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Environmental Protection Agency

Division of Surface Water

Total Maximum Daily Loads for Bacteria for the Sugar Creek Watershed

South Fork Sugar Creek

Final Report
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Ted Strickland, Governor
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1.0 INTRODUCTION

A 1998 water quality survey of the Sugar Creek watershed found that the bacteriological water quality criteria used to protect designated recreational beneficial stream uses were exceeded on numerous occasions and on a wide-spread basis (Ohio EPA, 2000). These findings were used as the basis to list the Sugar Creek watershed as impaired with respect to recreational uses on the Ohio 303(d) list (Ohio EPA, 2006). Fecal coliform and *Escherichia coli* (*E. coli*) bacteria are indicator organisms for the potential presence of pathogens in surface water resulting from the presence of untreated human or animal wastes, and they are the basis for recreational use water quality criteria in Rule 3745-1-07 of the Ohio Administrative Code (OAC).

The Clean Water Act and U.S. Environmental Protection Agency (USEPA) regulations require that states develop Total Maximum Daily Loads (TMDLs) for waters on the Section 303(d) lists. The TMDL and water quality restoration planning process involves several steps including watershed characterization, target identification, source assessment, and allocation of loads. The pollutant load is allocated among all sources within the watershed and voluntary (for nonpoint sources) and regulatory control (for point sources) measures are identified for attaining the source allocations. An implementation plan is also typically established to ensure that the control measures are effective at restoring water quality and all designated water uses.

The overall goals and objectives in developing the Sugar Creek bacteria TMDLs were to:

- Assess the water quality within the watershed and identify key issues associated with the impairments and potential pollutant sources.
- Use the best available science and available data to determine water quality conditions that will result in all streams fully supporting their designated uses.
- Prepare a final TMDL report that meets the requirements of the Clean Water Act and provides information to the key stakeholders that can be used to facilitate implementation activities to improve water quality.

A companion document (*Recreational Use Water Quality Survey of the Sugar Creek Watershed, 2005* (OEPA, 2006) provides a summary of all available water quality data in the Sugar Creek watershed and discusses several important issues related to the bacteria problem. This report documents the results of the TMDL analysis. Section 2 briefly describes the watershed and applicable water quality standards, Section 3 describes the methodology used to estimate the current and allowable bacteria loads, and Section 4 presents the resulting TMDLs. Key sources within each of the assessment units are discussed in Section 5.

Consistent with Ohio's current Continuous Planning Process (CPP), the draft TMDL report was available for public comment from June 14 through July 17, 2006. A copy of the draft report was posted on Ohio EPA's web page (www.epa.state.oh.us/dsw/tmdl/index.html). No public comments were received. A public meeting presenting the draft report was held in the watershed on June 20, 2006.

Public involvement is critical to the success of water restoration projects, including TMDL efforts. