Appendix

D

LOADING ANALYSIS INFORMATION
SCIOTO BRUSH CREEK WATERSHED

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D1 Recreation Use

Recreation use was not supported in multiple assessment units in which at least one site's geometric mean did not attain the water quality standards criteria. Sixty sites were sampled to determine recreation use support, and 39 (65%) were found to be in non-attainment of water quality standards.

A study was carried out to develop an *Escherichia coli* (*E. coli*) total maximum daily load (TMDL) as required by Section 303(d) of the Clean Water Act and the United States Environmental Protection Agency's Water Quality Planning and Management Regulations (Title 40 of the Code of Federal Regulations, Part 130). This TMDL report defines in-stream bacterial conditions, potential sources, bacteria targets and needed reductions and recommends implementation strategies.

D1.1 Justification of Method

In order to determine the magnitude of bacteria impairment and differentiate between types of bacteria sources contributing to impairment, load duration curves (LDCs) were calculated for analyzed sites following the methods described in U.S. EPA's *An Approach for Using Load Duration Curves in the Development of TMDLs* (U.S. EPA 2007). See Figure D-1 and Table D-1 for examples.

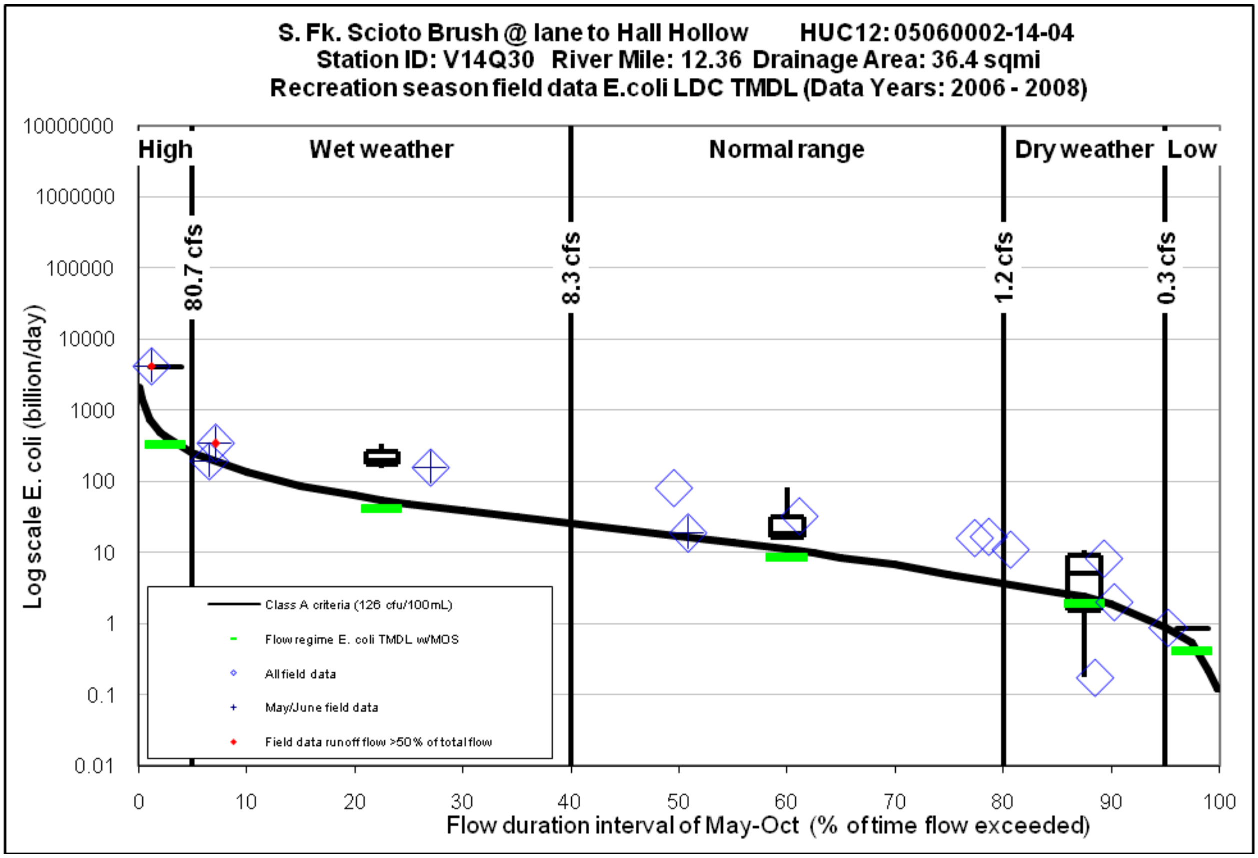

Figure D-1. Example load duration curve.

Table D-1. Example TMDL table calculations (from above load duration curve).

Flow regime TMDL analysis *E. coli* (billion bacteria/day)	High	Wet weather	Normal range	Dry weather	Low
Duration interval	0-5%	5-40%	40-80%	80-95%	95-100%
Samples per regime	1	3	5	4	1
Median sample load	4,099	194	19	5.1	0.9
TMDL	424.4	54.6	11.10	2.466	0.550
WLA	0.0	0.0	0.0	0.0	0.0
LA	326.8	42.0	8.54	1.899	0.423
MOS: 20%	84.9	10.9	2.22	0.493	0.110
AFG: 3%	12.7	1.6	0.3	0.074	0.016
Nonpoint (LA) % load reduction required	**92.0%**	**78.4%**	**53.8%**	**63.0%**	**51.2%**

Values were adjusted for rounding.

Of the 39 sites found to be in recreation use non-attainment during the summer of 2006, a subset of five sampling locations was established on four different streams within the watershed, and these sites were used for further study of the causes of recreation use impairment in non-attaining nested subwatersheds. These five sites included two sites on the mainstem of Scioto Brush Creek and three tributary sites. Table D-2 shows each LDC site and which nested subwatersheds are encompassed by that LDC.

Table D-2. Nested subwatersheds included in each *E. coli* load duration curve.

Load Duration Curve Site	Nested Subwatershed Location	Nested Subwatersheds Included
South Fork Scioto Brush Creek at lane to Hall Hollow	05060002 14 04	14 01 14 02 14 04 (through river mile 12.36)
Turkey Run at Newman Rd. near Blue Creek	05060002 14 04	14 04 (Turkey Run basin)
Scioto Brush Creek at State Route 348	05060002 15 04	15 01 15 02 15 03 15 04
Scioto Brush Creek at Colley Rd.	05060002 15 07	14 03 14 04 (downstream river mile 12.36) 14 05 15 05 15 06 15 07 (excluding Duck Run)
Duck Run at lane upstream of Reeds Run	05060002 15 07	15 07 (Duck Run basin)

D1.2 Load Duration Curves

Load duration curves can assist in distinguishing between point and nonpoint sources that contribute to *E. coli* loading by highlighting the flow conditions under which impairment occurs. At lower stream flow levels, little to no in-stream dilution of *E. coli* occurs because of lack of runoff caused by dry conditions. Because of this, any point source *E. coli* contributions to the stream will result in higher concentrations of *E. coli*. If there are a high number of samples under dry weather or low flow conditions that fall above the target curve, there is a likelihood of nearby point sources of *E. coli.* Examples of bacteria point sources include combined sewer overflows (CSOs), municipal separate storm sewer systems (MS4s) and wastewater treatment plants (WWTPs). High bacteria levels under low flow conditions may also indicate concentrated cattle grazing in the stream channel, leaking sewer lines, or failing home sewage treatment systems.

Under elevated flow conditions, point sources are assumed to be masked by in-stream dilution, implying that high *E. coli* loading is caused by precipitation washoff or erosion of contaminated land surfaces. Among many possibilities, some typical nonpoint sources of *E. coli* include manure spreading, stream bank erosion, and washoff from livestock feeding operations. Scenarios where high *E. coli* loads exist under mid-range flow conditions, or high loads occur under all conditions, can be attributed to a mixture of point and nonpoint sources. Site investigation using digital mapping, aerial photography or an on-the-ground visit can help develop priorities for implementation based on the LDC evidence for either point or nonpoint sources of *E. coli*.

It is important to note that the load duration curve method does not enable one to attribute impairment to any particular source; instead it is a tool used to determine determine pollutant loading under various flow conditions and the probable types of sources contributing to high loadings.

An outline of LDC development specific to the Scioto Brush Creek watershed is as follows:

1. An historical daily flow record was obtained for the USGS Gage 3237500 on adjacent Ohio Brush Creek for the period of record containing October 1940 through October 2008. Dates outside of the recreation season (May 1 through October 31) were excluded from the record. This flow record was then ordered and ranked to determine, for each daily flow, the percentage of the period of record when that flow was equaled or exceeded. This flow exceedance range constitutes the basis for the x-axis in each LDC graph. In order to generate specific load duration curves for each sampling site and calculate the stream flow that corresponds to each *E. coli* sampling event, a ratio of the drainage area of the sampling site to that of the Ohio Brush Creek gage was used (drainage-area yield method) and applied to the Ohio Brush Creek long-term flow record.
2. In-stream bacteria loads were determined for each sampling event using stream sample bacteria concentration in conjunction with flow data for each sampling location. At the appropriate flow, the corresponding *E. coli* concentration for a stream sample was plotted as a point on the y-axis of the LDC. In order to determine the sample sites' flow, sampling locations were assigned scaled flows based on the ratio of each sampling location's drainage area compared to that of the gage site.
3. Target *E. coli* loads were calculated by applying the applicable *E. coli* WQS concentration value at each flow exceedance value for the entire flow duration interval.
4. A margin of safety was added to account for uncertainty.
5. An allowance for future growth, based upon population growth projections, was factored into any needed load reductions.
6. The LDCs were divided into five hydrologic regimes and within each regime the total required nonpoint load reduction percentage is calculated by incorporating the margin of safety and allowance for future growth into the target load and determining the difference between this target and the existing load in each flow regime.

A “TMDL table” is associated with each LDC, detailing the information that is graphically presented in the LDC figure. Each table contains the following information for each hydrologic regime:

- number of samples
- median sample *E. coli* load
- total maximum daily load (TMDL)
- wasteload allocation (WLA)
- nonpoint load allocation (LA)
- margin of safety (MOS) load
- allowance for future growth (AFG) load
- nonpoint (LA) % load reduction required

Target and Existing Deviation

For a given impaired site, each hydrologic condition (high flows, wet weather conditions, normal conditions, dry weather conditions or low flows) was assigned a target bacteria loading rate (cfu/day) by multiplying the Class A *E. coli* water quality standard, 126 colony forming units (cfu)/100 ml, by the median flow of each hydrologic class at that site and a constant, used to convert cubic feet per second to milliliters per hour: $T = Q_m * S * C$; where T = target bacteria load, Q_m = median flow for a specific hydrologic class, S = water quality standard (126 cfu/100 ml) and C = a unit conversion constant (cubic feet per second to milliliters per day). Median observed bacteria loads in each hydrologic condition were compared to the median target value in that condition, after incorporating a margin of safety and allowance for future growth, in order to quantify needed reductions. Several of the sites at which load duration curves were created were located in primary contact recreation Class B streams (where the WQS is 161 cfu/100 ml). However, all of these sites were within five miles of Class A streams, so the Class A WQS was used to protect downstream uses.

Wasteload Allocation

There is one NPDES permitted sanitary discharger in the Scioto Brush Creek basin: Scioto County Local Schools, Northwest School (Ohio EPA Permit OPT00039), located at 692 Mohawk Drive, McDermott, Ohio in Scioto County. This facility discharges to Duck Run with a design flow of 0.031 million gallons per day (MGD).

Northwest School is assigned a wasteload allocation (WLA) based upon the design flow of the treatment facility and the Class A water quality standard applicable to its receiving water. Because any facility operates at most times at some fraction of its design flow, the WLA for this facility includes an amount of reserve capacity up to the design flow.

The wasteload allocation for this facility is accounted for in the only downstream LDC in the watershed, located at *Duck Run at a lane upstream of Reeds Run* (Duck Run river mile 1.56).

Load Allocation

The load duration curve method was selected to assign in-stream bacteria loads at a given site to one or several potential bacteria sources (see U.S. EPA 2007). In a load duration curve, patterns of bacteria impairment can be examined and addressed relative to the flow conditions under which they occur, which allows a set of potential bacteria sources specific to a given site to be highlighted. Under the highest flow conditions, point sources are likely to be masked by in-stream dilution; therefore, high bacteria measurements in these conditions are associated with precipitation washoff or erosion of contaminated land surfaces. Impairments under mid-range flows can be caused by a mixture of point and nonpoint sources. Under the lowest flow conditions, recreation use impairments are generally attributable to sources not associated with runoff events, such as a failing home sewage treatment system (HSTS) or in-stream livestock.

Sampling locations were visited under a range of different flow conditions during the recreation season. Daily loading of bacteria was calculated for each site utilizing *E. coli* stream sample data. Existing in-stream loads, target loads and load duration curves were calculated from the collected data. Using these data and notes about land use, recommendations regarding sources and potential implementation were developed.

Margin of Safety

The Clean Water Act requires that a TMDL include a margin of safety (MOS) to account for any lack of knowledge concerning the relationship between load and wasteload allocations and water quality. U.S. EPA guidance explains that the MOS may be implicit (i.e., incorporated into the TMDL through conservative assumptions in the analysis) or explicit (i.e., expressed in the TMDL as loadings set aside for the MOS).

An implicit MOS is incorporated in various ways, including in the derivation of the *E. coli* water quality criterion and in not considering the die-off of pathogens as part of the TMDL calculations. The implicit MOS is also enhanced by the use of the geometric mean target (which is a seasonal target) to calculate daily loads. In addition, an explicit MOS has been applied as part of all of the bacteria TMDLs by reserving 20% of the allowable load because of the broad fluctuation of *E. coli* concentrations that occurs in nature and the relatively low numbers of data points available for this analysis. The explicit MOS in each allocation is shown in the TMDL allocation tables throughout Section 5.

Critical Conditions

Critical conditions for in-stream bacteria vary by source and can occur across the hydrograph, from washoff of land-deposited bacteria under moist conditions to in-stream livestock and failing HSTSs in low flow conditions. Nonpoint sources to which bacteria loads are allocated in the Scioto Brush Creek basin include livestock, both manure washoff and in-stream animals, and failing HSTSs.

Allowance for Future Growth

An allowance for future growth (AFG) accounts for reasonably foreseeable increases in pollutant loads. AFGs were included in the *E. coli* and total phosphorus TMDLs.

The Scioto Brush Creek watershed lies within Adams and Scioto counties. The average population change projection from 2010 to 2020 of the two counties is an increase of 3% (ODD 2003). In order to ensure recreation use attainment in the future, an allowance for future growth of 3% was applied to each TMDL.

D2 Aquatic Life Use

D2.1 Linkage and Justification of Methods

The aquatic life use designation for warmwater habitat in Rarden Creek is partially impaired due to nutrients from cattle and direct habitat alteration. In the 8.05 square miles of drainage upstream of the site at RM 3.86 lie two small livestock farms with pastures adjacent to the streams. These are the only possible sources because land beyond the farms is predominantly undisturbed hilly tracts of mature forest. With the source (cattle pastures) being so straightforward, a direct quantification of nutrients (total phosphorus) is performed for the TMDL.

How the identified stressors lead to impaired uses

In freshwater systems, phosphorus is typically the nutrient that is in short supply relative to biological needs, which means that the productivity of aquatic plants and algae can be controlled by limiting the amount of phosphorus entering the water. Large diurnal swings in pH and dissolved oxygen may occur as excessive amounts of nutrients are metabolized by aquatic plants and algae. The range of these swings often exceeds the state water quality criteria established to protect fish and other aquatic organisms in their various life stages. The amount of phosphorus currently entering these waters exceeds the seasonal loading capacity and must be reduced if these water quality problems are to be resolved. The sources of phosphorus loading vary depending on the human activities and conditions in a specific watershed (U.S. EPA 2007).

Direct linkage

For the purpose of this TMDL, total phosphorus (total P) is used as an indicator for the degree of nutrient enrichment. While the Ohio EPA does not currently have statewide numeric criteria for nutrients, potential targets have been identified in a technical report titled *Association between Nutrients, Habitat, and the Aquatic Biota in Ohio Rivers and Streams* (Ohio EPA 1999). This document provides the results of a study analyzing the effects of nutrients on the aquatic biological communities of Ohio streams and rivers. The study reaches a number of conclusions and stresses the importance of habitat and other factors, in addition to in-stream nutrient concentrations, as having an impact on the health of biologic communities. The study also includes proposed total phosphorus target concentrations based on observed concentrations associated with acceptable ranges of expected biological communities. The total P and nitrogen targets used in this report are shown in the Nutrient TMDL Table in the Methods section near the end of the report. It is important to note that these nutrient targets are not codified in Ohio's water quality standards; therefore, there is a certain degree of flexibility as to how they can be used in TMDL development.

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

D2.2 Load Duration Curve

Chemistry samples were collected five times during the summer and fall of 2006 and twice in 2010. Impairments are based on scores from the biological samples; TMDLs are based on chemical samples. Nutrients from the pastures along Rarden Creek enter the streams by being washed off during precipitation events. Two samples (taken 9/12/2006 and 10/4/2006) were taken on the upslope and downslope of the hydrograph (Figure D-2), respectively, and they are the highest total phosphorus concentrations of the group, Table D-3. The other three samples in 2006 were taken during low flow conditions. Though the two sampling events in 2010 attempted to capture storms, they were taken during lower flows.

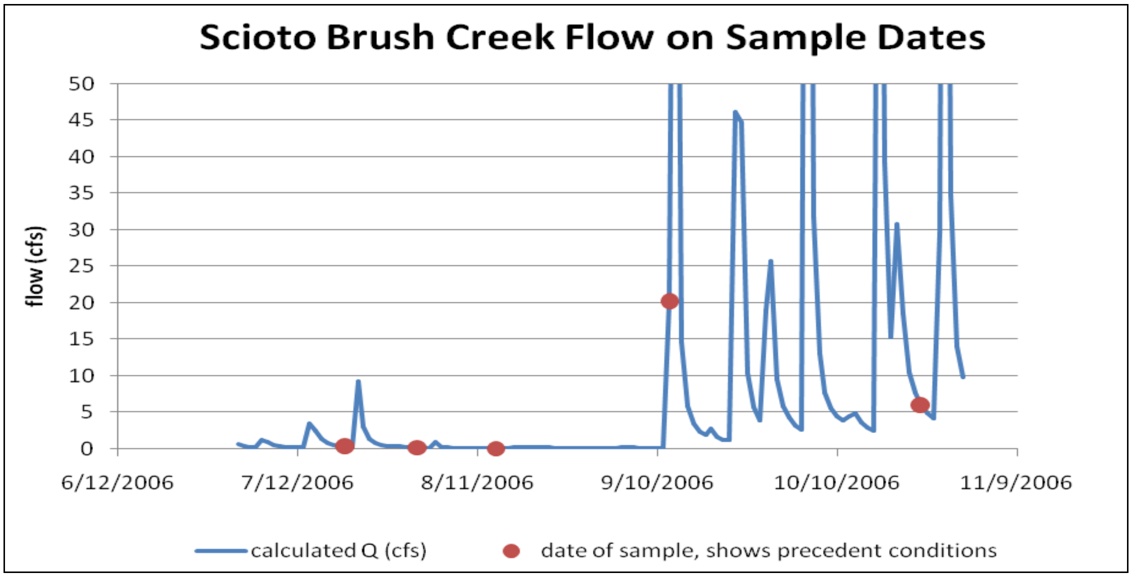

Figure D-2. Flow hydrograph for the Scioto Brush Creek watershed in 2006.

The long-term flow used for Rarden Creek is derived indirectly from the USGS gage in the next basin to the west, 03237500 Ohio Bush Creek near West Union. Bridge to water surface elevation (BWSE) measurements were taken sixteen times at Scioto Brush Creek at SR 348, a site near Rarden Creek. Of the 16 flow (Q) measurements, five were related to stream measurements at that site. From that BWSE to Q relationship, the other 11 BWSE measurements flows could be calculated. Those 16 flow measurements were then compared to Ohio Brush Creek gage measurements for the same dates and using that relationship a long-term (10 year) daily flow was calculated for the Scioto Brush Creek at State Route 348 site. Those flows were then reduced using a drainage area yield to fit the 8.05 square mile drainage area at the Rarden Creek site.

Table D-3. Flows and nutrient samples taken at Rarden Creek (RM 3.86).

Date of sample	Total Phosphorus (mg/l)	NO_3-NO_2 (mg/l)	Flow (cfs*) at Time of Sample
7/20/2006	0.013	0.25	0.291
8/1/2006	0.005	0.28	0.187
8/14/2006	0.005	0.26	0.042
9/12/2006	0.117	0.38	20.180
10/24/2006	0.162	0.48	5.928
6/2/2010	0.005	0.365	2.080
6/9/2010	0.005	0.32	8.279

* cfs = cubic feet per second

Calibration

The longterm flow calculations for Rarden Cr. at RM 3.6, for years 2000 to 2010, were calculated using a drainage area (D.A.) yield method with the Ohio Brush Creek USGS gage (03237500). The USGS gage drainage area is 387 square miles and the Rarden Creek site is 8.05 square miles. Measured flows at a nearby sentinel site at State Route 348 on Scioto Brush Creek were used to test that the D.A. yield calculated flows are valid.

