modeling framework selection
Components of the Qualitative Habitat Evaluation Index (QHEI) are used for the habitat and sediment TMDLs in this report. This subsection contains explanations of the QHEI and the development of using it as TMDLs.

The QHEI is an index to evaluate stream habitat quality. The index has six metrics (e.g., substrate quality) each of which is further divided by sub-metrics which often account for discrete habitat features (e.g., a specific size class of substrate). Based on a visual assessment of the study reach (typically 150-200 meters in length), a numeric value is assigned to indicate the quality of its habitat. This is determined by the sum of the scores for each of the metrics. The number values do not represent the quantity of any physical properties of the system but solely provide a means for comparing the quality of stream habitat between various locations. However, even though the numeric value is derived qualitatively, subjectivity is minimized because scores are based on the presence and absence and relative abundance of unambiguous habitat features. Objectivity was an important consideration in developing the QHEI and has since been evidenced through minimal variation between scores from various trained investigators at a given site as well as consistency with repeated evaluations (Rankin, 1989).

The six general aspects of physical habitat that the QHEI evaluates include channel substrate, instream cover, riparian characteristics, channel condition, pool/riffle quality, and gradient. Within each of these metrics, points are assigned to the sub-metrics based on their ecological utility as well as their relative abundance in the system. Demerits (i.e., negative points) are also assigned if certain habitat features or conditions are present which reduce the overall utility of the habitat (e.g., heavy siltation and embedded substrate). These points are summed within each of the six metrics to give a score for that particular aspect of stream habitat. The overall QHEI score is the sum of all of the metric scores.

Targets for the habitat TMDLs
For decades the Ohio EPA has used the QHEI to help understand the causes of aquatic life use impairment as well as in assigning appropriate aquatic life uses to stream segments. The strong correlation between the paired scores of the QHEI and the Index of Biotic Integrity (IBI), an important biometric in Ohio’s water quality standards, supports the idea that the QHEI is

assessing aspects of the stream system that are relevant to biological performance. The reliability that the QHEI demonstrates in predicting biological performance (the basis for aquatic life use attainment) as well as the relative ease of its application is the reason it is selected as the basis for the sediment and habitat TMDLs.

The numeric value assigned to a stream segment through the Qualitative Habitat Evaluation Index (QHEI) is qualitatively derived, however it is based on the presence and absence and relative abundance of unambiguous habitat features. QHEI scores can range from 12 to 100. The appropriate QHEI habitat target score is determined by statistical analysis of Ohio's statewide database of paired QHEI and IBI scores. Simple linear and exponential regressions and frequency analyses of combined and individual components of QHEI metrics in relation to the IBI have been examined. The regressions indicate that the QHEI is significantly correlated with the IBI. Scores greater than 75 indicate excellent stream habitat. Scores between 60 and 75 indicate good habitat quality and scores less than 45 demonstrate habitat not conducive to warm water habitat (WWH) (Ohio EPA, 1999).

The analysis of the QHEI components as they relate to IBI scores led to the development of a list of attributes that are associated with degraded communities. These attributes are modifications of natural habitat and are listed in Table D3-8. Modified attributes are further divided into high influence and moderate influence attributes based on the statistical strength of the relationships. The presence of these attributes can strongly influence the aquatic biology, and the QHEI score itself may not reflect this effect. Since other, less influential, habitat components are present, a QHEI score can be above 60 though habitat is impaired. Because of this, an accumulation of four modified attributes corresponds to fewer than 50% of sites achieving a WWH target IBI score of 40. High influence modified attributes are particularly detrimental. The presence of one is likely to result in impairment, and two will likely preclude a site from achieving an IBI of 40. The QHEI score of 60 or greater is correlated with IBIs of 40 or greater. These three factors appear to have about an equal weight. A complete habitat TMDL needs to reflect both a good QHEI score and the relative absence of these modified attributes (Ohio EPA, 1999).

The habitat TMDL equation presented in Table D3-9 reflects the relationship between the QHEI score, modified attributes and aquatic community performance. The TMDL is based upon a total score of three (3), and is the sum of three component scores each worth one point.

Table D3-8 QHEI modified attributes

QHEI categories	Modified attributes	
	High influence	Moderate modified attributes
QHEI score	- 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

QHEI categories	Modified attributes	
	High influence	Moderate modified attributes
		- High/moderate embeddedness - Ext/mod riffle embeddedness - No riffle

Table D3-9 Targets of the habitat TMDL

Scores for the TMDL							
QHEI score >= 60	+1	One or less of the high influence attributes present	+1	Four or less of the modified attributes present (high and moderate influence together)	+1	=	3

Targets for the sediment TMDLs

In the upper Scioto River watershed, several streams have sedimentation listed as a cause of impairment. In order to address this, numeric targets for sediment are also based upon the QHEI metrics. The QHEI substrate, riparian characteristic, and channel metrics all evaluate stream attributes related to sediment. Each of these factors influences the degree to which sediment affects a stream, and cumulatively serves as its numeric target.

The substrate metric evaluates the dominant substrate materials (i.e., based on texture size and origin) and the functionality of coarser substrate materials in light of the amount of silt cover and degree of embeddedness. This is a qualitative evaluation of the amount of excess fine material in the system and the degree to which the channel assimilates (i.e., sorts) the loading. The channel morphology metric considers sinuosity, riffle and pool development, channelization and channel stability. Except for stability each of these aspects are directly related to channel form and consequently how sediment is transported, eroded and deposited within the channel itself (i.e., this is related to both the system's assimilative capacity and loading rate). Stability reflects the degree of channel erosion which indicates the potential of the stream as being a significant source for the sediment loading. The bank erosion and riparian zone metric also reflects the likely degree of in-stream sediment sources. Finally, the evaluation of floodplain quality is related to the capacity of the system to assimilate sediment loads.

The individual components of the sediment TMDL are QHEI metric scores for substrate, channel and riparian. These metric target scores are based on the same associations made between QHEI and IBI results as explained in the habitat TMDL above (Ohio EPA, 1999). Table D3-10 show the minimum scores expected for the sediment TMDL.

Table D3-10 Targets of the sediment TMDL

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

TMDL using QHEI components

The empirical nature of the QHEI and the data that underlie it provide measurable targets that are parallel concepts to a loading capacity for a pollutant. By the scoring of metrics the QHEI provides a way to evaluate whether habitat is a limiting factor for the fish community, and by listing modified attributes the QHEI shows what are the likely stressors. These attributes could account for probable sources of sediment (i.e., riparian corridor, bank stability) and the effects on the stream itself (i.e., the historic sediment deposition). Because of this, the QHEI has aspects of both a loading model and a receiving stream model. When used with biological indices, the numeric measurability of the QHEI provides a means to monitor progress when implementing a TMDL and to validate that a target has been reached.

In summary, the reasonable connection between sedimentation and the QHEI, the strong correlation between QHEI score and biometrics, and the fact that other quantifiable indicators of sedimentation are typically problematic in their own right, justifies use of the QHEI for sediment TMDLs.

Margin of Safety
A MOS is implicitly incorporated into the sediment and habitat TMDLs through the use of conservative target values. The target values are developed though a 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 are analyzed to determine their magnitude at which WWH attainment is probable. Attainment does, however, occur at levels lower than the established targets. The difference between the habitat and sediment targets and the levels at which attainment actually occurs is an implicit margin of safety.

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

Allowance for Future Growth
Since no explicit loads are calculated for the habitat and sediment TMDLs, no future growth load can be allotted.

D3.3 Pathogen modeling (load duration curves)

An empirical method of determining TMDL bacteria loading and reductions is utilized in this report via load duration curves (LDCs). This method is appropriate since the sources of bacteria in Ohio streams can be differentiated by stream flow regime, as explained below. The main advantage of the use of LDCs is that it evaluates loading patterns within specific ranges of stream flow. This provides insight to importance of run off versus point sources or other loading that is not in response to overland wash off. The main shortcoming of this method is its lack of being able to differentiate various sources that may occur in the same flow regime (such as cows in stream and poorly operating home sewage treatment systems during periods of low flow).

Target development
TMDL numeric targets for *E. coli* bacteria are derived from bacteriological water quality standards. The criteria for *E. coli* specified in OAC 3745-1-07 are applicable outside the mixing zone and vary according to recreation use designation (e.g., class A, B, or C Primary Contact). The Scioto River downstream of its confluence with Taylor Creek and the Little Scioto River are both Class A streams in this watershed. This class indicates the most intensive recreation use.

The remainder of streams assessed in this watershed primary contact is designated Class B with the exclusion of Cottonwood Ditch. Cottonwood Ditch is primary contact designated Class C. For Class A streams the criteria states that the geometric mean of more than one *E. coli* sample taken in each recreational season (May through October) shall not exceed 126 colony forming units (cfu) per 100 ml. For Class B and C streams the geometric mean of more than one *E. coli* sample taken in each recreational season shall not exceed 161 and 206 cfu per100 ml respectively.

TMDLs are created for watersheds that drain to an assessment site that is not meeting the recreational use criterion described in the paragraph above. The criteria values are used as the TMDL targets for this impairment. If an LDC TMDL site within a Class B stream section, but within five river miles of a Class A designated section, then the Class A aspect of the criterion is applied to this TMDL.

Load duration curve development

To create TMDL LDCs, the flow duration for each TMDL site is determined. This involves calculating the flow expected for the full range of exceedance percentile. Since this beneficial use is only applicable to the recreation season, May through October, the stream flows used to calculate this range of exceedance percentile is only that of flows occurring May through October. Exceedance percentile stream flows are the probability that a given flow magnitude is exceeded. This normalizes the flows to a range of natural occurrences from extremely high flows (zero exceedance percentile) to extremely low flows (100). The flow curve is converted into a load duration curve by taking the product of each flow values, the water quality geometric mean standard and a conversion factor. These values, in *E. coli* counts per day are the TMDL for each flow condition. The resulting points are plotted to create a LDC. The LDC is broken up into five flow regimens and TMDL allocations are made for each of these regimens. The TMDL value used for these calculations is that at the middle of each flow regime.

The water quality samples for each impaired site are converted into loads by taking the product of the *E. coli* sample result, the flow at the time the sample was collected and a conversion factor (0.02446 for cfu/100 ml to Billion-org/day). Each calculated load is plotted as a point on the LDC plot and is then compared to the water quality TMDL load. Points that plot above the LDC represent deviations from the water quality standard and the daily allowable load. Points that plot below the curve represent samples in compliance with standards and the daily allowable load.

Water quality samples on the LDC curves are noted as diamonds. Samples taken when storm flow is greater than 50% of the flow are noted with the diamond with a red dot in the center (noted as “>50% SF” in the figures legend). This flow condition is determined using the sliding-interval method for streamflow hydrograph separation contained in the USGS HYSEP program (Sloto, 1996).

Box plots are shown for each flow regime with observed data. The center line of these boxes represents the median *E. coli* load for that flow regime. The top and bottom of the boxes represents the 75th and 25th percentiles respectively. The upper and lower vertical bar tails are the maximum and minimum observed loads respectively.

The load duration curves are grouped into five flow regimes noted with vertical lines and labels. These regimes are defined as the following:

- <u>High flow zone:</u> Stream flows in the 0 to 5 exceedance percentile range; these are related to flood flows.
- <u>Wet weather zone:</u> Flows in the 5 to 40 exceedance percentile range; these are flows in wet weather conditions.
- <u>Normal range zone:</u> Flows in the 40 to 80 exceedance percentile range; this are the median stream flow conditions.
- <u>Dry weather zone:</u> Flows in the 80 to 95 exceedance percentile range; these are related to dry weather flows.
- <u>Low flow zone:</u> Flows in the 95 to 100 exceedance percentile range; related to drought conditions.

All of the area beneath the TMDL curve is considered the *E. coli* loading capacity of the stream. The difference between this area and the area representing the current loading conditions is the load that must be reduced to meet water quality standards/targets. The final step to create an LDC is to determine where reductions need to occur. Samples in exceedance at the right side of the graph occur during low flow conditions, and significant sources might include wastewater treatment plants, malfunctioning home sewage treatment systems, illicit sewer connections and/or animals depositing waste directly to the stream. Any exceedance on the left side of the graph occurs during higher flow events and potential sources are likely land uses or management practices such as manure spreading or livestock production. These supply bacteria that are washed off upland areas with runoff. The LDC approach helps determine which implementation practices are most effective for reducing loads. Table D3-11 shows various pollutant sources and the flows contributing to their occurrence.

Table D3-11 Load duration curve flow zones and typical contributing sources

Contributing Source Area	Duration Curve Zone				
	High	Moist	Mid-Range	Dry	Low
Point source				M	H
Livestock direct access to streams				M	H
Home sewage treatment systems	M	M-H	H	H	H
Riparian areas		H	H	M	
Storm water: Impervious		H	H	H	
Combined sewer overflow (CSO)	H				
Storm water: Upland	H	H	M		
Field drainage: Natural condition	H	M			
Field drainage: Tile system	H	H	M-H	L-M	
Bank erosion	H	M			

H = high influence; M = moderate influence; L = low influence

Most sites with LDCs developed to be bacteria TMDLs are at what Ohio EPA refers to as sentinel sites. These sites are picked to represent HUC 12s and/or important drainage areas. The sites are sampled more frequently than the other survey sites. Water stage to stream discharge rating curve relationships are also created for each sentinel site. Knowing the stream discharge at each sampling of these sites allows for load calculations to be made without relying on the extrapolations to stream gages. Some additional non-sentinel sites are also utilized to create LDCs for bacteria TMDLs. These assessment sites were found to be impaired for that stream's recreational use, but do not have a sentinel site representing them. Table D3-12 shows the sentinel and non-sentinel sites and their drainage area. In order to determine each LDC's flow interval, stream flows are extrapolated to a USGS gage (station # 03219500 Scioto River near Prospect, OH). A simple drainage area ratio of the LDC site's watershed to the USGS gage's is then applied to the gage flows.

Table D3-12 LDC *E. coli* TMDL sites and their drainage areas

12-Digit HUC (05060001)	Stream Name	Class	Location	River Mile	Drainage Area (Sq. mi.)
01 01	Cottonwood Ditch	B[1]	Dst. McGuffey WWTP @ RR bridge	0.68	19.3
01 02	Scioto River	B	Arbogast Rd.	234.40	18.3
01 03	Taylor Creek	A[2]	State Route 67	0.76	16.3
01 04	Silver Creek	A[2]	State Route 67	2.32	11.3
02 01	Rush Creek	B	Winnimac Rd.	14.50	50.0
02 02	McDonald Ck	A[2]	State Route 37	2.70	12.3
02 03	Rush Creek	B	Mt. Olive-Green Camp Rd.	5.39	77.0
03 01	Rock Fork	A[2]	Kenton-Galion Rd.	1.10	23.1
03 02	L. Scioto R.	A	Marion @ Kenton-Galion Rd.	11.11	47.0
03 03	L. Scioto R.	A	Upstream Marion WWTP	6.50	86.0
03 04	L. Scioto R.	A	Owens-Green Camp Rd. (CR 104)	0.40	113.0
04 01	Scioto River	A	Leighton St.	212.50	160.0
04 03	Scioto R.	A	TR 199	207.30	178.0
04 04	Wildcat Ck.	A[2]	Larue-Kenton Rd. nr. Larue	0.49	22.2
04 05	Scioto R.	A	State Route 37	196.10	258.0
04 06	Scioto R.	A	Adj. Green Camp River Rd.	179.10	407.0
05 01	Patton Run	A[2]	Boundary Rd.	2.25	14.4
05 03	Kebler Run	A[2]	S of Prospect @ River Rd.	0.87	14.3
05 04	Fulton Creek	A[2]	St. Rt. 257	0.22	46.9

[1] Cottonwood Ditch is designated a Class C recreation use stream, however the LDC assessment site is within 5 river miles of its mouth into a Class B stream; therefore the Class B criteria is applied to this TMDL

[2] The TMDL for these watersheds are developed based on Class A recreation use criteria because the assessment site is within 5 river miles of a Class A segment.

Modeling condition, margin of safety and future growth

In order to use the LDCs developed for bacteria TMDLs an additional flow adjustment must be made. To account for all expected future growth in the watershed, TMDLs require that permitted public waste water treatment facilities be allocated at their full permitted design flow. Because of this the additional flow must be added into the flow duration curve. Since this flow is expected no matter what the flow regime of the stream, the additional flow is added across all flow conditions. Adjustments that are made for additional future growth are discussed below.

An explicit margin of safety (MOS) is computed in the upper Scioto River TMDLs. The MOS is used to reserve assimilative capacity and accounts for uncertainty in the LDC approach and in monitoring information. A 20% MOS is applied to account for broad fluctuations of *E. coli* concentrations that occur in nature and the relatively low number of data points available for this analysis. For LDC TMDLs, US EPA (2007) recommends this type of MOS for two reasons: 1) allocations will not exceed the load associated with the minimum flow in each regime; and 2) recognition that the uncertainty associated with effluent limits and water quality may vary across different flow conditions.

The critical condition for pathogens is the summer dry period when flows are lowest, and thus the potential for dilution is the lowest. Growth rates are higher and mortality rates lower in the warmer months further making this a critical time of the year for bacteria contamination. Likewise, summer is the period when the probability of recreational contact is the highest. For these reasons recreational use designations are only applicable in the period May through the end of October. Pathogen TMDLs are developed for the same time period in consideration of the critical condition, and for agreement with this uses criteria.

Permitted dischargers with NPDES permits that currently require disinfection (mostly WWTPs), are given a WLA of the product of their design flow, the target *E. coli* concentration and a conversion factor. Since these facilities operate no matter what the stream flow, their WLA is the same for all five flow regimes. The target bacteria concentration is set to the recreation use criteria, outlined above, applicable to the stream the effluent is discharged to. The exception to this is if the discharge point is within five river miles of a more restrictive primary contract recreation class. In these cases the criteria for the more restrictive class is applied to the discharge.

The City of Marion has combined sewer overflows (CSO) to the Little Scioto River watershed. The City has submitted to Ohio EPA a CSO Long Term Control Plan (LTCP), and the City's current NPDES permit dictates a schedule of compliance to follow their LTCP. This plan addresses the discharge of all CSO outfalls. This LTCP is to be fully implemented by the year 2020. US EPA 1995 outlines demonstration approach criteria for a successfully implemented CSO LTCP. The first criterion explains that the control plan must provide adequate protection so that a receiving stream can meet its designated uses. The second outlines that after implementation, if the remaining discharges prohibit uses to be attained, and other sources are not responsible, then a TMDL must be created to apportion pollutant loads. Since complete implementation of Marion's plan is paramount to determining if it provides adequate protection to beneficial stream uses, this is currently an unknown. Because of this each CSO has been allocated zero discharge for *E. coli*. This conservative approach is considered reasonable in light of the uncertainty explained above. The CSOs are not listed individually on the tables below.

In one assessment unit in the L. Scioto River watershed, HUC 05060001 03 04, ammonia is another cause of impairment. The source of this ammonia is the City of Marion's CSOs discharge. Implementing The LTCP should eliminate the impairment, as outlined in the 4B analysis in Appendix F.

The allocated loads of *E. coli* from home sewage treatment systems or direct manure deposits from livestock for the TMDLs are set to zero. This is because properly functioning HSTSs and proper livestock management should preclude *E. coli* and other pathogenic materials from being discharged to waters of the state.

The load remaining after the MOS and NDPES point source loads are allocated is divided between runoff from MS4 areas and non-MS4 areas. Since runoff from MS4s is regulated by Ohio EPA, this allocation is considered a WLA. The non-MS4 runoff is a LA. This division is carried out simply by applying the land area ratio of each type (MS4 and non-MS4) to the remaining E. coli load allowed for each TMDL. Specific MS4s are subdivided and identified on the bacteria TMDL tables.

Population projections for this watershed show insignificant growth in Marion and Kenton counties. Union and Delaware counties are expected continued growth, but not in the parts of those counties contained by this watershed. Because of this, a relatively low allowance for future growth (AFG) is reserved from the TMDL load, 2%.

D4 RESULTS

This section summarizes TMDLs results.

D4.1 Nutrient modeling results

This subsection outlines the nutrient TMDL results. Table D4-1 shows the existing and TMDL loads for each watershed receiving these TMDLs. The columns under “existing loads” show the loads from the GWLF model simulations (i.e., NPS). Along with total load, the point source (PS) and nonpoint source (NPS) are separated out in these columns. The columns under “allocations” breaks out the allocations for loading regulated through NPDES permits (HSTSs and public waste) and MS4s (WLA), unregulated nonpoint source loading (LA), a reserved loading for future NPDES based loading (AFG), and a margin of safety taken away from the total allotment (MOS) to better ensure that water quality problems will be resolved upon achieving the TMDL prescribed loadings. Table D4-2 shows the nonpoint source load allocation along with this allocations load per acre. Table D4-3 shows the specific NPDES permits’ existing and TMDL wasteload allocations.

A column on table D4-1 notes nonpoint source loads reduction required. In general watersheds with higher nutrient loads require a greater reduction percentage. Table D4-3 shows that a TP limit of 1.0 mg/l is recommended for all regulated NPDES permitted dischargers in these nutrient impaired watersheds except for plants with less than 0.025 MGD design flow. Two subwatersheds have NPDES discharges with less than 0.025 MGD design flows, 12-digit HUCs, 05060001 02 02 and -03 04. Two TMDL scenarios are presented for these watersheds. The first one, labeled “A”, shows the permitted outfalls with the lower design flows to have a 1.0 mg/l TP limit. Under the second scenario, labeled “B”, these outfalls receive no TP limit and thus continue to discharge at current loads. For most wastewater treatment plants in this watershed, a limit of 1.0 mg/l results in a notable reduction in point source nutrient load.

Table D4-1 Nutrient TMDLs, all loads in TP (kg-P/day)

12-Digit HUC (05060001)	Subwatershed	Existing Loads			NPS Reduction	TMDL	Allocations			
		PS	NPS	Total			WLA	LA	AFG	MOS
01 04[1]	McCoy Run	0.00	2.83	2.83	61.4%	1.18	0.00	1.09	0.02	0.06
02 02A[2]	McDonald Creek	0.26	4.46	4.72	59.7%	2.11	0.17	1.80	0.04	0.11
02 02B[2]					60.5%		0.20	1.76		
02 03	Lower Rush Creek	0.34	9.68	10.02	51.1%	5.50	0.38	4.74	0.11	0.28
03 01	Rock Fork	3.82	5.79	9.62	51.0%	5.25	2.05	2.84	0.10	0.26
03 04A[1,2]	Honey Creek	0.66	2.43	3.09	69.6%	1.16	0.34	0.74	0.02	0.06
03 04B[1,2]					86.2%		0.75	0.34		
04 02	Panther Creek	1.14	7.47	8.60	51.7%	4.25	0.34	3.61	0.08	0.21
04 04	Wildcat Creek	0.00	7.35	7.35	48.2%	4.09	0.00	3.81	0.08	0.20
05 04	Fulton Creek	3.38	13.51	16.89	50.6%	8.73	1.44	6.68	0.17	0.44

[1] These TMDLs are only for the portion of the HUC noted in the subwatershed column.
[2] “A” and “B” represent different scenarios for allocating the same TMDL value. Scenario “A” has lower wasteload allocations which require new NPDES permit limits for one or more facilities; scenario “B” does not require new NPDES limits and therefore has a larger wasteload allocation, but then requires a greater reduction in nonpoint source loading to achieve the associated lower load allocation.

Table D4-2 Nonpoint source allocations for the nutrient TMDLs

12-Digit HUC (05060001)	Subwatershed	Allocations LA (kg-P/day)	Allocations NPS (kg-P/acre/day)
01 04[1]	McCoy Run	1.09	2.09E-04
02 02A	McDonald Creek	1.80	1.91E-04
02 02B	McDonald Creek	1.76	1.87E-04
02 03	Lower Rush Creek	4.74	2.48E-04
03 01	Rock Fork	2.84	2.07E-04
03 04A[1,2]	Honey Creek	0.74	1.57E-04
03 04B[1,2]	Honey Creek	0.34	7.12E-05
04 02	Panther Creek	3.61	2.43E-04
04 04	Wildcat Creek	3.81	2.65E-04
05 04	Fulton Creek	6.68	2.24E-04

[1] These TMDLs are only for the portion of the HUC noted in the subwatershed column.
[2] "A" and "B" represent different scenarios for allocating the same TMDL value. Scenario "A" has lower wasteload allocations which require new NPDES permit limits for one or more facilities; scenario "B" does not require new NPDES limits and therefore has a larger wasteload allocation, but then requires a greater reduction in nonpoint source loading to achieve the associated lower load allocation.

Table D4-3 Individual NPDES wasteload allocations per 12-digit HUC for nutrient (TP) TMDLs

12-Dig HUC (05060001)	Subwatershed	NPDES/MS4	Existing load (kg/day)	Proposed limit (mg/l)	Allocation load (kg/day)
01 04[1]	McCoy Run	None	-	-	-
02 02A[5]	McDonald Creek	Ohio Fresh Eggs 001	0.10	1.0	0.07
02 02A[5]	McDonald Creek	Ohio Fresh Eggs 002	0.16	1.0	0.10
02 02B[5]	McDonald Creek	Ohio Fresh Eggs 001	0.16	No limit	0.10[3]
02 02B[5]	McDonald Creek	Ohio Fresh Eggs 002	0.16	1.0	0.10
02 03	Lower Rush Creek	1PB00025 - Rushsylvania WWTP	0.34	1.0	0.38
03 01	Rock Fork	2PG00036-001 - Grandview Estates SD 2A	2.27	1.0	0.76
03 01	Rock Fork	2PG00036-002 - Grandview Estates SD 2A	0.91	1.0	0.30
03 01	Rock Fork	2IJ00027 - National Lime & Stone Co Marion Plant[2]	0.64	1.0	0.64
03 01	Rock Fork	City of Marion MS4	1.03	-	0.34
03 04A[1,5]	Honey Creek	2PG00072 - Harmony Subdiv SD 5B	0.09	1.0	0.04
03 04A[1,5]	Honey Creek	2PR00040 - Pleasant Acres MH Community LLC	0.17	1.0	0.08
03 04A[1,5]	Honey Creek	2PR00240 - Morning View Care Center	0.04	1.0	0.03
03 04A[1,5]	Honey Creek	2PT00048 - Pleasant Local Schools	0.17	1.0	0.08
03 04A[1,5]	Honey Creek	2PW00004 - N Quarry Subdivision	0.20	1.0	0.08
03 04A[1,5]	Honey Creek	City of Marion MS4	0.21	-	0.05
03 04B[1,5]	Honey Creek	2PG00072 - Harmony Subdiv SD 5B	0.09	No limit	0.11[4]
03 04B[1,5]	Honey Creek	2PR00040 - Pleasant Acres MH Community LLC	0.17	No limit	0.23[4]
03 04B[1,5]	Honey Creek	2PR00240 - Morning View Care Center	0.04	No limit	0.08[4]
03 04B[1,5]	Honey Creek	2PT00048 - Pleasant Local Schools	0.17	1.0	0.08
03 04B[1,5]	Honey Creek	2PW00004 - N Quarry Subdivision	0.20	No limit	0.23[4]
03 04B[1,5]	Honey Creek	City of Marion MS4	0.21	-	0.02
04 02	Panther Creek	2PA00046- Mt Victory WWTP[2]	1.14	1.0	0.34

12-Dig HUC (05060001)	Subwatershed	NPDES/MS4	Existing load (kg/day)	Proposed limit (mg/l)	Allocation load (kg/day)
04 04	Wildcat Creek	None	-	-	-
05 04	Fulton Creek	4IW00121 - Richwood PWS[2]	0	-	-
		4PB00018 - Richwood WWTP	3.38	1.0	1.44

[1] These TMDLs are only for the portion of the HUC noted in the subwatershed column.
[2] Controlled discharge.
[3] This load is based on a calculated existing flow of 0.0175 MGD and TP concentration of 1.53 mg/l.
[4] These loads are based on permitted design flows and an assumed TP existing concentration of 3.0 mg/l.
[5] "A" and "B" represent different scenarios for allocating the same TMDL value. Scenario "A" has lower wasteload allocations which require new NPDES permit limits for one or more facilities; scenario "B" does not require new NPDES limits and therefore has a larger wasteload allocation, but then requires a greater reduction in nonpoint source loading to achieve the associated lower load allocation.

D4.2 Habitat and sediment results

This subsection includes tables D4-4 through D4-13 showing the results from the habitat and sediment TMDLs. Channel modifications and excessive sediment are the most common attributes impacting these streams' TMDLs. Excessive sediment is a result from actual channel modifications and from upland soil runoff.

Table D4-4 Habitat TMDLs for 10-digit HUC 05060001 01 Headwaters Scioto River

Habitat TMDL	TMDL Targets	Allocations: QHEI Score	Allocations: # of High Influence Attributes	Allocations: Total # of Modified Attributes	TMDL
		≥ 60= *1 pt*	< 2 = *1 pt*	< 5 = *1 pt*	*3 pts*

Existing Scores Stream/River (Use)	River mile	QHEI Score	# of High Influence Attributes	Total # of Modified Attributes	Sub-score: QHEI Score	Sub-score: High Influence	Sub-score: Tot # Mod Attributes	Total Habitat Score
05060001 01 02 - Headwaters Scioto River								
Scioto River	231.86	79.5	0	2	1	1	1	3
	224.20	32.5	2	9	0	0	0	0
	223.05	38.0	3	9	0	0	0	0

Table D4-5 Sediment TMDLs for 10-digit HUC 05060001 01 Headwaters Scioto River

<table>
<tr><th colspan="2" rowspan="5">TMDL Target
For WWH</th><th colspan="6">Sediment TMDL</th></tr>
<tr><th colspan="3">QHEI Categories</th><th rowspan="3">TOTAL TMDL SCORE</th><th colspan="2" rowspan="4"></th></tr>
<tr><th>Substrate</th><th>Channel</th><th>Riparian</th></tr>
<tr><th colspan="3">Allocations</th></tr>
<tr><th>≥ 13</th><th>≥ 14</th><th>≥ 5</th><th>32</th></tr>
<tr><td colspan="8"></td></tr>
<tr><th rowspan="2">Existing Scores
Stream/River (Use)</th><th rowspan="2">River mile</th><th colspan="3">QHEI Categories</th><th rowspan="2">Total Sediment Score</th><th rowspan="2">Deviation from target (%)</th><th rowspan="2">Main impairment category</th></tr>
<tr><th>Substrate</th><th>Channel</th><th>Riparian</th></tr>
<tr><th colspan="8">05060001 01 02 - Headwaters Scioto River</th></tr>
<tr><td rowspan="3">Scioto River</td><td>231.86</td><td>13.5</td><td>16.5</td><td>9.0</td><td>39.0</td><td>---</td><td>---</td></tr>
<tr><td>224.20</td><td>9.0</td><td>5.0</td><td>3.5</td><td>17.5</td><td>45.3</td><td>channel</td></tr>
<tr><td>223.05</td><td>8.0</td><td>6.0</td><td>4.0</td><td>18.0</td><td>43.8</td><td>channel</td></tr>
</table>

Table D4-6 Habitat TMDLs for 10-digit HUC 05060001 02 Rush Creek

Habitat TMDL	TMDL Targets	Allocations			TMDL
		QHEI Score	# of High Influence Attributes	Total # of Modified Attributes	
		≥ 60= *1 pt*	< 2 = *1 pt*	< 5 = *1 pt*	*3 pts*

Existing Scores Stream/River (Use)	River mile	QHEI Score	# of High Influence Attributes	Total # of Modified Attributes	Sub-score QHEI Score	Sub-score High Influence	Sub-score Tot # Mod Attributes	Total Habitat Score
05060001 02 01- Headwaters Rush Creek								
Rush Creek	26.26	66.0	0	4	1	1	1	3
05060001 02 02 - McDonald Creek								
McDonald Creek	9.17	38.0	3	9	0	0	0	0
	6.82	43.0	3	9	0	0	0	0
	2.70	45.0	2	8	0	0	0	0
05060001 02 03 - Dudley Run-Rush Creek								
Rush Creek	8.80	61.5	0	5	1	1	0	2

Table D4-7 Sediment TMDLs for 10-digit HUC 05060001 02 Rush Creek

TMDL Target For WWH	Sediment TMDL				
	QHEI Categories			TOTAL TMDL SCORE	
	Substrate	Channel	Riparian		
	Allocations				
	≥ 13	≥ 14	≥ 5	32	

Existing Scores Stream/River (Use)	River mile	QHEI Categories			Total Sediment Score	Deviation from target (%)	Main impairment category
		Substrate	Channel	Riparian			
05060001 02 01- Headwaters Rush Creek							
Rush Creek	26.26	12	16.0	5.0	33.0	---	substrate
05060001 02 02 - McDonald Creek							
McDonald Creek	9.17	10	6.0	3.0	19.0	40.6	channel
	6.82	12	8.0	3.0	23.0	28.1	channel
	2.70	11	10.5	4.5	26.0	18.8	channel
05060001 02 03 - Dudley Run-Rush Creek							
Rush Creek	8.80	12	13.0	4.5	29.5	7.8	riparian

Table D4-8 Habitat TMDLs for 10-digit HUC 05060001 03 Little Scioto River

Habitat TMDL	TMDL Targets	Allocations			TMDL
		QHEI Score	# of High Influence Attributes	Total # of Modified Attributes	
		≥ 60= *1 pt*	< 2 = *1 pt*	< 5 = *1 pt*	*3 pts*

Existing Scores Stream/River (Use)	River mile	QHEI Score	# of High Influence Attributes	Total # of Modified Attributes	Sub-score QHEI Score	Sub-score High Influence	Sub-score Tot # Mod Attributes	Total Habitat Score
05060001 03 01 - Rock Fork								
Rock Fork	8.13	35.5	4	9	0	0	0	0
	1.10	74.0	0	4	1	1	1	3
05060001 03 02 - Headwaters Little Scioto River								
Little Scioto River	25.59	40.5	1	6	0	1	0	1
	19.70	70.0	0	5	1	1	0	2
	11.10	49.5	1	7	0	1	0	1
05060001 03 03 - City of Marion-Little Scioto River								
Little Scioto River	9.24	73.5	0	4	1	1	1	3
05060001 03 04 - Honey Creek-Little Scioto River								
Honey Creek	0.01	58.5	1	5	0	1	0	1

Table D4-9 Sediment TMDLs for 10-digit HUC 05060001 03 Little Scioto River

TMDL Target For WWH		Sediment TMDL					
		QHEI Categories			TOTAL TMDL SCORE		
		Substrate	Channel	Riparian			
		Allocations					
		≥ 13	≥ 14	≥ 5	32		
Existing Scores Stream/River (Use)	**River mile**	**QHEI Categories**			**Total Sediment Score**	**Deviation from target (%)**	**Main impairment category**
		Substrate	**Channel**	**Riparian**			
05060001 03 01 - Rock Fork							
Rock Fork	8.13	10.0	4.0	3.5	17.5	45.3	channel
	1.10	18.0	16.0	6.0	40.0	---	---
05060001 03 02 - Headwaters Little Scioto River							
Little Scioto River	25.59	0	12.0	5.5	17.5	45.3	substrate
	19.70	15.0	14.0	10.0	39.0	---	---
	11.10	10.0	11.5	7.0	28.5	10.9	substrate
05060001 03 03 - City of Marion-Little Scioto River							
Little Scioto River	9.24	16.5	15.5	9.0	41.0	---	---
05060001 03 04 - Honey Creek-Little Scioto River							
Honey Creek	0.01	0	13.5	6.0	19.5	39.1	substrate

Table D4-10 Habitat TMDLs for 10-digit HUC 05060001 04 Panther Creek-Scioto River

Habitat TMDL	TMDL Targets	Allocations			TMDL
		QHEI Score	# of High Influence Attributes	Total # of Modified Attributes	
		≥ 60= *1 pt*	< 2 = *1 pt*	< 5 = *1 pt*	*3 pts*

Existing Scores Stream/River (Use)	River mile	QHEI Score	# of High Influence Attributes	Total # of Modified Attributes	Sub-score: QHEI Score	Sub-score: High Influence	Sub-score: Tot # Mod Attributes	Total Habitat Score
05060001 04 04 - Wildcat Creek								
Wildcat Creek	6.72	43.5	2	9	0	0	0	0
05060001 04 06 - Glade Run-Scioto River								
Scioto River	186.00	67.5	1	7	1	1	0	2

Table D4-11 Sediment TMDLs for 10-digit HUC 05060001 04 Panther Creek-Scioto River

TMDL Target For WWH		Sediment TMDL					
		QHEI Categories			TOTAL TMDL SCORE		
		Substrate	Channel	Riparian			
		Allocations					
		≥ 13	≥ 14	≥ 5	32		
Existing Scores Stream/River (Use)	**River mile**	**QHEI Categories**			**Total Sediment Score**	**Deviation from target (%)**	**Main impairment category**
		Substrate	**Channel**	**Riparian**			
05060001 04 04 - Wildcat Creek							
Wildcat Creek	6.72	11.5	7.5	2.5	21.5	32.8	riparian
05060001 04 06 - Glade Run-Scioto River							
Scioto River	186.00	8.5	13.0	9.0	30.5	4.7	substrate

Table D4-12 Habitat TMDLs for 10-digit HUC 05060001 05 Fulton Creek-Scioto River

Habitat TMDL	TMDL Targets	Allocations					TMDL
		QHEI Score	# of High Influence Attributes	Total # of Modified Attributes			
		≥ 60= *1 pt*	< 2 = *1 pt*	< 5 = *1 pt*			*3 pts*

Existing Scores Stream/River (Use)	River mile	QHEI Score	# of High Influence Attributes	Total # of Modified Attributes	Sub-score: QHEI Score	Sub-score: High Influence	Sub-score: Tot # Mod Attributes	Total Habitat Score
05060001 05 01- Patton Run								
Patton Run	2.25	56.5	2	6	0	0	0	0
05060001 05 04 - Fulton Creek								
Fulton Creek	16.30	27.0	4	9	0	0	0	0
	10.35	76.5	0	3	1	1	1	3
	8.70	42.5	2	9	0	0	0	0
Elliot Run	1.25	38.0	4	10	0	0	0	0

Table D4-13 Sediment TMDLs for 10-digit HUC 05060001 05 Fulton Creek-Scioto River

TMDL Target For WWH		Sediment TMDL					
		QHEI Categories			TOTAL TMDL SCORE		
		Substrate	Channel	Riparian			
		Allocations					
		≥ 13	≥ 14	≥ 5	32		
Existing Scores Stream/River (Use)	**River mile**	**QHEI Categories**			**Total Sediment Score**	**Deviation from target (%)**	**Main impairment category**
		Substrate	**Channel**	**Riparian**			
05060001 05 01- Patton Run							
Patton Run	2.25	6	12	5.5	23.5	26.6	substrate
05060001 05 04 - Fulton Creek							
Fulton Creek	16.30	0	4	2.0	6.0	81.3	substrate
	10.35	16	15	7.5	38.5	---	---
	8.70	4	8	4.0	16.0	50.0	substrate
Elliot Run	1.25	8	6	3.0	17.0	46.9	channel

D4.3 Pathogen modeling results

A summary of the bacteria TMDLs, wasteload allocation, load allocation, margin of safety, and allowance for future growth at each hydrologic condition is presented in Table D4-14 below. Recall, the TMDL value for each hydrologic condition is determined from the middle value on the LDC of each flow regime. Wasteload allocations for NPDES point sources that are expected to discharge at the same rate no matter what the stream's hydrologic condition receive the same value for all of those conditions.

Table D4-14 TMDL summary table (E. coli loads are expressed in billions of organisms per day).

Hydrologic Condition	High flows	Wet weather	Normal range	Dry weather	Low
Flow Duration Interval	0-5%	5-40%	40-80%	80-95%	95-100%
Cottonwood Ditch Dst. McGuffey WWTP @ RR bridge HUC12: 05060001 01 01					
Total Maximum Daily Load	340.3	43.3	8.7	3.9	3.2
Wasteload Allocation	1.9	1.9	1.9	1.9	1.9
Load Allocation	263.5	31.9	4.9	1.2	0.6
Margin of Safety	68.1	8.7	1.7	0.8	0.6
Allowance for future growth	6.81	0.87	0.17	0.08	0.06
Total load reduction required	*No Data*	39.4%	54.6%	53.5%	75.4%
Scioto R. W of Roundhead @ Arbogast Rd. HUC12: 05060001 01 02					
Total Maximum Daily Load	321.0	39.8	6.3	2.0	1.6
Wasteload Allocation	0.0	0.0	0.0	0.0	0.0
Load Allocation	250.4	31.0	4.9	1.5	1.2

Hydrologic Condition	High	Wet	Normal	Dry	Low
Margin of Safety	64.2	8.0	1.3	0.4	0.3
Allowance for future growth	*6.42*	0.8	0.13	0.04	0.03
Total load reduction required	*No Data*	None	79.7%	17.4%	61.0%
Taylor Creek at Kenton @ St. Rt. 67 HUC12: 05060001 01 03					
Total Maximum Daily Load	223.8	27.7	4.6	1.5	0.9
Wasteload Allocation	0.01	0.01	0.01	0.01	0.01
Load Allocation	174.5	21.6	3.6	1.2	0.7
Margin of Safety	44.8	5.5	0.9	0.3	0.2
Allowance for future growth	4.48	0.55	0.09	0.03	0.02
Total load reduction required	35.2%	89.9%	67.3%	*No Data*	44.8%
Silver Creek @ SR 67 HUC12: 05060001 01 04					
Total Maximum Daily Load	155.0	19.1	3.1	0.9	0.6
Wasteload Allocation	0.0	0.0	0.0	0.0	0.0
Load Allocation	120.9	14.9	2.4	0.7	0.5
Margin of Safety	31.0	3.8	0.6	0.2	0.1
Allowance for future growth	3.10	0.38	0.06	0.02	0.01
Total load reduction required	*No Data*	88.2%	90.2%	*No Data*	None
Rush Creek @ Winnemac Rd. HUC12: 05060001 02 01					
Total Maximum Daily Load	877.1	108.3	17.7	5.9	4.3
Wasteload Allocation	0.6	0.6	0.6	0.6	0.6
Load Allocation	683.5	83.9	13.2	4.0	2.8
Margin of Safety	175.4	21.7	3.5	1.2	0.9
Allowance for future growth	17.54	2.17	0.35	0.12	0.09
Total load reduction required	*No Data*	81.9%	82.7%	*No Data*	52.2%
McDonald Creek @ St. Rt. 37 HUC12: 05060001 02 02					
Total Maximum Daily Load	168.9	21.0	3.4	1.2	0.9
Wasteload Allocation	0.0	0.0	0.0	0.0	0.0
Load Allocation	131.7	16.3	2.6	1.0	0.7
Margin of Safety	33.78	4.19	0.68	0.25	0.18
Allowance for future growth	3.38	0.42	0.07	0.02	0.02
Total load reduction required	*No Data*	84.0%	None	*No Data*	None
Rush Creek S of New Bloomington @ Mt. Olive-Green Camp Rd. HUC12: 05060001 02 03					
Total Maximum Daily Load	1350.9	167.0	27.2	9.1	6.3
Wasteload Allocation	0.6	0.6	0.6	0.6	0.6
Load Allocation	1053.1	129.6	20.6	6.5	4.3
Margin of Safety	270.2	33.4	5.4	1.8	1.3
Allowance for future growth	27.02	3.34	0.54	0.18	0.13
Total load reduction required	*No Data*	40.3%	64.9%	None	2.3%
Rock Fork N of Marion @ Kenton-Galion Rd. HUC12: 05060001 03 01					
Total Maximum Daily Load	318.4	40.4	7.7	3.4	2.8
Wasteload Allocation	29.3	5.0	2.2	1.8	1.8
Load Allocation	219.1	26.5	3.8	0.8	0.4
Margin of Safety	63.7	8.1	1.5	0.7	0.6
Allowance for future growth	6.37	0.81	0.15	0.07	0.06
Total load reduction required	16.2%	40.6%	87.1%	None	None
L. Scioto R. N of Marion @ Kenton-Galion Rd. HUC12: 05060001 03 02					
Total Maximum Daily Load	645.4	79.8	12.9	4.3	3.1
Wasteload Allocation	20.1	2.6	0.5	0.2	0.2
Load Allocation	483.3	59.7	9.6	3.1	2.2
Margin of Safety	129.1	16.0	2.6	0.9	0.6

Hydrologic Condition	High	Wet	Normal	Dry	Low
Allowance for future growth	12.91	1.60	0.26	0.09	0.06
Total load reduction required	*No Data*	None	70.8%	*No Data*	88.3%
L Scioto R. at Marion, upst WWTP HUC12: 05060001 03 03					
Total Maximum Daily Load	1180.8	145.8	23.7	8.0	5.5
Wasteload Allocation	122.8	16.5	4.0	2.4	2.2
Load Allocation	798.3	97.2	14.5	3.9	2.1
Margin of Safety	236.2	29.2	4.7	1.6	1.1
Allowance for future growth	23.62	2.92	0.47	0.16	0.11
Total load reduction required	*No Data*	83.6%	56.3%	*No Data*	*No Data*
L. Scioto R. at Green Camp @ Owens-Green Camp Rd. (CR 104) HUC12: 05060001 03 04					
Total Maximum Daily Load	1604.0	244.1	83.8	62.9	59.8
Wasteload Allocation	212.3	71.5	55.0	52.8	52.6
Load Allocation	1038.8	118.9	10.4	0	0
Margin of Safety	320.8	48.8	16.8	8.8	6.1
Allowance for future growth	32.08	4.88	1.68	1.26	1.20
Total load reduction required	*No Data*	59.9%	58.5%	None	*No Data*
Scioto R. at Kenton @ Leighton St. HUC12: 05060001 04 01					
Total Maximum Daily Load	2196.8	271.2	44.4	14.8	10.5
Wasteload Allocation	2.0	2.0	2.0	2.0	2.0
Load Allocation	1711.5	209.6	32.7	9.6	6.2
Margin of Safety	439.4	54.2	8.9	3.0	2.1
Allowance for future growth	43.94	5.42	0.89	0.30	0.21
Total load reduction required	*No Data*	84.6%	51.8%	23.1%	62.5%
Scioto R. Dst. Kenton @ Twp. Rd. 199 HUC12: 05060001 04 03					
Total Maximum Daily Load	2456.9	315.0	62.3	29.3	24.66
Wasteload Allocation	13.6	13.6	13.6	13.6	13.6
Load Allocation	1902.8	232.1	35.0	9.3	5.7
Margin of Safety	491.4	63.0	12.5	5.9	4.9
Allowance for future growth	49.14	6.30	1.25	0.59	0.49
Total load reduction required	*No Data*	78.8%	None	No Data	41.4%
Wildcat Ck @ Larue-Kenton Rd. nr. Larue HUC12: 05060001 04 04					
Total Maximum Daily Load	304.8	37.6	6.2	2.2	1.5
Wasteload Allocation	0.0	0.0	0.0	0.0	0.0
Load Allocation	237.8	29.3	4.9	1.7	1.2
Margin of Safety	61.0	7.5	1.2	0.4	0.3
Allowance for future growth	6.10	0.75	0.12	0.04	0.03
Total load reduction required	*No Data*	87.0%	91.3%	*No Data*	92.8%
Scioto R. at LaRue @ St. Rt. 37 HUC12: 05060001 04 05					
Total Maximum Daily Load	3556.0	450.9	85.1	37.3	30.2
Wasteload Allocation	14.2	14.2	14.2	14.2	14.2
Load Allocation	2759.5	337.6	52.2	14.9	9.4
Margin of Safety	711.2	90.2	17.0	7.5	6.0
Allowance for future growth	71.12	9.02	1.70	0.75	0.60
Total load reduction required	*No Data*	58.0%	16.5%	39.8%	47.7%
Scioto R. Adj. Green Camp River Rd. HUC12: 05060001 04 06					
Total Maximum Daily Load	5603.3	705.5	127.9	52.7	41.6
Wasteload Allocation	15.9	15.9	15.9	15.9	15.9
Load Allocation	4354.7	534.4	83.9	25.2	16.5
Margin of Safety	1120.7	141.1	25.6	10.5	8.3
Allowance for future growth	112.1	14.1	2.6	1.1	0.8
Total load reduction required	No Data	47.5%	7.5%	None	No Data

Hydrologic Condition	High	Wet	Normal	Dry	Low
Patton Run @ Boundary Rd. HUC12: 05060001 05 01					
Total Maximum Daily Load	197.6	24.4	4.0	1.2	0.9
Wasteload Allocation	0.0	0.0	0.0	0.0	0.0
Load Allocation	154.1	19.0	3.1	1.0	0.7
Margin of Safety	39.5	4.9	0.8	0.2	0.2
Allowance for future growth	3.95	0.49	0.08	0.02	0.02
Total load reduction required	No Data	89.1%	None	69.3%	No Data
Kebler Run S of Prospect @ River Rd. HUC12: 05060001 05 03					
Total Maximum Daily Load	196.3	24.4	4.0	1.2	0.9
Wasteload Allocation	0.0	0.0	0.0	0.0	0.0
Load Allocation	153.1	19.0	3.1	1.0	0.7
Margin of Safety	39.3	4.9	0.8	0.2	0.2
Allowance for future growth	3.93	0.49	0.08	0.02	0.02
Total load reduction required	*No Data*	71.6%	8.8%	*No Data*	25.0%
Fulton Creek SE of Richwood @ St. Rt. 257 HUC12: 05060001 05 04					
Total Maximum Daily Load	643.9	79.5	12.9	4.3	3.1
Wasteload Allocation	2.3	2.3	2.3	2.3	2.3
Load Allocation	499.9	59.7	7.8	1.1	0.1
Margin of Safety	128.8	15.9	2.6	0.9	0.6
Allowance for future growth	12.88	1.59	0.26	0.09	0.06
Total load reduction required	No Data	36.3%	None	81.4%	62.9%

Figures D4-1 through D4-19 and tables D4-15 through D4-33 show the bacteria TMDL load duration curve and allocation table for each site assessed.

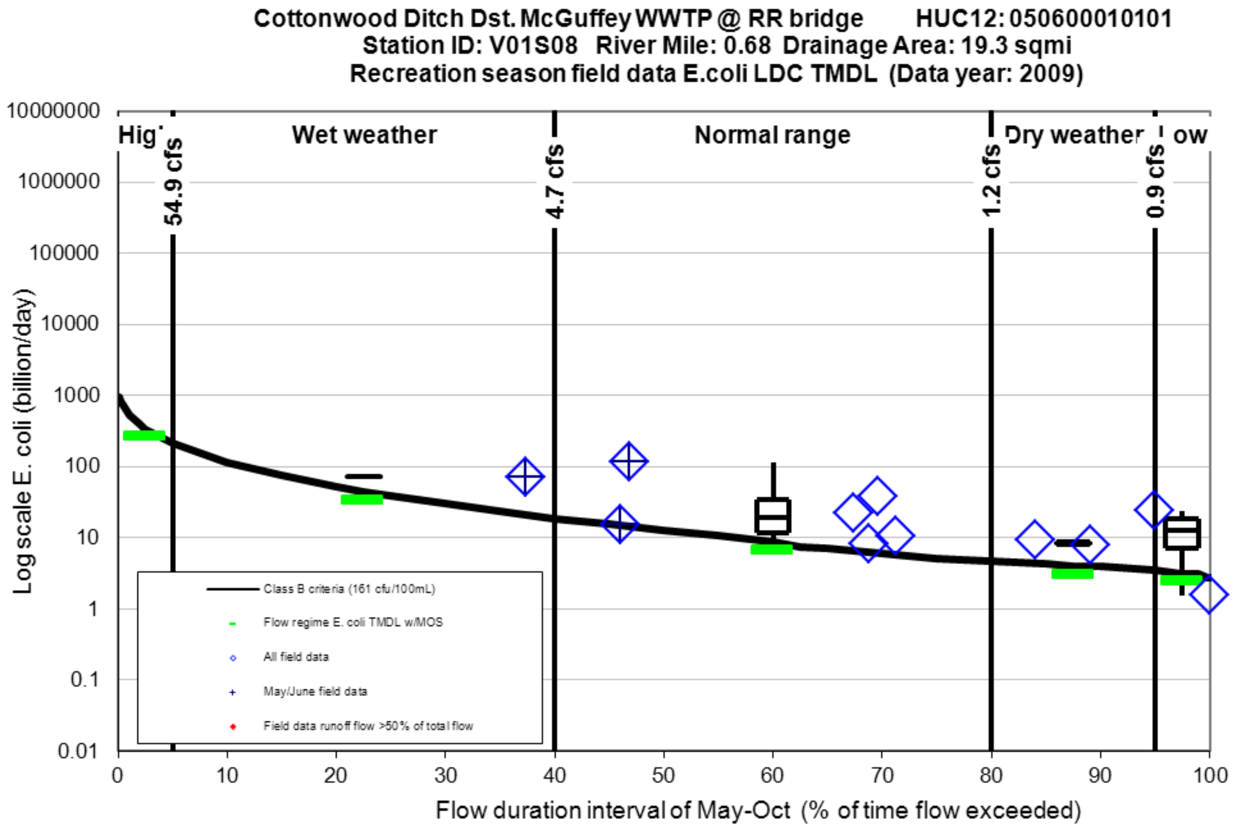

Figure D4-1 *E. coli* load duration curve for site on Cottonwood Ditch Dst. McGuffey WWTP @ RR bridge HUC12: 05060001 01 01

Table D4-15 *E. coli* TMDL table for site on Cottonwood Ditch Dst. McGuffey WWTP @ RR bridge HUC12: 05060001 01 01

Flow regime TMDL analysis (*E. coli* in billion organisms/day)	High flows	Wet weather	Normal range	Dry weather	Low
Flow duration regime interval	0-5%	5-40%	40-80%	80-95%	95-100%
Samples per regime	*No Data*	1	6	2	2
Median sample load	*No Data*	71.5	19.1	8.5	12.8
Total WLA	1.9	1.9	1.9	1.9	1.9
McGuffey STP - 2PA00006 WLA	0.7	0.7	0.7	0.7	0.7
Alger WWTP - 2PB00064 WLA	1.2	1.2	1.2	1.2	1.2
Load Allocation	263.5	31.9	4.9	1.2	0.6
Margin of Safety	68.1	8.7	1.7	0.8	0.6
Allowance for future growth	6.81	0.87	0.17	0.08	0.06
TMDL	340.3	43.3	8.7	3.9	3.2
Total load reduction required	*No Data*	39.4%	54.6%	53.5%	75.4%

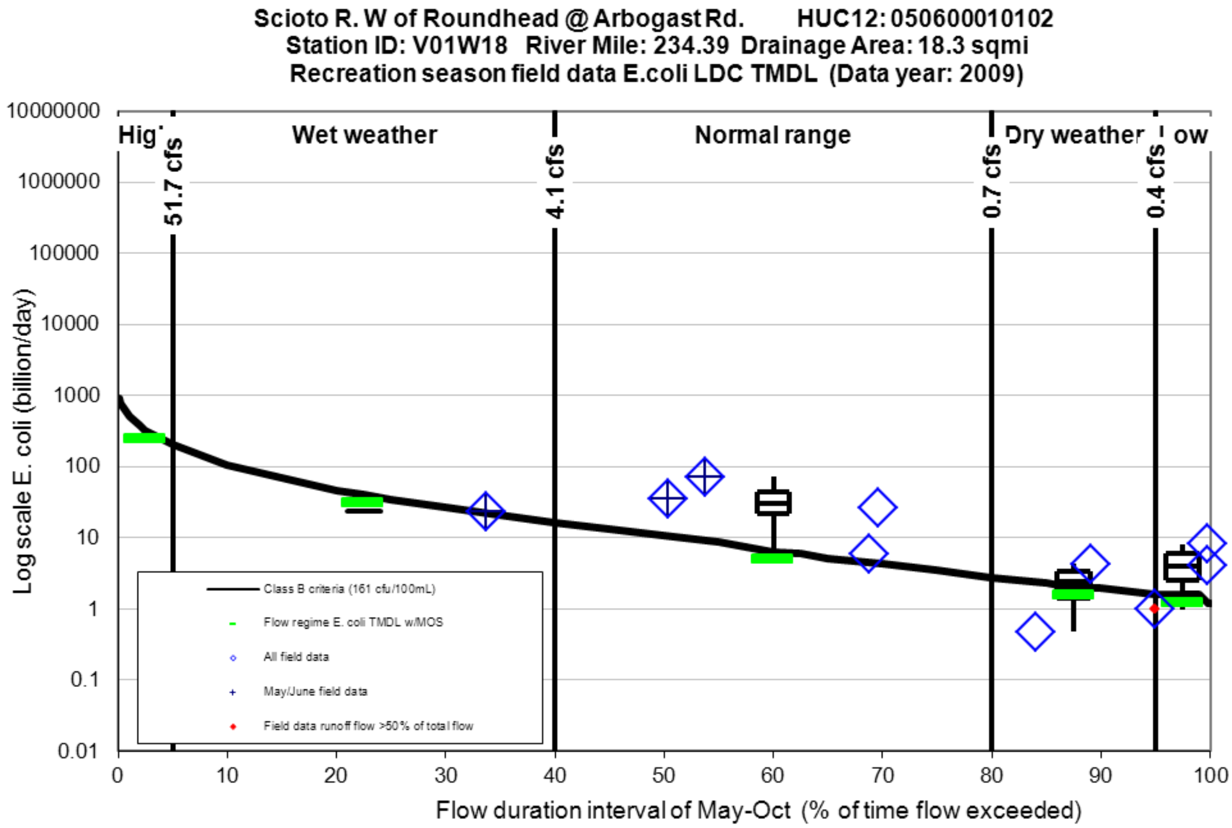

Figure D4-2 ***E. coli*** **load duration curve for site on Scioto R. W of Roundhead @ Arbogast Rd. HUC12: 05060001 01 02**

Table D4-16 ***E. coli*** **TMDL table for site on Scioto R. W of Roundhead @ Arbogast Rd. HUC12: 05060001 01 02**

Flow regime TMDL analysis (*E. coli* in billion organisms/day)	High flows	Wet weather	Normal range	Dry weather	Low
Flow duration regime interval	0-5%	5-40%	40-80%	80-95%	95-100%
Samples per regime	*No Data*	1	4	2	3
Median sample load	*No Data*	23.4	31.0	2.4	4.0
Total WLA	0.0	0.0	0.0	0.0	0.0
Load Allocation	250.4	31.0	4.9	1.5	1.2
Margin of Safety	64.2	8.0	1.3	0.4	0.3
Allowance for future growth	6.42	0.80	0.13	0.04	0.03
TMDL	321.0	39.8	6.3	2.0	1.6
Total load reduction required	*No Data*	None	79.7%	17.4%	61.0%

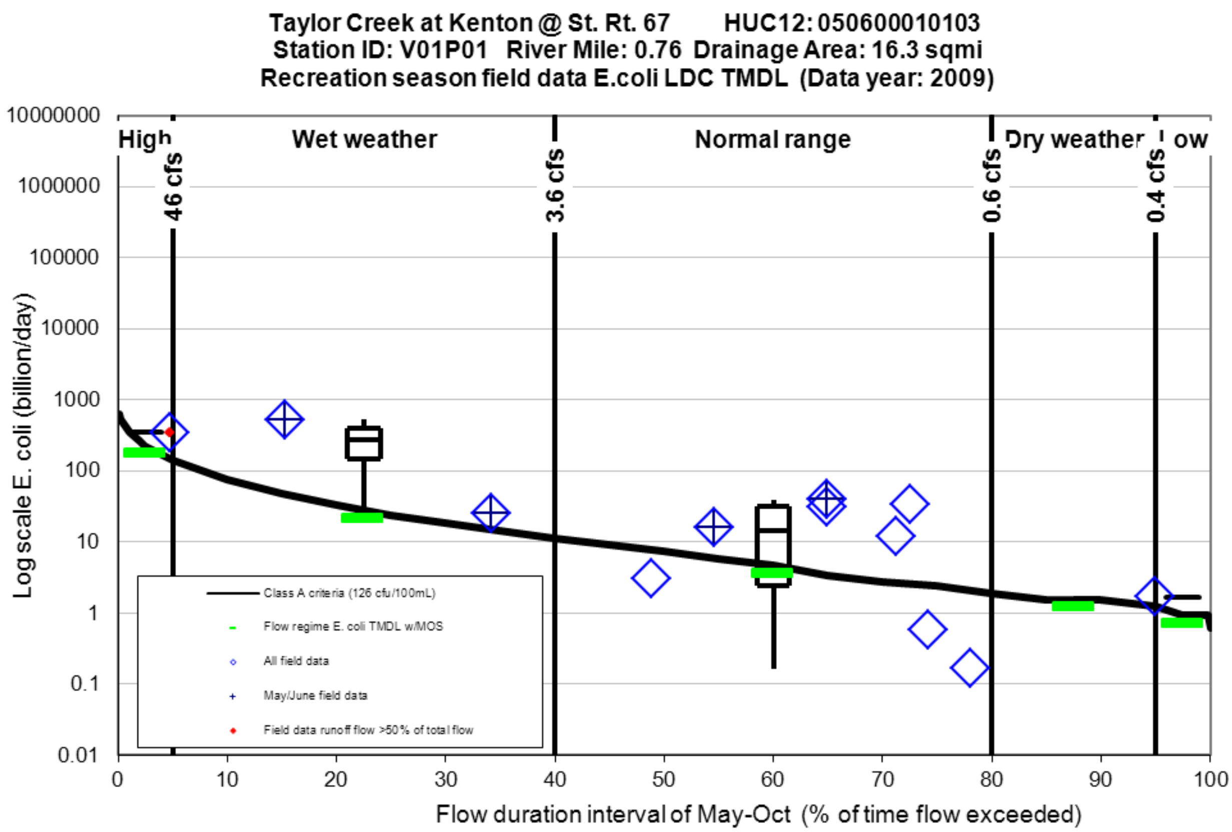

Figure D4-3 ***E. coli*** **load duration curve for site on Taylor Creek at Kenton @ St. Rt. 67 HUC12: 05060001 01 03**

Table D4-17 ***E. coli*** **TMDL table for site on Taylor Creek at Kenton @ St. Rt. 67 HUC12: 05060001 01 03**

Flow regime TMDL analysis (*E. coli* in billion organisms/day)	High flows	Wet weather	Normal range	Dry weather	Low
Flow duration regime interval	0-5%	5-40%	40-80%	80-95%	95-100%
Samples per regime	1	2	8		1
Median sample load	345	273.9	14.1		1.7
Total WLA (Green Hills Coach Park Ltd - 2PY00041)	0.01	0.01	0.01	0.01	0.01
Load Allocation	174.5	21.6	3.6	1.2	0.7
Margin of Safety	44.8	5.5	0.9	0.3	0.2
Allowance for future growth	4.48	0.55	0.09	0.03	0.02
TMDL	223.8	27.7	4.6	1.5	0.9
Total load reduction required	35.2%	89.9%	67.3%	*No Data*	44.8%

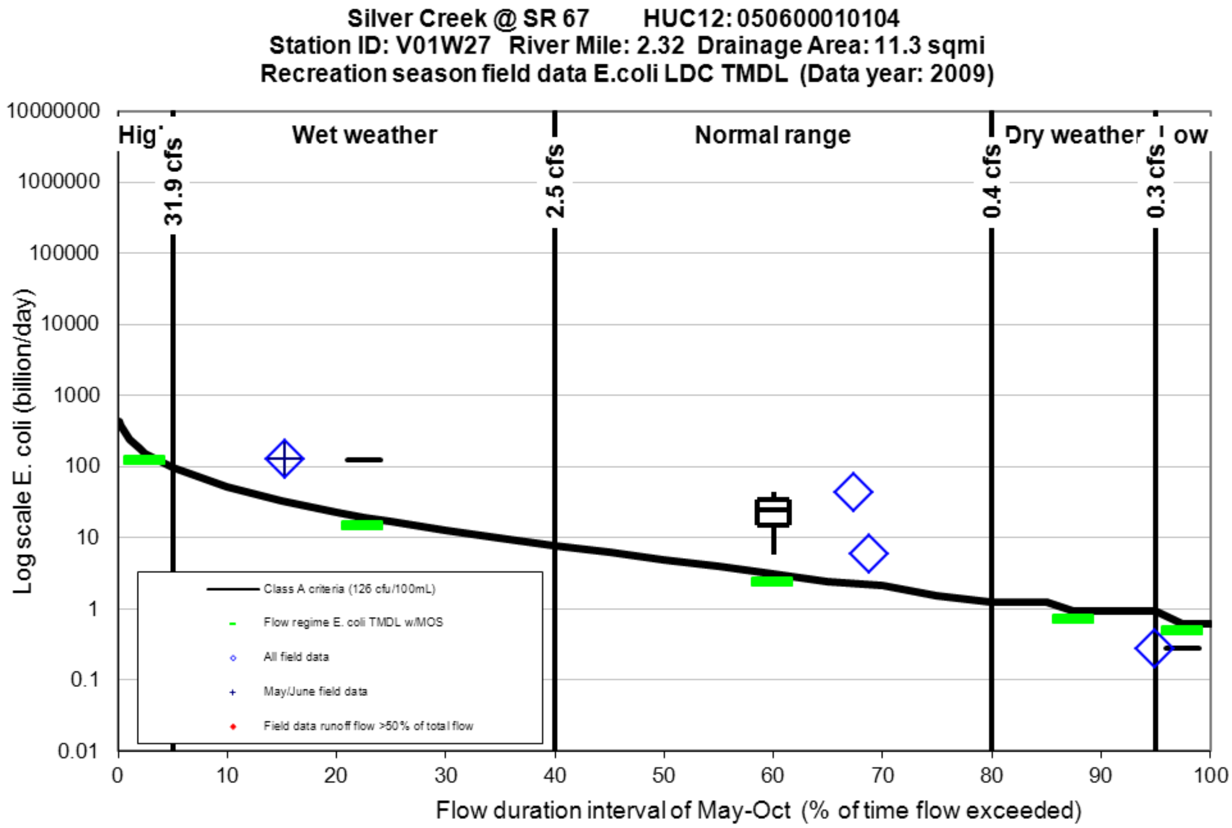

Figure D4-4 *E. coli* **load duration curve for site on Silver Creek @ SR 67 HUC12: 05060001 01 04**

Table D4-18 *E. coli* **TMDL table for site on Silver Creek @ SR 67 HUC12: 05060001 01 04**

Flow regime TMDL analysis (*E. coli* in billion organisms/day)	High flows	Wet weather	Normal range	Dry weather	Low
Flow duration regime interval	0-5%	5-40%	40-80%	80-95%	95-100%
Samples per regime	*No Data*	1	2	*No Data*	1
Median sample load	*No Data*	126.8	24.5	*No Data*	0.3
Total WLA	0.0	0.0	0.0	0.0	0.0
Load Allocation	120.9	14.9	2.4	0.7	0.5
Margin of Safety	31.0	3.8	0.6	0.2	0.1
Allowance for future growth	3.10	0.38	0.06	0.02	0.01
TMDL	155.0	19.1	3.1	0.9	0.6
Total load reduction required	*No Data*	88.2%	90.2%	*No Data*	None

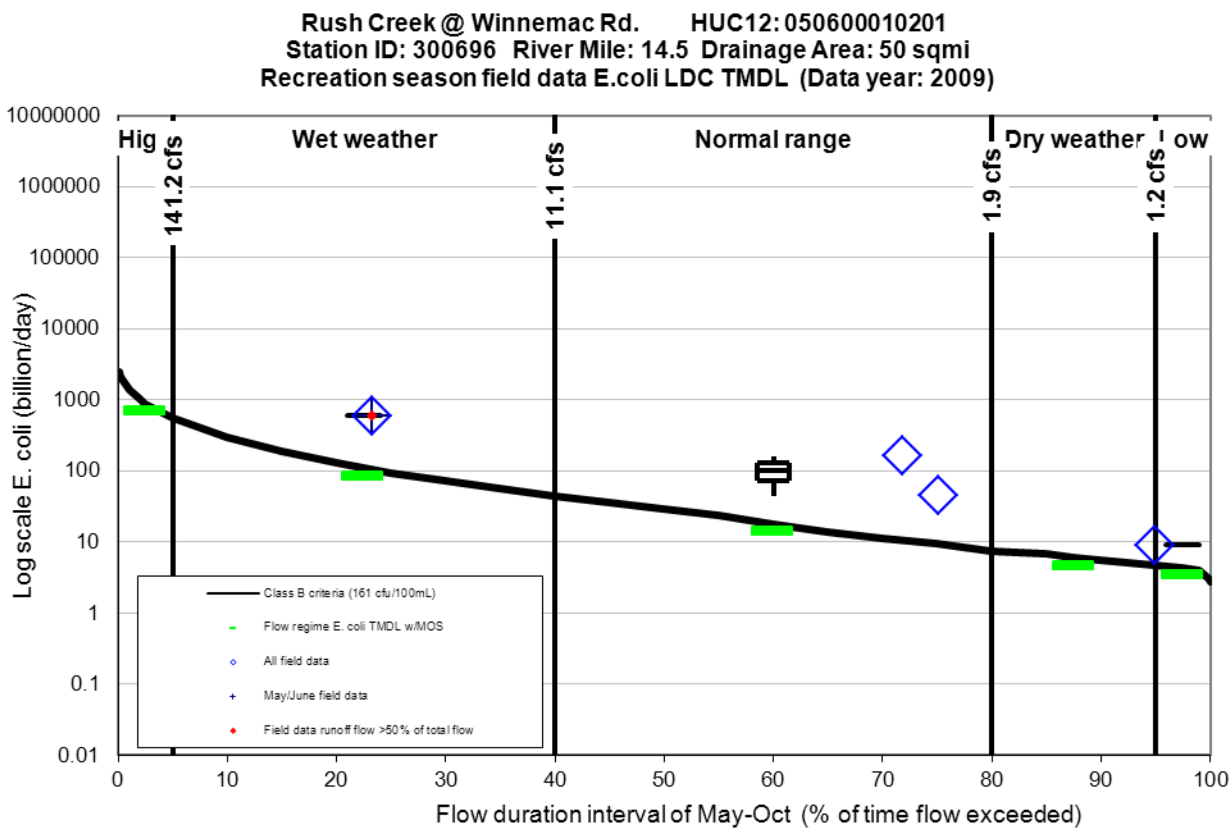

Figure D4-5 ***E. coli*** **load duration curve for site on Rush Creek @ Winnemac Rd. HUC12: 05060001 02 01**

Table D4-19 ***E. coli*** **TMDL table for site on Rush Creek @ Winnemac Rd. HUC12: 05060001 02 01**

Flow regime TMDL analysis (*E. coli* in billion organisms/day)	High flows	Wet weather	Normal range	Dry weather	Low
Flow duration regime interval	0-5%	5-40%	40-80%	80-95%	95-100%
Samples per regime	*No Data*	1	2	*No Data*	1
Median sample load	*No Data*	597.4	102.7	*No Data*	9.1
Total WLA (Rushsylvania WWTP - 1PB00025)	0.6	0.6	0.6	0.6	0.6
Load Allocation	683.5	83.9	13.2	4.0	2.8
Margin of Safety	175.4	21.7	3.5	1.2	0.9
Allowance for future growth	17.54	2.17	0.35	0.12	0.09
TMDL	877.1	108.3	17.7	5.9	4.3
Total load reduction required	*No Data*	81.9%	82.7%	*No Data*	52.2%

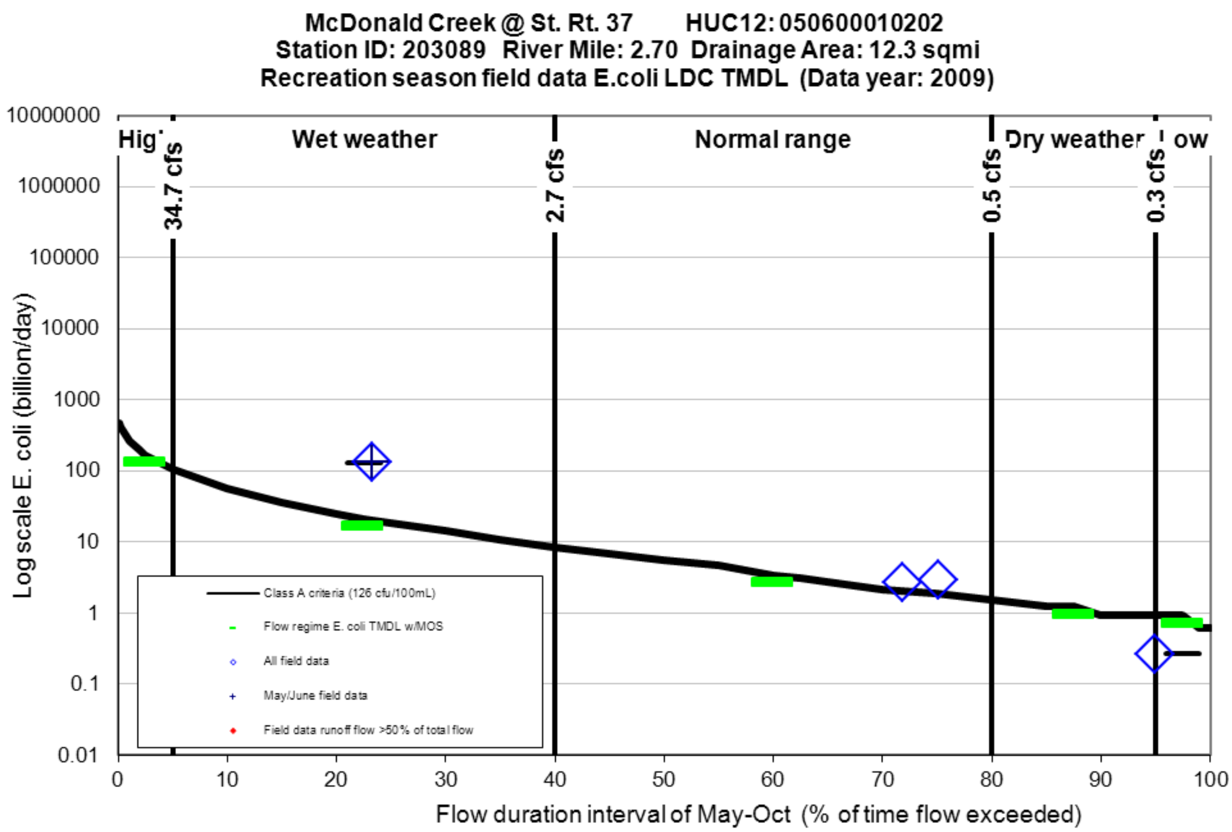

Figure D4-6 *E. coli* load duration curve for site on McDonald Creek @ St. Rt. 37 HUC12: 05060001 02 02

Table D4-20 *E. coli* TMDL table for site on McDonald Creek @ St. Rt. 37 HUC12: 05060001 02 02

Flow regime TMDL analysis (*E. coli* in billion organisms/day)	High flows	Wet weather	Normal range	Dry weather	Low
Flow duration regime interval	0-5%	5-40%	40-80%	80-95%	95-100%
Samples per regime	*No Data*	1	2	*No Data*	1
Median sample load	*No Data*	131.0	2.7	*No Data*	0.3
Total WLA	0.0	0.0	0.0	0.0	0.0
Load Allocation	131.7	16.3	2.6	1.0	0.7
Margin of Safety	33.78	4.19	0.68	0.25	0.18
Allowance for future growth	3.38	0.42	0.07	0.02	0.02
TMDL	168.9	21.0	3.4	1.2	0.9
Total load reduction required	*No Data*	84.0%	None	*No Data*	None

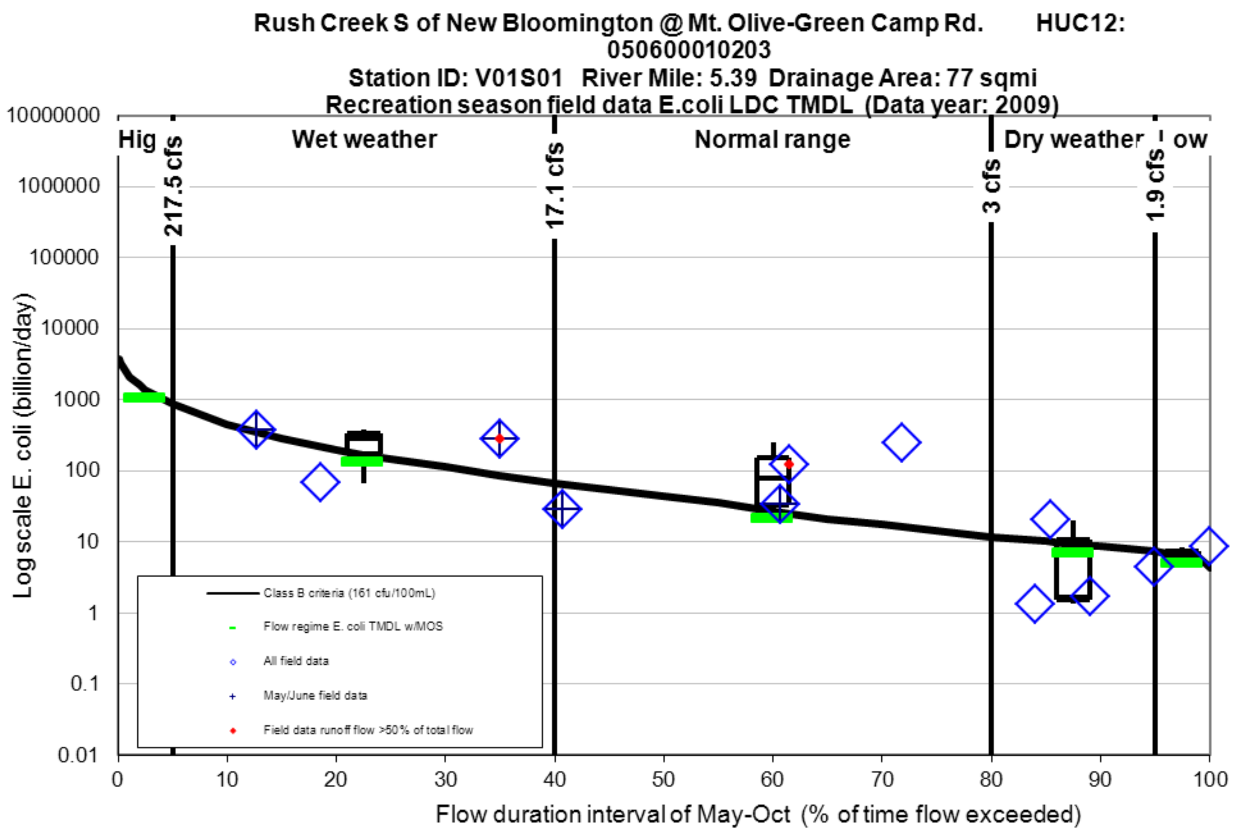

Figure D4-7 ***E. coli*** **load duration curve for site on Rush Creek S of New Bloomington @ Mt. Olive-Green Camp Rd. HUC12: 05060001 02 03**

Table D4-21 ***E. coli*** **TMDL table for site on Rush Creek S of New Bloomington @ Mt. Olive-Green Camp Rd. HUC12: 05060001 02 03**

Flow regime TMDL analysis (*E. coli* in billion organisms/day)	High flows	Wet weather	Normal range	Dry weather	Low
Flow duration regime interval	0-5%	5-40%	40-80%	80-95%	95-100%
Samples per regime	*No Data*	3	4	3	2
Median sample load	*No Data*	279.6	77.3	1.7	6.5
Total WLA (Rushsylvania WWTP - 1PB00025)	0.6	0.6	0.6	0.6	0.6
Load Allocation	1053.1	129.6	20.6	6.5	4.3
Margin of Safety	270.2	33.4	5.4	1.8	1.3
Allowance for future growth	27.02	3.34	0.54	0.18	0.13
TMDL	1350.9	167.0	27.2	9.1	6.3
Total load reduction required	*No Data*	40.3%	64.9%	None	2.3%

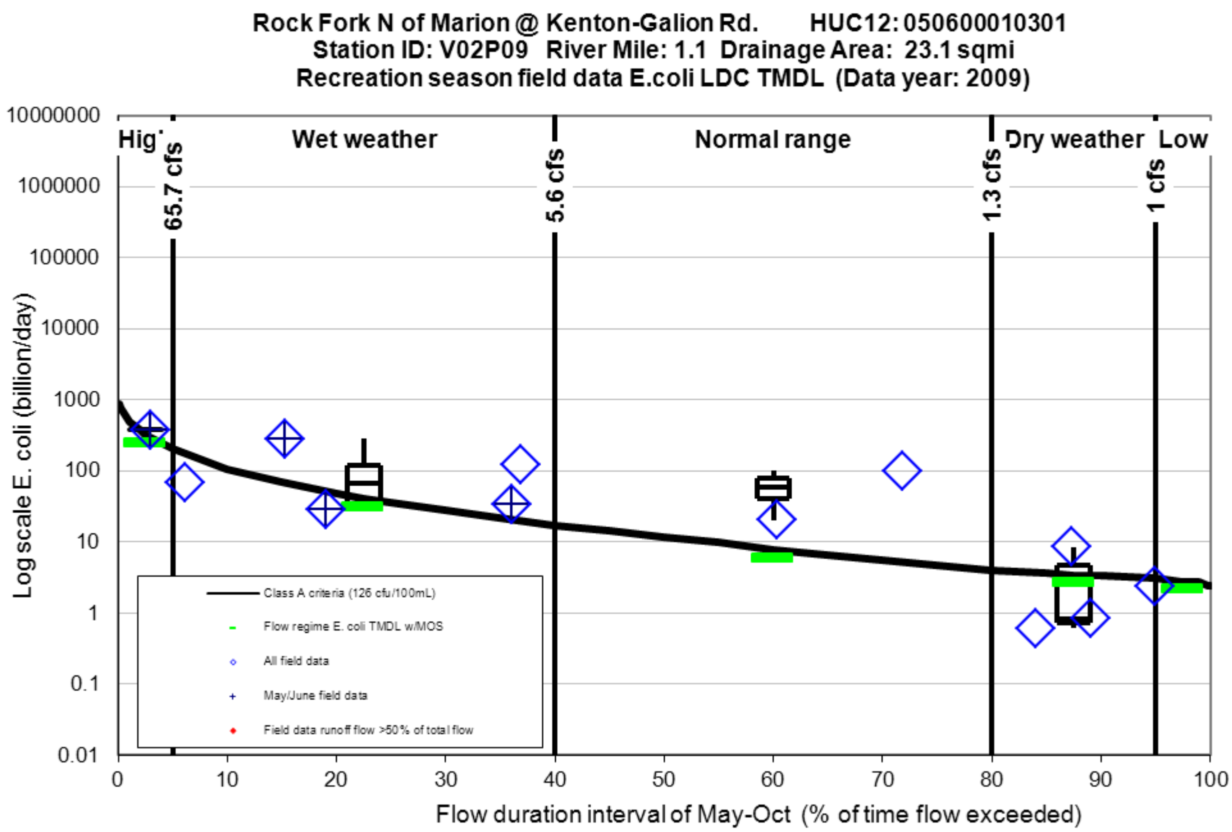

Figure D4-8 ***E. coli*** **load duration curve for site on Rock Fork N of Marion @ Kenton-Galion Rd. HUC12: 05060001 03 01**

Table D4-22 ***E. coli*** **TMDL table for site on Rock Fork N of Marion @ Kenton-Galion Rd. HUC12: 05060001 03 01**

Flow regime TMDL analysis (*E. coli* in billion organisms/day)	**High flows**	**Wet weather**	**Normal range**	**Dry weather**	**Low**
Flow duration regime interval	0-5%	5-40%	40-80%	80-95%	95-100%
Samples per regime	1	5	2	3	1
Median sample load	380	68.0	59.9	0.8	2.4
Total WLA	29.3	5.0	2.2	1.8	1.8
Grandview Estates-Outfall 001 -2PG00036 WLA	1.2	1.2	1.2	1.2	1.2
Grandview Estates-Outfall 002 2PG00036 WLA	0.5	0.5	0.5	0.5	0.5
Marion MS4 WLA	27.6	3.3	0.5	0.1	0.1
Load Allocation	219.1	26.5	3.8	0.8	0.4
Margin of Safety	63.7	8.1	1.5	0.7	0.6
Allowance for future growth	6.37	0.81	0.15	0.07	0.06
TMDL	318.4	40.4	7.7	3.4	2.8
Total load reduction required	16.2%	40.6%	87.1%	None	None

