APPENDIX B

LOADING ANALYSIS INFORMATION
LOWER LITTLE MIAMI RIVER WATERSHED

Table of Contents

B1 Introduction

Several different causes of aquatic life use impairment exist in the Lower Little Miami River watershed. The primary impairment(s) for each stream is addressed by the creation of a TMDL. This document explains the modeling considerations that are involved with calculating these TMDLs. Refer to the primary TMDL report for a complete listing of the causes and sources of impairments of all of the assessed streams in this watershed. Additionally this document addresses stream segments with recreational use impairment via bacteria TMDLs.

B2 Target development and modeling approach

The modeling methods used are determined by evaluating the sources of pollutants and stressors and stream conditions, then choosing the most efficient approach to adequately quantify the problems. Additionally, a measurable numeric target must be used in determining what the TMDLs are and subsequently, the reductions that are needed to meet water quality standards. The remainder of this section outlines the cause-and-effect relationship between each impairment cause and the numeric target developed to address it.

B2.1 Nutrient Enrichment Target Development

Nutrients are identified as a cause of impairment at several assessment sites in the Lower LMR basin. Nutrients rarely approach concentrations in the ambient environment that are toxic to aquatic life, and nutrients in small amounts are essential to the functioning of healthy aquatic ecosystems. However, nutrient concentrations in excess of the needs of a balanced ecosystem can exert negative effects by increasing algal and aquatic plant life production (Sharpley, 1999). This increases turbidity, decreases average dissolved oxygen concentrations and increases fluctuations in diel dissolved oxygen and pH levels. 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; the IBI and ICI scores reflect this shift and a stream may be precluded from achieving its aquatic-life use designation.

Phosphorus is selected as the nutrient to focus on because it is frequently the limiting nutrient to algal growth in the fresh water streams of Ohio. While the Ohio EPA does not currently have statewide numeric criteria for phosphorus, potential targets have been identified in a technical report titled *Association Between Nutrients, Habitat, and the Aquatic Biota in Ohio Rivers and Streams* (Ohio EPA, 1999). This document provides the results of a study analyzing the effects of nutrients and other parameters on the biological communities of Ohio streams. It recommends total phosphorus (TP) target concentrations based on observed concentrations associated with acceptable ranges of biological community performance. The targets applicable to the lower LMR watershed are shown in Table B-1. It is important to note that these targets are not codified in Ohio's water quality standards; therefore, there is a certain degree of flexibility as to how they can be used in a TMDL setting.

Table B-1 Total phosphorus targets applicable to the lower LMR watershed

Watershed size	EWH	WWH
Headwaters (drainage area < 20 mi^2)	-	0.08
Wadable (drainage area ≥ 20 mi^2 < 200 mi^2)	-	0.10
Small Rivers drainage area ≥ 200 mi^2 < 1000 mi^2)	0.10	-
Large Rivers (drainage area > 1000 mi^2)	0.15	-

Total phosphorus for warm water habitat sites

There are several WWH designated streams that are impaired due to nutrients in the lower LMR watershed. All of these sites have a different type of source of nutrient enrichment. The non attaining streams are also geographically spread apart a great deal. Because of this, each stream will be dealt with in a manner that specifically addresses its source of nutrient enrichment.

B2.2 TSS and CBOD 5-day Target Development

Two watersheds receive TMDLs to address combined sewer overflows (CSOs); both are direct tributaries to the Little Miami River. The CSOs on both of these streams are owned by the Metropolitan Sewer District of Greater Cincinnati, Hamilton County, Ohio (MSD). Duck Creek drains 15.5 mi^2 and has 43 CSOs, some of which are no longer active. In addition to aquatic life use impairment throughout Duck Creek, this tributary is also causing impairment in the mainstem Little Miami River. Clough Creek drains 8.31 mi^2 and has two active CSOs discharging to it. Total suspended solids (TSS) and CBOD 5-day were determined to be used as parameters requiring control due to the cause and source assessment of impairment.

The State of Ohio does not have numeric water quality criteria for TSS or CBOD 5-day. The targets found in the *Association Between Nutrients and the Aquatic Biota of Ohio River and Streams* (Ohio EPA, 1999), are not suitable because urban sites were excluded from the data to come up with these reference values. The fact that these values would be inappropriate is reinforced when they are compared to expected (non-CSO) urban storm water concentrations (US EPA, 2001a). The lowest expected urban storm water concentrations for these parameters are at or above the 95th percentile of expected values for the reference sites in the Ohio EPA Associations document.

An alternative target utilized for these TMDLs is from a U.S. EPA guidance, Combined Sewer Overflows Guidance For Long-Term Control Plan (US EPA, 1995). This document outlines, "demonstrative and presumptive" approaches to successful control of CSOs. One of these approaches is described as 85% control of volume of annual average total CSO discharges (US EPA, 1995, page 3-7). MSD indicates various existing proportions of CSOs under control ranging from 11% to 98%. For this TMDL, it is assumed that 85% of existing CSO flow requires further control in order to mitigate aquatic life use impairment. This conservative approach in derivation of the numeric target outlined above is defended as the implicit margin of safety. While stringent, this level of control is prudent considering the fact that despite existing levels of CSO control the impaired streams still show very low biological indices scores. In fact, the pollutants flowing into Duck Creek continue downstream to cause non attainment in the mainstem LMR downstream of its confluence. Furthermore, it should be noted that Ohio EPA and MSD are involved in a consent decree requiring MSD to create an acceptable long term control plan in accordance with US EPA guidelines (Metropolitan Sewer District of Greater Cincinnati, 2006). While this TMDL is intended to address non attainment caused by pollutants originating from CSO sources, an acceptable long term control plan will include much more detail and regulatory oversight of CSOs than will implementation directly outlined in this TMDL.

B2.3 Sediment/Habitat Target Development

In order for an aquatic community to be healthy it must have adequate habitat. The absence or low quality of stream habitat hampers the ability of aquatic organisms to successfully reproduce, acquire food, or find protection from other species and stressful environmental conditions leading to reduced or absent populations of aquatic species. A compounding effect of wide-spread degraded habitat is that source populations of sensitive aquatic species dwindle and migrate to areas that do have suitable habitat quality.

The qualitative habitat evaluation index (QHEI) was developed by the Ohio EPA (Rankin, 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 bio-criteria makes it an appropriate tool for developing habitat TMDLs.

The QHEI assigns a numeric value to an individual stream segment (typically 150-200 meters 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 (Rankin, 1989).

The QHEI evaluates six general aspects of physical habitat that include channel substrate, instream cover, riparian characteristics, channel condition, pool/riffle quality, and gradient. Within each of these categories or metrics, 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 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.

In terms of sediment, although in of itself it can be damaging to the aquatic community, its negative impact is typically restricted to the fact that it degrades stream habitat. Specifically, sediment fills in void spaces that occur between larger substrates such as cobbles and gravels, rendering those spaces inaccessible to organisms. The function of the substrate also decreases because flow of water through these spaces is limited, and with it dissolved oxygen and nutrition sources. The QHEI captures these deleterious results of excessive fine sediment loading therefore, it is appropriate to use in developing sediment TMDLs.

Sediment TMDL targets and the qualitative habitat evaluation index (QHEI)
Numeric targets for sediment are based upon metrics of the QHEI, specifically those that consider particular aspects of stream habitat closely related to and/or impacted by the sediment delivery and transport processes occurring in the system.

The QHEI metrics used in the sediment TMDL are the substrate, channel morphology, and bank erosion and riparian zone. Table B-3 lists targets for each of these metrics.

- 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 has assimilated (i.e., sorts) the loading. Higher levels of mud/muck/silt, that cover the substrate have significant negative impacts on the fish community, impacting the reproduction, feeding, and overall health of the biotic community.
- 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. Excessive sedimentation fills in the pools and covers up the riffles, resulting in

a more uniform, flat stream bed, severely impacting the feeding and reproductive habitat in the stream.

- The bank erosion and riparian zone metric also reflects the likely degree of instream sediment sources. The evaluation of floodplain quality is included in this metric which is related to the capacity of the system to assimilate sediment loads. Specifically, floodplains sort the sediment load during floods where heavier coarse substrates tend to remain in the main channel whereas fine grained sediment can occupy the floodplain areas and subsequently be deposited as the flow recedes after the storm event. If the floodplain is inaccessible or truncated, then this sediment cannot be removed from the system and will likely degrade habitat and water quality.

Each of these factors (substrate, channel, riparian) influences the degree to which siltation affect a stream, and cumulatively serves as its numeric target.

Analysis of Lower LMR Watershed QHEI Data to Develop Targets

Only WWH stream segment data are used for analysis of QHEI data for this TMDL. The minimum statewide QHEI target is 60 for WWH sites (Ohio EPA, 1999). However, when analyzed on a watershed scale, it has been determined that basin specific goals of QHEI and its subcategories are appropriate for TMDL development.

Initially an analysis is carried out to assure the QHEI scores are a good tool for assessing habitat as a cause of impairment. To determine if the QHEI values indicate habitat issues with respect to biological attainment groups, a box plot is generated showing the QHEI data for each attainment group (Figure B-2). In each box shown in Figure B-2, and the following box plots in this report, the horizontal line through the middle is that group of data's median. The upper and lower lines that make the top and bottom of the boxes are the 75^{th} and 25^{th} percentiles respectively. The upper and lower vertical line tails above and below each box are the 95^{th} and 5^{th} percentiles respectively.

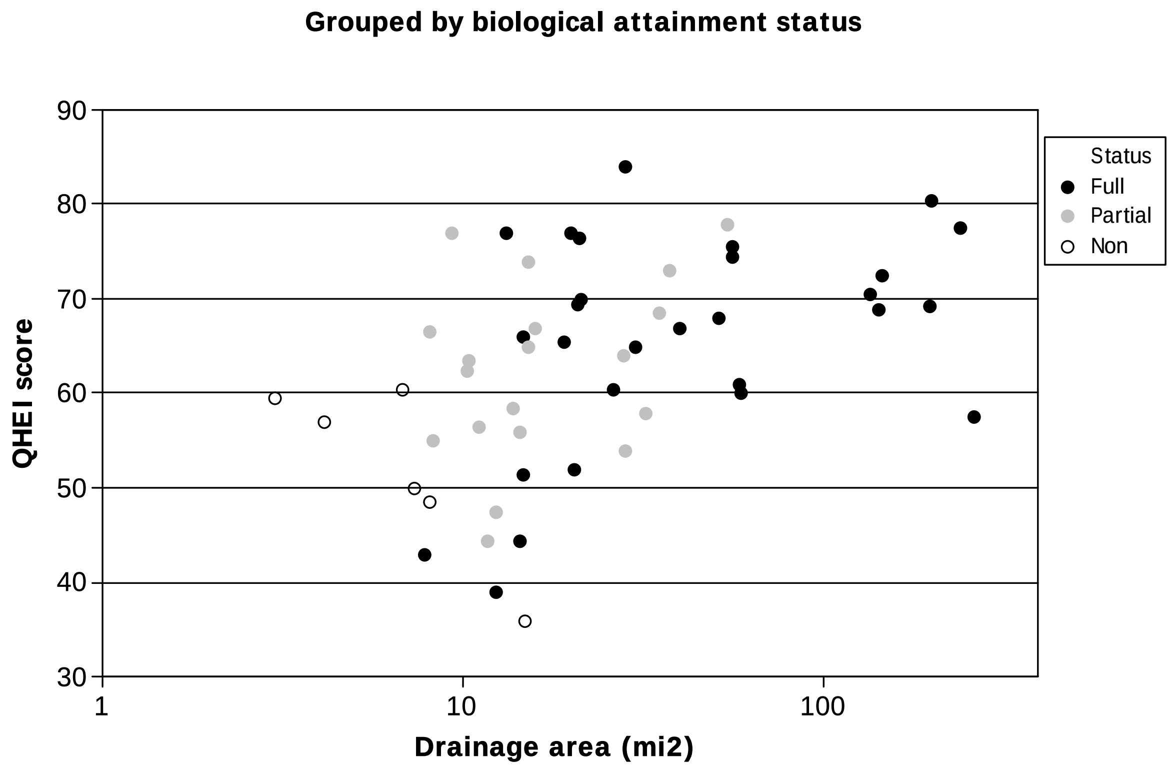


Figure B-1 Lower LMR watershed WWH QHEI score vs. site drainage area

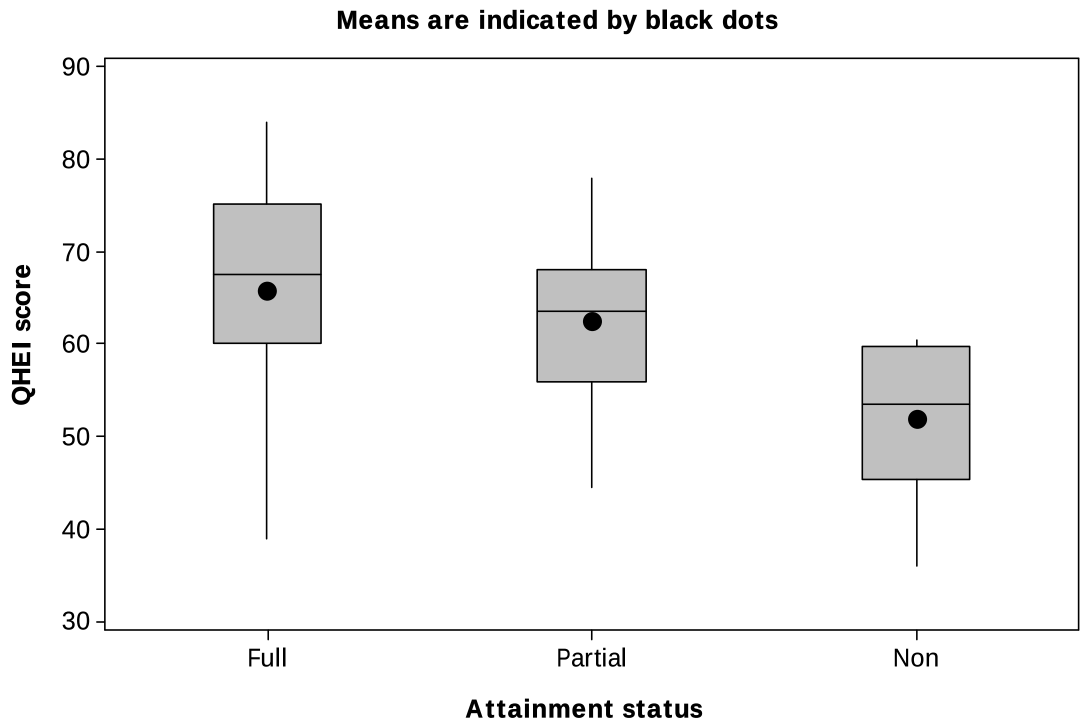


Figure B-2 Lower LMR watershed WWH QHEI scores by biological attainment status

As can be observed from the box plot in Figure B-2, it appears the non attainment group QHEI data set is significantly lower than the other datasets. To assure that a statistical difference in the QHEI score data sets for the LMR watershed does exist, a statistical hypothesis test is completed. Anderson-Darling normality test indicate all three data sets are normal [full ($P=0.085$), partial ($P= 0.914$), non ($P=0.329$)]; where $P \geq 0.05$ indicates a normal distribution.

Because of the normality of the data sets, a one way analysis of variance (ANOVA) is utilized to determine if a significant difference exists in any one of three (full, partial and non attainment) data set means when compared to the other data set means. The null hypothesis is that all data set means are equal. The alternative hypothesis is that at least one of the means is not equal to the others. A five percent level of significance is chosen for the test.

Details of the ANOVA are presented in Table B-2. The P value for the analysis is 0.018 indicating a statistically significant failure to accept the null hypothesis. This analysis assures within 95% certainty that at least one of the attainment group QHEI means does not equal the others. The number of individual values within each group status is noted in Table B-2 as “N”. Additional statistical analysis is not warranted for this determination.

Table B-2 One-way ANOVA of QHEI versus Attainment Status

```
Source  DF    SS   MS     F      P
Status   2   967  484  4.33  0.018
Error   50  5580  112
Total   52  6547


                               Individual 95% CIs For Mean
                               Based on Pooled StDev
Level     N   Mean  StDev  --------+---------+---------+---------+-
Full     28  65.85  11.53                           (-----*-----)
Partial  19  62.58   9.33                       (------*------)
Non       6  51.92   9.23  (-----------*------------)
                           --------+---------+---------+---------+-
                               49.0      56.0      63.0      70.0
Pooled StDev = 10.56
```

The non attainment group has significantly lower QHEI values than the full attainment group. An increase in habitat quality is needed to increase the non attainment group deficit. If habitat quality was enhanced at the non attainment group sites to the quality of the full attainment group and all other variables were equivalent, the non attainment stream would be restored to full attainment status. Therefore, a TMDL for total QHEI and the individual subcategories can be developed from the full attainment group values. Each full attainment group dataset was analyzed statistically. The total QHEI statistics are presented in Figure B-5. A target value for QHEI and for each subcategory is chosen to be the lowest value of the 95th percent confidence interval of the full attainment group median. This value statistically assures with 95 percent confidence that the population median of the QHEI or subcategory is at least greater than the target. This goal also provides assurance that an acceptable intrinsic safety factor for the TMDL is provided because a 5% significance is very conservative.

Because the QHEI total score is comprised of seven subcategories of habitat, the value of this index can be significantly affected by a large depletion in one category as well as small depletion in multiple categories. Therefore, TMDL goals are created individually for the QHEI and its subcategories. This technique insures that proper subcategory of the QHEI which is causing the impairment at a particular site is slated for mitigation. In addition, this procedure provides an estimate of effort required to eliminate the impairment cause by providing a magnitude of QHEI points enhancement needed to become similar to a full attainment site.

Figure B-3 provides descriptive statistics of the WWH QHEI full attainment data set. Boxplots of QHEI subcategories grouped by full, partial and non attainment sites are displayed in Figures B-4, B-6, B-8, B-10, B-12, B-14 and B-16 for the subcategories substrate, cover, channel, riparian, pool, riffle and gradient respectively. Descriptive statistics for the full attainment datasets for each subcategory are shown in Figures B-5, B-7, B-9, B-11, B-13, B-15 and B-17.

The lowest value of the 95th percent confidence interval of the median for each of the QHEI subcategories is the TMDL value for that subcategory. The same statistic is used to determine the total QHEI score target. Table B-3 summarizes the TMDL value for the total QHEI score and each of the subcategories. With the Table B-3 TMDL targets, each of the biological sampling sites within the watershed can be compared for habitat and bedload attainment.

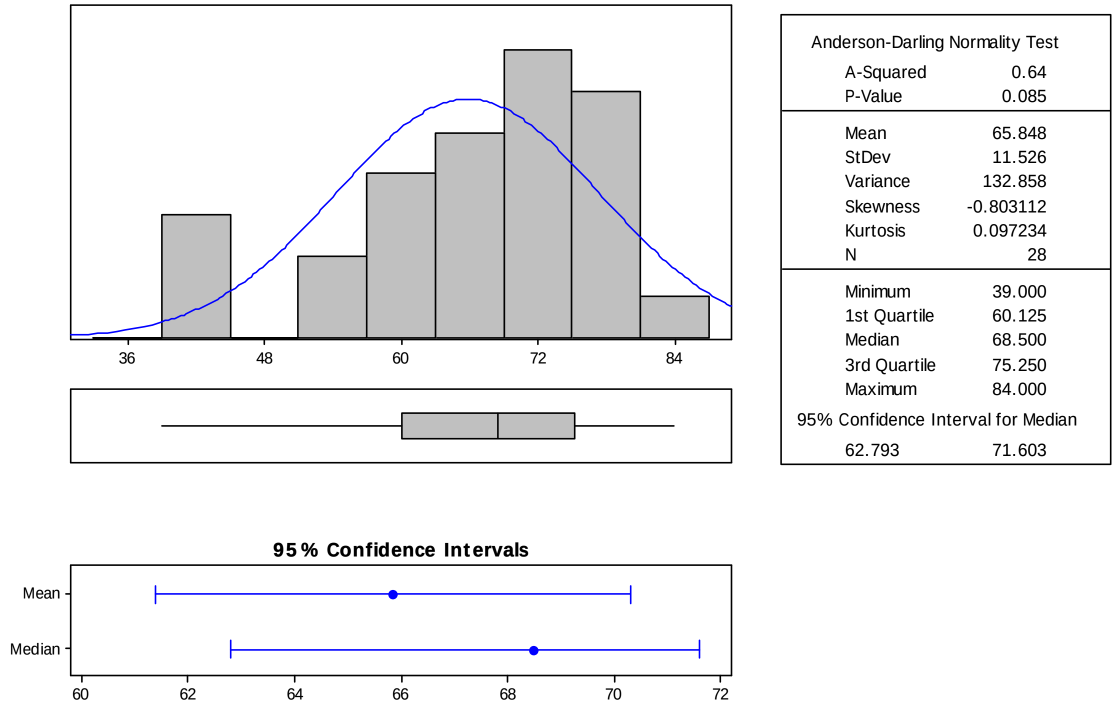


Figure B-3 Lower LMR WWH QHEI total scores for full attainment status

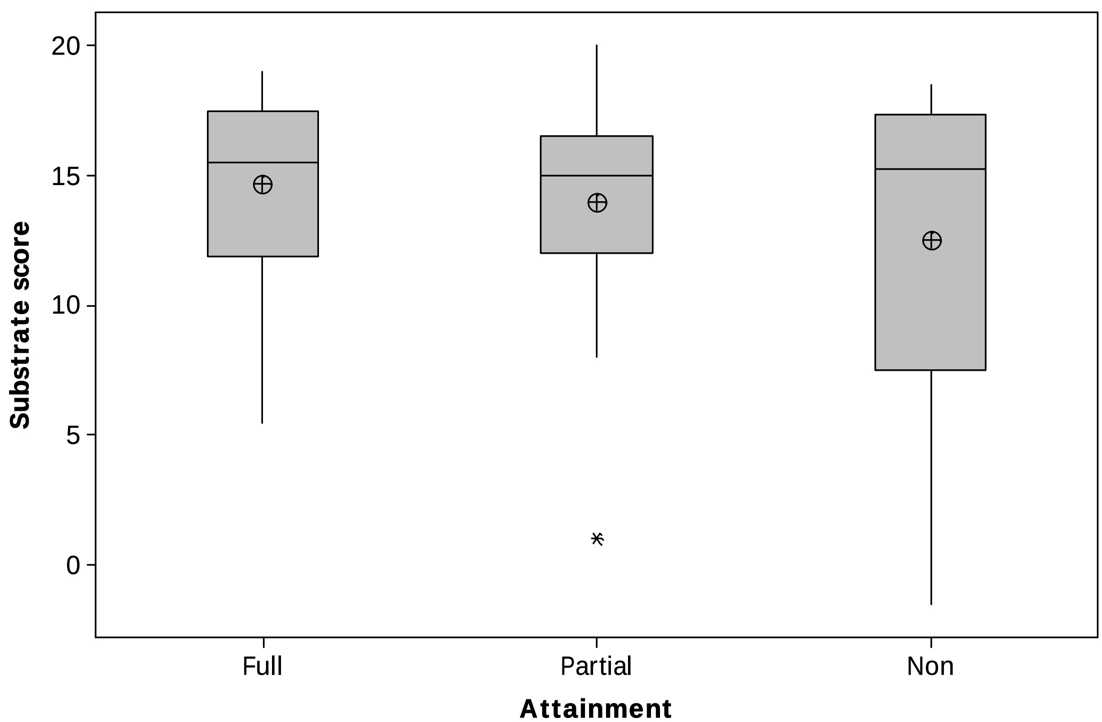


Figure B-4 Box-whisker plots of lower LMR WWH substrate scores by attainment group (circles with a cross are the means)

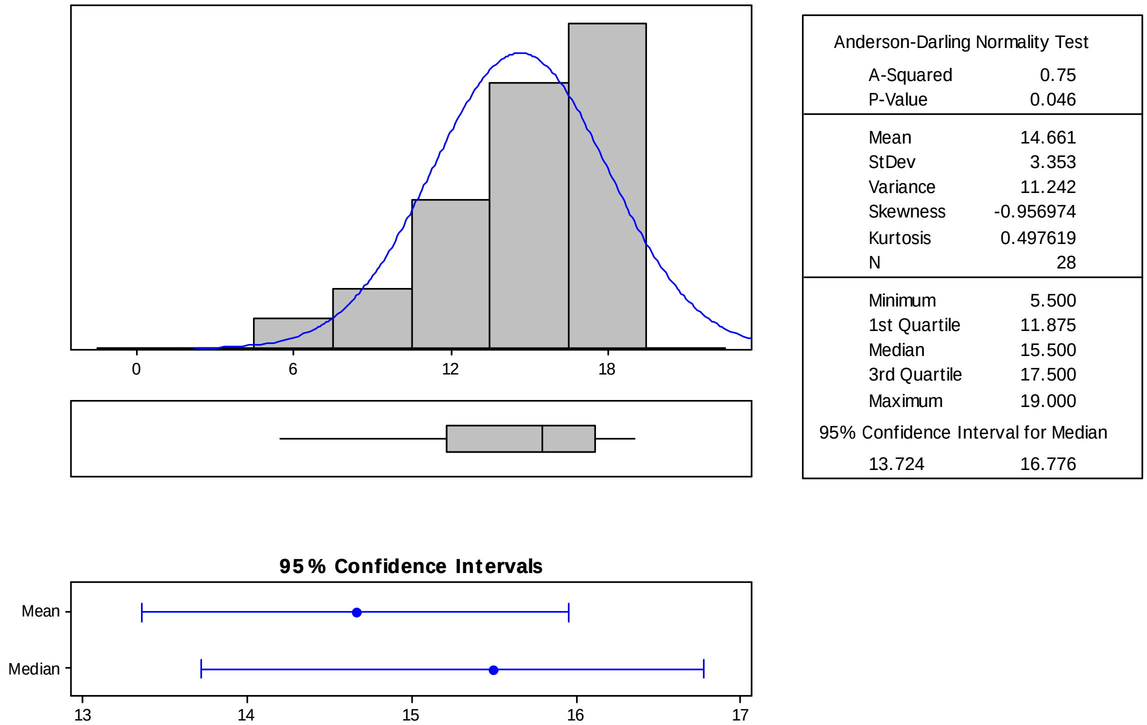


Figure B-5 **Histogram of lower LMR WWH substrate scores for full attainment status sites**

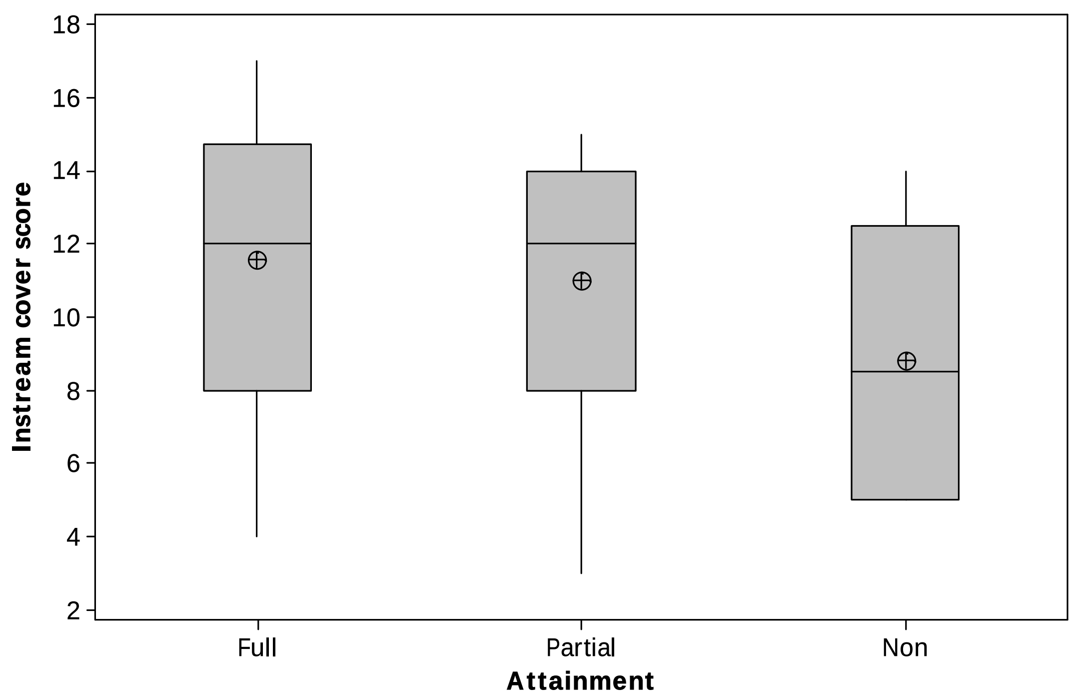


Figure B-6 **Box-whisker plots of lower LMR WWH cover scores by attainment group (circles with a cross are the means)**

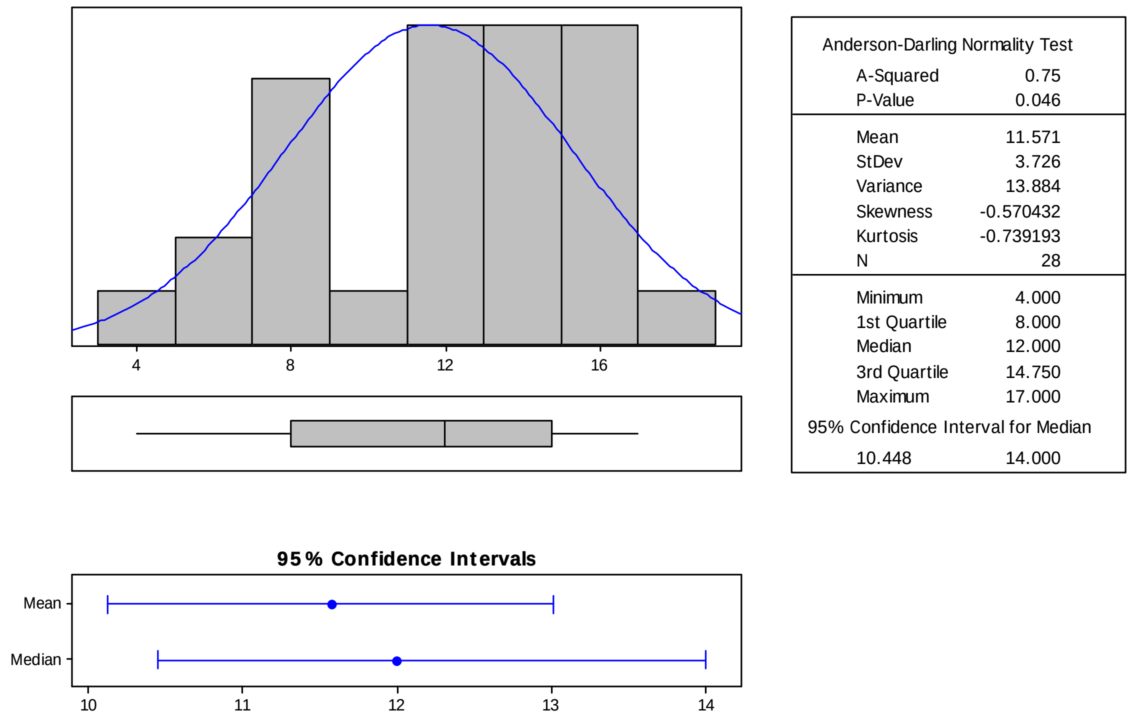


Figure B-7 Histogram of lower LMR WWH instream cover scores for full attainment status sites

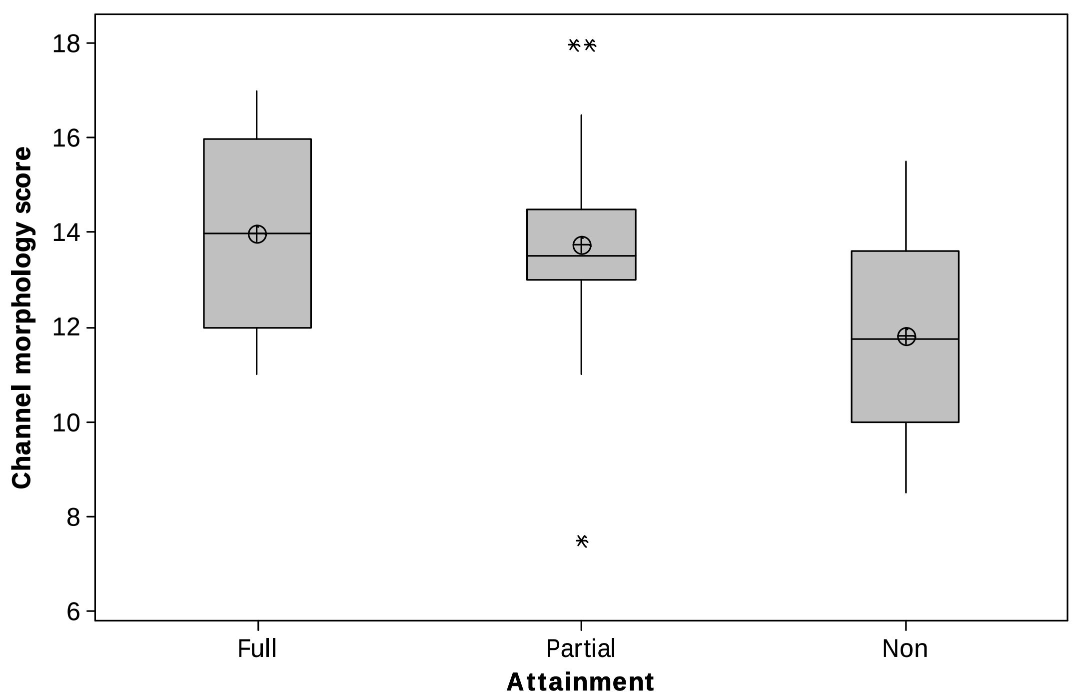


Figure B-8 Box-whisker plots of lower LMR WWH channel scores by attainment group (circles with a cross are the means)

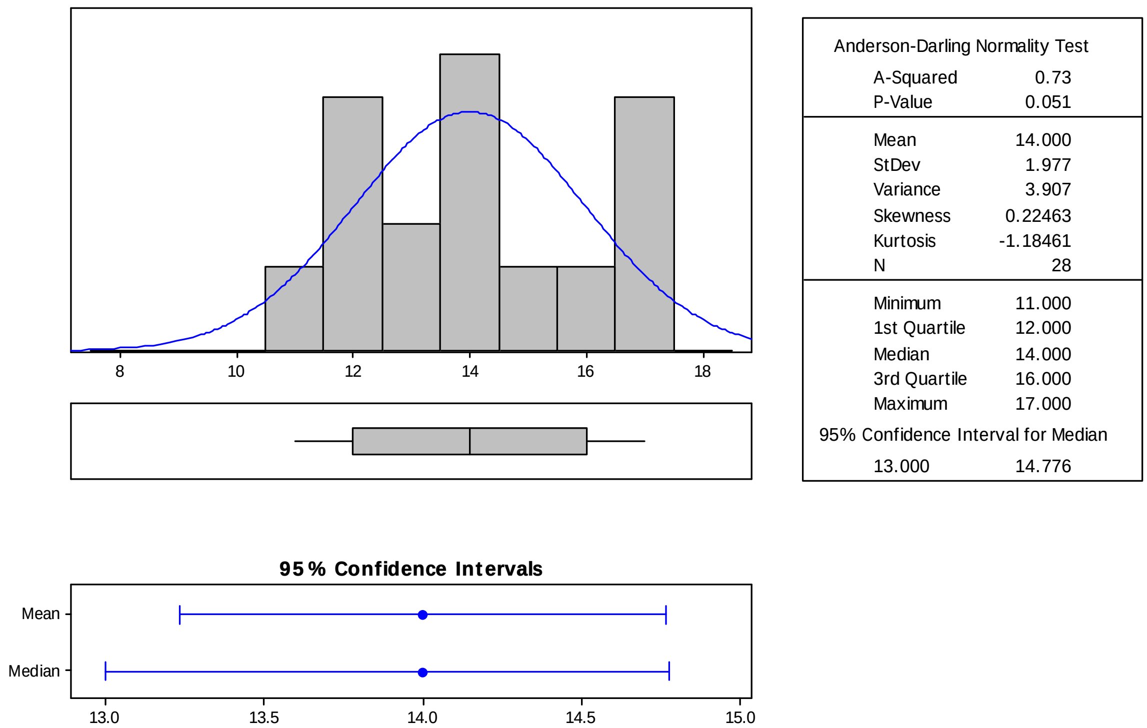


Figure B-9 Histogram of lower LMR WWH channel scores for full attainment status sites

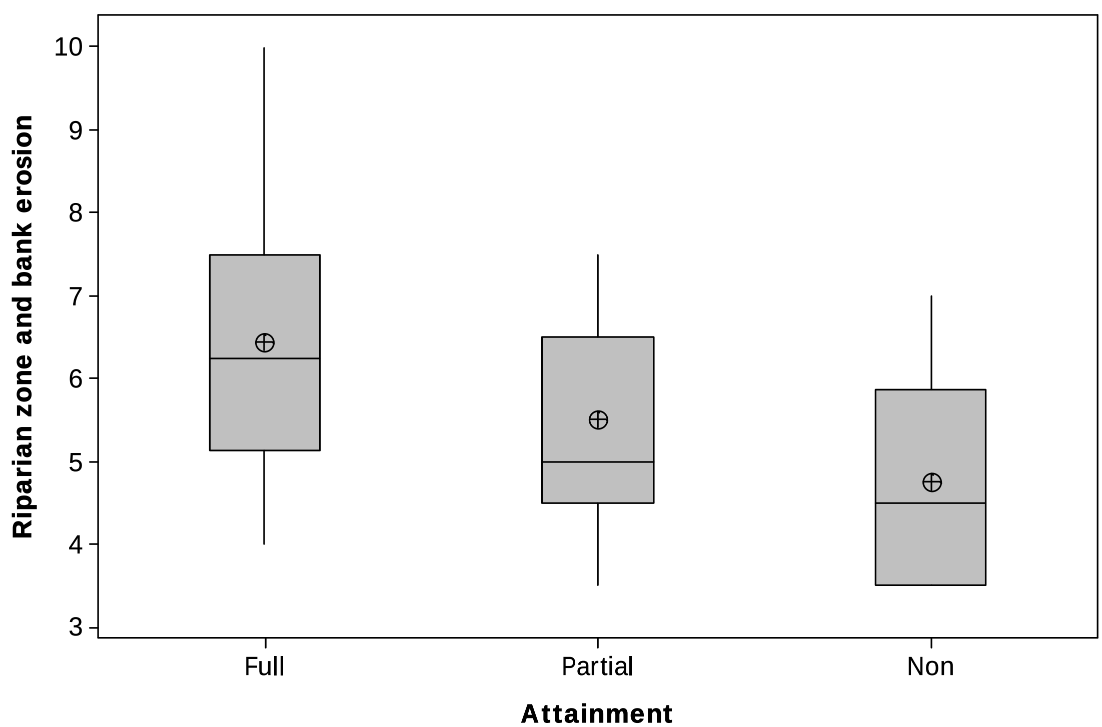


Figure B-10 Box-whisker plots lower LMR WWH Riparian scores by attainment group (circles with a cross are the means)

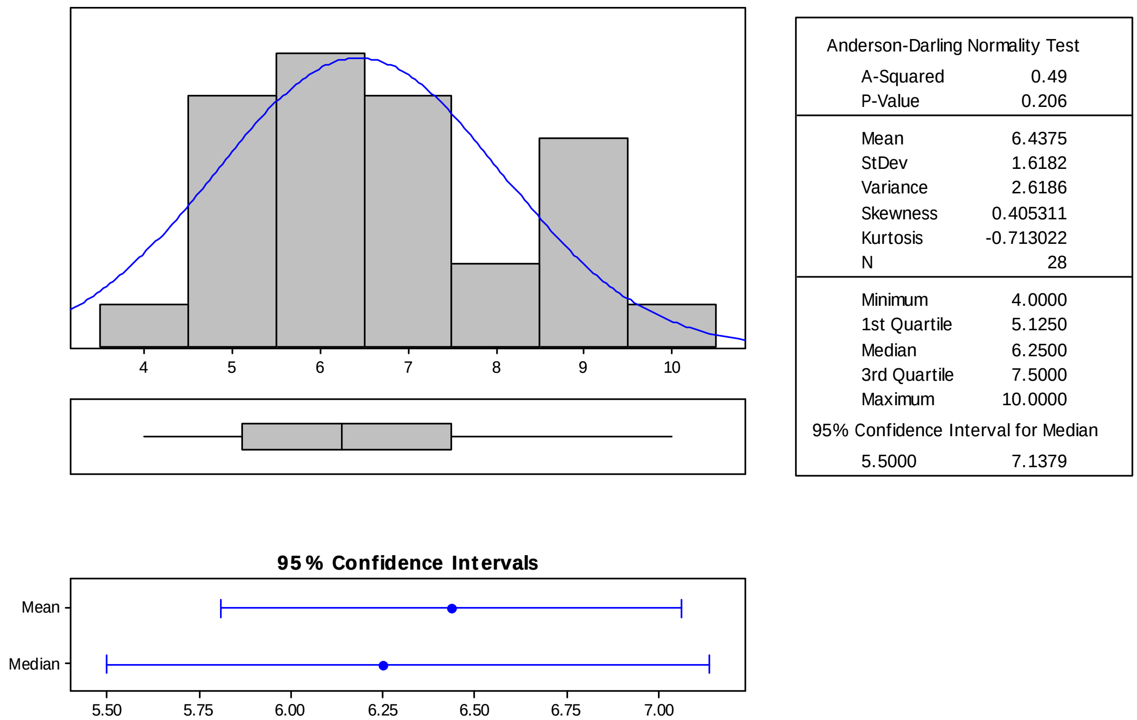


Figure B-11 Histogram of lower LMR WWH riparian scores for full attainment status sites

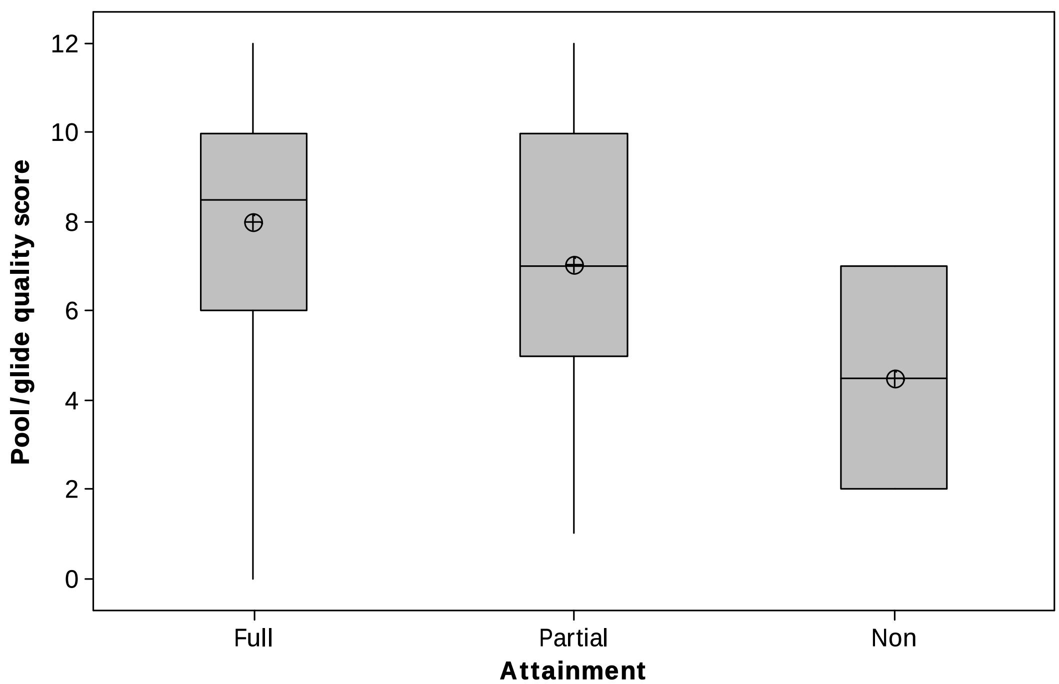


Figure B-12 Box-whisker plots of lower LMR WWH pool scores by attainment group (circles with a cross are the means)

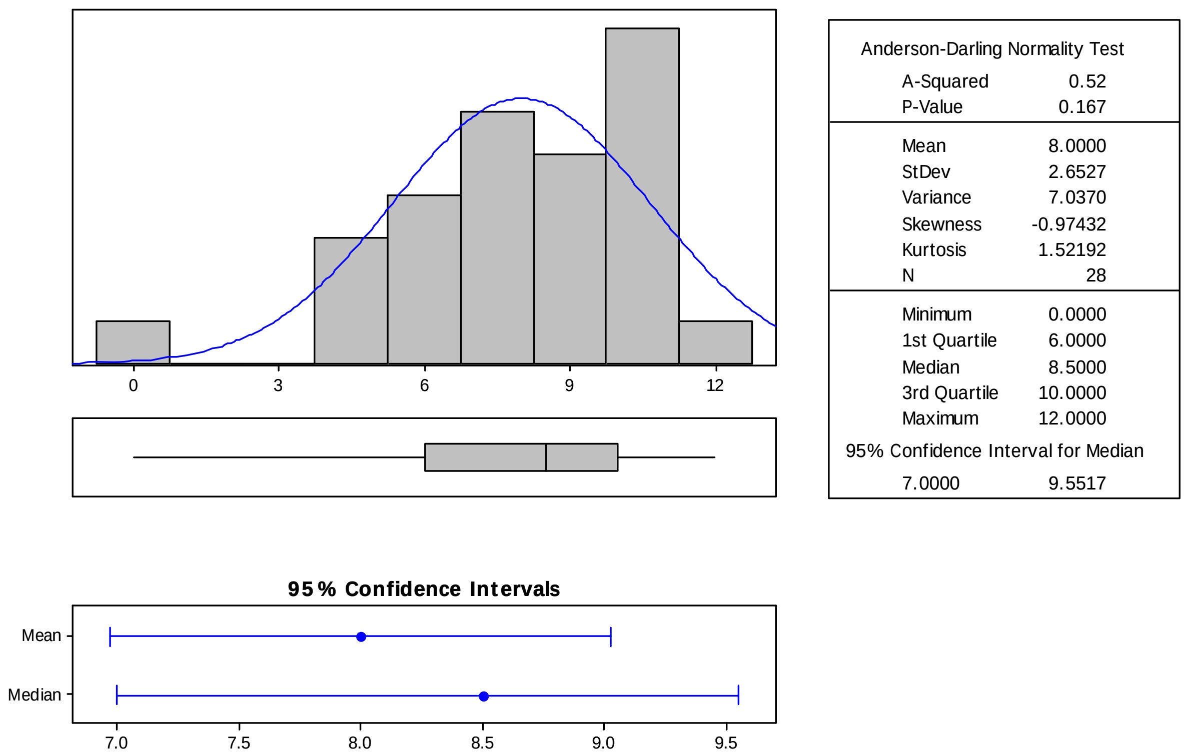


Figure B-13 Histogram of lower LMR WWH pool scores for full attainment status sites

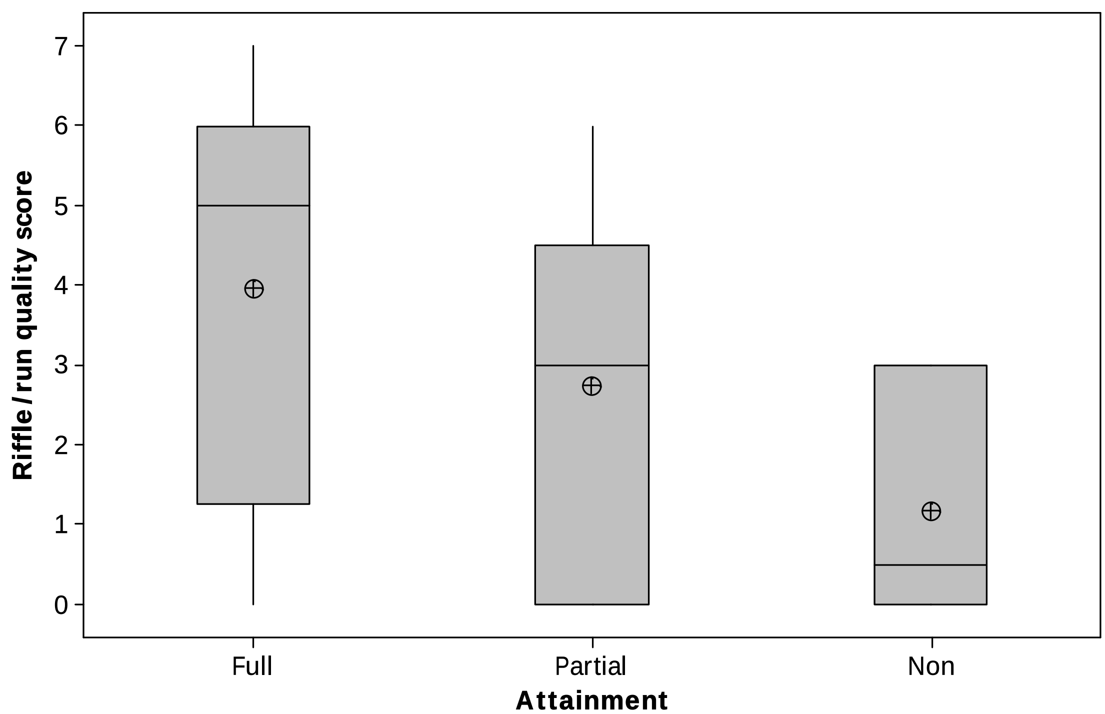


Figure B-14 Box-whisker plots of lower LMR WWH riffle scores by attainment group (circles with a cross are the means)

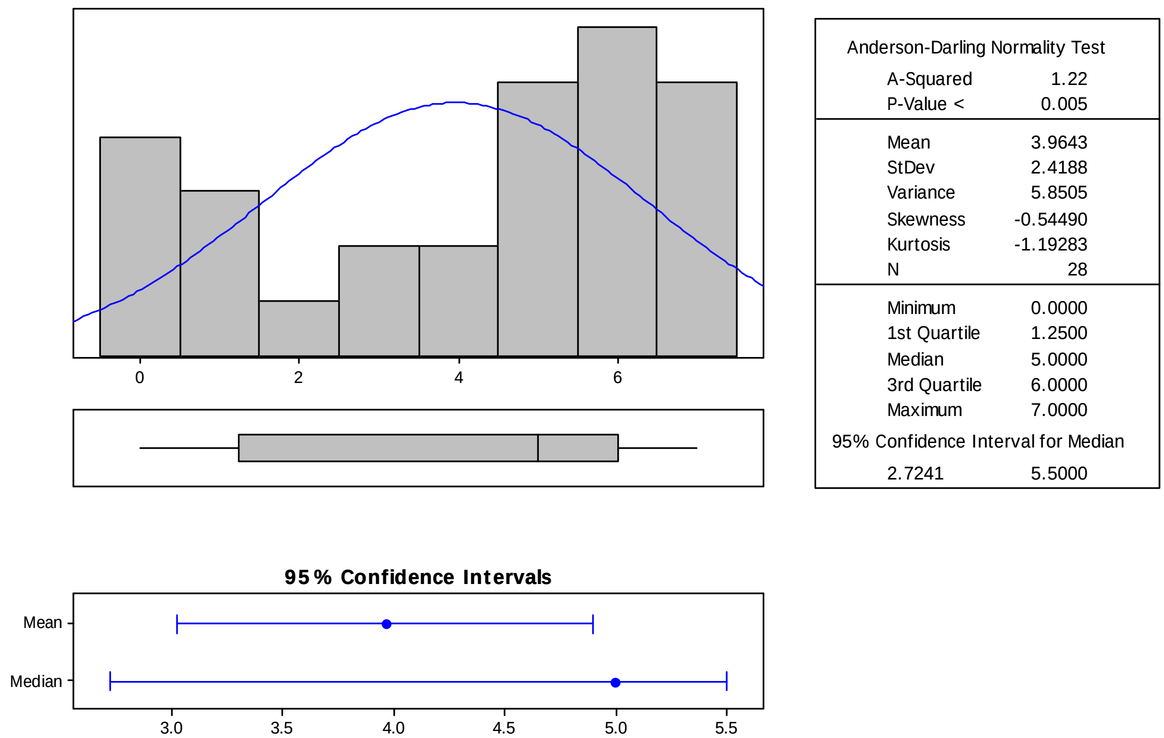


Figure B-15 Histogram of lower LMR WWH riffle scores for full attainment status sites

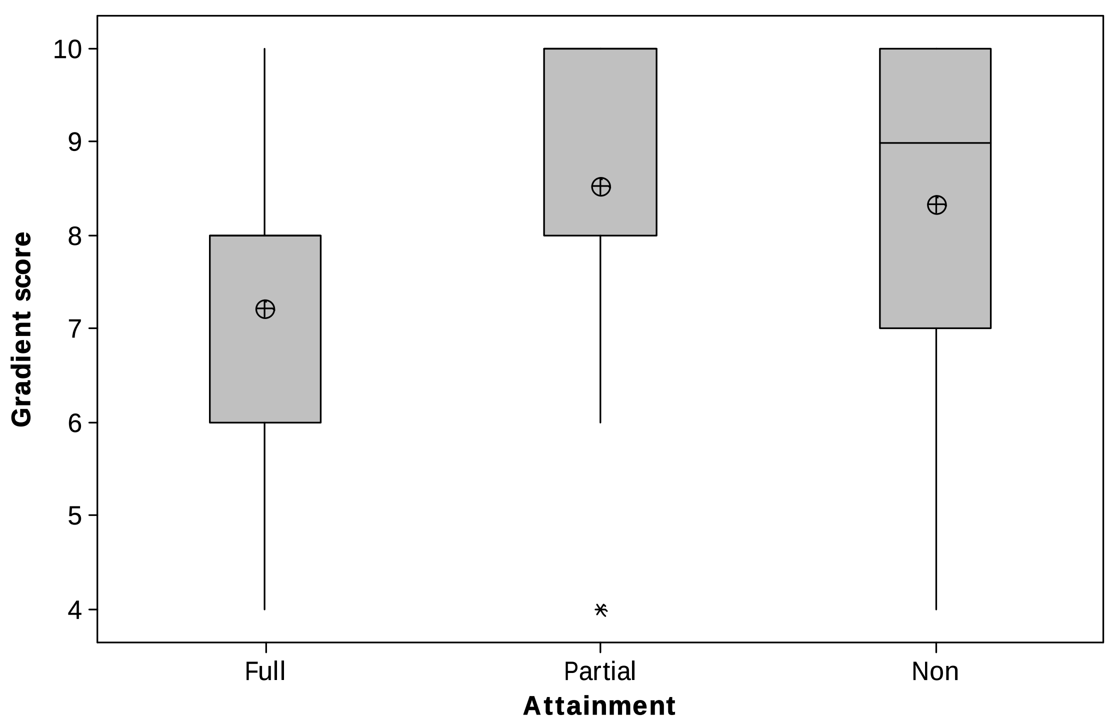


Figure B-16 Box-whisker plots of lower LMR WWH gradient scores by attainment group (circles with a cross are the means)