First, five flows measured in 2006 at the Scioto Brush Creek at S.R. 348 sentinel site were related to their corresponding bridge to surface water elevation (BWSE) measurements using the “Type 2” regression technique in the USGS program called "reduced major axis" (RMA) regression (USGS 1982). Using the relationship, flows were calculated for the other 11 BWSEs measured at that site, resulting in a total of 16 measured or calculated flows. Second, those 16 flow values were compared to the D.A. yield calculated flows for the gravel road site on Rarden Creek using a linear relationship. One Ohio Brush Creek USGS gage value from 9/2/2006 deviated from the calculated value—20.16 cfs versus 0.327 cfs, respectively. There was a storm that day in the Ohio Brush Creek basin and it is assumed that it was only localized and did not affect the Scioto Brush Creek basin, so those data were removed from the regression calculation. With those data points excluded, the R^2 value for the linear relationship is 0.93 (see Figure D-3).

In summary, the good relationship between the D.A. yield longterm flow calculations and the sentinel site based measured and calculated flows demonstrate that the D.A. yield calculated flows are valid and sound to use in a LDC.

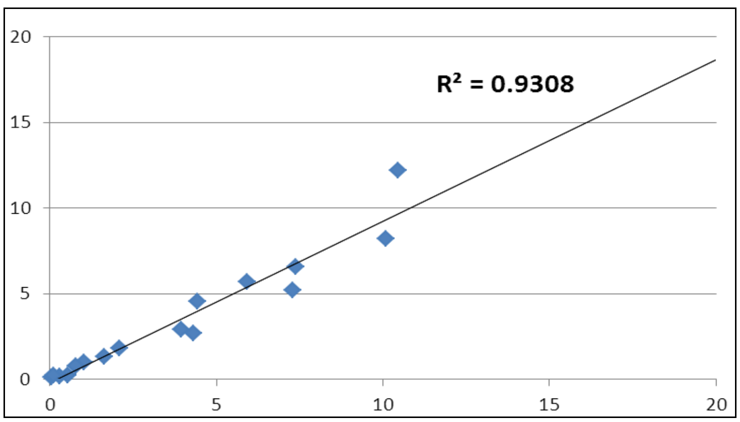

Figure D-3. Comparison of sentinel site-based measured and calculated flows to drainage area yield based on calculated flows.

MOS and Future Growth

The Clean Water Act requires that a TMDL include a margin of safety (MOS) to account for any lack of knowledge concerning the relationship between load and wasteload allocations and water quality. U.S. EPA guidance explains that the MOS may be implicit (i.e., incorporated into the TMDL through conservative assumptions in the analysis) or explicit (i.e., expressed in the TMDL as loadings set aside for the MOS).

An explicit MOS of 10% is included. The MOS is set at 10% because of the uncertainty about flows based on the distance from the site to the USGS gage used for the flow calculation basis, a key factor of the load calculation.

Critical Conditions

Since LDCs develop TMDLs for different flow conditions, critical flow conditions are adequately addressed. Total phosphorus is introduced during storm runoff from active pastures so reductions during high flows are important. The only necessary reduction is in the wet/spring weather category.

Allowance for Future Growth

For the total phosphorus TMDL, which is limited to a single stream in 05060002 15 02 (Rarden Creek at RM 3.86), the allowance for future growth was given based on trends in cattle numbers. The four-year trend in Scioto County is a 15.9 percent decrease in numbers of cattle (USDA 2011). The farms affecting Rarden Creek are small and the cattle herds there could feasibly increase, though not by much given the small acreage. Therefore, to set aside load for future increases in the local herds, a 5% allowance for future growth is made.

D2.3 Qualitative Habitat Evaluation Index Assessment

Habitat TMDL Targets and the Qualitative Habitat Evaluation Index (QHEI)

Poor habitat quality is an environmental condition, rather than a pollutant load, so development of a load-based TMDL for habitat is not possible. Nonetheless, habitat is an integral part of stream ecosystems and has a significant impact on aquatic community assemblage and consequently on the potential for a stream to meet the biocriteria within Ohio's water quality standards (see below). In addition, U.S. EPA acknowledges that pollutants, conditions or other environmental stressors can be subject to the development of a TMDL to abate those stressors in order to meet water quality standards (U.S. EPA 1991). Thus, sufficient justification for developing habitat TMDLs is established.

The Qualitative Habitat Evaluation Index (QHEI) was developed by the Ohio EPA (Ohio EPA 1989) with one of the objectives being to create a means for distinguishing impacts to the aquatic community from pollutant loading versus poor stream habitat. The design of the QHEI in conjunction with its statistically strong correlation to the biocriteria makes it an appropriate tool for developing habitat TMDLs.

The QHEI assigns a numeric value to an individual stream segment (typically 150-200 m in length) based on the quality of its habitat. The actual number values of the QHEI scores do not represent the quantity of any physical properties of the system but provide a means for comparing the relative quality of stream habitat. 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. Reduced subjectivity 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 (Ohio EPA 1989).

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

Since its development the QHEI has been used to evaluate habitat at most biological sampling sites and currently there is an extensive database that includes QHEI scores and other water quality variables. Strong correlations exist between QHEI scores and its component submetrics and the biological indices used in Ohio's water quality standards such as the Index of Biotic Integrity (IBI). Through statistical analyses of data for the QHEI and the biological indices, target values have been established for QHEI scores with respect to the various aquatic life use designations (Ohio EPA 1999). For aquatic life use designations of warmwater habitat (WWH) and exceptional warmwater habitat (EWH), respective overall QHEI scores of 60 and 75 are targeted to provide reasonable certainty that habitat is sufficient to support biological community expectations.

One of the strongest correlations found through these statistical analyses described above is the negative relationship between the number of "modified attributes" and the IBI scores. Modified attributes are features or conditions that have low value in terms of habitat quality and therefore are assigned relatively fewer points or negative points in the QHEI scoring. A subgroup of the modified attributes shows a stronger impact on biological performance; these are termed high influence modified attributes.

In addition to the overall QHEI scores, targets for the maximum number of modified and high influence modified attributes have been developed. For streams designated as WWH, there should no more than four modified attributes, of which no more than one should be a high influence modified attribute. For EWH streams, there should be no more than two modified attributes and zero high influence attributes. Table D-4 lists modified and high influence modified attributes and provides the QHEI targets used for this habitat TMDL.

Table D-4. QHEI targets for the habitat TMDL.

	Overall QHEI Score		**All Modified Attributes**	
			High Influence Modified Attributes	**All Other Modified Attributes**
Range of Possibilities	12 to 100 points		- Channelized or No Recovery - Silt/Muck Substrate - Low Sinuosity - Sparse/No Cover - Max Pool Depth < 40 cm (wadeable streams only)	- Recovering Channel - Sand Substrate (boat sites) - Hardpan Substrate Origin - Fair/Poor Development - Only 1-2 Cover Types - No Fast Current - High/Moderate Embeddedness - Ext/Mod Riffle Embeddedness - No Riffle
Targets	**WWH**	Overall score ≥ 60	Total number < 2	Total number < 5[1]
	EWH	Overall score ≥ 75	Total number < 0	Total number < 35[1]
TMDL Points if Target Satisfied	+1		+1	+1

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

For simplicity, a pass/fail distinction is made to determine whether each of the three targets is being met. Targets are set for: 1) the total QHEI score; 2) maximum number of all modified attributes; and 3) maximum number of high influence modified attributes only. If the minimum target is satisfied, then that category is assigned a “1”, if not, it is assigned a “0”. To satisfy the habitat TMDL, the stream segment in question should achieve a score of three.

Seasonality and Critical Conditions

Habitat is generally a static condition of a stream. Exceptions include major modifications made by humans (or some animals like beavers) or changes in the hydrology or sediment loading of the watershed (again, typically a man made situation). Since habitat is relatively static, seasonality has little meaning. Specifically, absent a major disturbance, habitat quality does not change across the seasons but rather over much longer timescales. Finally, there is no seasonal “loading” associated with habitat but instead habitat evolves through changes in morphology and riparian vegetation.

The concept of critical condition has more meaning for habitat. There are times of the year when poor habitat quality is particularly detrimental to the aquatic community, especially summer low flows. Low flow conditions stress the community and competition for space occurs. Under these conditions the greatest threat is a drying of the stream where most aquatic species can survive for only a short period. The availability of a sufficient amount of water is affected by the quality of the stream habitat. Coarse bed substrates are often areas of water storage, and when they are not embedded with fine sediments (a manifestation of degraded habitat) they are accessible to small aquatic species. Deep pools also act as reservoirs when water becomes scarce. An intact riparian corridor will mitigate low flow conditions by reducing direct sunlight, keeping water temperatures lower than what they may otherwise be, which helps to sustain dissolved oxygen concentrations, mitigates excessive increases in metabolic rates and reduces water loss through pan evaporation).

Margin of Safety

The Clean Water Act requires that a TMDL include a margin of safety (MOS) to account for any lack of knowledge concerning the relationship between load and wasteload allocations and water quality. U.S. EPA guidance explains that the MOS may be implicit (i.e., incorporated into the TMDL through conservative assumptions in the analysis) or explicit (i.e., expressed in the TMDL as loadings set aside for the MOS).

There is an implicit margin of safety applied to the habitat TMDLs based on conservative target values used. The targets from the *Association Between Nutrients, Habitat, and the Aquatic Biota in Ohio Rivers and Streams* (Ohio EPA 1999) are conservative because attainment of aquatic life uses has been demonstrated even when the targets are not met.

D3 Results

In the following subsections, results are presented for each cause of impairment (bacteria, nutrients and habitat).

D3.1 Bacteria Results

In the sequence of figures and tables below, the load duration curve for each site (Figures D-4 through D-8) is shown, followed by the TMDL table for that site.

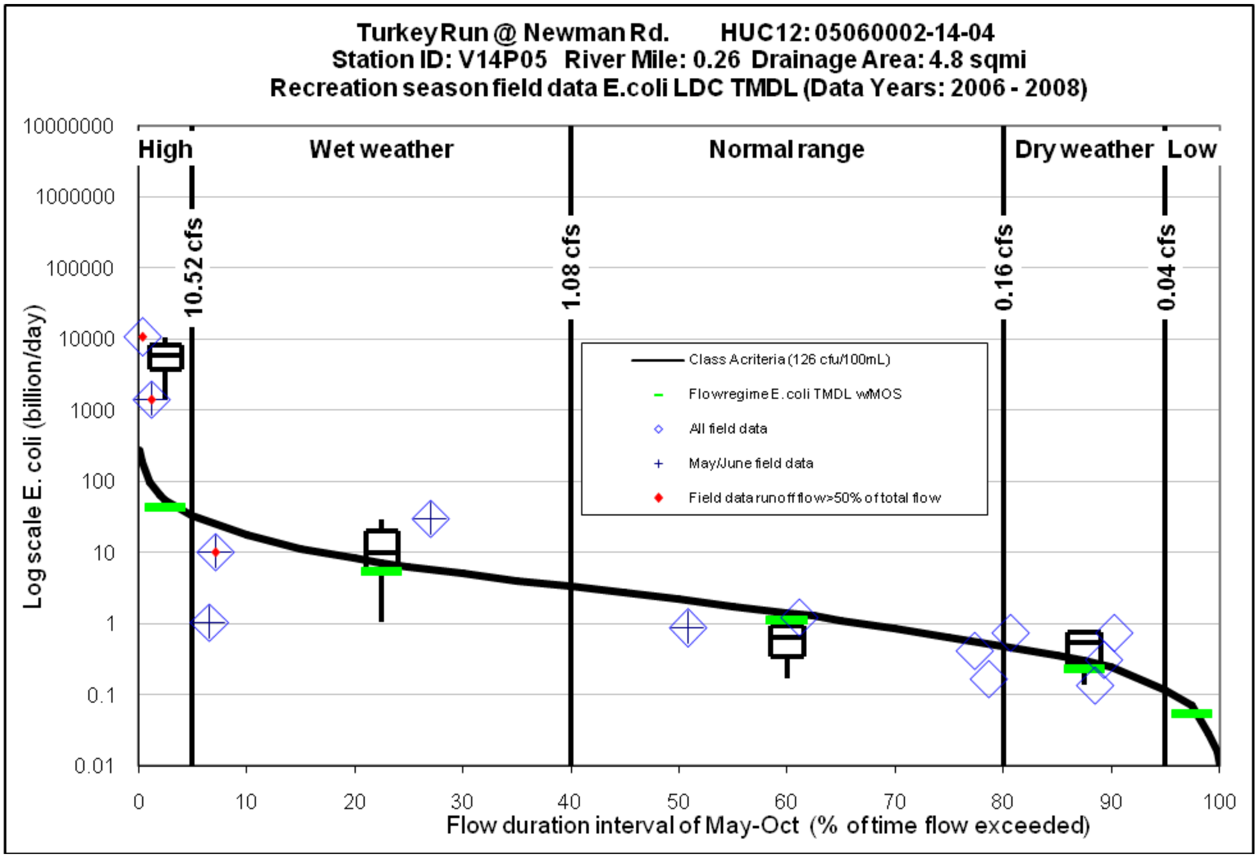

Figure D-4. Load duration curve for site on Turkey Run at Newman Rd.

Table D-5. TMDL table for site on Turkey Run at Newman Rd.

Flow regime TMDL analysis *E. coli* (billion bacteria/day)	**High**	**Wet weather**	**Normal range**	**Dry weather**	**Low**
Duration interval	0-5%	5-40%	40-80%	80-95%	95-100%
Samples per regime	2	3	4	4	N/A
Median sample load	5,974	10	1	0.5	N/A
TMDL	55.3	7.1	1.44	0.304	0.072
WLA	0.0	0.0	0.0	0.0	0.0
LA	42.6	5.5	1.11	0.234	0.055
MOS: 20%	11.1	1.4	0.29	0.061	0.014
AFG: 3%	1.7	0.2	0.04	0.009	0.002
Nonpoint (LA) % load reduction required	**99.3%**	**45.2%**	**0%**	**56.2%**	No Data

Values were adjusted for rounding.

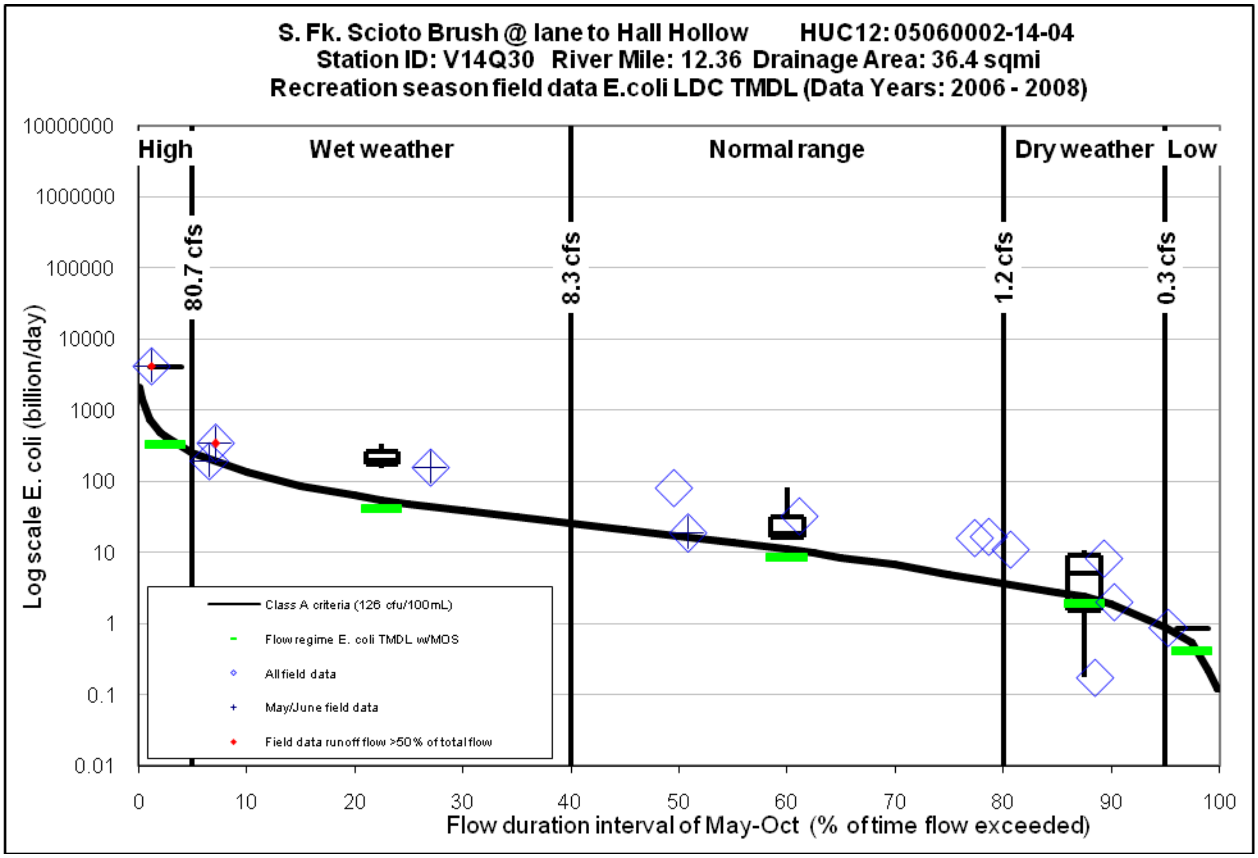

Figure D-5. Load duration curve for site on South Fork Scioto Brush Creek at lane to Hall Hollow.

Table D-6. TMDL table for site on South Fork Scioto Brush Creek at lane to Hall Hollow.

Flow regime TMDL analysis ***E. coli*** **(billion bacteria/day)**	**High**	**Wet weather**	**Normal range**	**Dry weather**	**Low**
Duration interval	0-5%	5-40%	40-80%	80-95%	95-100%
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Median sample load	4,099	194	19	5.1	0.9
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Nonpoint (LA) % load reduction required	**92.0%**	**78.4%**	**53.8%**	**63.0%**	**51.2%**

Values were adjusted for rounding.

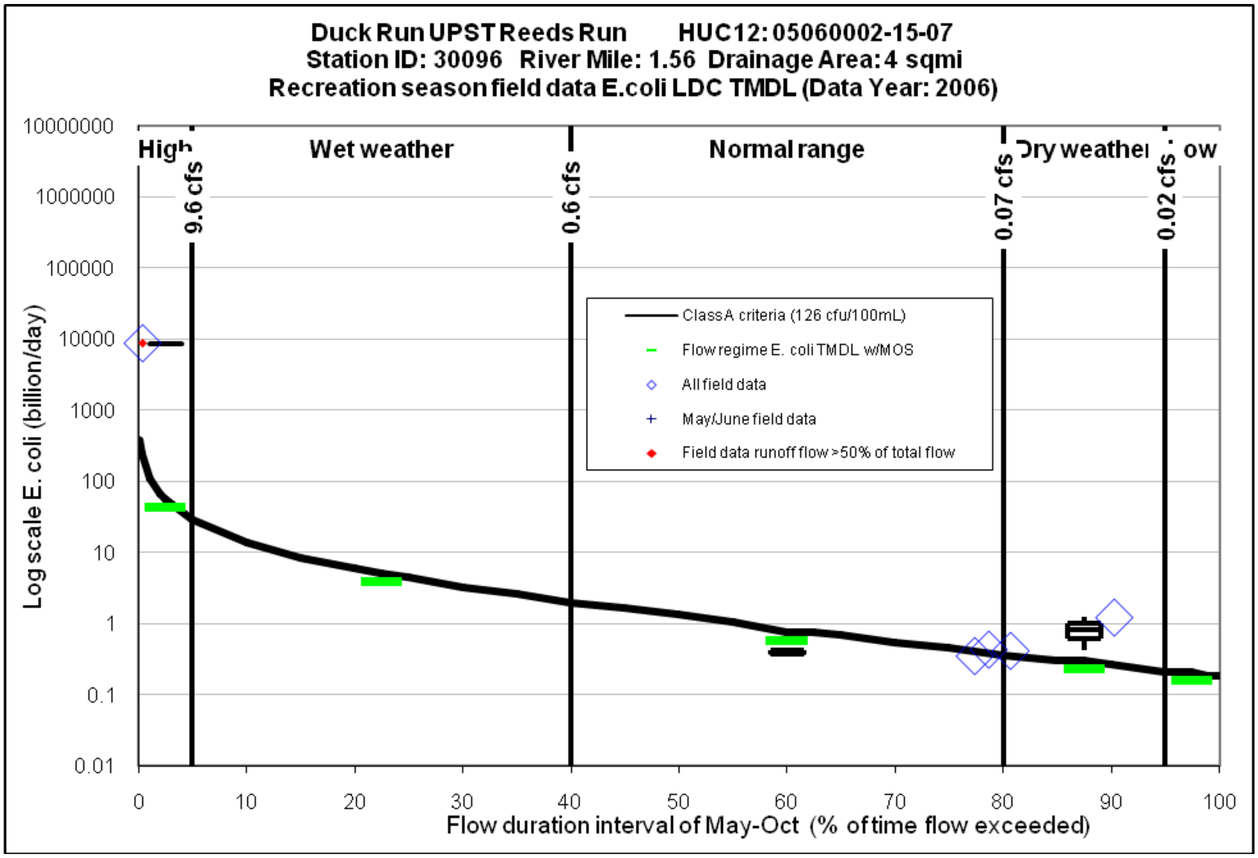

Figure D-6. Load duration curve for site on Duck Run upstream Reeds Run.

Table D-7. TMDL table for site on Duck Run upstream Reeds Run.

Flow regime TMDL analysis *E. coli* (billion bacteria/day)	**High**	**Wet weather**	**Normal range**	**Dry weather**	**Low**
Duration interval	0-5%	5-40%	40-80%	80-95%	95-100%
Samples per regime	1	N/A	2	2	N/A
Median sample load	8,653	N/A	0	0.8	N/A
TMDL	56.2	5.1	0.76	0.302	0.209
WLA	0.148	0.148	0.148	0.148	0.148
LA	43.2	3.8	0.44	0.085	0.013
MOS: 20%	11.2	1.0	0.15	0.060	0.042
AFG: 3%	1.7	0.2	0.02	0.009	0.006
Nonpoint (LA) % load reduction required	**99.5%**	No Data	**0%**	**89.7%**	No Data

Values were adjusted for rounding.