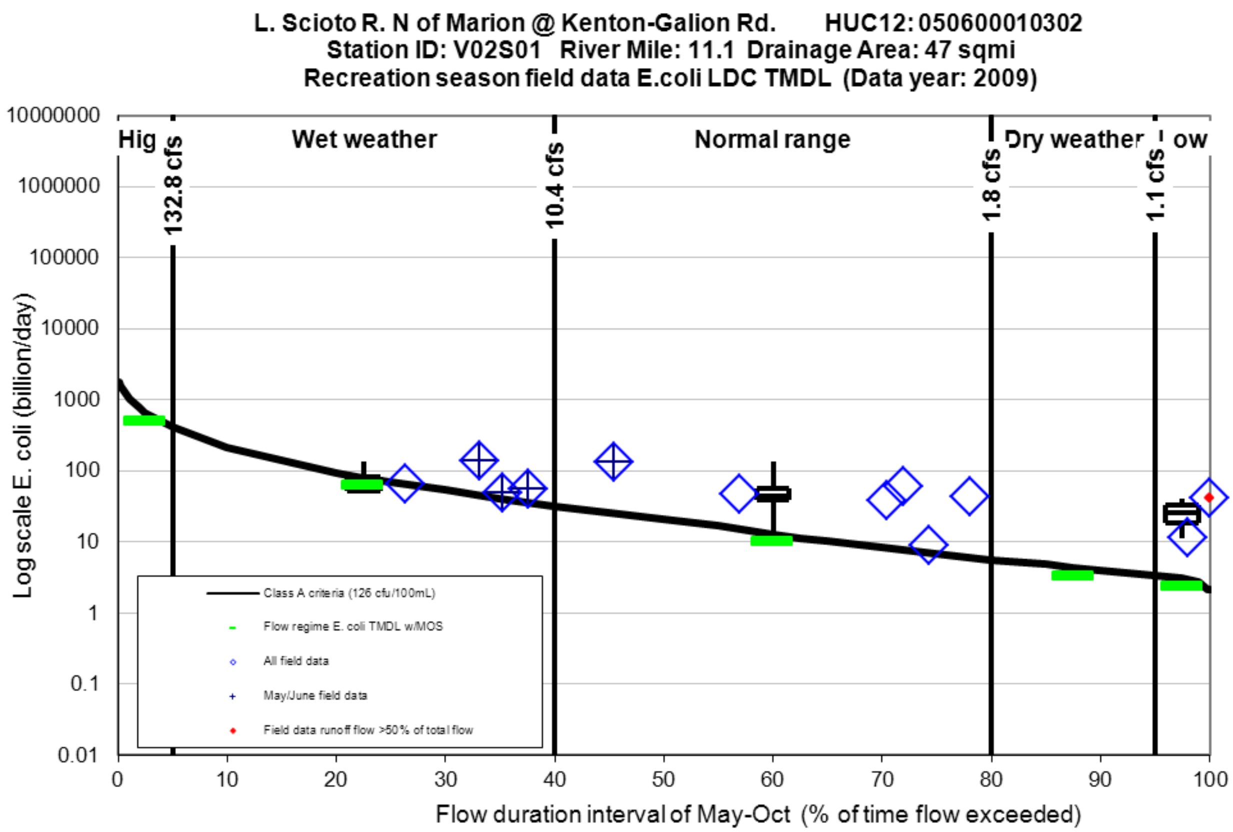

Figure D4-9 ***E. coli*** **load duration curve for site on L. Scioto R. N of Marion @ Kenton-Galion Rd. HUC12: 05060001 03 02**

Table D4-23 ***E. coli*** **TMDL table for site on L. Scioto R. N of Marion @ Kenton-Galion Rd. HUC12: 05060001 03 02**

Flow regime TMDL analysis (*E. coli* in billion organisms/day)	High flows	Wet weather	Normal range	Dry weather	Low
Flow duration regime interval	0-5%	5-40%	40-80%	80-95%	95-100%
Samples per regime	*No Data*	4	6	*No Data*	2
Median sample load	*No Data*	60.4	44.4	*No Data*	26.3
Total WLA	20.1	2.6	0.5	0.2	0.2
Ridgedale Elementary School - 2PT00049 WLA	0.1	0.1	0.1	0.1	0.1
Bucyrus MS4 WLA	20.0	2.5	0.4	0.1	0.1
Load Allocation	483.3	59.7	9.6	3.1	2.2
Margin of Safety	129.1	16.0	2.6	0.9	0.6
Allowance for future growth	12.91	1.60	0.26	0.09	0.06
TMDL	645.4	79.8	12.9	4.3	3.1
Total load reduction required	*No Data*	None	70.8%	*No Data*	88.3%

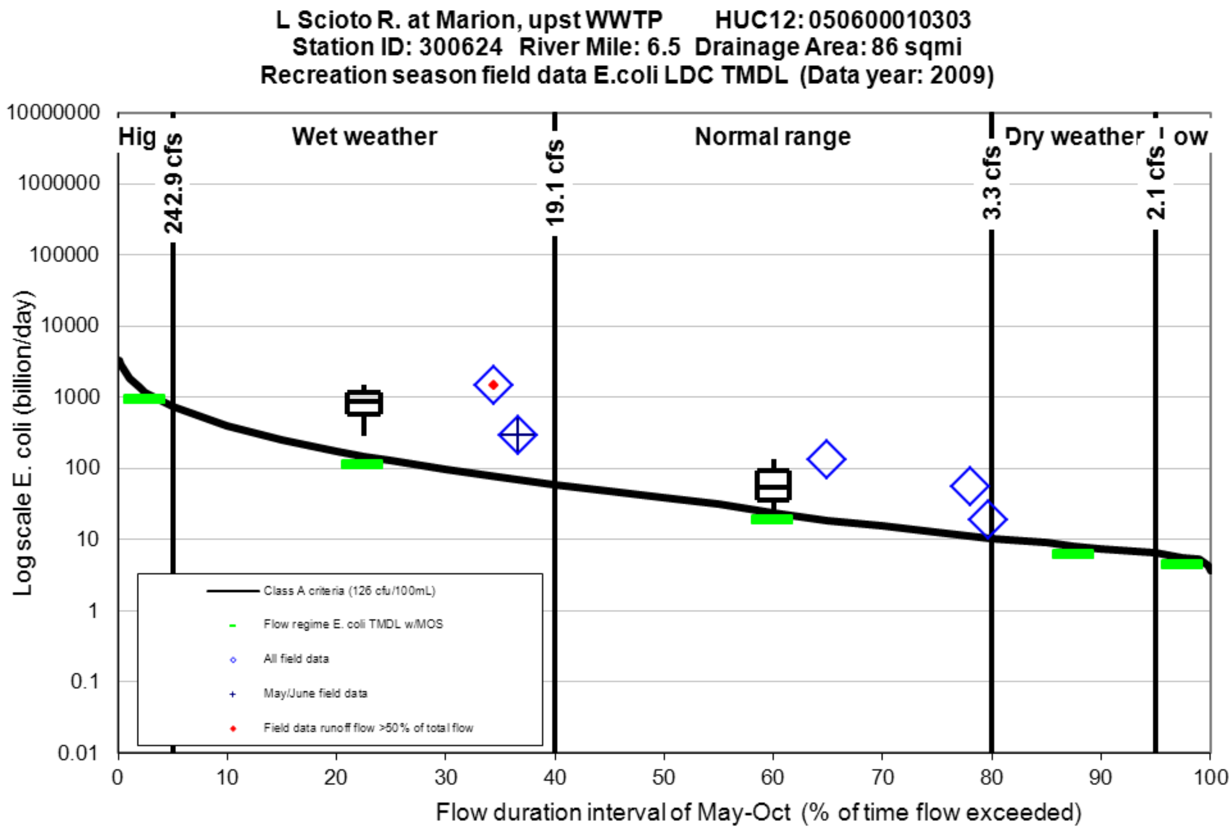

Figure D4-10 *E. coli* **load duration curve for L Scioto R. at Marion, upst Marion WWTP HUC12: 05060001 03 03**

Table D4-24 *E. coli* **TMDL for L Scioto R. at Marion, upst WWTP HUC12: 05060001 03 03**

Flow regime TMDL analysis (*E. coli* in billion organisms/day)	High flows	Wet weather	Normal range	Dry weather	Low
Flow duration regime interval	0-5%	5-40%	40-80%	80-95%	95-100%
Samples per regime	*No Data*	2	3	*No Data*	*No Data*
Median sample load	*No Data*	887.3	54.3	*No Data*	*No Data*
Total WLA	122.8	16.5	4.0	2.4	2.2
Grandview Estates-Outfall 001 - 2PG00036 WLA	1.2	1.2	1.2	1.2	1.2
Grandview Estates-Outfall 002 2PG00036 WLA	0.5	0.5	0.5	0.5	0.5
Ridgedale Elementary School - 2PT00049 WLA	0.1	0.1	0.1	0.1	0.1
Marion MS4 WLA	100.9	12.2	1.8	0.5	0.3
Bucyrus MS4 WLA	20	2.5	0.4	0.1	0.1
Load Allocation	798.3	97.2	14.5	3.9	2.1
Margin of Safety	236.2	29.2	4.7	1.6	1.1
Allowance for future growth	23.62	2.92	0.47	0.16	0.11
TMDL	1180.8	145.8	23.7	8.0	5.5
Total load reduction required	*No Data*	83.6%	56.3%	*No Data*	*No Data*

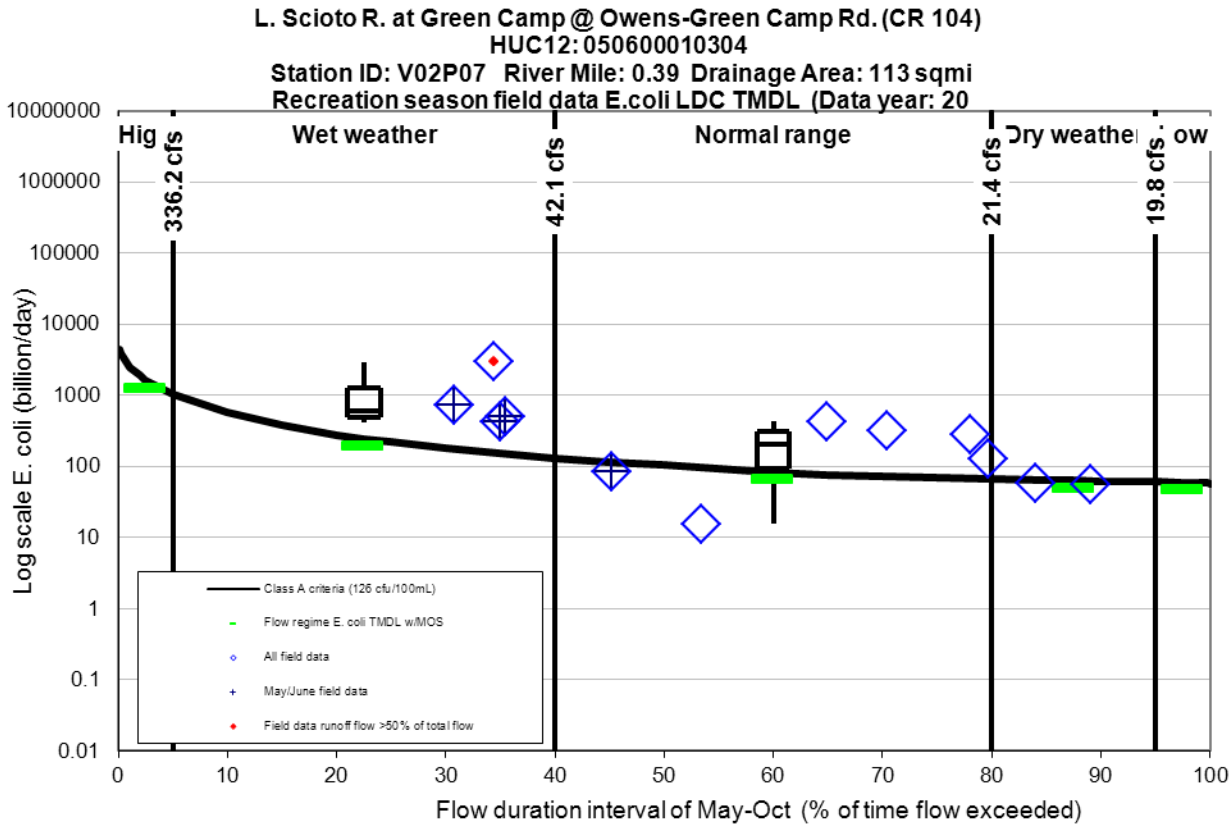

Figure D4-11 ***E. coli*** **load duration curve for site on L. Scioto R. at Green Camp @ Owens-Green Camp Rd. (CR 104) HUC12: 050600010304**

Table D4-25 *E. coli* TMDL table for site on L. Scioto R. at Green Camp @ Owens-Green Camp Rd. (CR 104) HUC12: 05060001 03 04

Flow regime TMDL analysis (*E. coli* in billion organisms/day)	High flows	Wet weather	Normal range	Dry weather	Low
Flow duration regime interval	0-5%	5-40%	40-80%	80-95%	95-100%
Samples per regime	*No Data*	4	6	2	*No Data*
Median sample load	*No Data*	609.1	202.2	55.8	*No Data*
Total WLA	212.3	71.5	55.0	52.8	52.6
Grandview Estates-Outfall 001 - 2PG00036 WLA	1.2	1.2	1.2	1.2	1.2
Grandview Estates-Outfall 002 2PG00036 WLA	0.5	0.5	0.5	0.5	0.5
Ridgedale Elementary School - 2PT00049 WLA	0.1	0.1	0.1	0.1	0.1
Marion WPC - 2PD00011 WLA	50.1	50.1	50.1	50.1	50.1
Pleasant Local Schools - 2PT00048 WLA	0.2	0.2	0.2	0.2	0.2
Pleasant Acres MH Community LLC - 2PR00040 WLA	0.1	0.1	0.1	0.1	0.1
North Quarry Subdivision - 2PW00004 WLA	0.1	0.1	0.1	0.1	0.1
Harmony Subdiv SD 5B - 2PG00072 WLA	0.05	0.05	0.05	0.05	0.05
Morning View Care Center - 2PR00240	0.04	0.04	0.04	0.04	0.04
Marion MS4 WLA	140.0	16.7	2.2	0.4	0.11
Bucyrus MS4 WLA	20	2.5	0.4	0.10	0.10
Load Allocation	1038.8	118.9	10.4	-3.8	-5.9
Margin of Safety	320.8	48.8	16.8	12.6	12.0
Allowance for future growth	32.08	4.88	1.68	1.26	1.20
TMDL	1604.0	244.1	83.8	62.9	59.8
Total load reduction required	*No Data*	59.9%	58.5%	None	*No Data*

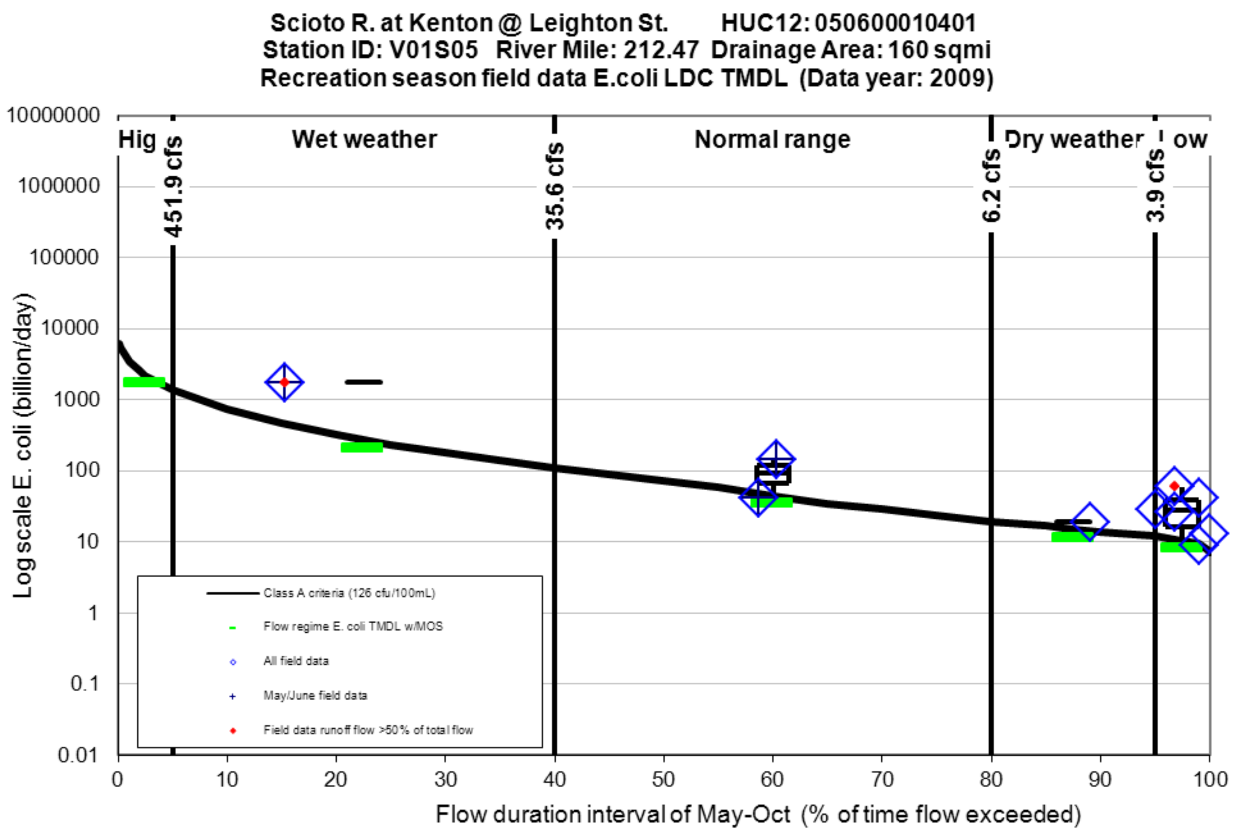

Figure D4-12 ***E. coli*** **load duration curve for site on Scioto R. at Kenton @ Leighton St. HUC12: 05060001 04 01**

Table D4-26 ***E. coli*** **TMDL table for site on Scioto R. at Kenton @ Leighton St. HUC12: 05060001 04 01**

Flow regime TMDL analysis (*E. coli* in billion organisms/day)	High flows	Wet weather	Normal range	Dry weather	Low
Flow duration regime interval	0-5%	5-40%	40-80%	80-95%	95-100%
Samples per regime	*No Data*	1	2	1	6
Median sample load	*No Data*	1759.4	92.0	19.2	27.9
Total WLA	2.0	2.0	2.0	2.0	2.0
Reed Road WWTP - 2PG00004 WLA	0.04	0.04	0.04	0.04	0.04
McGuffey STP - 2PA00006 WLA	0.7	0.7	0.7	0.7	0.7
Alger WWTP - 2PB00064 WLA	1.2	1.2	1.2	1.2	1.2
Green Hills Coach Park Ltd - 2PY00041 WLA	0.01	0.01	0.01	0.01	0.01
Load Allocation	1711.5	209.6	32.7	9.6	6.2
Margin of Safety	439.4	54.2	8.9	3.0	2.1
Allowance for future growth	43.94	5.42	0.89	0.30	0.21
TMDL	2196.8	271.2	44.4	14.8	10.5
Total load reduction required	*No Data*	84.6%	51.8%	23.1%	62.5%

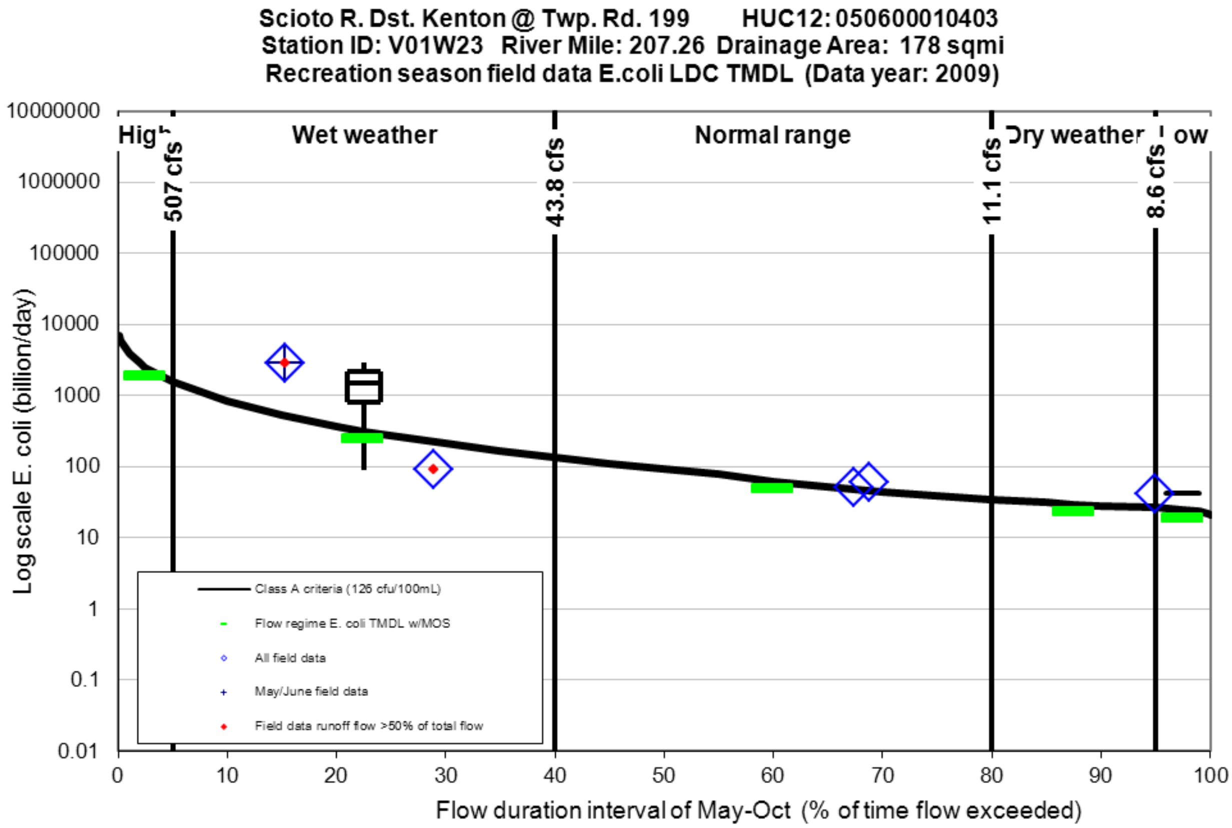

Figure D4-13 *E. coli* **load duration curve for site on Scioto R. Dst. Kenton @ Twp. Rd. 199 HUC12: 05060001 04 03**

Table D4-27 *E. coli* **TMDL table for Scioto R. Dst. Kenton @ Twp. Rd. 199 HUC12: 05060001 04 03**

Flow regime TMDL analysis (*E. coli* in billion organisms/day)	High flows	Wet weather	Normal range	Dry weather	Low
Flow duration regime interval	0-5%	5-40%	40-80%	80-95%	95-100%
Samples per regime	*No Data*	2	2	*No Data*	1
Median sample load	*No Data*	1487.7	54.9	*No Data*	42.1
Total WLA	13.6	13.6	13.6	13.6	13.6
Reed Road WWTP - 2PG00004 WLA	0.04	0.04	0.04	0.04	0.04
McGuffey STP - 2PA00006 WLA	0.7	0.7	0.7	0.7	0.7
Alger WWTP - 2PB00064 WLA	1.2	1.2	1.2	1.2	1.2
Green Hills Coach Park Ltd - 2PY00041 WLA	0.01	0.01	0.01	0.01	0.01
Morton Buildings Inc - 2PR00233 WLA	0.02	0.02	0.02	0.02	0.02
Fairwayview STP - 2PG00012 WLA	0.2	0.2	0.2	0.2	0.2
Kenton WWTP - 2PD00020 WLA	11.4	11.4	11.4	11.4	11.4
Load Allocation	1902.8	232.1	35.0	9.3	5.7
Margin of Safety	491.4	63.0	12.5	5.9	4.9
Allowance for future growth	49.14	6.30	1.25	0.59	0.49
TMDL	2456.9	315.0	62.3	29.3	24.66
Total load reduction required	*No Data*	78.8%	None	No Data	41.4%

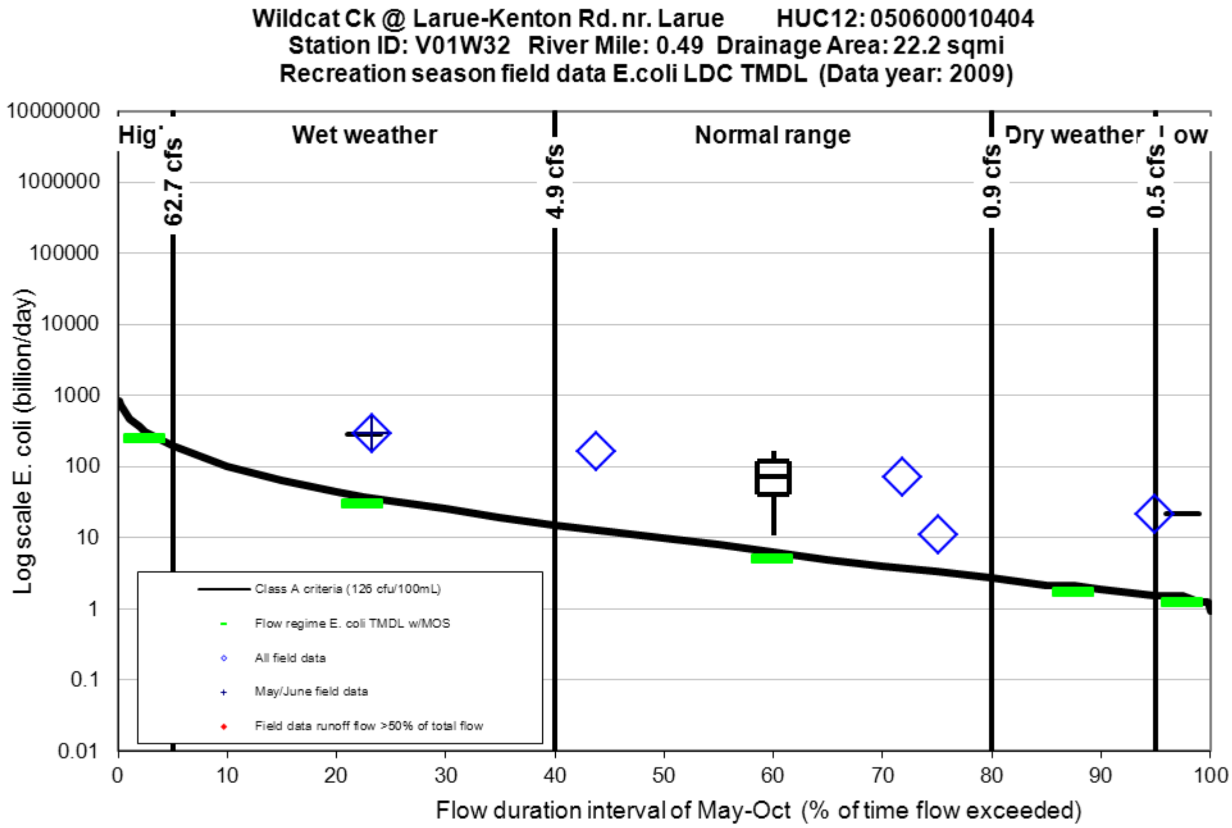

Figure D4-14 ***E. coli*** **load duration curve for site on Wildcat Ck @ Larue-Kenton Rd. nr. Larue HUC12: 050600010404**

Table D4-28 ***E. coli*** **TMDL table for site on Wildcat Ck @ Larue-Kenton Rd. nr. Larue HUC12:05060001 04 04**

Flow regime TMDL analysis (*E. coli* in billion organisms/day)	High flows	Wet weather	Normal range	Dry weather	Low
Flow duration regime interval	0-5%	5-40%	40-80%	80-95%	95-100%
Samples per regime	*No Data*	1	3	*No Data*	1
Median sample load	*No Data*	288.3	71.3	*No Data*	21.5
Total WLA	0.0	0.0	0.0	0.0	0.0
Load Allocation	237.8	29.3	4.9	1.73	1.2
Margin of Safety	61.0	7.5	1.2	0.4	0.3
Allowance for future growth	6.10	0.75	0.12	0.04	0.03
TMDL	304.8	37.6	6.2	2.2	1.5
Total load reduction required	*No Data*	87.0%	91.3%	*No Data*	92.8%

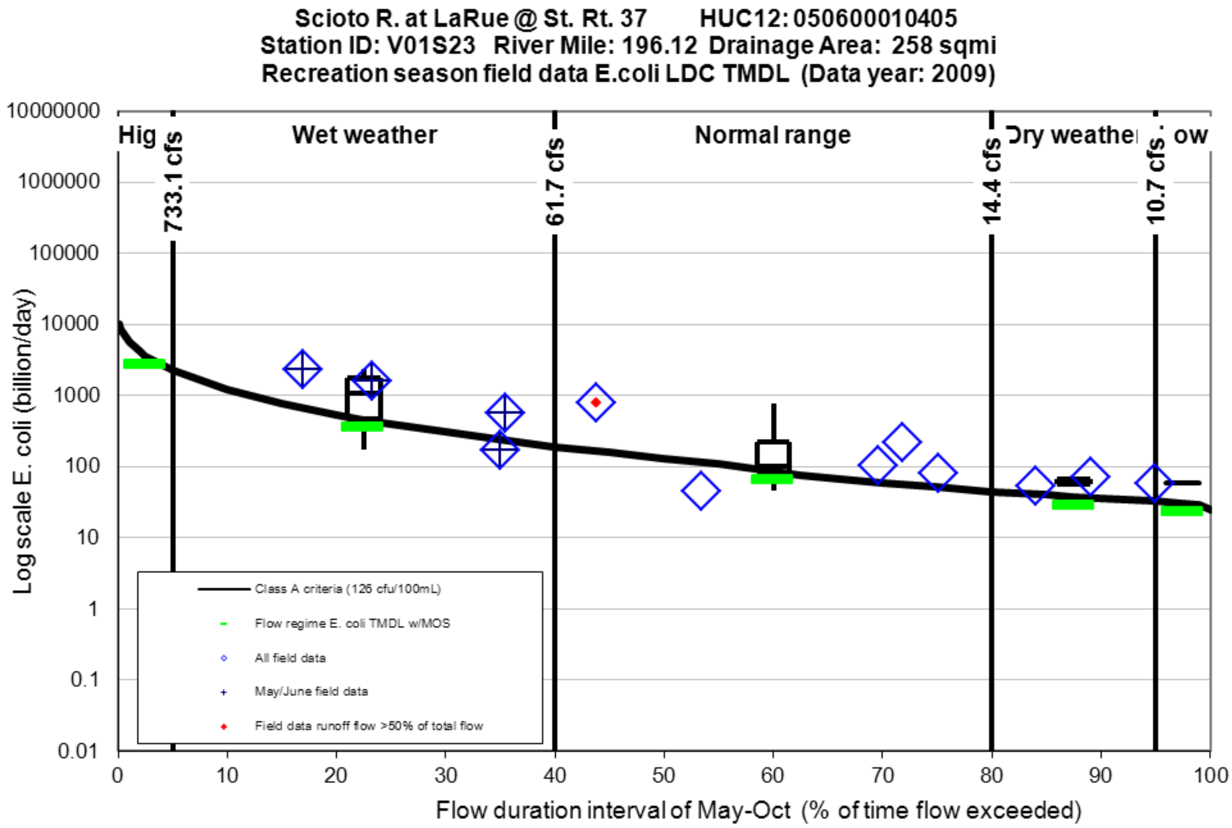

Figure D4-15 ***E. coli*** **load duration curve for site on Scioto R. at LaRue @ St. Rt. 37 HUC12: 05060001 04 05**

Table D4-29 *E. coli* TMDL table for site on Scioto R. at LaRue @ St. Rt. 37 HUC12: 050600010405

Flow regime TMDL analysis (*E. coli* in billion organisms/day)	High flows	Wet weather	Normal range	Dry weather	Low
Flow duration regime interval	0-5%	5-40%	40-80%	80-95%	95-100%
Samples per regime	*No Data*	4	5	2	1
Median sample load	*No Data*	1073.4	101.9	61.9	57.8
Total WLA	14.2	14.2	14.2	14.2	14.2
Reed Road WWTP - 2PG00004 WLA	0.04	0.04	0.04	0.04	0.04
McGuffey STP - 2PA00006 WLA	0.7	0.7	0.7	0.7	0.7
Alger WWTP - 2PB00064 WLA	1.2	1.2	1.2	1.2	1.2
Green Hills Coach Park Ltd - 2PY00041 WLA	0.01	0.01	0.01	0.01	0.01
Morton Buildings Inc - 2PR00233 WLA	0.02	0.02	0.02	0.02	0.02
Fairwayview STP - 2PG00012 WLA	0.2	0.2	0.2	0.2	0.2
Kenton WWTP - 2PD00020 WLA	11.4	11.4	11.4	11.4	11.4
Mt Victory WWTP - 2PA00046 WLA	0.5	0.5	0.5	0.5	0.5
Eldridge Station Hills WWTP - 2PG00005 WLA	0.04	0.04	0.04	0.04	0.04
Load Allocation	2759.5	337.6	52.2	14.9	9.4
Margin of Safety	711.2	90.2	17.0	7.5	6.0
Allowance for future growth	71.12	9.02	1.70	0.75	0.60
TMDL	3556.0	450.9	85.1	37.3	30.2
Total load reduction required	*No Data*	58.0%	16.5%	39.8%	47.7%

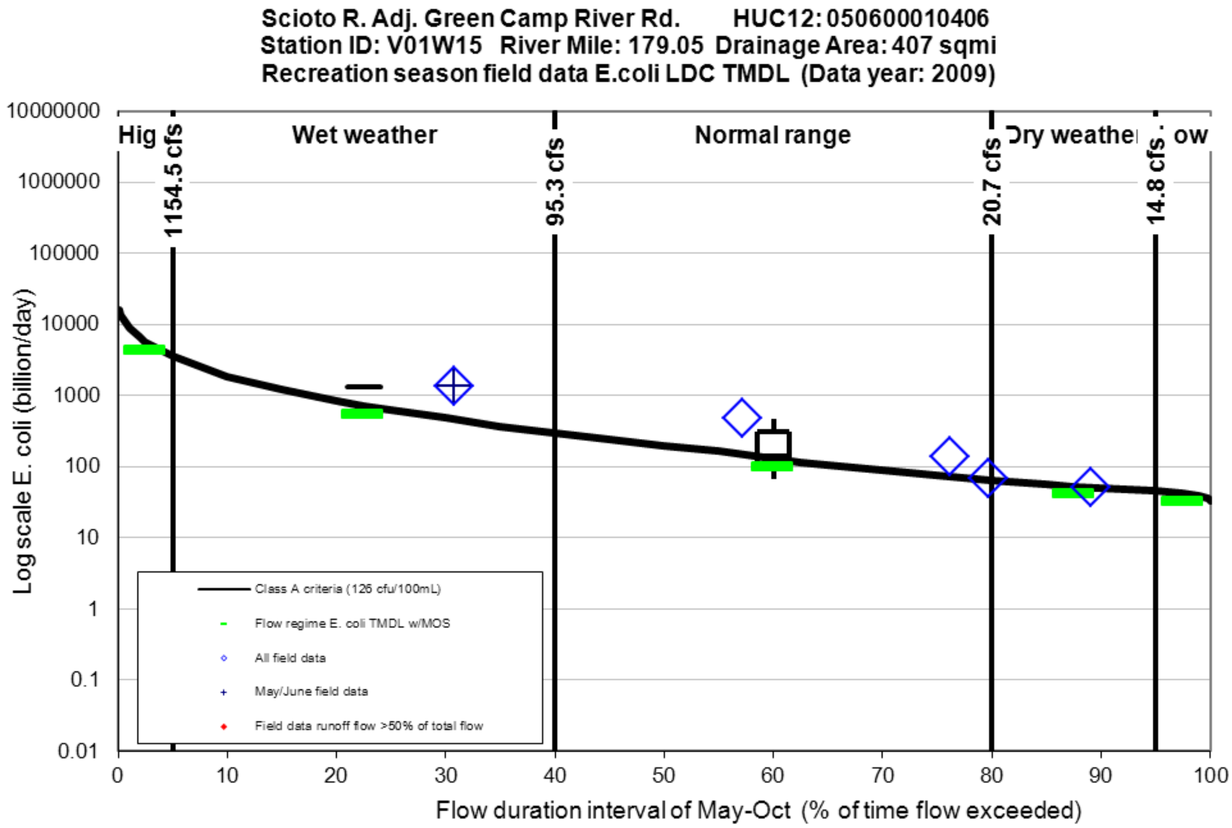

Figure D4-16 ***E. coli*** **load duration curve for site on Scioto R. Adj. Green Camp River Rd. HUC12: 05060001 04 06**

Table D4-30 *E. coli* TMDL table for site on Scioto R. Adj. Green Camp River Rd. HUC12: 05060001 04 06

Flow regime TMDL analysis (*E. coli* in billion organisms/day)	High flows	Wet weather	Normal range	Dry weather	Low
Flow duration regime interval	0-5%	5-40%	40-80%	80-95%	95-100%
Samples per regime	*No Data*	1	3	1	*No Data*
Median sample load	*No Data*	1343.7	138.3	50.2	*No Data*
Total WLA	15.9	15.9	15.9	15.9	15.9
Reed Road WWTP - 2PG00004 WLA	0.04	0.04	0.04	0.04	0.04
McGuffey STP - 2PA00006 WLA	0.7	0.7	0.7	0.7	0.7
Alger WWTP - 2PB00064 WLA	1.2	1.2	1.2	1.2	1.2
Green Hills Coach Park Ltd - 2PY00041 WLA	0.01	0.01	0.01	0.01	0.01
Morton Buildings Inc - 2PR00233 WLA	0.02	0.02	0.02	0.02	0.02
Fairwayview STP - 2PG00012 WLA	0.2	0.2	0.2	0.2	0.2
Kenton WWTP - 2PD00020 WLA	11.4	11.4	11.4	11.4	11.4
Mt Victory WWTP - 2PA00046 WLA	0.5	0.5	0.5	0.5	0.5
Eldridge Station Hills WWTP - 2PG00005 WLA	0.04	0.04	0.04	0.04	0.04
Rushsylvania WWTP - 1PB00025 WLA	0.6	0.6	0.6	0.6	0.6
LaRue WWTP - 2PA00051 WLA	0.5	0.5	0.5	0.5	0.5
New Bloomington WWTP - 2PA00065 WLA	0.6	0.6	0.6	0.6	0.6
Elgin High School - 2PT00052 WLA	0.1	0.1	0.1	0.1	0.1
Load Allocation	4354.7	534.4	83.9	25.2	16.5
Margin of Safety	1120.7	141.1	25.6	10.5	8.3
Allowance for future growth	112.1	14.1	2.6	1.1	0.8
TMDL	5603.3	705.5	127.9	52.7	41.6
Total load reduction required	*No Data*	47.5%	7.5%	None	*No Data*

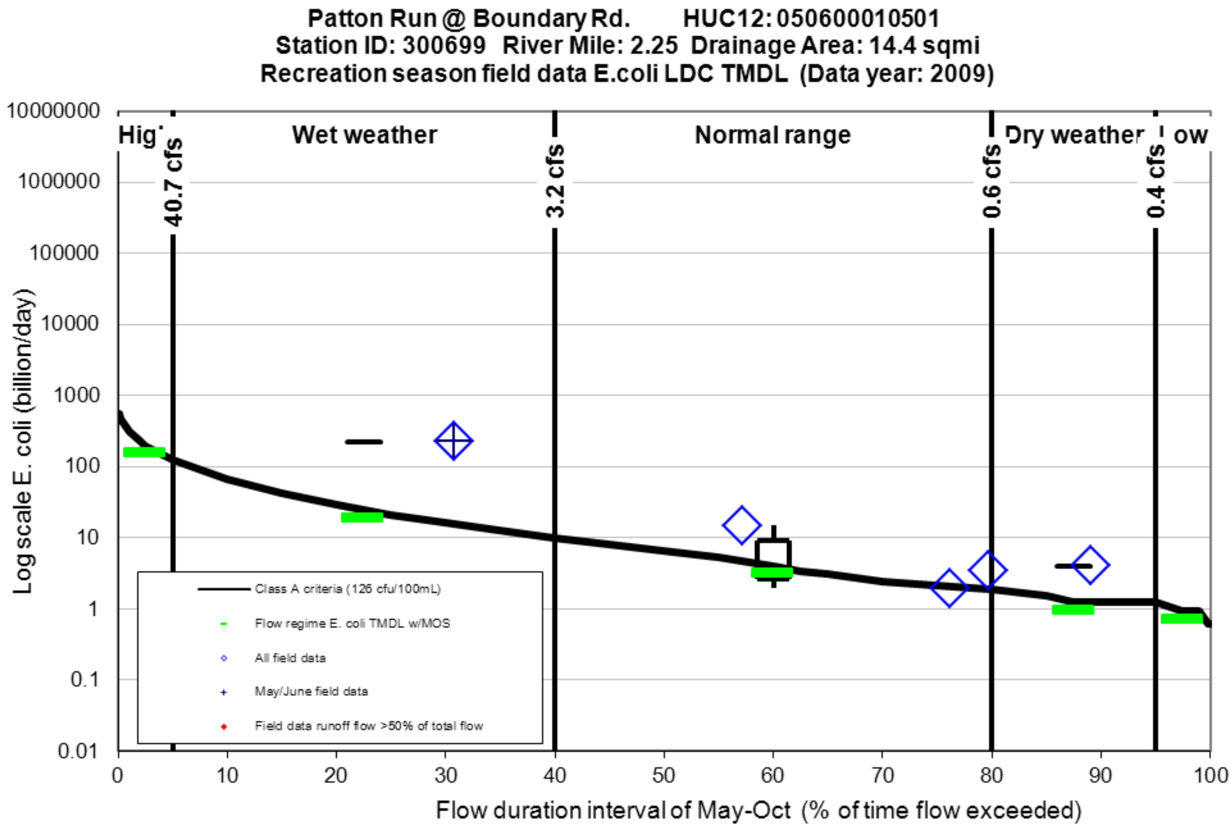

Figure D4-17 ***E. coli*** **load duration curve for site on Patton Run @ Boundary Rd. HUC12: 05060001 05 01**

Table D4-31 ***E. coli*** **TMDL table for site on Patton Run @ Boundary Rd. HUC12: 05060001 05 01**

Flow regime TMDL analysis (*E. coli* in billion organisms/day)	High flows	Wet weather	Normal range	Dry weather	Low
Flow duration regime interval	0-5%	5-40%	40-80%	80-95%	95-100%
Samples per regime	*No Data*	1	3	1	*No Data*
Median sample load	*No Data*	223.7	3.4	4.0	*No Data*
Total WLA	0.0	0.0	0.0	0.0	0.0
Load Allocation	154.1	19.0	3.1	1.0	0.7
Margin of Safety	39.5	4.9	0.8	0.2	0.2
Allowance for future growth	3.95	0.49	0.08	0.02	0.02
TMDL	197.6	24.4	4.0	1.2	0.9
Total load reduction required	*No Data*	89.1%	None	69.3%	*No Data*

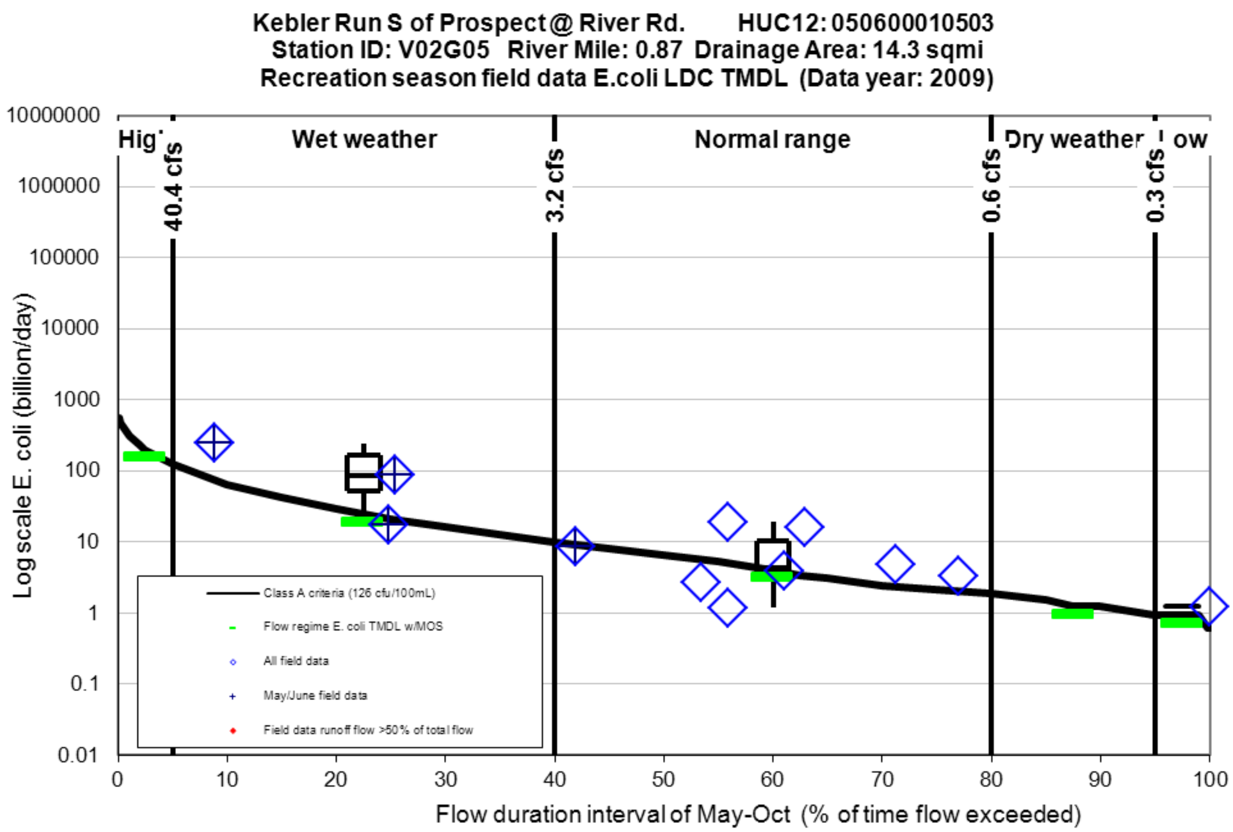

Figure D4-18 ***E. coli*** **load duration curve for site on Kebler Run S of Prospect @ River Rd. HUC12: 05060001 05 03**

Table D4-32 ***E. coli*** **TMDL table for site on Kebler Run S of Prospect @ River Rd. HUC12: 05060001 05 03**

Flow regime TMDL analysis (*E. coli* in billion organisms/day)	High flows	Wet weather	Normal range	Dry weather	Low
Flow duration regime interval	0-5%	5-40%	40-80%	80-95%	95-100%
Samples per regime	*No Data*	3	8	*No Data*	1
Median sample load	*No Data*	85.6	4.4	*No Data*	1.2
Total WLA	0.0	0.0	0.0	0.0	0.0
Load Allocation	153.1	19.0	3.1	1.0	0.7
Margin of Safety	39.3	4.9	0.8	0.2	0.2
Allowance for future growth	3.93	0.49	0.08	0.02	0.02
TMDL	196.3	24.4	4.0	1.2	0.9
Total load reduction required	*No Data*	71.6%	8.8%	*No Data*	25.0%

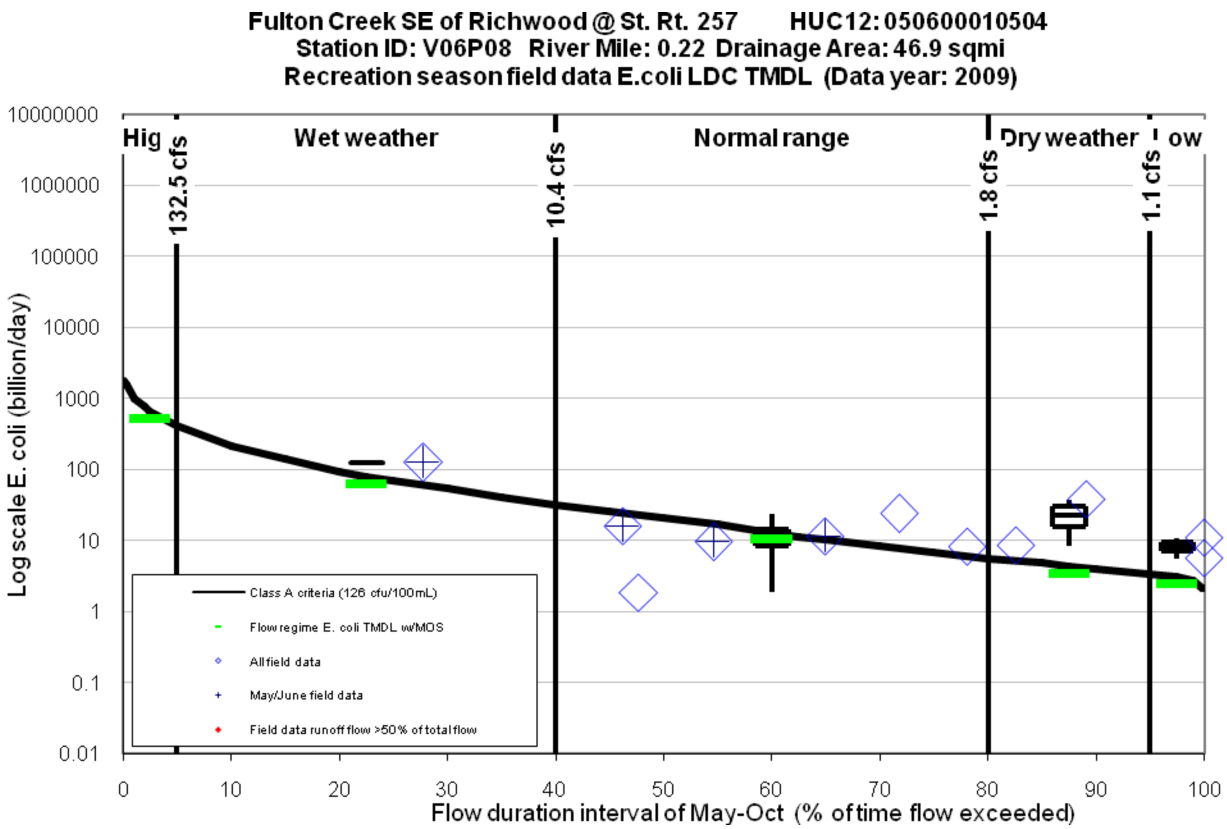

Figure D4-19 ***E. coli*** **load duration curve for site on Fulton Creek SE of Richwood @ St. Rt. 257 HUC12: 05060001 05 04**

Table D4-33 ***E. coli*** **TMDL table for site on Fulton Creek SE of Richwood @ St. Rt. 257 HUC12: 05060001 05 04**

Flow regime TMDL analysis (*E. coli* in billion organisms/day)	High flows	Wet weather	Normal range	Dry weather	Low
Flow duration regime interval	0-5%	5-40%	40-80%	80-95%	95-100%
Samples per regime	*No Data*	1	6	2	2
Median sample load	*No Data*	124.9	10.4	23.2	8.3
Total WLA (Richwood WWTP - 4PB00018)	2.3	2.3	2.3	2.3	2.3
Load Allocation	499.9	59.7	7.8	1.1	0.1
Margin of Safety	128.8	15.9	2.6	0.9	0.6
Allowance for future growth	12.88	1.59	0.26	0.09	0.06
TMDL	643.9	79.5	12.9	4.3	3.1
Total load reduction required	No Data	36.3%	None	81.4%	62.9%

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