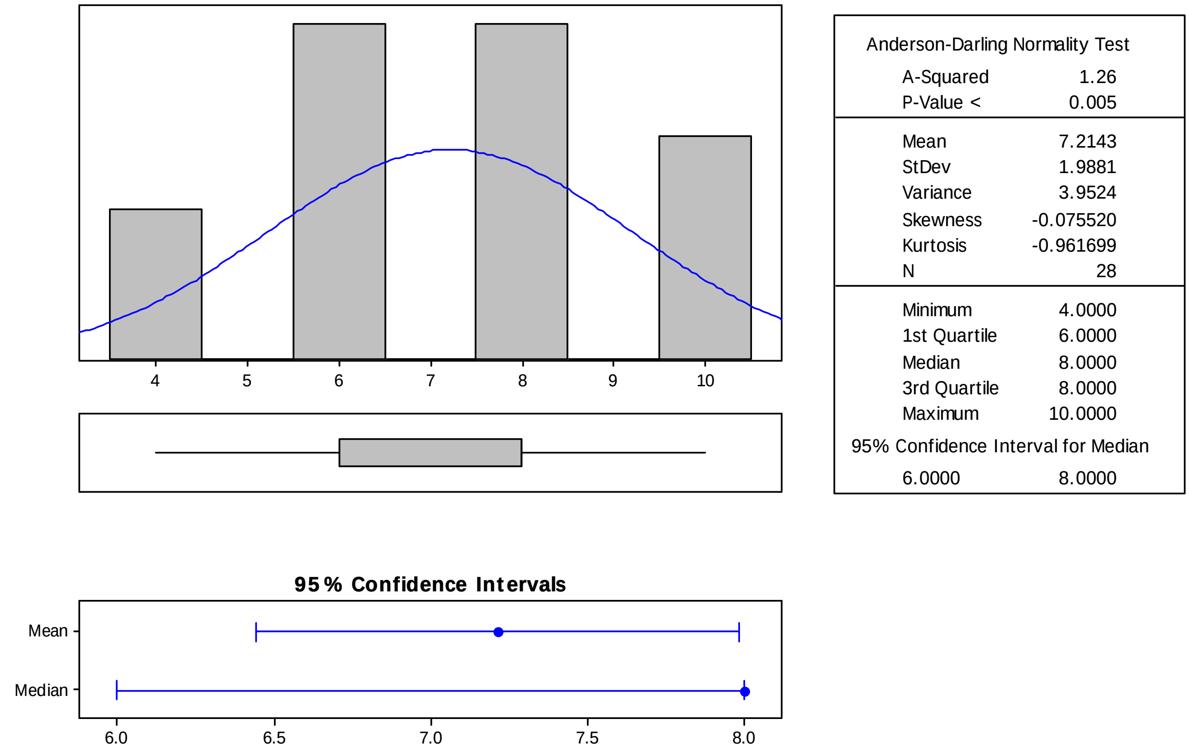


Figure B-17 Histogram of lower LMR WWH gradient scores for full attainment status sites

Table B-3 TMDL targets for QHEI subcategory scores for lower LMR WWH streams

<table>
<tr><th colspan="2">Applicable TMDLs</th><th>QHEI metric</th><th>TMDL target score</th></tr>
<tr><td rowspan="8">Metrics used for the habitat TMDLs</td><td></td><td>Total QHEI score</td><td>58.4</td></tr>
<tr><td rowspan="3">Metrics used for the sediment TMDLs</td><td>Substrate</td><td>13.7</td></tr>
<tr><td>Riparian</td><td>5.5</td></tr>
<tr><td>Channel</td><td>13.0</td></tr>
<tr><td></td><td>Cover</td><td>10.5</td></tr>
<tr><td></td><td>Pool</td><td>7.0</td></tr>
<tr><td></td><td>Riffle</td><td>2.7</td></tr>
<tr><td></td><td>Gradient</td><td>6.0</td></tr>
</table>

B2.4 Dissolved Oxygen/Chemical Oxygen Demand Target Development

Two watersheds are impacted by glycol based discharges from the Airborne Express (ABX) airport east of Wilmington. The airport has an NPDES permit for discharge of treated glycol-laden storm water to Lytle Creek and Indian Run (permit number 1II00031). The areas impacted by this discharge consist of Lytle Creek downstream of this discharge at RM 10.65 and Cowan Creek's tributary Indian Run at RM 0.42 and Cowan Creek downstream of Indian Run.

Due to the oxygen demanding nature of the pollutants discharged from the ABX storm water treatment systems and the observed low D.O. in Indian Run and Cowan Creek, D.O. is an appropriate parameter for TMDL development. The State of Ohio has codified D.O. water quality criteria for the protection of aquatic life (Chapter 3745-1 Ohio Administrative Code table 7-1). These criteria stipulate that instantaneous instream D.O. outside of any effluent mixing zone cannot be below 4.0 mg/l and an average D.O. sample cannot be below 5.0 mg/l for warmwater habitat streams. All streams being considered for this TMDL are designated warmwater habitat.

B2.5 Bacteria, Recreational Use Target Development

Elevated bacteria loading is the cause of recreational use impairment for several streams in the lower Little Miami 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. There are promulgated water quality standards for the geometric mean concentration for *E. coli* bacteria (§OAC 3745-1-07). These values serve as the targets used in the development of the TMDLs that address recreation use impairments.

TMDL numeric targets for *E. coli* bacteria are derived from bacteriological water quality standards. The criterion for *E. coli* specified in §OAC 3745-1-07 are applicable outside the mixing zone and vary for waters that are classified as primary contact recreation (PCR). Furthermore, this criterion designates streams that support frequent primary contact recreation; Class A streams. The mainstem Little Miami River throughout all of this study area is designated a Class A stream. The remainder of streams assessed in this watershed are Class B primary contact recreation streams. These are streams that support infrequent primary contact recreation activities. For Class A streams the standard states that the geometric mean of more than one *E. coli* sample taken in each recreational season (May through October) shall not exceed 126 counts per 100 ml. The standard for Class B streams states that the geometric mean of more than one *E. coli* sample taken in each recreational season shall not exceed 161 counts per 100 ml.

TMDLs are for watersheds that drain to an assessment site that is not meeting the recreational use criterion described in the paragraph above.

B3 Modeling methods

This section outlines the modeling method approaches used. Within the first subsection, nutrient enrichment, there are several methods that have been employed. Multiple methods are necessary due to differences in the nature of the enrichment sources and stream settings. The margin of safety (MOS) and critical condition is described in each of these methods sections.

B3.1 Nutrient Enrichment Methods

Lytle Creek

Lytle Creek drains 20 square miles and is a tributary to Todd Fork upstream of Cowan Creek and the Village of Clarksville. The headwaters of Lytle Creek are on the grounds of the Wilmington (ABX) airport, and the creek then flows through the City of Wilmington. The most upstream two assessment sites on Lytle Creek are listed as not meeting aquatic life use attainment due to sedimentation and nutrient/ eutrophication. The major source of this impairment is due to enrichment from deicing chemicals and the breakdown components of these chemicals being discharged from the ABX storm water treatment facility. A separate TMDL has been created for the pollutants from this facility; see Section B3.4.

Two spring field surveys took place in 2008 on Lytle Creek. The primary purpose of these surveys was to better characterize the ABX source impact to Lytle Creek and adjacent tributaries. However, data collected from these surveys show the nutrient enrichment from the Wilmington WWTP. Figures B-18 and B-19 show stream longitudinal plots of dissolved oxygen and T.P. from upstream to downstream Lytle Creek. Both of these surveys show the diel dissolved oxygen range becoming much greater downstream of the Wilmington WWTP (especially the May 7-9 survey) and both show that the instream TP becomes elevated downstream of the plant. The June 10-12 survey in Figure B-19 occurred after a storm and is less pronounced.

The third and fourth assessment sites on Lytle Creek moving from up to downstream are downstream of the Wilmington WWTP. These two sites are likely impacted by the ABX pollutants to a certain extent. As explained in the ABX sourced pollutants TMDL, the critical condition for the organic enrichment caused by these pollutants occurs in the late winter and early spring period. However nutrient enrichment from nutrients contributed by Wilmington WWTP is the primary source of impairment for the two assessment sites downstream of the plant. The critical condition for these pollutants occurs in the summer low flow period; a different condition than the ABX pollutants. Both impacts to Lytle Creek should be addressed in order to mitigate aquatic life use impairment.

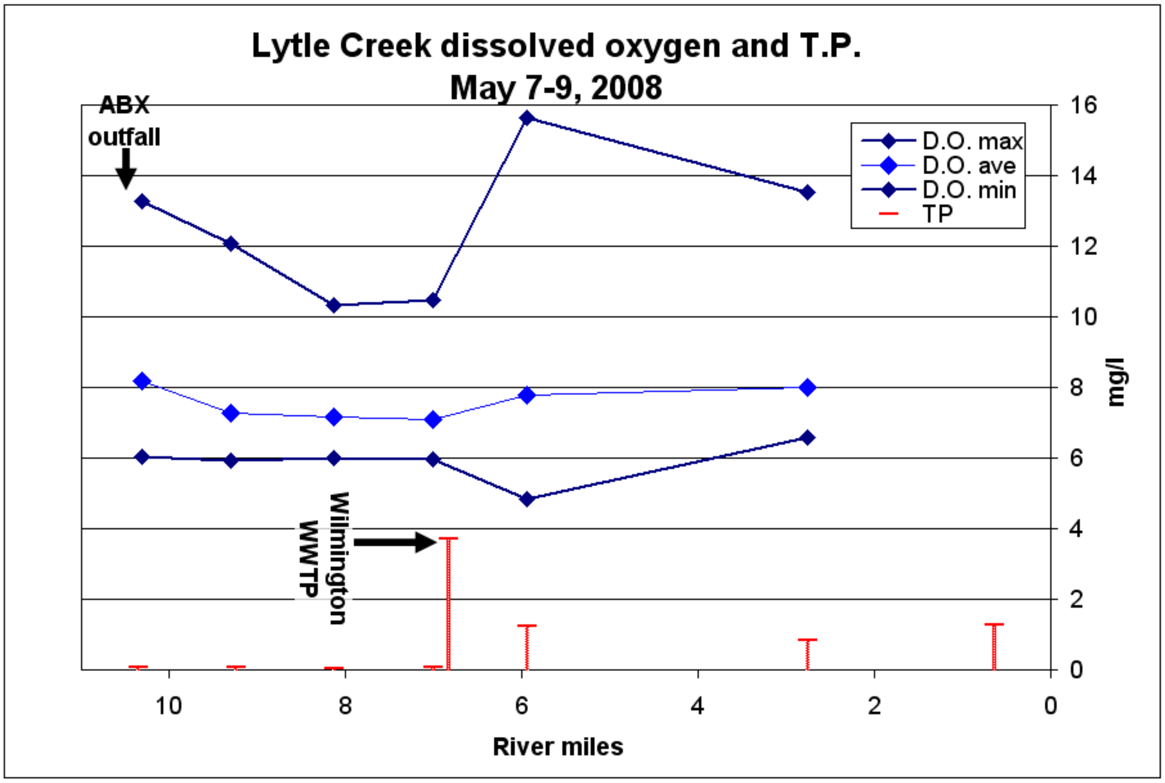


Figure B-18 Lytle Creek dissolved oxygen and TP from May 7-9, 2008.

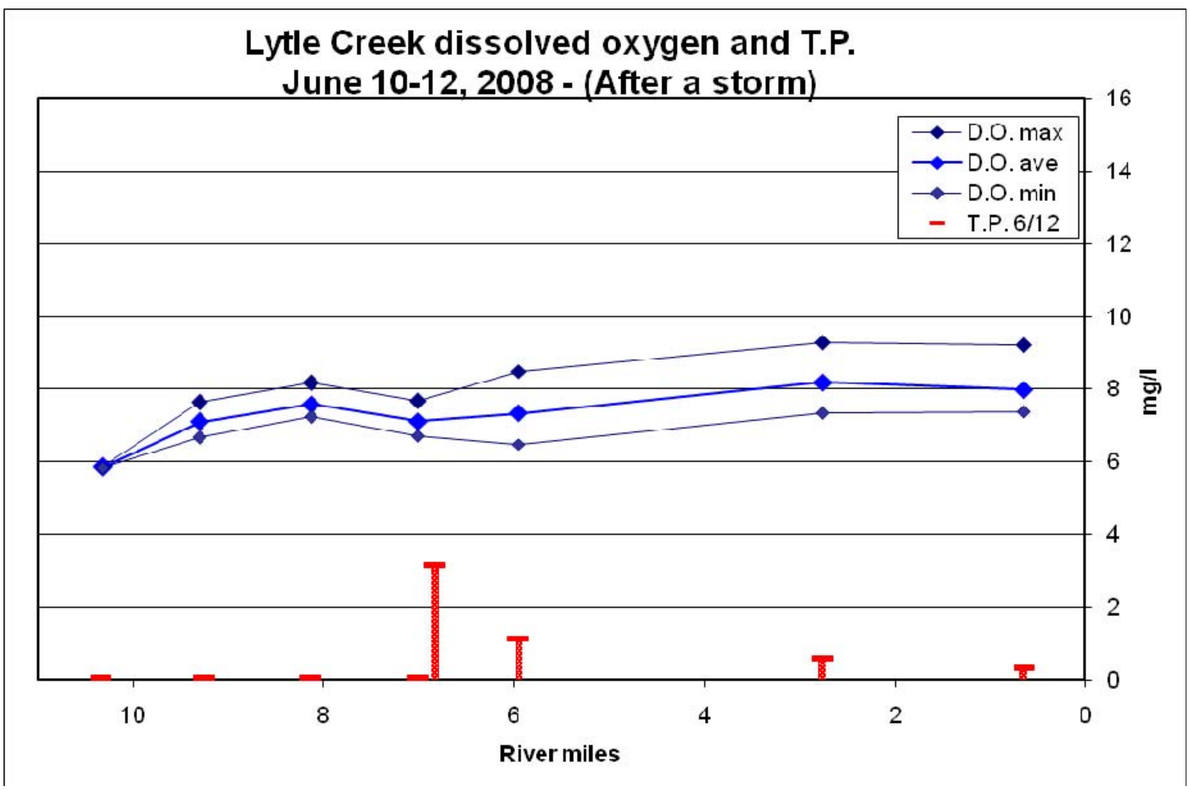


Figure B-19 Lytle Creek dissolved oxygen and TP from June 10-12, 2008 (after a storm).

From the summertime 2007 assessment sampling, the average TP samples in Lytle Creek just upstream the Wilmington WWTP (RM 7.01, Nelson Rd.) and further upstream adjacent Townsend Field (RM 9.3, in Wilmington College's campus) were 0.10 and 0.16 mg/l respectively with six samples each. These values are significantly lower than the two sites downstream of the Wilmington WWTP with average values of 2.69 (at RM 5.94) and 1.81mg/l; again with six samples each.

Based on the TP targets used in this TMDL (see Table B-1), 0.08 mg/l is the target to be used in Lytle Creek. In order to determine what modeling approach is applicable to address the nutrient enrichment for Lytle Creek a critical condition must be set. During the low flow summer period very little runoff occurs. The standard low flow statistic used by Ohio EPA for modeling TMDLs relating to dissolved oxygen, a parameter impacted by nutrient enrichment, is the 7-consecutive day 10-year recurrence interval, or 7Q10. Using a drainage area yield from a nearby USGS station (station 03243400), the 7Q10 low flow for the whole Lytle Creek watershed is determined to be 0.067 cfs.

Since the Wilmington WWTP is the only known point source of low flow TP to Lytle Creek in the summertime, a simple mass balance approach is used to determine the TP TMDL for this watershed. Using landuse analysis, nonpoint source TP is calculated for this watershed based on TP ranges expected from streams draining various landuses (Dai, 2000). Table B-4 shows the landuse and TP data used for this calculation.

Table B-4 Landuse and assumed TP used for the Lytle Creek critical condition flow

Landuse	Area (mi^2)	TP (mg/l)
Open Water	0.05	0
Developed land	5.31	0.05
Barren Land (Rock/Sand/Clay)	0.02	0.02
Forest	5.92	0.02
Grassland/Herbaceous	0.03	0.02
Pasture/Hay	2.60	0.08
Cultivated Crops	6.48	0.08
TOTAL	20.42	0.05*

* This is the area weighted TP concentration

The TMDL is determined by taking total flow, the sum of the 7Q10 watershed flow and the WWTP design flow, times the target concentration. Since the NPS concentration, 0.05 mg/l, is below the target no load reduction is required. The WWTP WLA is determined by subtracting the NPS LA from the TMDL. All of the pertinent information regarding these calculations is shown in Table B-5.

Table B-5 Parameters and calculations considered for mass balance modeling on Lytle Creek at the Wilmington WWTP outfall

Row	Parameter	Value	Unit	Justification/calculation
A	$_{7Q10}$ for Lytle Creek watershed	0.07	cfs	Critical condition, calculated by area yield.
B	TP concentration for watershed	0.05	mg/l	Explained above and in Table B-1
C	NPS LA	0.01	Kg/day	A*B*conv factor
D	Wilmington WWTP design flow	3.00 4.64	MDG cfs	NPDES permit
E	Total flow		cfs	A + D
F	Target concentration	0.08	mg/l	See Section B2.1
G	TMDL	0.92	Kg/day	E * F * conv factor
H	Wilmington WWTP WLA	0.91	Kg/day	G-C
I	Wilmington WWTP concentration limit	0.08	mg/l	H / (D * conv factor)

A margin of safety for this TMDL is implicitly incorporated through the conservative nature of the calculations. Instream TP decay via plant assimilation and sorption to stream sediments is occurring, especially downstream of the Wilmington WWTP. Figure B-19 above illustrates the TP decay observed. This is noted from the declining height of the red bars on the bottom of the graph moving downstream from the WWTP. The margin of safety for this TMDL utilizes an implicit approach because the instream nutrient transport assumptions are conservative.

Indian Run and Cowan Creek

Indian Run and Cowan Creek both have nutrient/eutrophication listed as causes of aquatic life use impairment. The source of this impairment is from ABX and is addressed in a separate TMDL; see Section B3.4.

Second Creek

Four sites were assessed on Second Creek, a 19.96 square mile tributary to Todd Fork downstream of Clarksville. Figure B-21, at the end of this subsection, is a map of the land use classifications of Second Creek. This figure shows the location of the assessment sites on this stream. The upper (eastern) section of Second Creek's watershed drains an area primarily in agricultural land use. Downstream of this area Second Creek flows through the Village of Blanchester. Downstream of Blanchester the stream drains a mix of forested and agricultural land uses.

Table B-6 shows the TP results of 2007 summertime sampling. At all sites on Second Creek, each of the samples exceeded the 0.08 mg/l TP target for WWH headwater streams. The most upstream assessment site, Second Creek at Columbus Street (river mile 10.54), is in non attainment of aquatic life use expectations. Nutrient/ eutrophication is the cause of impairment at this site. The average TP of the six samples taken at this site in the summer of 2007 was 0.35 mg/l with little variation (standard deviation of 0.09). This site represents the watershed upstream of Blanchester, and is impacted by upstream agricultural uses. Poor nutrient management, especially from row crops is believed to be the source of the excessive nutrients.

At river mile 9.45, the next assessment site is downstream of the Blanchester WWTP. Discharger monitoring records indicate that the WWTP's effluent had an average TP concentration of 0.97 mg/l throughout the summer of 2007. Furthermore, a sewage system leak was found draining to Second Creek during the 2007 survey. The Village of Blanchester has corrected this leak, and it is not believed to be contributing to existing aquatic life use impairment. As expected, the site at river mile 9.45 has an average TP greater than the most upstream site. The remaining two sites downstream show elevated TP being assimilated from the two upstream sources discussed here. Figure B-20 shows a plot of the average and standard deviation TP for the four sites monitored in 2007.

Table B-6 TP values at Second Creek assessment sites

RM	Site location on Second Creek	Mean*	Standard deviation
10.94	@ Columbus St. (upstream Blanchester WWTP)	0.35	0.09
9.45	@ SR 123 (downstream Blanchester WWTP)	0.63	0.12
6.55	@ Gustin-Rider Rd	0.47	0.07
1.53	@ Cozaddale RD (near Butlerville)	0.27	0.12

* Six samples taken at each site on the same day throughout the summer of 2007

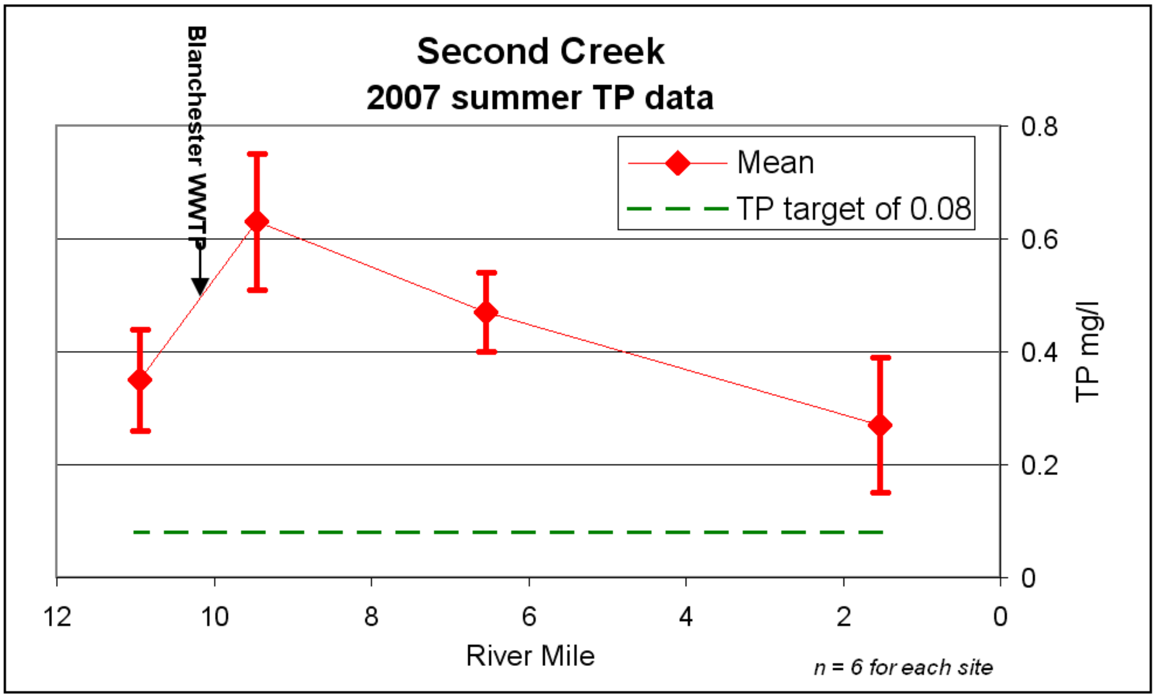


Figure B-20 TP data for Second Creek in the summer of 2007.

Because upstream nonpoint source agriculture and the Blanchester WWTP are both contributing to a nutrient load impacting Second Creek, a TMDL critical condition representing some flow from both of these sources is utilized. A stream flow representative of the flows sampled during the 2007 assessment season is used. This flow is greater than the $_{7Q10}$ flow statistic used in watersheds with point source dominated sources, like Lytle Creek in this report. This flow condition is used in order to model the TP TMDL in an empirical manner using the observed TP data.

Flow was not measured at the Second Creek assessment sites during the 2007 survey. However stage measurements were made at four sentinel sites in the Todd Fork watershed throughout this survey. Stage to flow relationships exist in order to determine loadings at these sentinel sites. As determined by the 2007 survey field staff, the sentinel site to have the most proportional flows during grab samples to Second Creek is Todd Fork at US 22/SR 3. This site is very close to the mouth of Todd Fork. The drainage area at this site is 261 square miles. Second Creek's drainage area is 19.96 square miles. A simple drainage area ratio is used to compute the flow for Second Creek at each day of sampling. Table B-7 shows the flow values. The average flow of these flows, 1.99 cfs, is used to be the critical condition flow.

Table B-7 Flow values on sampling days for the Todd Fork at US 22/SR 3 sentinel site and calculated for the Second Creek watershed

Date (in 2007)	Sentinel site (cfs)	Calculated for Second Ck flow (cfs)
July 11	118.03	9.03
July 25	15.52	1.19
August 8	7.28	0.56
August 22	7.70	0.59
September 5	1.16	0.09
September 12	6.48	0.50

The modeling method employed for this TMDL is an empirical one. As explained above both nonpoint and point sources of TP are to be considered in the modeling critical condition. Therefore, a flow for the Blanchester WWTP during this critical condition needs to be determined. In checking the discharge monitoring reports (DMR), an average effluent flow of 0.59 cfs was reported for the six days that sampling took place. A TP mass balance is also used to determine the average effluent flow during the sampling days. Using the TP monitoring data from the river mile 10.54 and 9.45 sites (data are shown above in Table B-6) and the DMR of 0.96 mg/l TP throughout the summer of 2007, a flow of 0.52 cfs is calculated for the WWTP for this flow condition. This flow is very similar to the DMR flow and 0.52 cfs will be used to calculate the TMDL. With the critical condition total watershed flow and WWTP flow determined, the difference between the two is set as the nonpoint source flow. This is 1.43 cfs.

A margin of safety is implicitly incorporated into this TMDL through the conservative nature of the calculations. Instream TP decay via plant assimilation and sorption to stream sediments is occurring, especially downstream of the Blanchester WWTP. This is expected given that here the stream drains much less intensive agriculture land uses, has improved instream habitat (improved QHEI scores) and a more intact wooded riparian (see Figure B-21). Figure B-20 above illustrates the TP decay observed. Because no instream TP decay is being calculated it is considered an implicit margin of safety, and no explicit margin of safety is required.

Concentration allocations for all sources of flow are made in order to meet the TP target concentration of 0.08 mg/l. Table B-8 shows the allocations made for the nonpoint source flow and are based on TP ranges from Dai, 2000. Because of the most upstream sampling site's elevated TP (average of 0.35 mg/l) and the nearly total agricultural land use, it is assumed that agriculture contributes the highest amount of TP from nonpoint sources. Because of this, agricultural land is allotted the highest allocation. The average TP concentration of all the nonpoint source flow is 0.06 mg/l. With this information a mass balance equation is used to determine what the WWTP's TP limit is for this critical condition. This TP limit is 0.13 mg/l. Table B-9 shows the data used for this calculation.

Table B-8 Nonpoint source TP concentration allocations by landuse

Land use	Area (mi^2)	Allocated TP concentration (mg/l)
Agriculture	13.04	0.08
Forested	4.90	0.02
Developed non ag	2.02	0.05
Total land use	19.96	0.06

Table B-9 Values used to determine the Blanchester WWTP TP limit at critical condition flow

	Flow (cfs)	TP concentration (mg/l)
Nonpoint sources Land uses	1.47	0.06
Point Sources Blanchester WWTP	0.52	0.13
Total	1.99	0.08*

* This value is based on the flow weighted average of the two sources listed above.