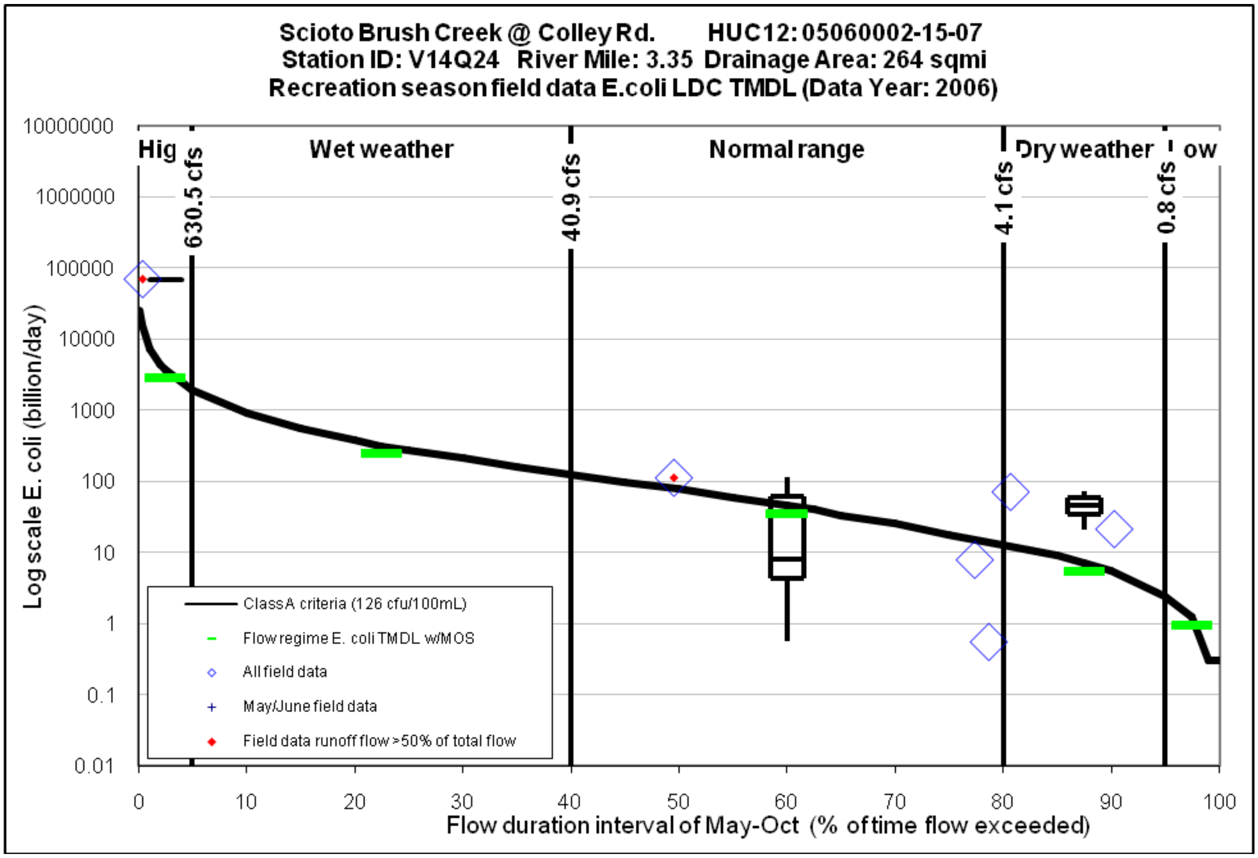

Figure D-7. Load duration curve for site on Scioto Brush Creek at Colley Rd.

Table D-8. TMDL table for site on Scioto Brush Creek at Colley Rd.

Flow regime TMDL analysis ***E. coli*** **(billion bacteria/day)**	**High**	**Wet weather**	**Normal range**	**Dry weather**	**Low**
Duration interval	0-5%	5-40%	40-80%	80-95%	95-100%
Samples per regime	1	N/A	3	2	N/A
Median sample load	69,177	N/A	7.92	46.442	N/A
TMDL	3,691.4	315.3	46.23	7.089	1.233
WLA	0.0	0.0	0.0	0.0	0.0
LA	2,842.3	242.8	35.60	5.459	0.949
MOS: 20%	738.3	63.1	9.25	1.418	0.247
AFG: 3%	110.7	9.5	1.39	0.213	0.037
Nonpoint (LA) % load reduction required	**96%**	No Data	**0%**	**88%**	No Data

Values were adjusted for rounding.

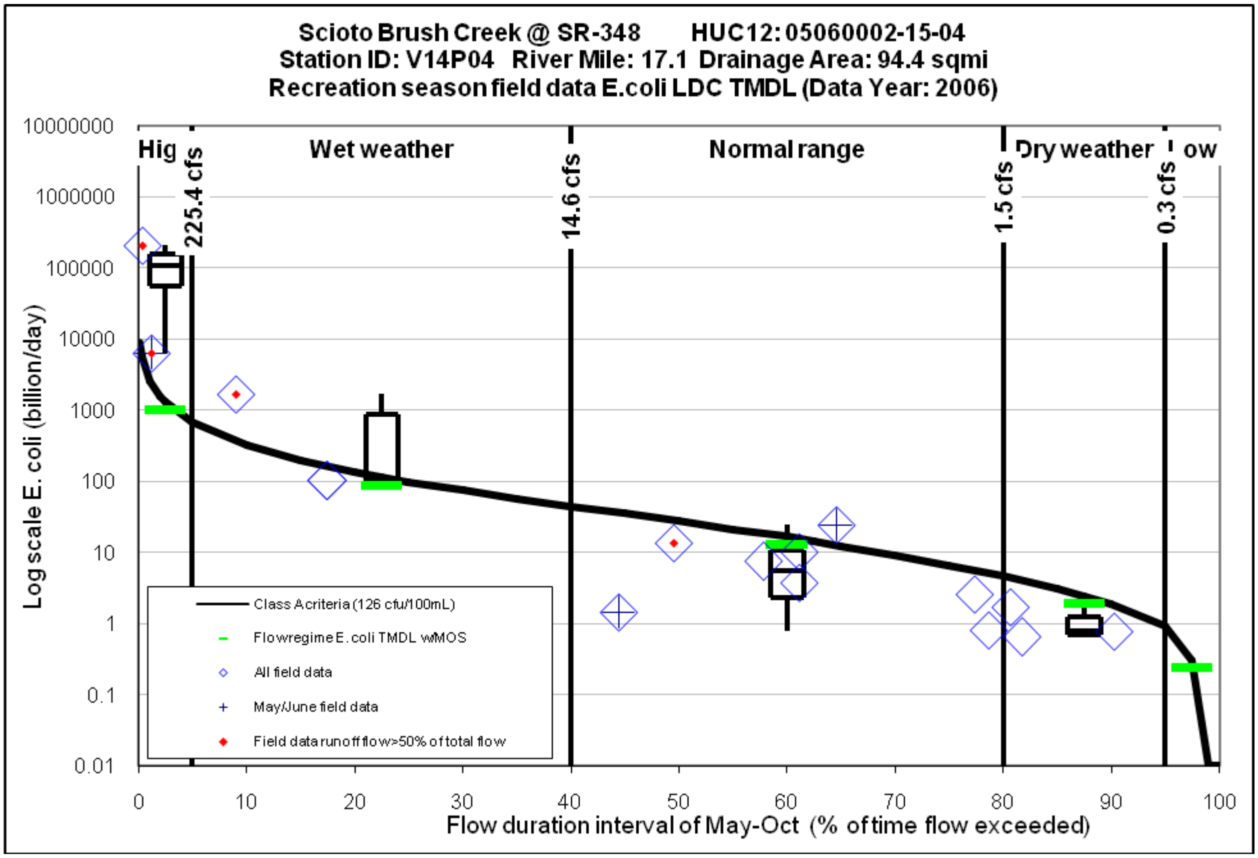

Figure D-8. Load duration curve for site on Scioto Brush Creek at State Route 348.

Table D-9. TMDL table for site on Scioto Brush Creek at State Route 348.

Flow regime TMDL analysis *E. coli* (billion bacteria/day)	High	Wet weather	Normal range	Dry weather	Low
Duration interval	0-5%	5-40%	40-80%	80-95%	95-100%
Samples per regime	2	3	8	3	N/A
Median sample load	105,260	101.7	5.61	0.776	N/A
TMDL	1,319.8	112.8	16.64	2.466	0.308
WLA	0.0	0.0	0.0	0.0	0.0
LA	1,016.3	86.9	12.82	1.899	0.237
MOS: 20%	264.0	22.6	3.33	0.493	0.062
AFG: 3%	39.6	3.4	0.50	0.074	0.009
Nonpoint (LA) % load reduction required	**99%**	**15%**	**0%**	**0%**	No Data

Values were adjusted for rounding.

D3.2 Nutrient Results

Figure D-9 shows the Rarden Creek total phosphorus LDC. A 19.4% reduction is needed during wet weather.

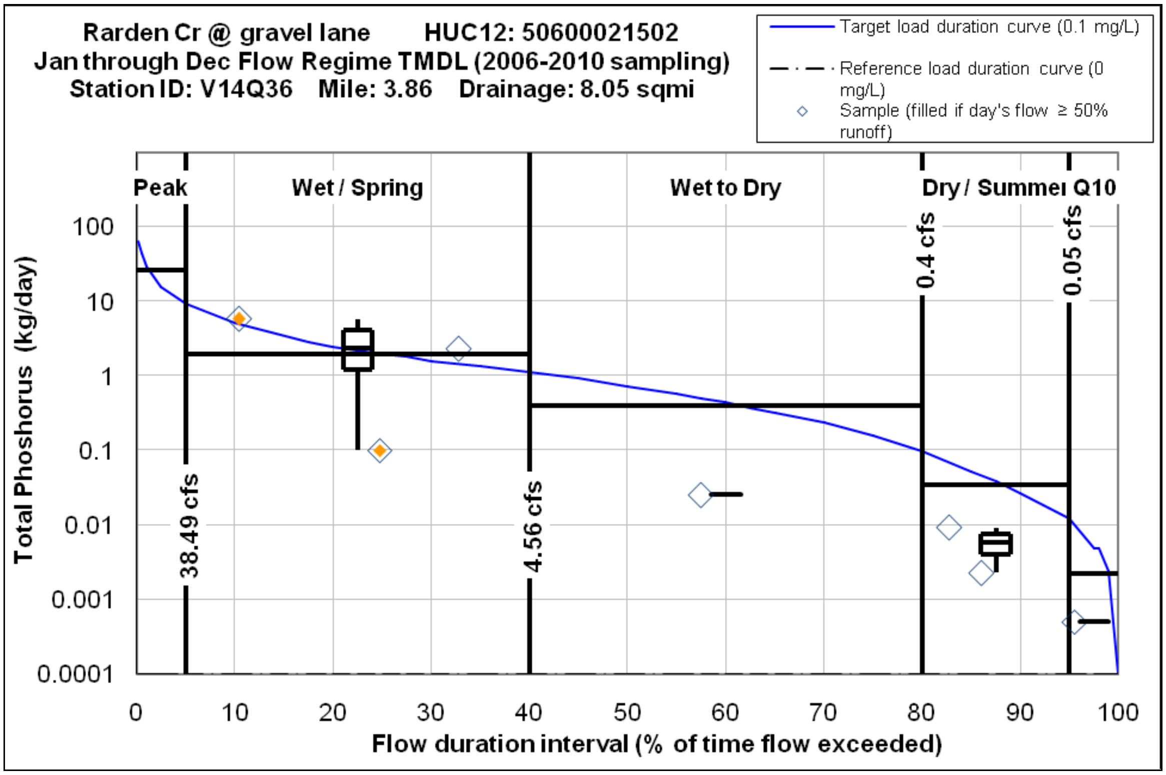

Figure D-9. Total phosphorus load duration curve for site at Rarden Creek (RM 3.86).

Table D-10 summarizes the TMDL. There are no permitted dischargers in the Rarden Creek basin; therefore, all the reduction will be taken from the load allocation (nonpoint source).

Table D-10. Total phosphorus TMDL table for site on Rarden Creek (RM 3.86).

Flow regime TMDL analysis Total phosphorus (kg/day)	Peak	Wet / Spring	Wet to Dry	Dry / Summer	Low
Duration interval	0-5%	5-40%	40-80%	80-95%	95-100%
Samples collected per flow regime	0	3	1	2	1
Median grab sample load	N/A	2.35	0	0.0	0.0
TMDL (explicit 10% MOS included)	**26.1**	**1.99**	**0.396**	**0.035**	**0.002**
Allowance for future growth (5%)	1.31	0.100	0.020	0.002	0.000
Estimated % load reduction needed	No Data	**19.4%**	**0%**	**0%**	**0%**
Load allocation	24.8	1.89	0.377	0.033	0.002
Wasteload allocation	0.000	0.000	0.000	0.000	0.000

Values were adjusted for rounding.

D3.3 Habitat Alteration Results

The results of the habitat assessment for the sites impaired due to habitat alteration in Rarden Creek, Scioto Brush Creek, and Beech Fork are shown below in Table D-11.

Table D-11. Habitat TMDL results table.

	Use	**Allocations**			**Subscore**			**TMDL**
	WWH	**> 60 = 1 pt**	**< 2 = 1 pt**	**< 5 = 1 pt**				**3 pts**
TMDL Targets	**EWH**	**> 75 = 1 pt**	**0 = 1 pt**	**< 3 =1 pt**				**3 pts**
Existing Scores Stream/River (Use) (Nested Subwatershed)	River Mile	QHEI Score	# of High Influence Attributes	Total # of Modified Attributes	QHEI	High Influence	# Modified Attributes	Total Habitat Score
Beech Fork (EWH) (05060002 14 06)	1.9	36.5	4	5	0	0	0	0
Rarden Cr. (WWH) (05060002 15 02)	3.8	45.5	4	5	0	0	0	0
Scioto Brush Cr. (EWH) (05060002 15 03)	24.3	58.5	0	5	0	1	0	1

* The Moderate Influence Attributes includes the high influence attributes, thus there is a total of 5 moderate influence attributes.

The scores in the table above show that none of the three sites meet minumum habitat targets. Based on a target of 3 points, Rarden Cr. and Beech Fork both missed the target by 3 points and Scioto Brush Creek missed by 2.

D4 References

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