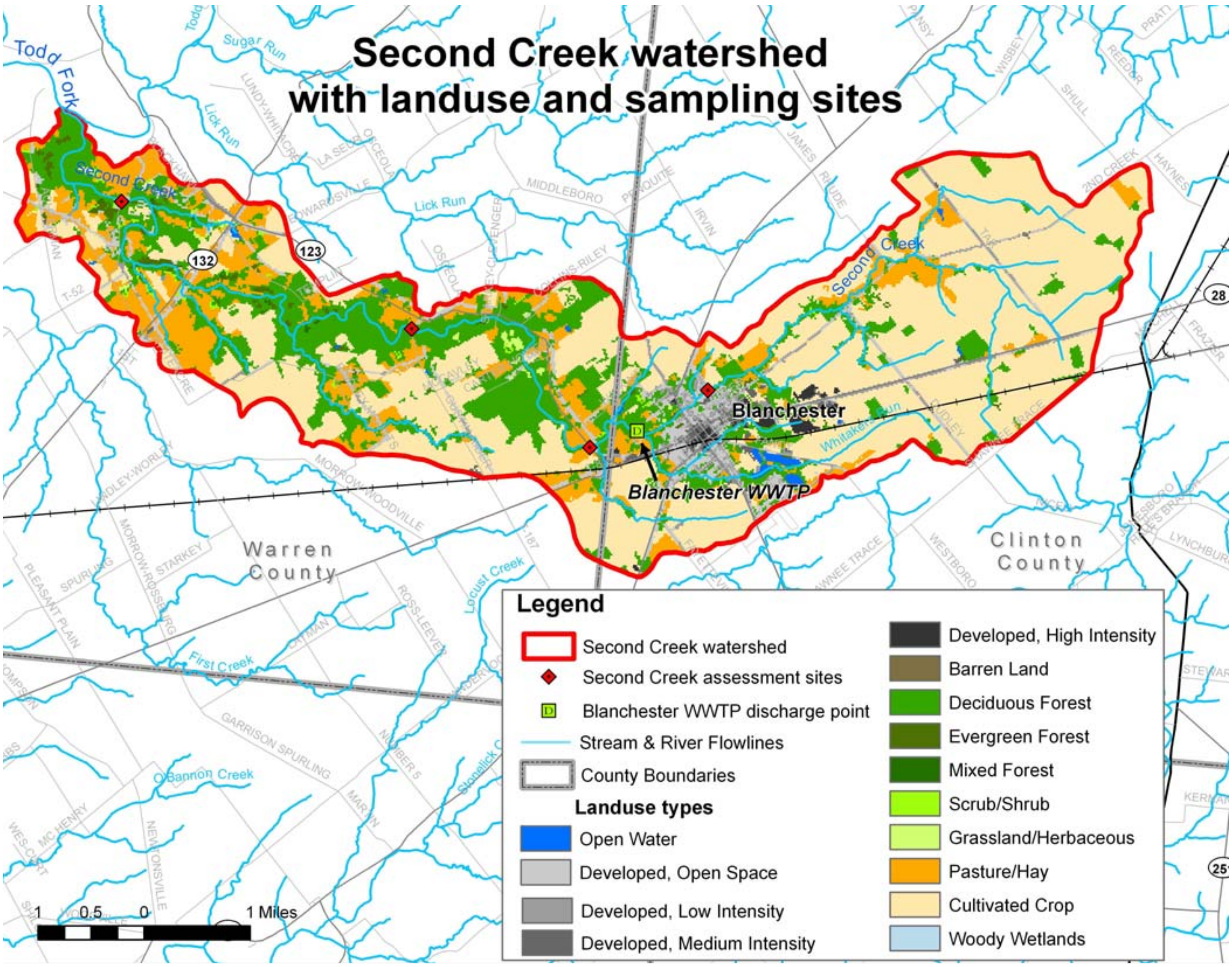


Figure B-21 Second Creek watershed with land use and sampling sites.

First Creek

First Creek drains a watershed of 19.52 square miles of mixed land uses. The one assessment site on First Creek does not meet aquatic life use expectations. The cause of impairment is organic enrichment. Instantaneous dissolved oxygen measurements were taken at each of the six sampling events in the summer of 2007. These measurements resulted in a minimum of 3.95 mg/l and a maximum of 7.33 mg/l. The 3.95 mg/l value is a violation of water quality standards. The TP results for the six 2007 summer samples at the First Creek assessment site found an average concentration of 0.13 mg/l; with a minimum of 0.054 and a maximum of 0.252.

Based on these data and field assessment the primary source of this enrichment is determined to be from failing home sewage treatment systems (HSTSs).

The Village of Butlerville is drained by First Creek. This village is unsewered with a population of 245 and about 80 homes. The failure rate of the village's HSTSs is unknown. Upon Ohio EPA's request, local health department conducted inspections of Butlerville individual properties. Evidence of sewage in storm drains were observed due to this survey (Warren County Combined Health District , 2009). Since these HSTSs are believed to be the primary source of First Creek's impairment, and any direct discharges of failing HSTSs to waters of the State are illicit, limiting pollutants from HSTSs is the main point source allocation in this TMDL. Limiting allowable loads from HSTSs to zero is a simple and practicable manner to address this cause of impairment. This method of TMDL calculation is implicitly conservative. Therefore no explicit margin of safety is necessary.

B3.2 TSS and CBOD 5-day

Data supplied to Ohio EPA from MSD explain the CSOs total volume of overflow discharge and the number of occurrences over a multiple year period. From these data an average volume per overflow event is determined for each CSO and a total average volume per overflow for Duck and Clough creeks is determined (Table B-10). As explained in Section B2.2 the volumes listed here represent the current flows and includes the MSD reported existing controls. For modeling purposes it is assumed that these volumes are the daily CSO flow for days with a typical CSO event.

Table B-10 CSO volume per event

Receiving stream	Number of CSOs	Average volume per event from all CSOs (MG)*
Duck Creek	43	19.39
Clough Creek	2	2.94

* MG = million gallons; Data includes events from Metropolitan Sewer District of Greater Cincinnati, 2006

More complete data for two of the Duck Creek draining CSOs (#549 and #136) were provided to Ohio EPA. These data contain effluent quality, amount of discharge and amount of rainfall (from the closest gage and an average of gages used by MSD). Taken as daily data, these included 65 and 57 CSO events for CSO #549 and #136 respectively between June, 2001 and July, 2003. Figures B-22 and B-23 show the distribution, as box plots, of TSS and CBOD 5-day respectively for these two CSOs. Table B-11 shows the median values of these parameters for the two CSOs. Averages of these medians were calculated to be 294 mg/l and 32.5 mg/l TSS and CBOD 5-day respectively. These values are used to represent CSO effluent quality for all of the CSOs in the two watersheds being modeled. These values fall within the range provided by US EPA as expected CSO effluent quality (US EPA, 2001a).

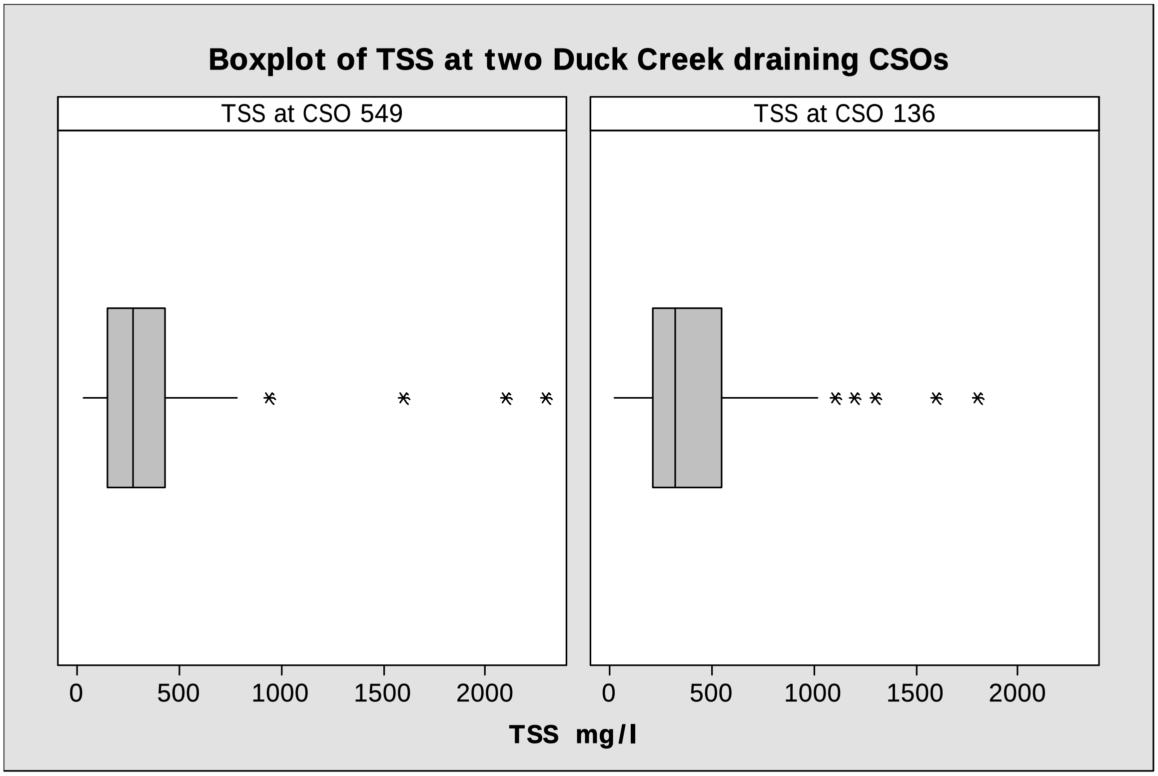


Figure B-22 Boxplot of TSS at two Duck Creek draining CSOs.

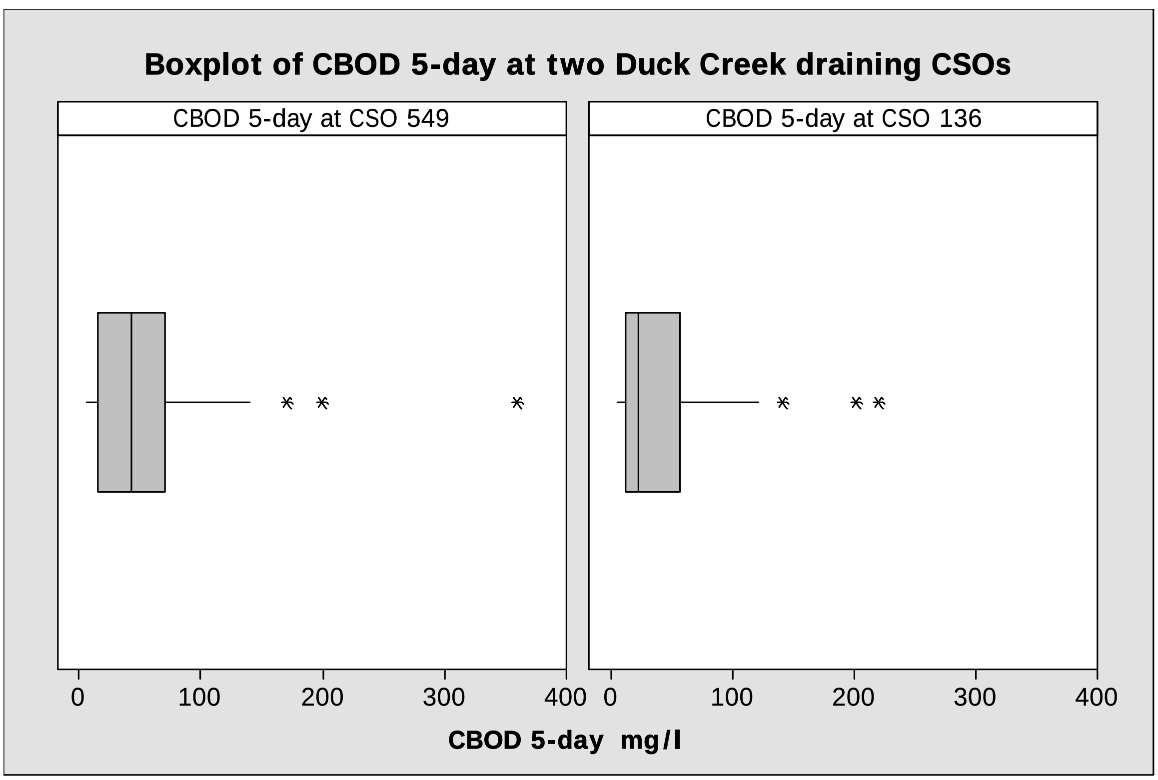


Figure B-23 Boxplot of CBOD 5-day at two Duck Creek draining CSOs.

Table B-11 Median effluent quality values for MSD's CSO discharges on Duck and Clough Creeks.

CSO	TSS mg/l	CBOD 5-day
#136	320	22
#549	268	43
Average of medians	**294**	**32.5**

Rainfall data from overflow events for the two CSOs with extra data were analyzed. Of the several rain gages that MSD monitors, the gage closest to these Duck Creek CSOs is gage #150. The daily rainfall for this gage and the average of all MSD gages is reported for each CSO flow event for the two CSOs. Boxplots of the distribution of these data are presented in Figure B-24.

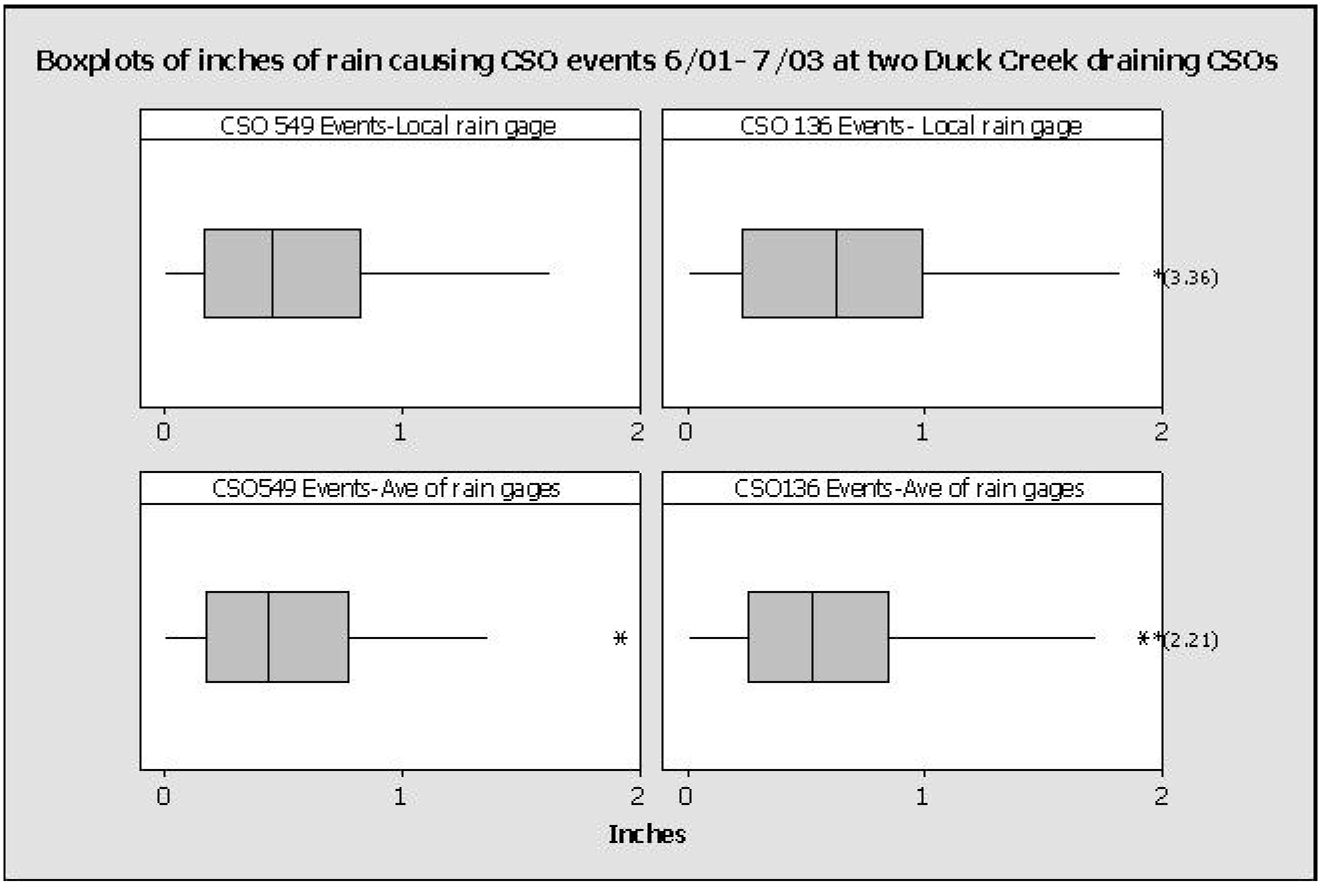


Figure B-24 Boxplots of inches of rain causing CSO discharges from 6/1 to 6/7 2003 at two CSO outfalls on Duck Creek.

Efforts to determine the critical condition storm to apply to all CSOs in the Duck and Clough creeks' watersheds were carried out. The average of the medians of the daily rainfall on event days is 0.51 inches. This was too low of a rainfall value to use to apply to all CSOs. This is because in applying the runoff model TR-55 (USDA, 1986) for these two watersheds given a storm of this rainfall yields 9.67 MG and 2.54 MG in Duck and Clough creeks respectively. In referring to Table B-10 above, it is clear that this storm does not produce enough storm water to even equal the amount of flow in the CSOs (i.e, 19.39 and 2.94 MGD respectively). If this storm were the typical storm in which the typical CSO flow is observed it would mean a very large portion of the storm water is captured in the CSO or that a great amount of sanitary sewer water is included in the CSO flow relative to the storm water runoff. Since the effluent quality observed for the two Duck Creek CSOs, Table B-11, does not fall on either of the extremes (highly diluted with storm water or highly concentrated with sewage) of the range of concentrations expected (US EPA, 2001a), these possibilities can be ruled out.

In order to consider a storm with more rainfall for the critical condition the 75th percentile rainfall from the data provided was evaluated. The average of the gages' 75th percentile is a storm of 0.835 inches. Again employing the runoff model TR-55, a storm of this size yields 44.69 and 17.04 MG in Duck and Clough creeks respectively. These runoff values are more reasonable when compared to the average CSO flow from all Duck and Clough creeks, and this storm will be used as the CSO critical condition. Table B-12 shows the rainfall values and calculated runoff.

Table B-12 Rainfall values and calculated runoff

Stream	Rainfall (in)	Runoff/storm water (MG)
Duck Creek	0.510	9.67
	0.835*	44.69*
Clough Creek	0.510	2.54
	0.835*	17.04*

* Critical condition

This method of TMDL calculation is implicitly conservative. Therefore no explicit margin of safety is necessary.

B3.3 Sediment/Habitat Methods

The bedload and habitat QHEI components for each assessment site are compared to the watershed specific targets developed above. This method of TMDL calculation is implicitly conservative. Therefore no explicit margin of safety is necessary.

B3.4 Dissolved Oxygen/Chemical Oxygen Demand

Previous modeling work for the ABX permit has assumed the stream's critical condition is during storm flows when high loads of deicing chemicals are discharged. TMDL modeling staff toured ABX treatment facilities and the streams receiving its treated storm water on April 30, 2008. The staff noted degradation of the receiving streams. Observed in this tour were stream substrates extensively covered with filamentous bacteria growth. Figure B-25 shows Lytle Creek growth-covered substrate near the campus of the College of Wilmington (about 1.4 river miles downstream from the ABX outfall) on April 30, 2008. Some of this growth was later identified as *Beggiatoa sp.*

Due to the observations made on April 30, 2008 a survey monitoring DO and chemistry parameters was carried out the following week. Figures B-26 and B-27 show the maximum, average and minimum D.O. data for several sites in Lytle and Cowan creeks during this survey. These D.O. data were collected every hour for about 48 hours at each site. In Figure B-26 shows the D.O. of Lytle Creek does not violate water quality criteria. Field observations noted less bacteria growth on the stream bed during this survey compared to the previous week. Discharge monitoring reports submitted to Ohio EPA from ABX seem to back up the fact that the high oxygen demand discharge was finishing up for the season in Lytle Creek at the time of the survey (Table B-13).

Figure B-27 shows D.O. criterion violations were observed for both the 24-hour average and the minimum aspects of the standard in Indian Run and downstream of Indian Run in Cowan Creek. It is important to note that no D.O. violations are observed on Cowan Creek upstream of Indian Run. Table B-13 shows the ABX Indian Run treatment facility was discharging elevated biochemical oxygen demanding waters. During this survey a fish kill was observed in Cowan Creek. Investigators from the Ohio Department of Natural Resources were in the watershed and informed field staff that reports to them indicated dead fish as early as Tuesday, May 6, 2008. They concluded that low instream D.O. was the cause of the fish kill.

The observations described above were carried out at times when the airport's treatment systems were discharging glycol-laden storm water captured earlier in the winter during deicing events. These discharges contained much lower pollutant loads than the permit limits, which were based on winter storm flow modeling. However, the warmer stream temperature and lack of any significant dilution in the receiving streams resulted in high oxygen demanding pollutants to cause water quality degradation. Because of this, in order to address aquatic life use impairment, a non-storm flow critical condition must be considered for the waters receiving the ABX discharges. The seven consecutive day low flow calculated over a ten-year recurrence interval ($_{7Q10}$) upstream flow is used to represent the stream flow for this critical condition per Ohio EPA rules [3745-2-11 (B)].

Figure B-25 Lytle Creek substrate covered with filamentous bacteria growth (4/30/08)

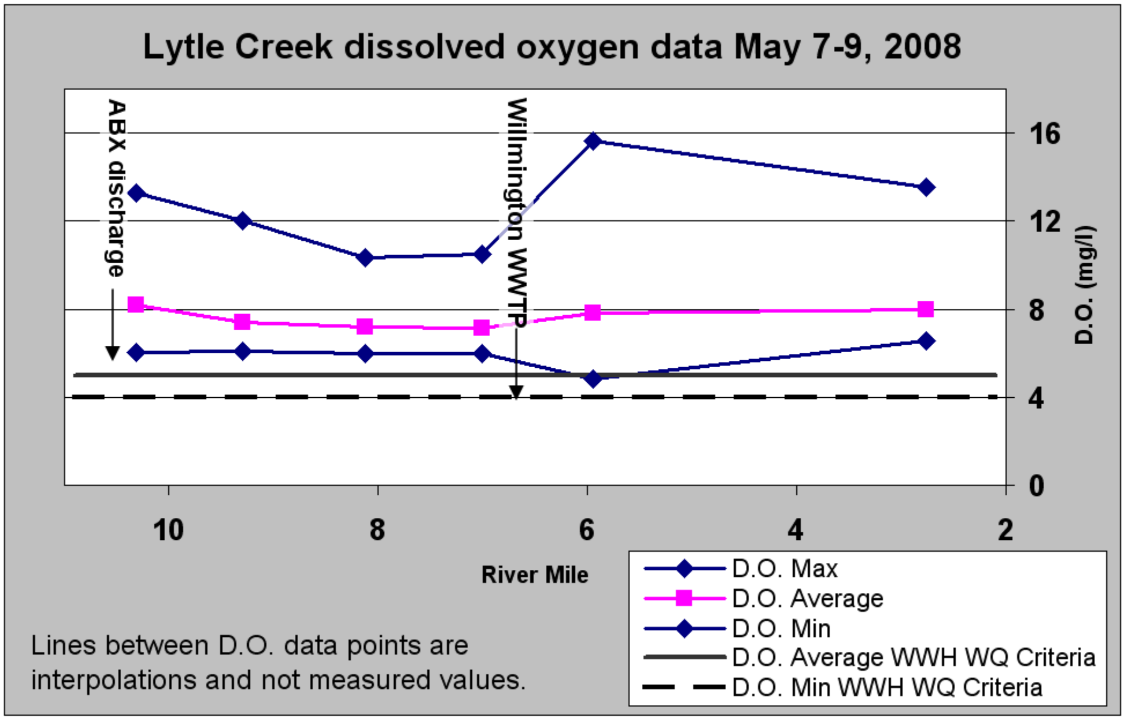


Figure B-26 Dissolved oxygen data for Lytle Creek from May 7th to 9th, 2008.

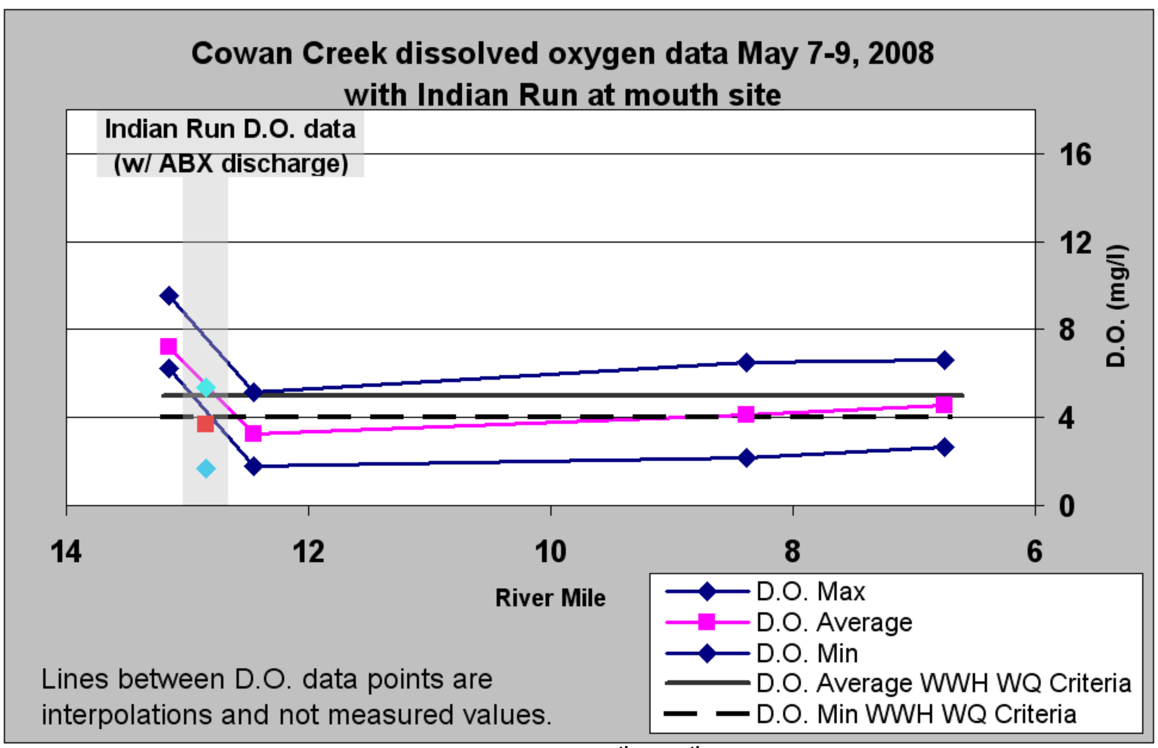


Figure B-27 Dissolved oxygen data from May 7th to 9th, 2008 for Cowan Creek with Indian Run at the mouth site.

Table B-13 ABX Discharge monitoring reports submitted to Ohio EPA for the period of 4/23-5/6/08 for chemical oxygen demand (mg/l)

Date	31 Lytle Creek	32 Indian Run
4/23/2008	32	212
4/24/2008	5	119
4/25/2008	No discharge*	140
5/6/2008	No discharge*	346

* No flow data is submitted for these days at this outfall therefore it is assumed that no discharge occurred

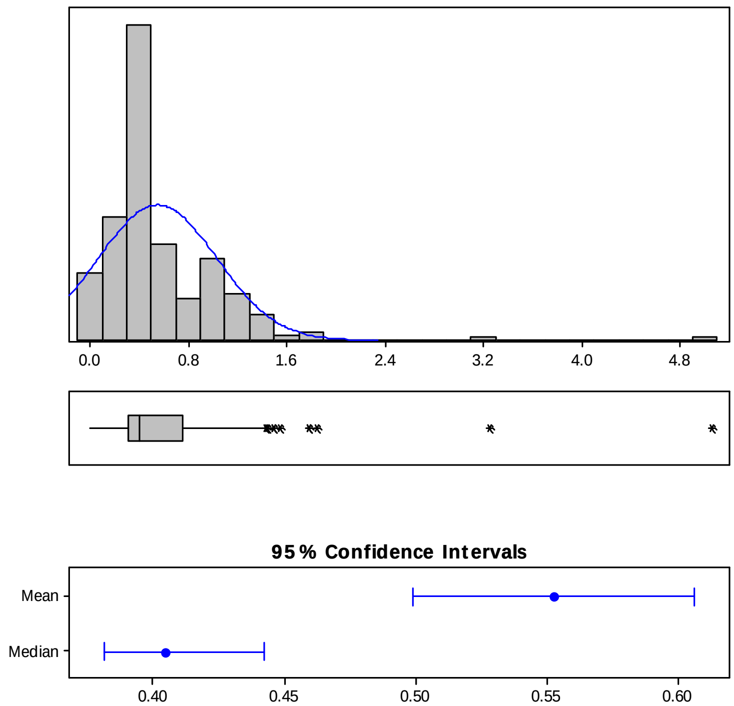
Existing limits for ABX's NPDES permit are for the parameter chemical oxygen demand (COD). The primary reason for this is because COD water quality values are relatively easy and fast to determine compared to carbonaceous biochemical oxygen demand (CBOD). Since propylene glycol, the main deicing component in the ABX discharge, is highly biodegradable, no difference between COD and CBOD ultimate is assumed in modeling for this TMDL. A ratio of CBOD ultimate to CBOD 5-day concentrations has been created for the treated discharge of ABX by consultants hired by the facility. This ratio is employed to determine CBOD 5-day for D.O. modeling in this TMDL; the equation for this is CBOD 5-day = 0.609 * COD - 21.2.

In order to model instream D.O. for various loads discharged from the two ABX treatment facilities, a flow for the facility is assumed. A graphical summary of general statistics for the discharge flows from monitoring reports submitted to Ohio EPA for the discharge to Lytle Creek (outfall 031) and Indian Run (outfall 032) has been made (Figures B-28 and B-29); the period of record is 2004-2008. These flow data are reported in million gallons per day (MGD). This analysis of the data distribution show non-normal (Anderson-Darling Normality Test $P < 0.05$) and positively skewed distributions for both outfalls. Because of this, a flow value greater than the median is picked to represent the critical condition flow. The flow of 0.5 MGD is a practical choice for both outfalls because it is greater than the median and it falls within the histogram's bin with the highest frequency for each outfall's data. Furthermore, using this flow in order to determine TMDL values is an implicit margin of safety. This is because the flow used is greater than the median observed flow (19% and 32% for outfalls 31 and 32 respectively), but not greater than the third quartile percentile of either outfall.

Modeling for this TMDL was carried out as a multi-segment version of EPA's Simplified Method (US EPA, 1980). This model simulates D.O. and ammonia by solving the Streeter-Phelps equation. It takes into account CBOD and ammonia decay rates, reaeration, sediment oxygen demand and photosynthesis/respiration in a steady flow condition. In addition to the May 7-9, 2008 survey described above, an additional 3-day survey was conducted in June, 2008. Water quality data, time of travel information and some general stream cross-sections were measured during this survey to be utilized for this D.O. modeling.

Since D.O. and decay rates differences due to seasonal temperature are critical in assessing pollutants from ABX, modeling for several time periods is necessary. To determine these time periods, an analysis of the 75th percentile of stream temperature for each month of all Ohio EPA STORET data collected in Clinton County occurred. Based on this analysis, the following time periods are grouped together to each be considered for a TMDL: 1) November through February, 2) March through April and 3) May. Due to the nature of the ABX treatment facilities, glycol laden storm water can be held and treated, and re-treated, as storage space is available. May is not grouped with other months due to its higher temperatures and the unlikelihood that future deicing events would occur for the season. After discussions with permits staff at Ohio EPA it was determined that an additional time period of June through October, thus covering all of the year, be modeled. This was deemed necessary to allow a permit limit to be developed for these warm months if, in a given year, the facility is still treating glycol from the winter. The stream temperature used in modeling for each of these time periods is the 75th percentile value determined for each time period from the same data population described above in this paragraph (Table B-14).

Lytle Creek has zero upstream flow during 7Q10 flow conditions for all times of the year, and therefore no upstream flow is considered. Cowan Creek does have some upstream flow during 7Q10 conditions for some periods of the year. The flows are calculated from USGS published 7Q10 flows for a representative gage applied to a drainage area ratio of the gage and upstream Cowan Creek watershed. Water quality values for these upstream flows are based on data observed in Cowan Creek upstream of Indian Run. These values are within the normal range of unpolluted waters for warmwater habitat streams.



Anderson-Darling Normality Test	
A-Squared	14.85
P-Value <	0.005
Mean	0.55276
StDev	0.48116
Variance	0.23151
Skewness	3.6453
Kurtosis	26.6541
N	313
Minimum	0.00000
1st Quartile	0.30850
Median	0.40500
3rd Quartile	0.75700
Maximum	5.06000
95% Confidence Interval for Mean	
0.49925	0.60627
95% Confidence Interval for Median	
0.38169	0.44231
95% Confidence Interval for StDev	
0.44619	0.52212

Figure B-28 Histogram of the ABX treatment discharge flow (MGD) to Lytle Creek, outfall 031

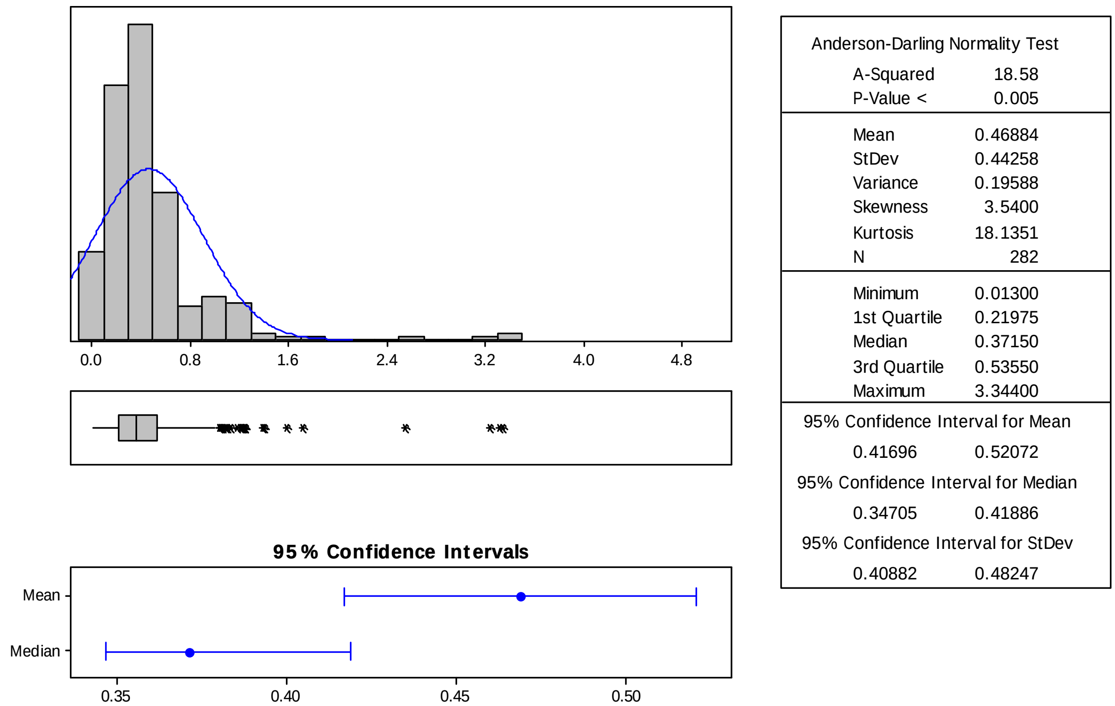


Figure B-29 Histogram of the ABX treatment discharge flow (MGD) to Indian Run, outfall 032

Table B-14 Temperatures used in modeling for time periods

Time period	Stream temp (°C) used in modeling
November - February	8
March - April	10.5
May	17.25
June - October	22

B3.5 Bacteria, Recreational Use Methods

An empirical method of determining TMDL loading and reductions is utilized for bacteria with load duration curves (LDCs).

In order to make LDCs the flow duration for each recreation use impaired site on the Lower LMR is determined. This involves calculating the flow (cfs) expected for the full range of exceedance percentile. This normalizes the flows to a range of natural occurrences from extremely high flows (0 exceedance percentile) to extremely low flows (100). The flow curve is converted into a load duration curve by taking the product of all flow values, the water quality geometric mean standard and a conversion factor. These values, in *E. coli* colony forming units (or counts) per day are the TMDL for each flow condition. The resulting points are plotted to create a LDC.

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. 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.

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. Those exceedances 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. The exceedences on the left side of the graph occur during higher flow events and potential sources are land uses or management practices such as manure spreading or livestock production, which supply bacteria that is washed off with runoff. The LDC approach helps determine which implementation practices are most effective for reducing loads.

Figure B-30 shows an example of a LDC where some of the observed *E. coli* loads exceed allowable loads in some flow zones sampled. Samples that were taken when storm flow was greater than 50% of the flow are noted with the diamond filled in red (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 and Crouse, 1996). Note that flows are grouped into five flow regimes. These regimes are defined as the following:

High flow zone:	Stream flows in the 0 to 10 exceedance percentile range; these are related to flood flows.
Moist zone:	Flows in the 10 to 40 exceedance percentile range; these are flows in wet weather conditions.
Mid-range zone:	Flows in the 40 to 60 exceedance percentile range; this are the median stream flow conditions.
Dry zone:	Flows in the 60 to 90 exceedance percentile range; these are related to dry weather flows.
Low flow zone:	Flows in the 90 to 100 exceedance percentile range; related to drought conditions.

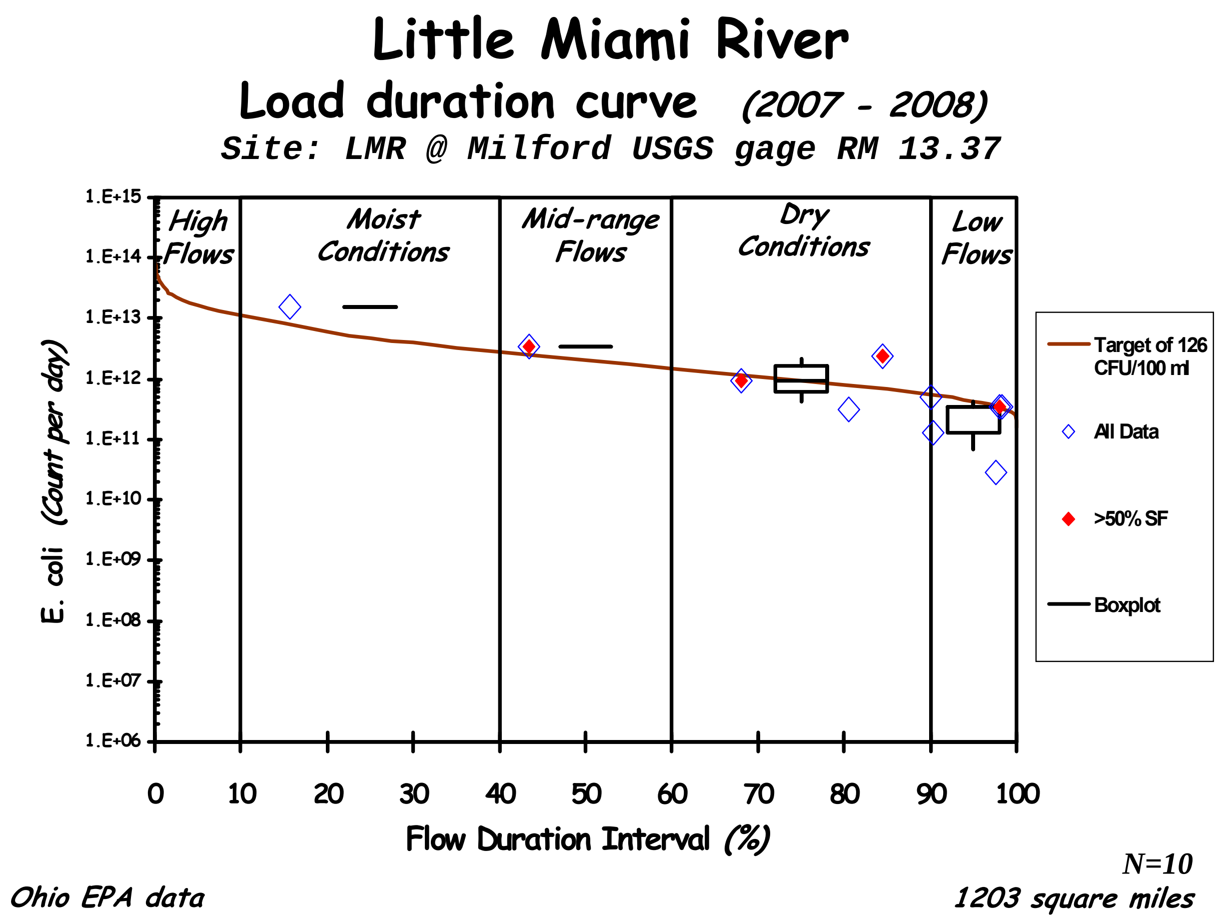


Figure B-30 **Little Miami River load duration curve at the Milford USGS gage.**

In order to calculate the load duration curve and the load for each *E. coli* sample, each site's flow duration interval must be calculated. In order to determine the load duration curve for each LDC site, stream flows are extrapolated using a USGS gage (station # 03245500 Little Miami River at Milford OH). For most sites a simple drainage area ratio of the LDC site to the USGS gage is applied to the gage flows to determine the LDC site's flows.

The flow duration curve for the Little Miami River mainstem site downstream of Caesar Creek (Shaw property) is created using a different method than described above. At this site, like most recreational use impaired sites, a stage to flow relationship has been made for a nearby bridge. However, unlike most other sites with this relationship this site has been sampled far greater amount of times due to monitoring being carried out by dischargers in the upper Little Miami River watershed. Because of this, the stream flows known at this site can be compared to the flows at the Little Miami River at Milford USGS gage flows for the same day and the next day. Analyses are applied to find the best fit predictor regression equation for this site by using the USGS gage flow data. A linear relationship of the same day's USGS gage flow found the best fit (R^2 value of 0.9616). This equation is used to determine the entire flow duration curve for the downstream Caesar Creek site. The USGS gage station that is used for flow estimations has a drainage area of approximately 1203 mi^2, and most of the LDC sites included in this TMDL drain less than 100 mi2. Such a size discrepancy can introduce uncertainty to the flow estimates using the unit-area approach. Due to a high amount of wastewater treatment plant effluent making up the low flow of the mainstem, this uncertainty is likely to be greater in low flows.

However, this uncertainty is deemed acceptable as this gage is in the same watershed, and in fact all sites drain to it. Table B-15 shows the drainage area and ratios used for each LDC site.

The LDC that is created for the Little Miami River at the USGS gage site in Milford needs no flow relationship calculations. The daily stream flow data from the gage is used.

The methods described above for calculating flow duration intervals are only used for calculating the LDC's loading capacity. At all sites except for the Second Creek site the flow used to calculate the load for each sampling event is determined via the flow determined at the exact time of sampling. These flows are determined by using a stage to flow curves made for each site at a nearby bridge. However, the flows used to calculate the existing sample loads for the Second Creek LDC are determined using the same drainage area ratio to the USGS gage that is used to determine the flow duration interval.

Table B-15 Drainage area for each LDC site and the drainage area ratio used to calculate stream flow for the *E. coli* loading capacity (TMDL)

12-Digit HUC	Stream Name	Location	River Mile	Drainage Area (Sq. mi.)	Drainage Area Ratio
Mainstem/ 050902020801	Little Miami R.	Dst Caesar Cr (Shaw property)	50.25	658	na*
Mainstem/ 050902021403	Little Miami R.	Wooster Pike (Milford gage)	13.07	1203	1.00
050902020704	Todd Fork	SR 22/3 (Morrow)	0.14	261	0.217
050902020603	Lytle Creek	Clarksville Rd	0.65	19.8	0.016
050902020701	East Fork Todd Fork	SR 132 (Clarksville)	1.60	37.3	0.031
050902020702	Second Creek	SR 123 (Dst Blanchester WWTP)	9.42	11.0	0.009
050902020803	Turtle Creek	SR 48	0.52	58.0	0.048
050902020901	Muddy Creek	Mason-Morrow Rd (Dst Mason WWTP)	0.54	15.2	0.013

* The flow duration interval for this site was calculated a different manner than the drainage area ratio method. See the above section.

Using load duration curves takes advantage of the principle that loads often vary depending on flow and that different sources may contribute loads at different flow conditions. An advantage to the load duration curve approach is that the analysis can directly assist in determining implementation practices that are most effective for reducing loads based on flow magnitude. For example, if loads exceed allowable LDC mostly during storm and winter snow melt events, then implementation efforts can be targeted to best management practices that most effectively reduce loads associated with that type of runoff. Table B-16 shows various pollutant sources and the loads they are associated with.

Table B-16 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	H	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			

To account for any lack of knowledge concerning the relationship between load and wasteload allocations and water quality an explicit MOS is applied for this watershed's bacteria TMDLs. US EPA (2001b) notes that, "significant uncertainty regarding whether pathogen discharges are attributable to human or to natural sources and the anticipated cost of controls is especially high. However, more detailed approaches are likely to cost more, require more data, and take more time to complete." Furthermore, using the LDC method to calculate pathogen TMDLs rules out the ability to utilize implicit MOS approaches. Due to this, the MOS is calculated as 10% of the allowable load that is calculated for each flow zone which is based o guidance provided by U.S., EPA in their Protocols for Developing Pathogen TMDLs (U.S. EPA, 2001).

The critical condition for pathogens is the summer dry period when flows are lowest, and thus the potential for dilution is the lowest. Summer is also the period when the probability of recreational contact is the highest. For these reasons recreational use designations are only applicable in the period May 1 to October 31. Pathogen TMDLs are developed for the same May to October 31 time-period in consideration of the critical condition, and for agreement with Ohio WQS.

B4 Modeling results and TMDLs

This section contains the modeling results. The loading capacity TMDL and suggested load allocations are provided for each impaired stream section. Where necessary a discussion is provided.

B4.1 Nutrient and Organic Enrichment Results

Lytle Creek
Table B-17 shows the critical condition existing, allocation and TMDL values for the Lytle Creek TP TMDL. These values are based on the calculations shown above methods section Table B-4 and B-5. The vast majority of existing TP in Lytle Creek is from the Wilmington WWTP. Based on these modeling results, implementation to mitigate this stream's impairment due to nutrients should focus on the WWTP's contribution as a priority.

Table B-17 Lytle Creek TMDL values

	Loading	
	Existing (kg/day)	Allocated (kg/day)[1]
Load (nonpoint source)	0.021[2]	0.013
Wasteload Wilmington WWTP	**34.21**[3]	**0.913**
Wasteload ABX	**-** [4]	**0**
TMDL	**-**	**0.922**[5]

1 Margin of safety is implicit
2 Load allocation is based on the calculated full 20 mi^2 7Q10 flow (see Table 3.10). Existing load is based on the average of the two non-WWTP impacted sampling sites monitoring data (TP= 0.13 mg/l).
3 Existing WWTP load based on projected effluent quality of discharger monitoring reports and median discharged flow from a period of record (2003-2007)
4 ABX has closed all storm water discharges to Lytle Creek
5 Value does not sum exactly due to rounding for the table

Second Creek
The Blanchester WWTP's current average design flow discharge of 0.99 million gallons a day is regularly exceeded by the plant. However, this is not an indication of a need for plant expansion, but rather illustrates the current difficulties the village has with sewage collection and treatment. Blanchester is currently in the process of making improvements to their WWTP and associated collection system. The first phase of this process involves the installation of an equalization basin and wet-weather pump station. A permit to install has been issued by Ohio EPA for this phase of work. Construction was to begin on December 2008 and to be completed by January 2010. The existing design flow will be used for the wasteload allocation because the facility design flow is not expected to go up and, once the first phase of improvements are made, plant discharges should be less variable. The TP concentration limit calculated for the TMDL critical condition is applied to the design flow. Table B-18 shows the existing, allocation and TMDL values.

Table B-18 Existing loads, allocations and TMDLs for Second Creek.

	Loading	
	Existing (kg/day)	**Allocated (kg/day)**
Load (nonpoint source)	1.29*	0.22
Wasteload (point source) - Blanchester WWTP	4.33†	0.49
TMDL	-	0.71

* Existing load based on an assumed TP concentration of 0.35 mg/l from all existing nonpoint sources
† Existing WWTP load based on projected effluent quality of discharger monitoring reports and median discharged flow for the period of record 2004-2008

First Creek

Installing a centralized sewage treatment system is the most practical means to address this stream's source of pollution. Based on this, a wasteload allocation for TP from HSTSs of zero is determined reasonable. Nonpoint sources of TP are allocated to the target concentration of 0.08 mg/l. Some nonpoint source TP reductions may be required for this target to be met. Table B-19 shows the allocation loads and a TMDL for a typical summertime flow condition, 2.0 cfs.

Table B-19 First Creek TP TMDL for a 2.0 cfs flow condition

	Allocation (kg/day)
Load* (nonpoint source)	0.39
Wasteload (point source) - Home sewage treatment systems	0
TMDL	0.39

* Assumes a TP concentration of 0.08 mg/l

B4.2 TSS and CBOD 5-day

The existing load for the TSS and CBOD 5-day is calculated for Duck and Clough creek's watershed using the typical CSO effluent water quality (see Table B-11) and calculated runoff for a storm of 0.835 inches (see Table B-12). A percentage of sanitary sewer and storm water making up the CSO flow is calculated based on the typical observed effluent quality of CSOs (see Table B-11) and reference values for these parameters in urban storm water runoff and sanitary sewers (US EPA 2001). This generalization results in a typical Duck and Clough creeks' CSO flow that is made up of 45% sanitary sewer (8.82 and 1.34 million gallons Duck and Clough creeks respectively) and 55% storm water (10.57 and 1.60 million gallons Duck and Clough creeks respectively). Based on this assumption, Tables B-20 and B-22 show the TSS and CBOD 5-day loads respectively for the existing critical condition.

In order to reach the target of 85% existing CSO volume control, total CSO loads are reduced 85%. For the purposes of this TMDL, the percentages of sanitary sewer and storm water in CSOs are assumed to be held the same as in the existing conditions calculations. The same 0.835 inches storm is considered for this loading capacity calculation, and therefore the same amount of total storm water is considered. Because of CSO reductions, much more storm water is considered to be non-CSO storm water. Tables B-21 and B-23 outline the TSS and CBOD 5-day TMDL loads respectively. Figures B-31 and B-32 show the load reductions from existing to TMDL for TSS in Duck and Clough creeks respectively. Figures B-33 and B-34 show the load reductions from existing to TMDL for CBOD 5-day in Duck and Clough creeks respectively.

Table B-20 Existing conditions for TSS loading

Stream	Existing CSO			Existing non-CSO storm water			Total
	Flow MG	Conc. mg/l	Load kg/day	Flow MG	Conc mg/l	Load kg/day	Load kg/day
Duck Ck	19.39	294.00	21580.89	34.11	70.00	9039.43	**30620.32**
Clough Ck	2.94	294.00	3270.91	15.44	70.00	4090.22	**7361.13**

Table B-21 TMDL TSS loads

Stream	TMDL CSO			TMDL non-CSO storm water			Total
	Flow MG	Conc. mg/l	**CSO Wasteload allocation kg/day**	Flow MG	Conc. mg/l	**MS4 Wasteload allocation kg/day**	**TMDL kg/day**
Duck Ck	2.91	294.00	3237.13	43.10	70.00	11421.12	**14658.25**
Clough Ck	0.44	294.00	490.64	16.80	70.00	4451.20	**4941.83**

Table B-22 Existing conditions for CBOD 5-day loading

Stream	Existing CSO			Existing non-CSO storm water			Total
	Flow MG	Conc. mg/l	Load kg/day	Flow MG	Conc. mg/l	Load kg/day	Load kg/day
Duck Ck	19.39	32.50	2385.64	34.11	15.50	2001.59	**4387.23**
Clough Ck	2.94	32.50	361.58	15.44	15.50	905.69	**1267.27**

Table B-23 TMDL CBOD 5-day loads

Stream	TMDL CSO			TMDL non-CSO storm water			Total
	Flow MG	Conc. mg/l	**CSO Wasteload allocation kg/day**	Flow MG	Conc . mg/l	**MS4 Wasteload allocation kg/day**	**TMDL kg/day**
Duck Ck	2.91	32.50	357.85	43.10	15.50	2528.96	**2886.81**
Clough Ck	0.44	32.50	54.24	16.80	15.50	985.62	**1039.86**

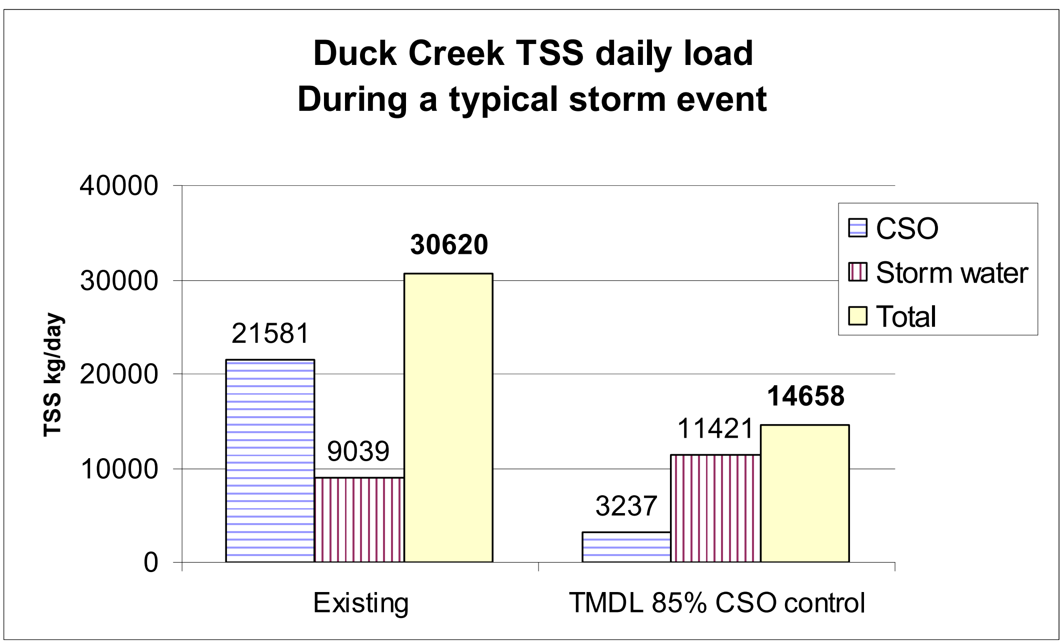


Figure B-31 Duck Creek TSS daily load during a typical storm event.

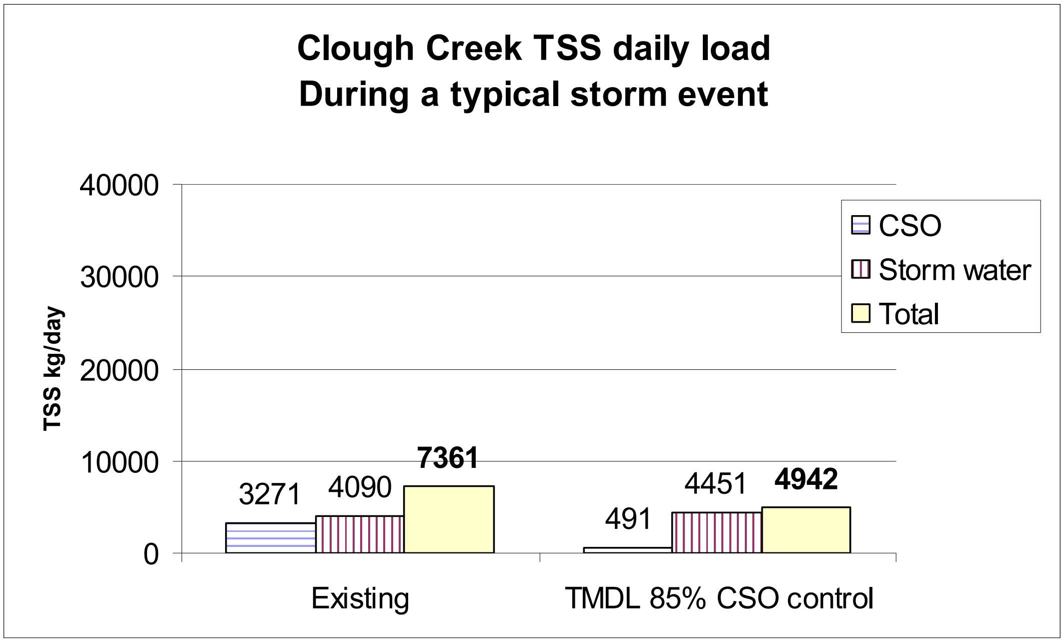


Figure B-32 **Clough Creek TSS daily load during a typical storm event.**

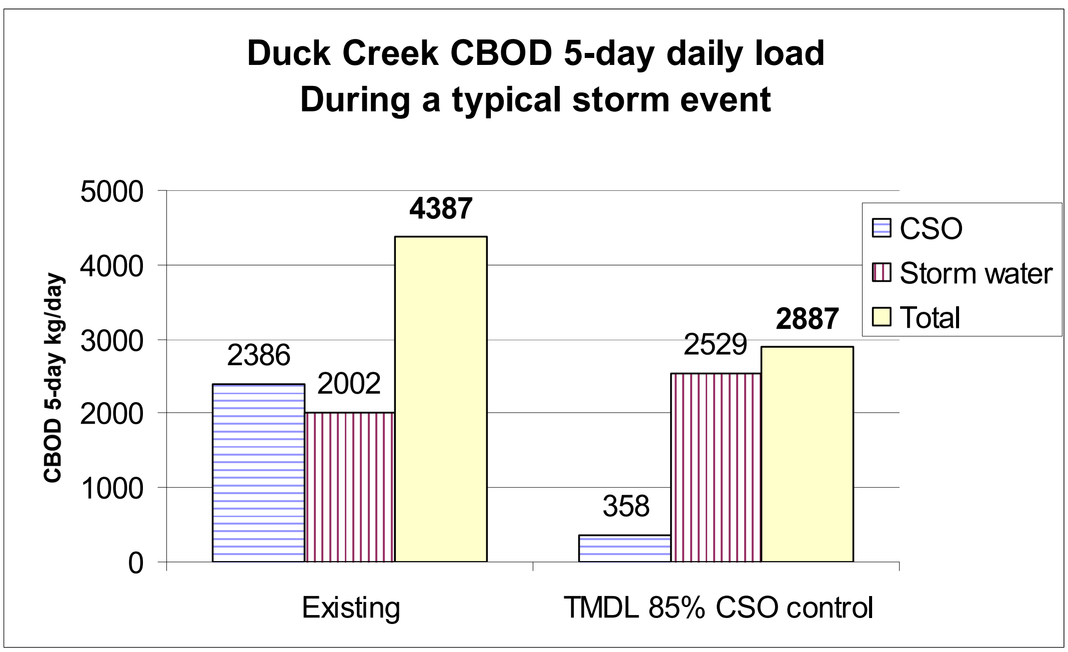


Figure B-33 **Duck Creek CBOD 5-day daily load during a typical storm event.**

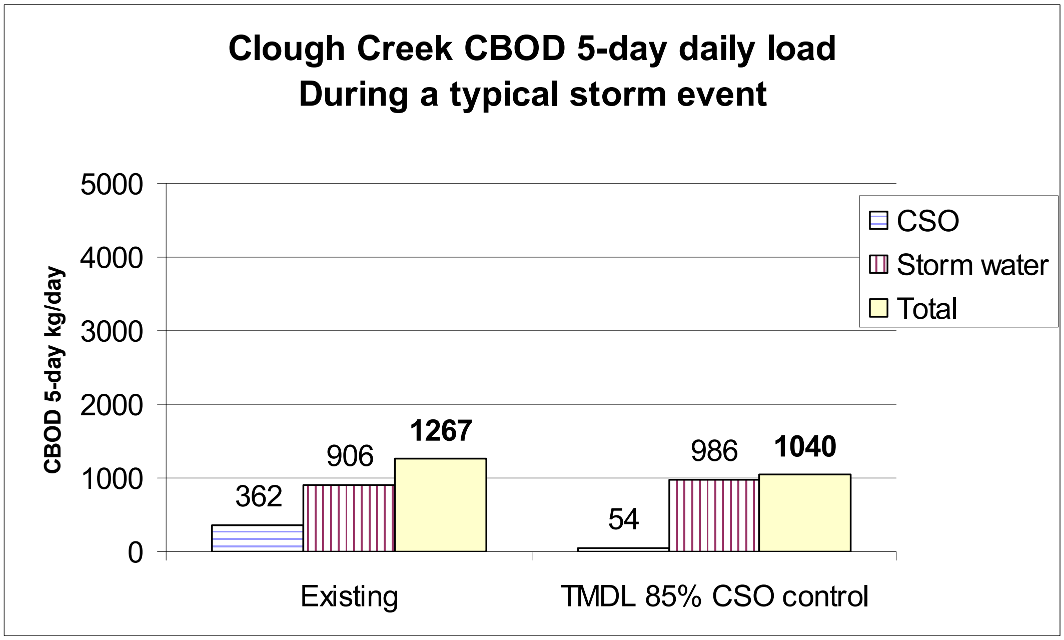


Figure B-34 Clough Creek CBOD 5-day daily load during a typical storm event.

B4.3 Sediment/Habitat Results

The bedload and habitat QHEI components comparison to TMDL results are summarized in Table B-24. Sites are organized by HUC12. Allocations in the table are specific to the QHEI categories (e.g., substrate metric) and the 12-digit HUC watersheds. The target values are listed at the top of each column. The TMDL values are valid for WWH streams in the lower LMR watershed only. These TMDL targets are not applicable to the mainstem LMR because it is designated as exceptional warmwater habitat, so the mainstem QHEI scores are not shown. The non attaining Duck Creek stream section that is designated limited resource waters habitat and the Dry Run site designated cold water habitat are also do not have established QHEI targets. However these two sites are listed on the table for completeness since each have another stream segment that is WWH. Non attainment biological sites are presented in bold and partial attainment with italics in Table B-24. The percent deviation of the actual QHEI and QHEI subcategory scores from the allowable TMDL is provided in the table.

Table B-24 Sediment and Habitat TMDLs for lower LMR watershed based on QHEI metrics (total score and substrate, riparian, and channel scores).

Stream/River name (use)		River mile	Aquatic Life Attainment	QHEI Score TMDL ≥ 58.4 Actual	QHEI Score TMDL ≥ 58.4 % Deficit	Substrate score TMDL ≥ 13.7 Actual	Substrate score TMDL ≥ 13.7 % Deficit	Riparian score TMDL ≥ 5.5 Actual	Riparian score TMDL ≥ 5.5 % Deficit	Channel score TMDL ≥ 13.0 Actual	Channel score TMDL ≥ 13.0 % Deficit
509020206-01	Dutch Creek	0.28[H]	Full	51.5	4	---	---	5	---	13	---
509020206-02	Todd Fork	32.72[H]	Full	44.5	4.5	---	---	7	---	12	---
		25.2[W]	Full	84	5.5	---	---	17	---	17	---
509020206-03	**Lytle Creek**	***9.3[H]***	***Non***	***59.5***	***3.5***	***36***	***23***	***12***	***---***	***15.5***	***---***
		7.01[H]	***Partial***	***66.5***	***4***	***27***	***12***	***15***	***---***	***14.5***	***---***
		5.95[H]	***Partial***	***77***	***7***	***---***	***12***	***14***	***---***	***18***	***---***
		2.76[H]	Partial	67	7.5	---	---	7	33	16.5	---
		0.65[H]	Full	77	6.5	---	---	16	---	16.5	---
509020206-04	Cowan Creek	16.62[H]	Partial	65	3.5	36	---	11	---	14.5	---
		13.2[W]	Full	60.5	4.5	---	---	16	---	14	---
	Indian Run	0.2[H]	Non	57	3.5	36	---	14	---	10.5	19
	Cowan Creek	***12.45[W]***	***Partial***	*58*	*6.5*	***---***	***93***	***15***	***---***	***14***	***---***
509020206-05	Cowan Creek	6.8[W]	Full	67	10	---	---	16	---	14	---
		2.82[W]	Full	68	7.5	---	---	12	---	13	---
		0.6[W]	Full	78	7	---	---	14	---	16.5	---
509020206-06	Todd Fork	19.5[W]	Full	74.5	8.5	---	---	14	---	14.5	---
		17.1[W]	Full	70.5	6.5	---	---	12	---	14	---
		15.1[W]	Full	69	8.5	---	---	8	---	14	---
509020207-01	East Fork Todd Fork	18.29[H]	Full	43	5.5	---	---	8	---	12	---
		17.28[H]	Full	66	6.5	---	---	14	---	16	---
		11.46[W]	Partial	64	5.5	---	20	14	---	13	---

Stream/River name (use)		River mile	Aquatic Life Attainment	QHEI Score		QHEI category: Substrate score		QHEI category: Riparian score		QHEI category: Channel score	
				TMDL ≥ 58.4		**TMDL ≥ 13.7**		**TMDL ≥ 5.5**		**TMDL ≥ 13.0**	
				Actual	% Deficit	**Actual**	**% Deficit**	**Actual**	**% Deficit**	**Actual**	**% Deficit**
		7.12^{W}	Partial	68.5	5	9	---	13	---	13	---
		1.6^{W}	Partial	73	6	---	---	14	---	13	---
509020207 -02	**Second Creek**	10.94^{H}	Non	60.5	5.5	---	---	12	---	12.5	4
		9.45^{H}	***Partial***	***56.5***	***4.5***	***18***	***1***	***8***	***24***	***14.5***	***---***
		6.55^{H}	Full	77	7	---	---	14	---	17	---
		1.53^{H}	Full	65.5	8.5	---	---	12	---	17	---
509020207 -03	First Creek	3.83^{H}	Partial	58.5	6.5	---	---	8	24	13	---
509020207 -04	Todd Fork	12.2^{W}	Full	72.5	7	---	---	10	---	15	---
		8.53^{W}	Full	69.25	7.25	---	---	8	---	11	---
		5.6^{W}	Full	80.5	8.5	---	---	12	---	16.5	---
		2.65^{W}	Full	77.5	9	---	---	13	---	16	---
		0.14^{W}	Full	57.5	4.5	---	---	5	---	13	---
509020208-02	**Little Muddy Creek**	***3.22^{H}***	***Partial***	***44.5***	***5***	***9***	***42***	***9***	***14***	***7.5***	***42***
		1.02^{W}	Full	52	4.5	---	---	11	---	12	---
509020208 -03	Turtle Creek	7.43^{H}	Partial	47.5	5	9	---	3	71	12	8
		6.23^{W}	Full	70	5.5	---	---	15	---	13.5	---
		4.85^{W}	Full	65	5.5	---	---	15	---	12	---
		0.52^{W}	Full	61	6	---	---	7	---	13.5	---
	Dry Run **CWH**	1.79^{H}	Full	55	6	---	---	8	---	12	---
	Dry Run	0.18^{H}	Non	50	5	9	---	5	52	11	15

Stream/River name (use)		River mile	Aquatic Life Attainment	QHEI Score		QHEI category					
						Substrate score		**Riparian score**		**Channel score**	
				TMDL ≥ 58.4		**TMDL ≥ 13.7**		**TMDL ≥ 5.5**		**TMDL ≥ 13.0**	
				Actual	% Deficit	**Actual**	**% Deficit**	**Actual**	**% Deficit**	**Actual**	**% Deficit**
509020209 -01	**Muddy Creek**	2.5 H	Partial	62.5	4.5	18	1	12	---	13.5	---
		0.54 H	***Partial***	***74***	***7***	***---***	***---***	***13***	***---***	***18***	***---***
509020209 -02	O'Bannon Creek	10.14 H	Non	48.5	7	---	1	5	52	13	---
		8.27 H	Partial	56	5	9	---	10	5	12	8
		4.37 W	Partial	54	4	27	12	12	---	11	15
		1.84 W	Full	75.5	6	---	---	15	---	17	---
		0.26 W	Full	60	5	---	---	12	---	12	---
509020214-01	Sycamore Creek	1.1 H	Partial	63.5	6	---	---	11	---	13	---
		0.5 W	Full	69.5	4.5	---	---	13	---	11	---
		0.1 W	Full	76.5	6	---	---	13	---	11.5	---
509020214-04	**Duck Creek *LRW***	**3.3 H**	**Non**	**24.5**	**3.5**	36	107	3	71	6	54
	Duck Creek	***0.95 H***	***Non***	36	4	***27***	***111***	***5***	***52***	***8.5***	***35***
509020214-06	**Clough Creek**	***0.42 H***	***Partial***	55	5	***9***	***---***	***6***	***43***	***13.5***	***---***

H – Headwater site, W – Wading site, B – Boat site Bold – Non Biological Attainment, *Bold & Italic – Partial Biological Attainment*

Bold italics indicates sites that are impaired by sediment only therefore only the substrate, riparian and channel QHEI metrics are used as the TMDL surrogates for sediment.

Bold underline indicates the site that is impaired for habitat only therefore all QHEI metrics (including the total score) are used as the TMDL surrogates for habitat.

Table B-25 Habitat TMDLs based on QHEI metrics (cover, pool, riffle, and gradient scores) for lower LMR watershed.

Stream/River name (use)		River mile	Aquatic Life Attainment	QHEI category							
				Cover Score TMDL ≥ 10.5		**Pool score TMDL ≥ 7.0**		**Riffle score TMDL ≥ 2.7**		**Gradient score TMDL ≥ 6.0**	
				Actual	**% Deficit**	**Actual**	**% Deficit**	**Actual**	**% Deficit**	**Actual**	**% Deficit**
5090202 06-01	Dutch Creek	0.28^{H}	Full	5	---	6	---	2.5	---	8	---
5090202 06-02	Todd Fork	32.72^{H}	Full	7	---	6	---	0	---	6	---
		25.2^{W}	Full	17	---	10	---	6.5	---	10	---
509020206 -03	**Lytle Creek**	***9.3^{H}***	***Non***	***12***	---	7	---	1	63	10	---
		7.01^{H}	***Partial***	***15***	**---**	**9**	**---**	**2**	**26**	**10**	**---**
		5.95^{H}	***Partial***	***14***	**---**	**12**	**---**	**4**	**---**	**10**	**---**
		2.76^{H}	Partial	7	33	7	---	4.5	---	10	---
		0.65^{H}	Full	16	---	11	---	4.5	---	6	---
509020206 -04	Cowan Creek	16.62^{H}	Partial	11	---	6	14	4	---	10	---
		13.2^{W}	Full	16	---	5	---	0	---	6	---
	Indian Run	0.2^{H}	Non	14	---	5	29	3	---	4	33
	Cowan Creek	***12.45^{W}***	***Partial***	***15***	**---**	**10**	**---**	**1.5**	**44**	**10**	**---**
509020206 -05	Cowan Creek	6.8^{W}	Full	16	---	9	---	1	---	6	---
		2.82^{W}	Full	12	---	9	---	6	---	4	---
		0.6^{W}	Full	14	---	11	---	5.5	---	6	---
50902020 6-06	Todd Fork	19.5^{W}	Full	14	---	8	---	6	---	6	---
		17.1^{W}	Full	12	---	9	---	6	---	8	---
		15.1^{W}	Full	8	---	7	---	6.5	---	8	---
509020207 -01	East Fork Todd Fork	18.29^{H}	Full	8	---	4	---	0	---	8	---
		17.28^{H}	Full	14	---	5	---	3	---	8	---
		11.46^{W}	Partial	14	---	9	---	1.5	44	10	---
		7.12^{W}	Partial	13	---	6	14	5	---	10	---
		1.6^{W}	Partial	14	14	---	---	6	---	8	---
50902 0207-02	**Second Creek**	10.94^{H}	Non	12	---	4	43	0	100	8	---
		9.45^{H}	***Partial***	***8***	**24**	**4**	**43**	**2**	**26**	**10**	**---**

Stream/River name (use)		River mile	Aquatic Life Attainment	QHEI category: Cover Score TMDL ≥ 10.5		Pool score TMDL ≥ 7.0		Riffle score TMDL ≥ 2.7		Gradient score TMDL ≥ 6.0	
				Actual	% Deficit	Actual	% Deficit	Actual	% Deficit	Actual	% Deficit
		6.55[H]	Full	14	---	8	---	5	---	8	---
		1.53[H]	Full	12	---	8	---	5	---	4	---
509020207-03	**First Creek**	3.83[H]	Partial	8	24	1	86	0	100	10	---
509020207-04	**Todd Fork**	12.2[W]	Full	10	---	9	---	5.5	---	10	---
		8.53[W]	Full	8	---	9	---	5.5	---	10	---
		5.6[W]	Full	12	---	11	---	7	---	8	---
		2.65[W]	Full	13	---	10	---	5.5	---	8	---
		0.14[W]	Full	5	---	6	---	5	---	8	---
509020208-02	**Little Muddy Creek**	***3.22[H]***	***Partial***	***9***	**14**	**5**	**29**	**0**	**100**	**10**	**---**
		1.02[W]	Full	11	---	6	---	1	---	6	---
509020208-03	Turtle Creek	7.43[H]	Partial	3	71	2	71	0	100	8	---
		6.23[W]	Full	15	---	10	---	2	---	10	---
		4.85[W]	Full	15	---	10	---	1	---	10	---
		0.52[W]	Full	7	---	7	---	4	---	6	---
	Dry Run **CWH**	1.79[H]	Full	8	---	4	---	1	---	10	---
	Dry Run	0.18[H]	Non	5	52	2	71	0	100	10	---
509020209-01	**Muddy Creek**	2.5[H]	Partial	12	---	10	---	3	---	6	---
		0.54[H]	***Partial***	***13***	**---**	**9**	**---**	**4**	**---**	**8**	**---**
509020209-02	O'Bannon Creek	10.14[H]	Non	5	52	2	71	0	100	8	---
		8.27[H]	Partial	10	5	3	57	0	100	8	---
		4.37[W]	Partial	12	---	7	---	0	100	8	---
		1.84[W]	Full	15	---	12	---	6.5	---	4	---
		0.26[W]	Full	12	---	7	---	4	---	6	---
509020214-01	Sycamore Creek	1.1[H]	Partial	11	---	7	---	5	---	6	---

Stream/River name (use)		River mile	Aquatic Life Attainment	QHEI category							
				Cover Score		**Pool score**		**Riffle score**		**Gradient score**	
				TMDL ≥ 10.5		**TMDL ≥ 7.0**		**TMDL ≥ 2.7**		**TMDL ≥ 6.0**	
				Actual	**% Deficit**	**Actual**	**% Deficit**	**Actual**	**% Deficit**	**Actual**	**% Deficit**
		0.5^W	Full	13	---	11	---	5	---	6	---
		0.1^W	Full	13	---	11	---	7	---	10	---
50902014-04	**Duck Creek *LRW***	**3.3^H**	**Non**	**3**	**71**	**3**	**57**	**0**	**100**	**10**	**---**
	Duck Creek	***0.95^H***	***Non***	***5***	52	7	---	3	---	10	---
50902014-06	**Clough Creek**	***0.42^H***	***Partial***	***6***	**43**	**6**	**14**	**4**	**---**	**4**	**33**

H – Headwater site, W – Wading site, B – Boat site, Bold – Non Biological Attainment, *Bold & Italic – Partial Biological Attainment*

Bold italics indicates sites that are impaired by sediment only therefore only the substrate, riparian and channel QHEI metrics are used as the TMDL surrogates for sediment.

Bold underline indicates the site that is impaired for habitat only therefore all QHEI metrics (including the total score) are used as the TMDL surrogates for habitat.

The TMDL deficiencies are reviewed on a watershed scale. Both the number of sites with deficiency for each subcategory and the magnitude of percent deficiency are plotted. Figure B-35 indicates the number of sites for QHEI and the subcategories which do not meet the watershed TMDL. Both partial and non attainment sites are represented in the figure. This figure shows that riparian, pool and riffle scores contribute greatly to the deficiencies for the watershed.

To observe the magnitude of the deficiencies within these categories Figure B-36 and B-37 show partial and non attainment sites, separately. Pool and riffle scores create a large deficiency from TMDL targets for both partial and non attainment WWH sites within the lower LMR watershed. The TMDL for substrate has the greatest deficiency for non attainment sties. Eight sites have 100 percent deficit with regard to riffle scores. The QHEI scores zero points for the riffle metric if no riffles are present during evaluation. Although little can often be done to enhance riffle and pool scores, much can be accomplished to enhance substrate scores within this watershed. Channel, cover, and riparian deficits indicate varying degrees of impairments.

Figure B-38 provides a comprehensive overview of habitat and bedload TMDL deficiencies within the lower LMR watershed's WWH assessed sites. This figure is a dotplot histogram for percent deficiencies of the QHEI and subscores. Each dot within this graph represents one observation of either Non or Partial attainment sites. This plot indicates that deficiencies occur in all subcategories.

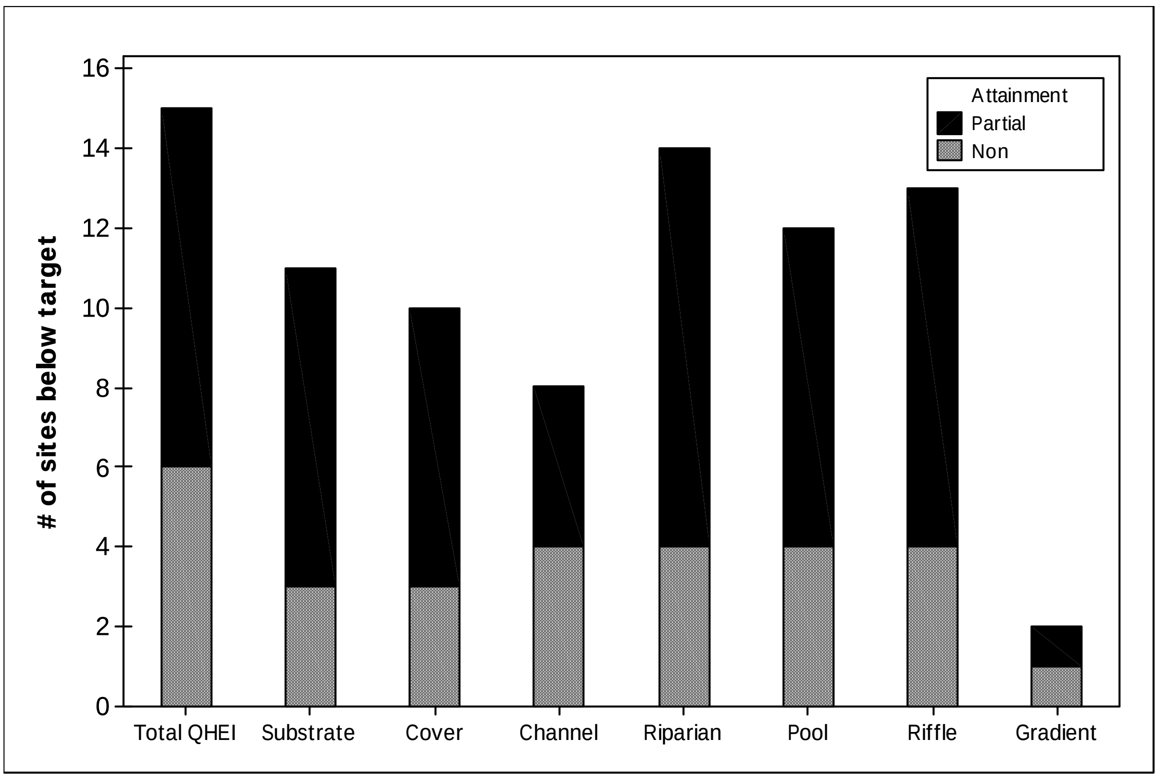


Figure B-35 Frequency of WWH sites below habitat and bedload TMDL.

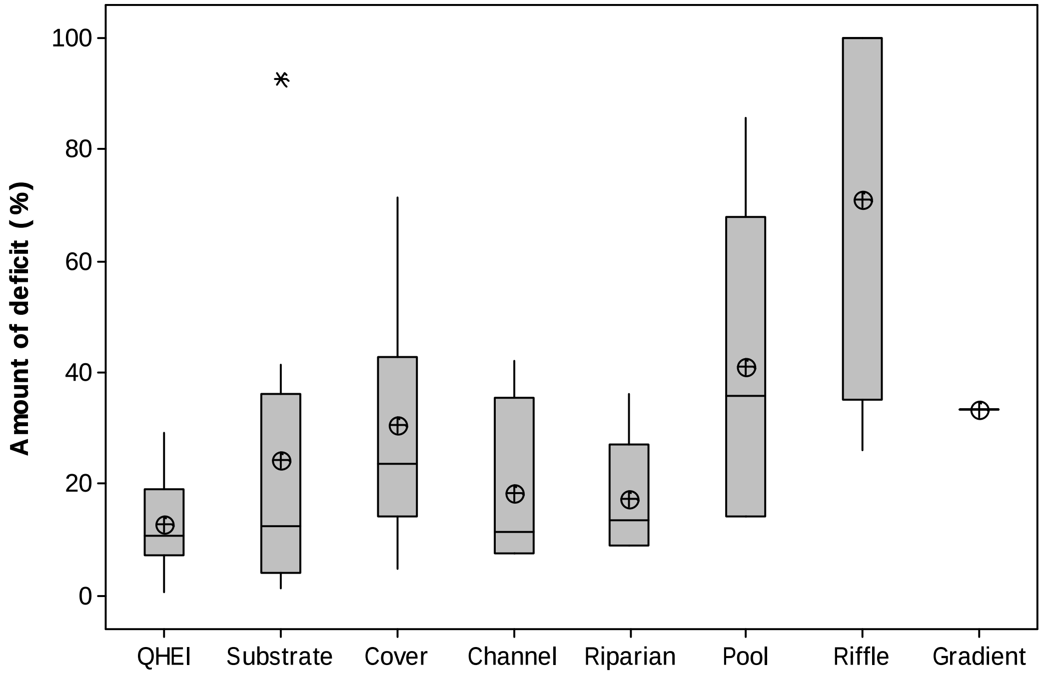


Figure B-36 Boxplot of the amount below TMDL target (%) for partial attainment WWH sites (circles with a cross are the means).

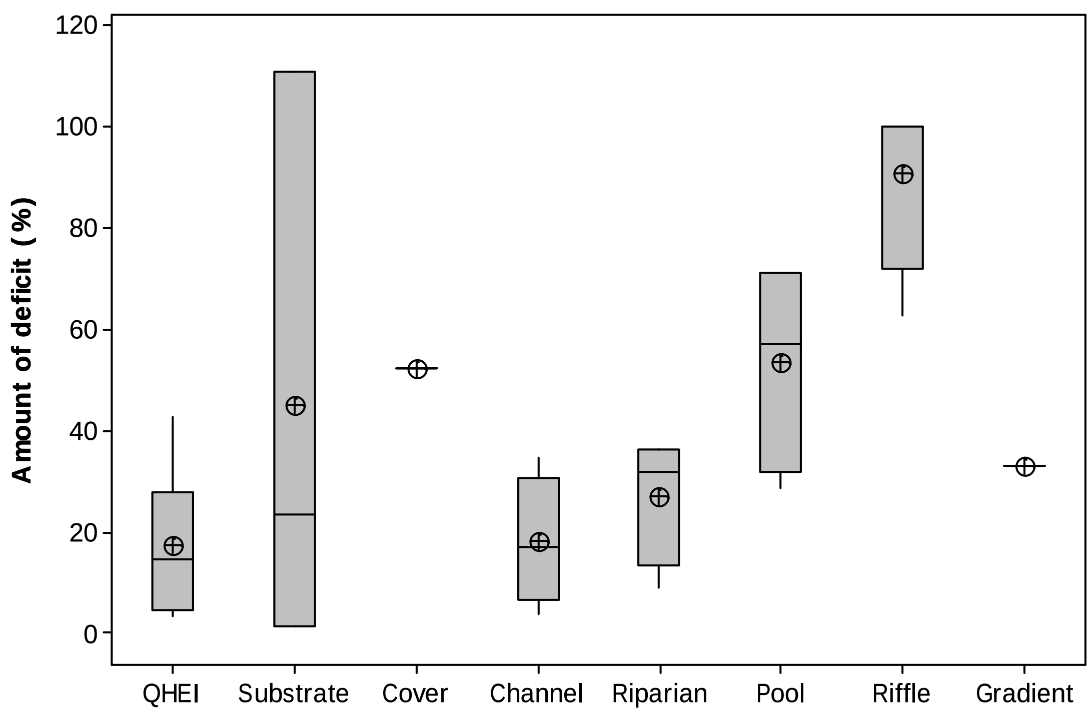


Figure B-37 Boxplot of amount below TMDL target (%) for non attainment WWH sites (circles with a cross are the means).

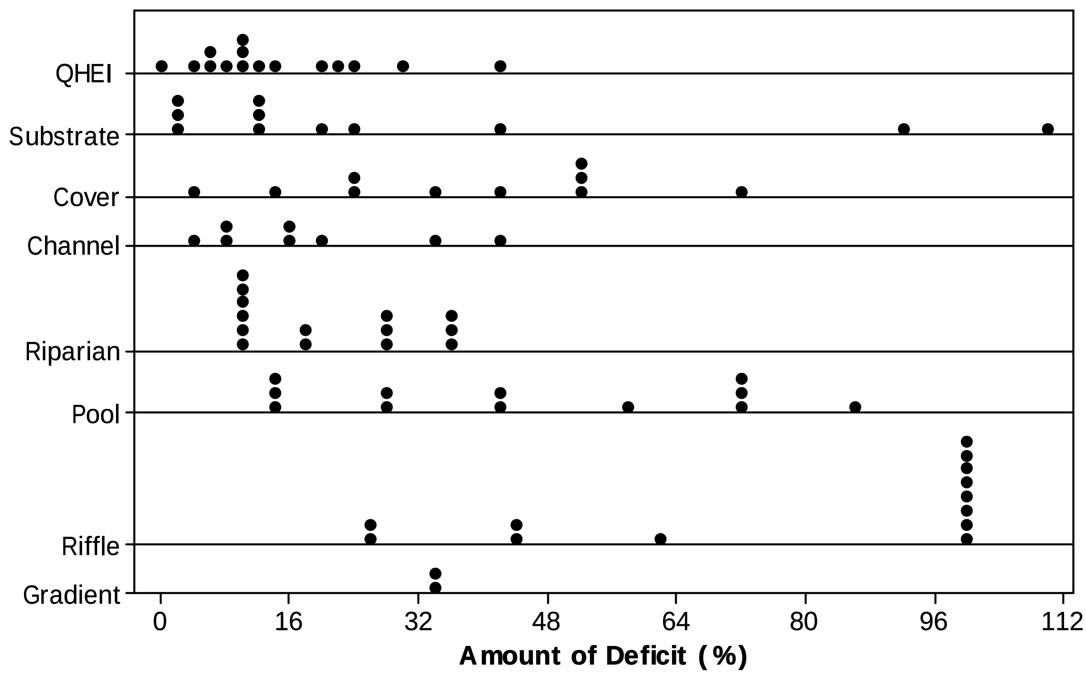


Figure B-38 Dotplot of the amount below TMDL targets for the QHEI and subcategories for the non and partial attainment WWH lower LMR sites.

B4.4 Dissolved Oxygen/Chemical Oxygen Demand Results

Modeling scenarios are carried out in both streams examining progressively lower discharge concentrations. The pollutant value that is protective of the D.O. TMDL target (the average D.O. criterion) is determined for each stream for each of the time periods defined in Table B-25 Figures B-39 and B-40 show the instream D.O. longitudinal profile for Lytle Creek and the Indian Run/Cowan Creek complex respectively.

Lytle Creek's D.O. modeling results, Figure B-39, show relatively the same pattern of D.O. depletion for all four conditions considered. This is also the same pattern observed during the May 2008 D.O. for the reach below ABX to Wilmington WWTP (Figure B-28 above). In all of these scenarios the oxygen demanding pollutant continues to deplete D.O. as the stream flows downstream throughout the modeling reach. Modeling is not carried out past the Wilmington WWTP because it is assumed the flow from this plant significantly raises the D.O. of the stream. This is because, 1) Wilmington's permit limits require low BOD and relatively high D.O. discharges and 2) observations of Lytle Creek downstream of the Wilmington WWTP show a nutrient enriched environment very different from the oxygen depleted conditions upstream. The Lytle Creek D.O. results and COD values calculated from this modeling are as expected in that the colder the water, the more pollutant load the stream can accept without excessive D.O. depletion.

The Indian Run and Cowan Creek modeling results, Figure B-40, show that in two of the time periods the D.O. bottoms out in Indian Run and in the other two the lowest D.O. occurs further downstream in Cowan Creek. The primary reason for this is because of the different stream temperatures in each condition play a part in the differences in the lowest D.O. river mile. Also the varying amount of upstream flow changes instream velocity and thereby D.O. reaeration. Despite these differences, the same pattern is seen as modeled in Lytle Creek in that the colder the water temperature, the greater the COD load the stream can receive without D.O. criterion violation. t can also be noted the same pattern of longitudinal average instream D.O. is predicted as was observed in the field (Figure B-29). The main difference from the predicted and observed however is that the pollutant load was greater during the latter and therefore D.O. standard violations and a fish kill occurred.

Table B-25 shows the allocations and TMDL for each time period for both Lytle and Cowan creek's watersheds. For Lytle Creek the point of compliance for this TMDL is just upstream the Wilmington WWTP (river mile 6.83). The Wilmington WWTP is a source of aquatic life use impairment to Lytle Creek further downstream; however, this impairment is caused by a different type of pollutant (nutrients). It is therefore dealt with in a different TMDL. The point of compliance for the Cowan Creek watershed is upstream of the Cowan Creek Lake at river mile 6.75. As noted in Section B3.4, the margin of safety for this TMDL is implicit.

The concentration limits for the ABX storm water treatment facilities (Table B-25) are protective of the aquatic life use during low flow periods. Current permit limits are acceptable for higher (runoff period) stream flows. Using the same D.O. model described here, Ohio EPA can provide a flow cut-off at which the existing higher effluent limits are acceptable. Based on this work, the existing COD limits for both treatment facilities would be appropriate when flows in Cowan Creek upstream of Indian Run are at or exceed 7.1 cfs.

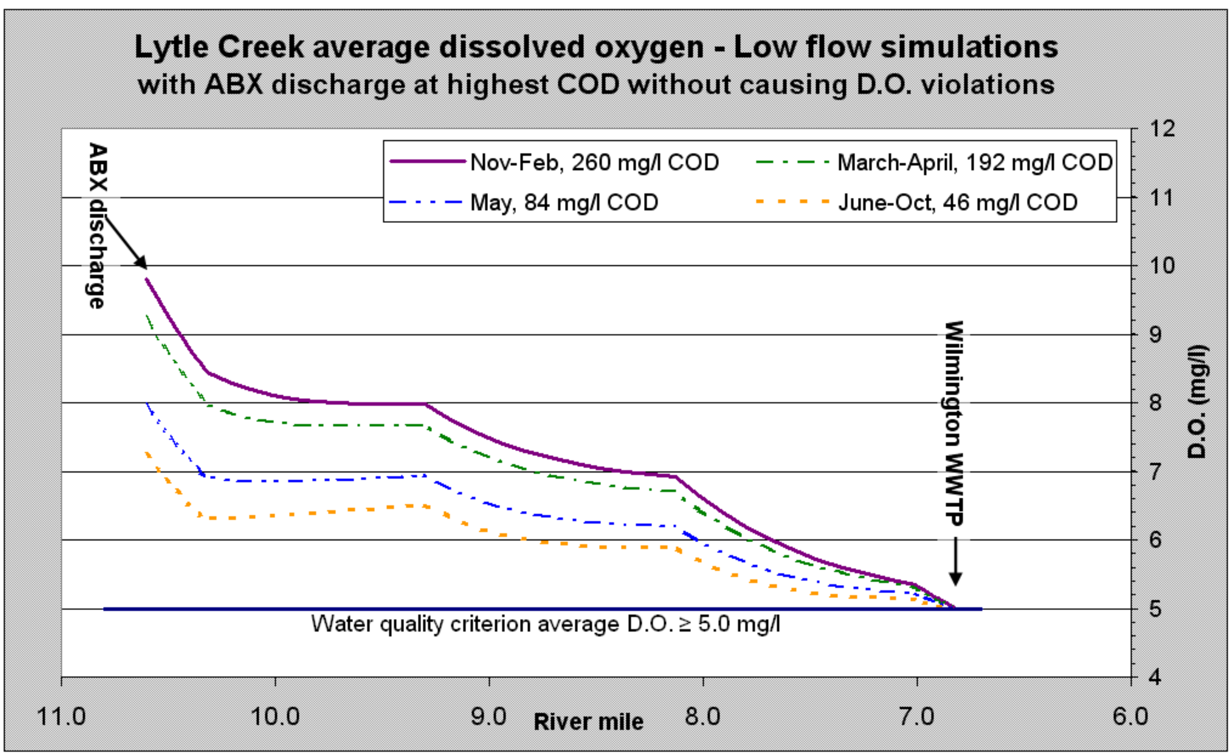


Figure B-39 Average dissolved oxygen concentrations during simulated low flow conditions on Lytle Creek at the maximum COD discharge form ABX without violating the dissolved oxygen standard.

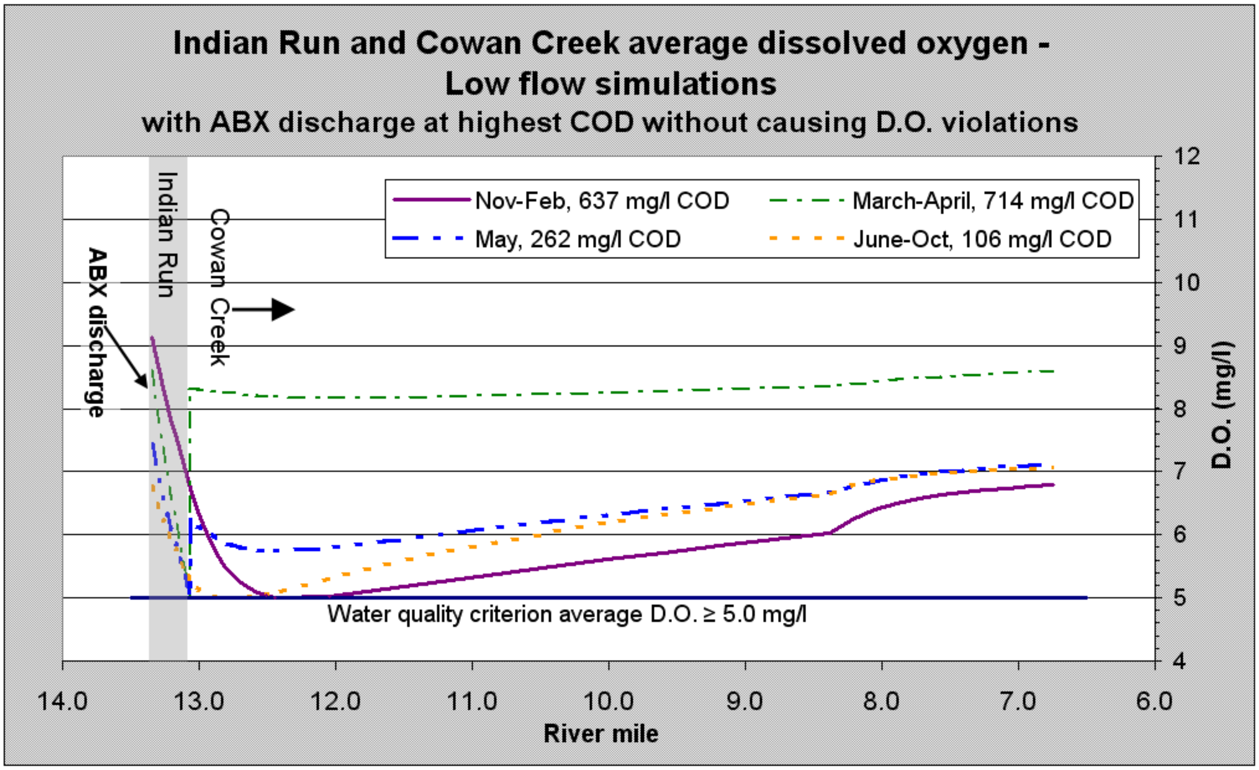


Figure B-40 Average dissolved oxygen concentrations during simulated low flow conditions on Indian Run and Cowan Creek at the maximum COD discharge form ABX without violating the dissolved oxygen standard.

Table B-26 COD TMDLs for Lytle and Cowan creeks

Stream	Allocation	Nov - Feb		March - April		May		June - October	
		Load[1]	Conc[2]	Load[1]	Conc[2]	Load[1]	Conc[2]	Load[1]	Conc[2]
Lytle Ck at sources	WLA for ABX	492.10	260	363.40	192	158.99	84	87.06	46
	LA Upstream	0	No flow	0	No flow	0	No flow	0	No flow
	TMDL	492.10	-	363.40	-	158.99	-	87.06	-
Cowan Ck at sources	WLA for ABX	1205.65	637	1351.39	714	495.89	262	200.63	106
	LA Upstream	0	No flow	35.65	Back-ground	6.90	Back-ground	0	No flow
	TMDL	1205.65	-	1387.04	-	502.79	-	200.63	-

[1] Loads are in kg/day
[2] Concentrations are in mg/l

B4.5 Bacteria, Recreational Use Results

For each sampling site that has recreational use impairment an LDC has been created. These LDCs represent the entire watershed draining to the sampling site. TMDLs have been developed for each of the five flow regimes examined in each LDC. The load at the middle of each flow regime is used for the TMDL. For example, the median flow load is used for the mid-range flow regime. Load and wasteload allocations (LA and WLA respectively) have been determined for each of these flow regimes in each LDC. Since stream flow can change rapidly, all loads (TMDLs and allocations) are determined as a daily count of *E. coli*.

The first step of load allocation takes 10% from the TMDL load and sets this aside as the margin of safety.
Permitted dischargers with NPDES permits that currently require disinfection of their final effluent (mostly wastewater treatment plants, 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. In a few of the LDC watersheds, this WLA is greater than the calculated TMDL load for the low flow regime. This is reflective of two aspects of the LDC method. The first reason is that most WWTPs are not currently at their design flow, and therefore the flow duration interval calculated is not great enough in the low flow regime. The second reason can be attributed to error in the calculation of the flow duration curve. This issue is compensated for by raising the TMDL when this occurs to the NPDES WLA. Since no runoff/non point source loads are expected at this flow regime this adjustment has no impact on LAs. This issue is more problematic in the Muddy Creek TMDL. This is because the main effluent from the Mason WWTP No. 2 plant is discharged in this watershed. This facility has an extremely high design flow, 13 million gallon per day, that discharges to a relatively small sized watershed 15.2 square miles. Because of this the WLA for the WWTP is greater than the calculated TMDL for not just the low flow regime, but also the dry conditions and mid-range flows. As in the other cases where this occurs the TMDL is raised to the WLA for these additional flow regimes. This however allows for no LA from runoff sources in these regimes.

Once margin of safety and NPDES WLAs are determined for each flow condition's TMDL, the remaining load is assigned to runoff loads. Any home sewage treatment systems or direct livestock existing loads of *E. coli* are not allocated, hence they are assigned no load. The runoff loads are 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 an 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.

Figures B-41 through B-48 show the LDCs. Tables B-26 through B-35 show the TMDL and allocation loads for each recreational use impaired watershed. In each figure the actual calculated loads are displayed as hollowed blue diamonds, while those with greater than 50 percent storm flow contributions also have a solid red diamond in the center. The geometric mean of existing data for each flow regime is included in these tables along with the load duration curve represented with the solid red line. The percent load reduction required to meet the TMDL is also provided for each flow regime, where data has been collected.

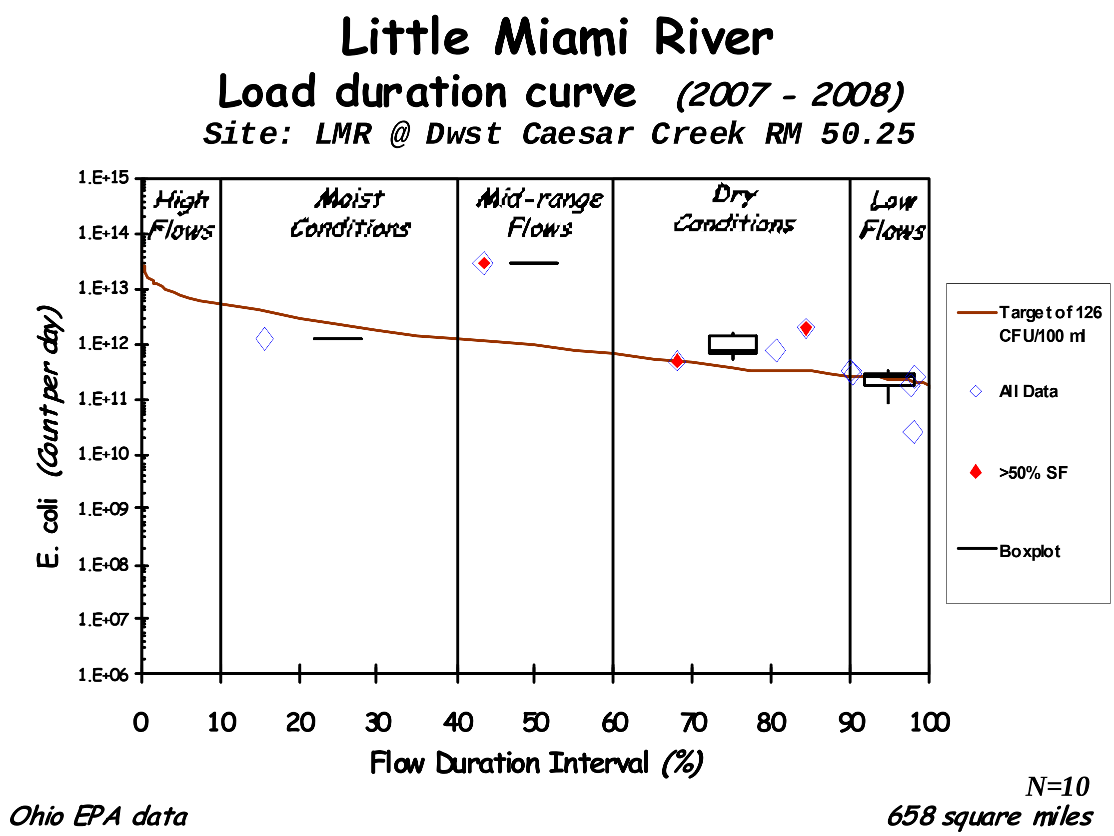


Figure B-41 Load duration curve for Little Miami River (RM 50.25)

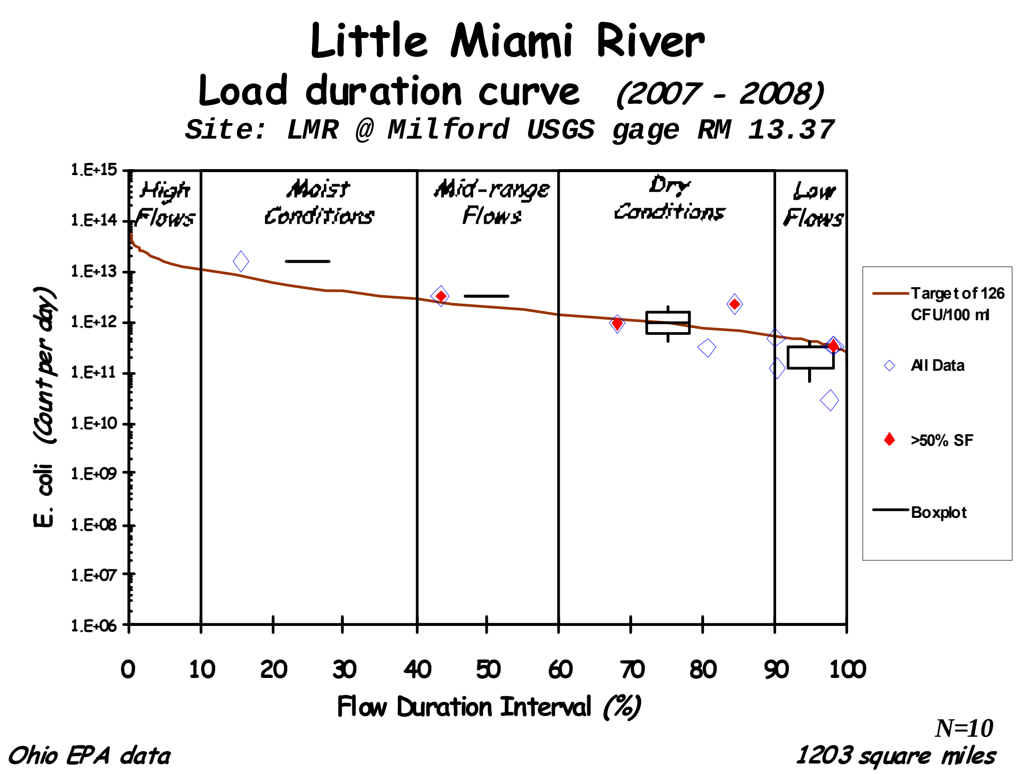


Figure B-42 Load duration curve for Little Miami River (RM 13.37)

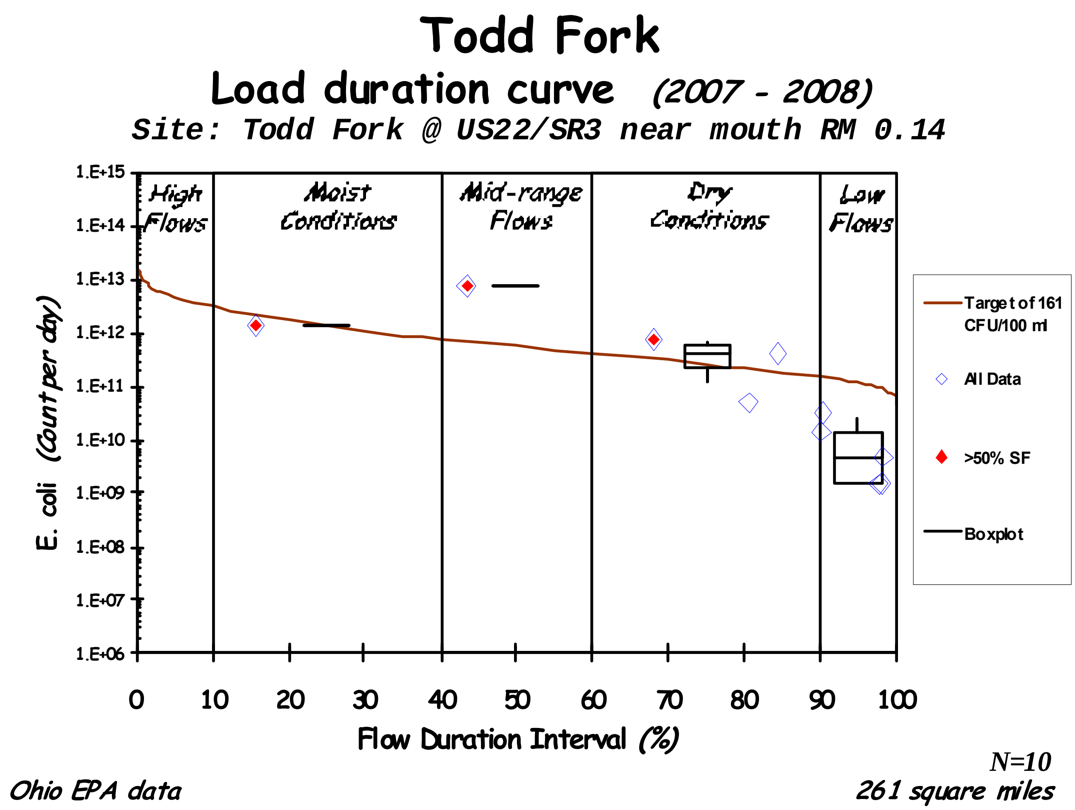


Figure B-43 Load duration curve for Todd Fork in HUC 05090202 07 04

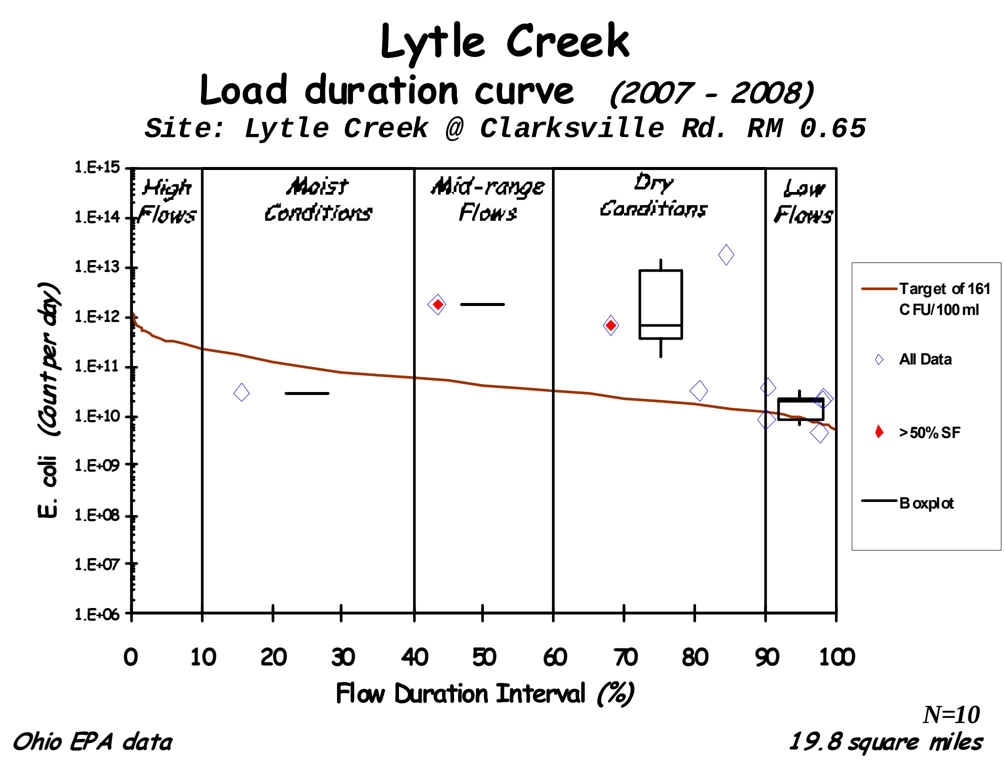


Figure B-44 Load duration curve for Lytle Creek in HUC 05090202 06 03

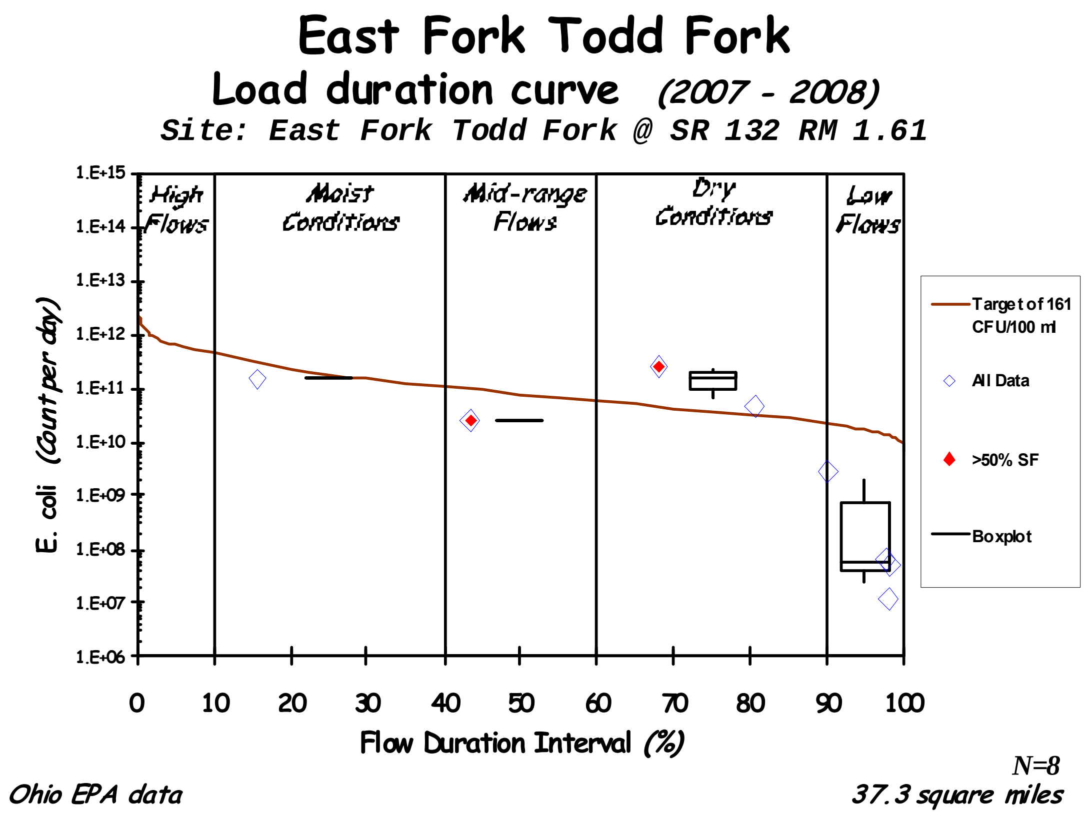


Figure B-45 Load duration curve for East Fork Todd Fork in HUC 05090202 07 01

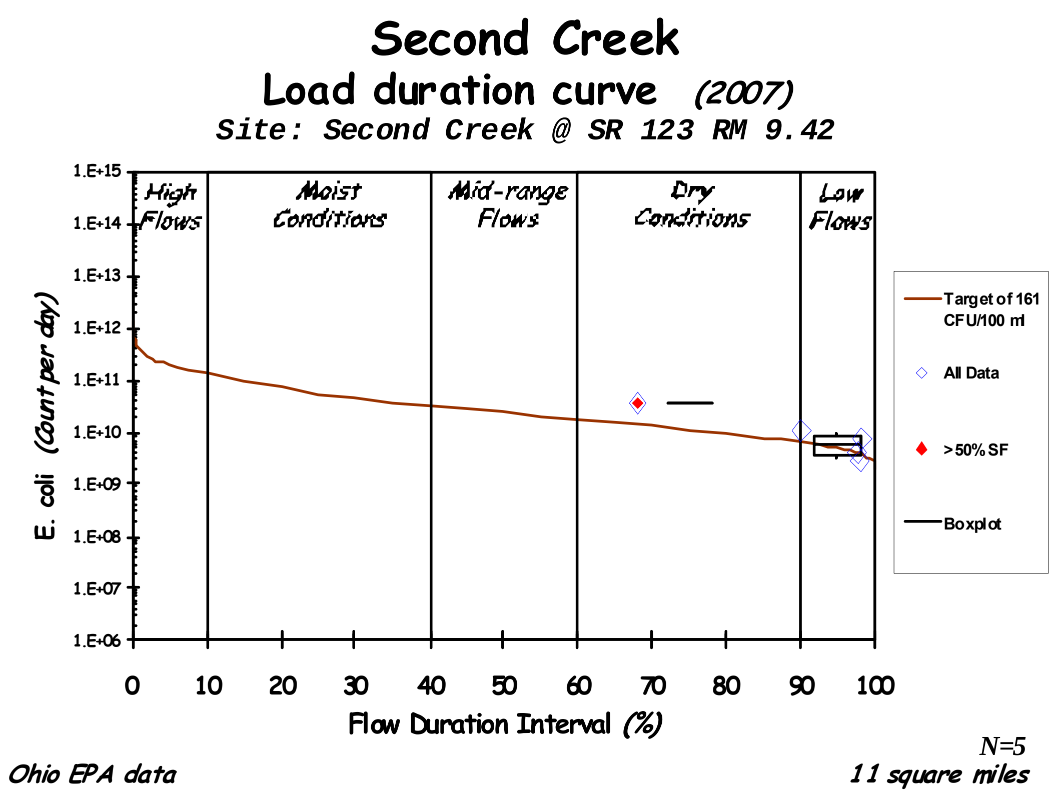
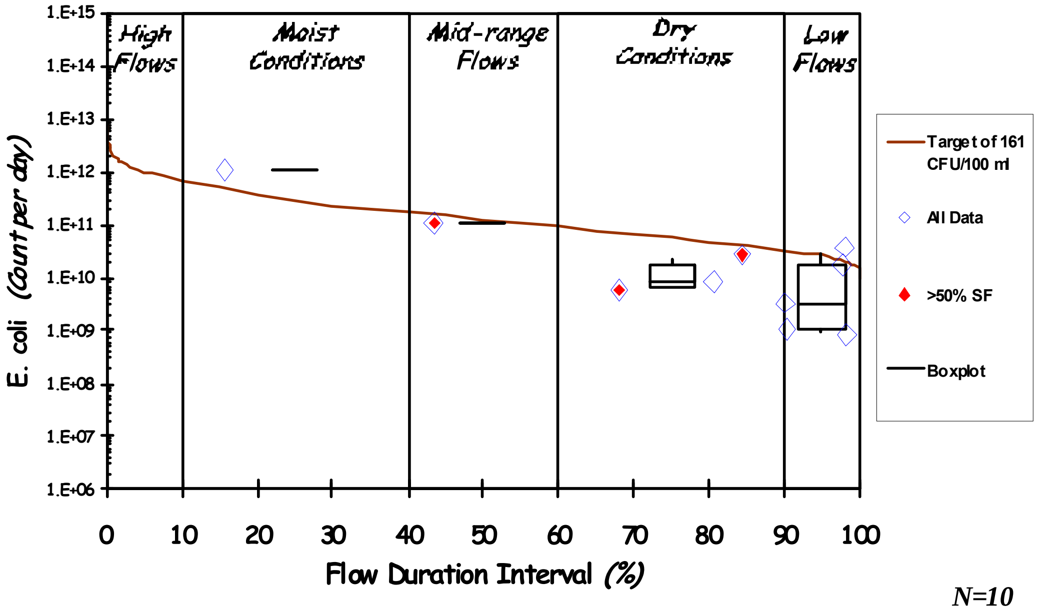


Figure B-46 Load duration curve for Second Creek in HUC 05090202 07 02

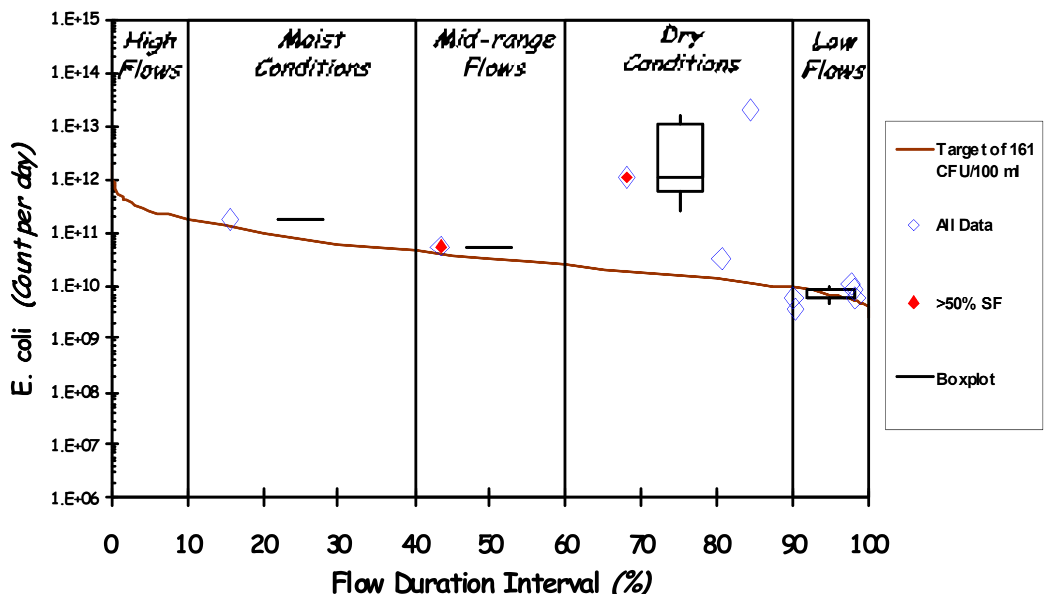
Turtle Creek
Load duration curve (2007 - 2008)
Site: Turtle Ck @ SR 48 RM 0.52



N=10
Ohio EPA data
58.0 square miles

Figure B-47 Load duration curve for Turtle Creek in HUC 05090202 01 04

Muddy Creek
Load duration curve (2007 - 2008)
Site: Muddy Ck @ Mason-Morrow-Milgrove Rd RM 0.54.



N=10
Ohio EPA data
15.2 square miles

Figure B-48 Load duration curve for Muddy Creek in HUC 05090202 09 01

Table B-27 Bacteria existing loads and TMDL for Little Miami River downstream of Caesar Creek (Shaw propertyHUC 05090202-90-01 RM 50.25 Values in *E. coli* count/day

Flow exceedance percentile	High Flows 0-10	Moist Conditions 10-40	Mid-Range Flows 40-60	Dry Conditions 60-90	Low Flows 90-100
Current Load (geometric mean)	No Data	1.29E+12	2.87E+13	9.18E+11	1.63E+11
TMDL= LA+WLA+MOS	7.96E+12	2.23E+12	9.12E+11	3.75E+11	2.39E+11
LA	6.19E+12	1.81E+12	6.17E+11	1.34E+11	1.19E+10
WLA: WWTP See Table B-27 for details	2.03E+11	2.03E+11	2.03E+11	2.03E+11	2.03E+11
WLA: MS4 Springfield	1.26E+10	3.26E+09	1.11E+09	2.41E+08	2.16E+07
WLA: MS4 Dayton	7.56E+11	1.96E+11	6.70E+10	1.45E+10	1.30E+09
MOS (10%)	7.96E+11	2.23E+11	9.12E+10	3.75E+10	2.39E+10
TMDL Reduction (%)	No Data	0%	96.82%	59.18%	0%

Table B-28 NPDES WWTPs and their WLA for Little Miami River downstream of Caesar Creek (Shaw property) at RM 50.25 in HUC 05090202-90-01.

NPDES Facility	NPDES #	WLA at all flows
South Charleston WWTP	1PB00028	1.14E+09
Reid Primary Middle School	1PT00120	5.72E+07
Clifton WWTP	1PA00023	1.38E+08
Yellow Springs WWTP	1PC00013	2.86E+09
Cedarville WWTP	1PB00006	2.67E+09
Eastern Regional Water Reclamation Facility	1PL00001	6.20E+10
Beavercreek WRRF	1PK00003	4.05E+10
Xenia Ford Road WWTP	1PD00015	1.72E+10
East Clinton High School	1PT00085	4.77E+07
Budget Inn	1PX00054	1.18E+08
Pilot Travel Centers LLC No 016	1PZ00019	2.62E+07
McDonalds Restaurant	1PZ00041	4.77E+07
Roberts Development Commerce Park WWTP	1PZ00113	2.38E+09
Total		2.03E+11

Table B-29 Bacteria existing loads and TMDL for Little Miami River downstream Wooster Pike (Milford gage) HUC 05090202-90-01 RM 13.07. Units for *E. coli* concentrations are count/day.

Flow exceedance percentile	High Flows 0-10	Moist Conditions 10-40	Mid-Range Flows 40-60	Dry Conditions 60-90	Low Flows 90-100
Current Load (geometric mean)	No Data	1.54E+13	3.35E+12	8.93E+11	1.84E+11
TMDL= LA+WLA+MOS	1.67E+13	4.81E+12	2.06E+12	9.46E+11	6.15E+11*
LA	1.22E+13	3.19E+12	1.10E+12	2.48E+11	0
WLA: WWTP See Table B-29 for details	5.59E+11	5.59E+11	5.59E+11	5.59E+11	5.59E+11
WLA :MS4 Springfield	1.43E+10	3.72E+09	1.28E+09	2.89E+08	0
WLA: MS4 Dayton	8.60E+11	2.24E+11	7.70E+10	1.74E+10	0
WLA: MS4 Wilmington	5.61E+10	1.46E+10	5.03E+09	1.14E+09	0
WLA: MS4 Cincinnati	1.20E+12	3.11E+11	1.07E+11	2.42E+10	0
WLA: MS4 Lebanon	1.04E+11	2.71E+10	9.32E+09	2.10E+09	0
MOS (10%)	1.67E+12	4.81E+11	2.06E+11	9.46E+10	5.59E+10
TMDL Reduction (%)	No Data	68.80%	38.40%	0%	0%

* The TMDL in this category is greater than calculated for the LDC because the curve reflects current flows, and the TMDL include flows from future expansion of waste water treatment plants (permitted design flows).

Table B-30 NPDES WWTPs and their TMDL WLA for Little Miami River downstream Wooster Pike (Milford gage) HUC 05090202-90-01 RM 13.07.

NPDES Facility	NPDES #	WLA at all flows	NPDES Facility	NPDES #	WLA at all flows
South Charleston WWTP	1PB00028	1.14E+09	Camp Swoneky	1PX00055001	1.67E+08
Reid Primary Middle School	1PT00120	5.72E+07	Mason WWTP No 2	1PC00004002	2.00E+09
Clifton WWTP	1PA00023	1.38E+08	Shadow Lake Village MHP	1PV00040001	2.62E+08
Yellow Springs WWTP	1PC00013	2.86E+09	Combs Inc Country Kitchen WWTP	1PR00049001	9.54E+07
Cedarville WWTP	1PB00006	2.67E+09	Warren Co Career Center	1PT00071001	1.19E+08
Eastern Regional Water Reclamation Facility	1PL00001	6.20E+10	ODOT Rest Area 08-38	1PZ00073001	1.91E+08
Beavercreek WRRF	1PK00003	4.05E+10	Joy Acres MHP	1PV00049001	1.67E+08
Xenia Ford Road WWTP	1PD00015	1.72E+10	Mason WWTP No 2	1PC00004001	6.20E+10
East Clinton High School	1PT00085	4.77E+07	Dale Acres WWTP	1PG00096001	7.15E+07
Budget Inn	1PX00054	1.18E+08	O'Bannon Creek Regional WWTP	1PK00017001	2.10E+10
Pilot Travel Centers LLC No 016	1PZ00019	2.62E+07	MidWestern Childrens Home	1PT00093001	7.63E+07
McDonalds Restaurant	1PZ00041	4.77E+07	Lebanon WWTP	1PC00003001	2.86E+10
Roberts Development Commerce Park WWTP	1PZ00113	2.38E+09	Lower Little Miami WWTP	1PK00018001	6.94E+10
Jamestown STP	1PB00015	4.29E+09	Sycamore Creek WWTP	1PK00005001	2.86E+10
Glady Run WWTP	1PD00016	1.91E+10	Sycamore Creek WWTP	1PK00005002	2.86E+10
Waynesville WWTP	1PB00032	3.39E+09	Sycamore Creek WWTP	1PK00005003	4.29E+10
Sugarcreek WRF	1PK00014	4.72E+10	Wards Corner Regional WWTP	1PK00021001	9.54E+09
Caesar Lake MHP	1PV00114	2.30E+08	Arrowhead Park WWTP	1PH00014001	6.68E+08
Wilmington WWTP	1PD00013	1.43E+10	Polk Run WWTP	1PK00019001	3.82E+10
Clarksville WWTP	1PA00024	4.29E+08	Miami Trails WWTP	1PW00023001	1.91E+09
Caesar Creek Flea Market	1PX00003	4.77E+07	Indian Lookout WWTP	1PG00041001	2.15E+08
Thousand Trails Inc Wilmington Preserve WWTP	1PX00010	5.72E+07	Bramblewood WWTP	1PG00067001	2.00E+08
Martinsville-Midland WWTP	1PH00031	7.25E+08	Lake Remington MHP	1PV00101001	1.22E+08
Blanchester WWTP	1PB00003	4.72E+09	Total	-	5.59E+11
Joy Outdoor Education Center	1PZ00045	5.72E+07			

Table B-31 Bacteria existing loads and TMDL for Todd Fork at SR 22/3 (Morrow) HUC 05090202 07 04 RM 0.04. Units for *E. coli* concentrations are count/day.

Flow exceedance percentile	High Flows 0-10	Moist Conditions 10-40	Mid-Range Flows 40-60	Dry Conditions 60-90	Low Flows 90-100
Current Load (geometric mean)	No Data	1.43E+12	7.35E+12	2.55E+11	5.56E+09
TMDL= LA+WLA+MOS	4.63E+12	1.33E+12	5.72E+11	2.62E+11	1.21E+11
LA	4.07E+12	1.16E+12	4.85E+11	2.12E+11	8.73E+10
WLA: Wilmington WWTP	1.43E+10	1.43E+10	1.43E+10	1.43E+10	1.43E+10
WLA: Clarksville WWTP	4.29E+08	4.29E+08	4.29E+08	4.29E+08	4.29E+08
WLA: Caesar Creek Flea Market	4.77E+07	4.77E+07	4.77E+07	4.77E+07	4.77E+07
WLA: Thousand Trails Inc Wilmington Preserve WWTP	5.72E+07	5.72E+07	5.72E+07	5.72E+07	5.72E+07
WLA: Martinsville-Midland WWTP	7.25E+08	7.25E+08	7.25E+08	7.25E+08	7.25E+08
WLA: Blanchester WWTP	4.72E+09	4.72E+09	4.72E+09	4.72E+09	4.72E+09
WLA: Joy Outdoor Education Center	5.72E+07	5.72E+07	5.72E+07	5.72E+07	5.72E+07
WLA: MS4 Wilmington	7.42E+10	2.11E+10	8.83E+09	3.86E+09	1.59E+09
MOS (10%)	4.63E+11	1.33E+11	5.72E+10	2.62E+10	1.21E+10
TMDL Reduction (%)	No Data	7.01%	92.22%	0%	0%

Table B-32 Bacteria existing loads and TMDL for Lytle Creek HUC 05090202 06 03RM 0.65. Units for *E. coli* concentrations are count/day.

Flow exceedance percentile	High Flows 0-10	Moist Conditions 10-40	Mid-Range Flows 40-60	Dry Conditions 60-90	Low Flows 90-100
Current Load (geometric mean)	No Data	3.08E+10	1.72E+12	7.36E+11	1.49E+10
TMDL= LA+WLA+MOS	3.51E+11	1.01E+11	4.34E+10	1.99E+10	1.57E+10*
LA	2.37E+11	6.01E+10	1.94E+10	2.82E+09	0
WLA: Wilmington WWTP	1.43E+10	1.43E+10	1.43E+10	1.43E+10	1.43E+10
WLA: MS4 Wilmington	6.53E+10	1.66E+10	5.35E+09	7.80E+08	0
MOS (10%)	3.51E+10	1.01E+10	4.34E+09	1.99E+09	1.43E+09
TMDL Reduction (%)	No Data	0%	97.47%	97.29%	0%

* The TMDL in this category is greater than calculated for the LDC because the curve reflects current flows, and the TMDL include flows from future expansion of waste water treatment plants (permitted design flows).

Table B-33 Bacteria existing loads and TMDL for East Fork Todd Fork at SR 132 (Clarksville) HUC 05090202 07 01 RM 1.6. Units for *E. coli* concentrations are count/day.

Flow exceedance percentile	High Flows 0-10	Moist Conditions 10-40	Mid-Range Flows 40-60	Dry Conditions 60-90	Low Flows 90-100
Current Load (geometric mean)	No Data	1.5E+11	2.57E+10	1.08E+11	1.04E+08
TMDL= LA+WLA+MOS	6.62E+11	1.91E+11	8.17E+10	3.75E+10	1.73E+10
LA	5.95E+11	1.71E+11	7.28E+10	3.30E+10	1.49E+10
WLA: Martinsville-Midland WWTP	7.25E+08	7.25E+08	7.25E+08	7.25E+08	7.25E+08
MOS (10%)	6.62E+10	1.91E+10	8.17E+09	3.75E+09	1.73E+09
TMDL Reduction (%)	No Data	0%	0%	65.26%	0%

Table B-34 Bacteria existing loads and TMDL for Second Creek at SR 123 (Dst Blanchester WWTP) HUC 05090202 07 02 RM 9.45. Units for *E. coli* concentrations are count/day.

Flow exceedance percentile	High Flows 0-10	Moist Conditions 10-40	Mid-Range Flows 40-60	Dry Conditions 60-90	Low Flows 90-100
Current Load (geometric mean)	No Data	No Data	No Data	3.70E+10	5.44E+09
TMDL= LA+WLA+MOS	1.95E+11	5.62E+10	2.41E+10	1.11E+10	5.19E+09
LA	1.71E+11	4.58E+10	1.70E+10	5.23E+09	0
WLA: Blanchester	4.72E+09	4.72E+09	4.722E+09	4.72E+09	4.722E+09
MOS (10%)	1.95E+10	5.62E+09	2.41E+09	1.11E+09	5.19E+08
TMDL Reduction (%)	No Data	No Data	No Data	70.14%	4.60%

Table B-35 Bacteria existing loads and TMDL for Turtle Creek at SR 48 HUC 05090202 01 04 RM 0.52. Units for *E. coli* concentrations are count/day.

Flow exceedance percentile	High Flows 0-10	Moist Conditions 10-40	Mid-Range Flows 40-60	Dry Conditions 60-90	Low Flows 90-100
Current Load (geometric mean)	No Data	1.15E+12	1.08E+11	1.09E+10	4.63E+09
TMDL= LA+WLA+MOS	1.03E+12	2.96E+11	1.27E+11	5.83E+10	2.70E+10
LA	6.98E+11	1.99E+11	8.43E+10	3.76E+10	1.63E+10
WLA: Mason WWTP No 2 (outfall 002)	2.00E+09	2.00E+09	2.00E+09	2.00E+09	2.00E+09
WLA: Shadow Lake Village MHP	2.62E+08	2.62E+08	2.62E+08	2.62E+08	2.62E+08
WLA: Combs Inc Country Kitchen WWTP	9.54E+07	9.54E+07	9.54E+07	9.54E+07	9.54E+07
WLA: Warren Co Career Center	1.19E+08	1.19E+08	1.19E+08	1.19E+08	1.19E+08
ODOT Rest Area 08-38	1.91E+08	1.91E+08	1.91E+08	1.91E+08	1.91E+08
WLA: MS4 Wilmington	8.85E+10	2.53E+10	1.07E+10	4.77E+09	2.07E+09
WLA: MS4 Cincinnati	1.38E+11	3.93E+10	1.66E+10	7.42E+09	3.22E+09
MOS (10%)	1.03E+11	2.96E+10	1.27E+10	5.83E+09	2.70E+09
TMDL Reduction (%)	No Data	74.26%	0%	0%	0%

Table B-36 Bacteria existing loads and TMDL for Muddy Creek at Mason-Morrow Rd (Dst Mason WWTP) HUC 05090202 09 01 RM 0.54. Units for *E. coli* concentrations are count/day.

Flow exceedance percentile	High Flows 0-10	Moist Conditions 10-40	Mid-Range Flows 40-60	Dry Conditions 60-90	Low Flows 90-100
Current Load (geometric mean)	No Data	1.76E+11	5.6E+10	9.14E+11	6.47E+09
TMDL= LA+WLA+MOS	2.70E+11	7.76E+10	6.82E+10*	6.82E+10*	6.82E+10*
LA	5.42E+10	2.36E+09	0	0	0
WLA: Mason WWTP No 2 (outfall 001)	6.20E+10	6.20E+10	6.20E+10	6.20E+10	6.20E+10
WLA: MS4 Cincinnati	1.27E+11	5.51E+09	0	0	0
MOS (10%)	2.70E+10	7.76E+09	6.20E+09	6.20E+09	6.20E+09
TMDL Reduction (%)	No Data	55.95%	0%	92.54%	0%

* The TMDL in this category is greater than calculated for the LDC because the curve reflects current flows, and the TMDL include flows from future expansion of NPDES waste water treatment plants (permitted design flows).

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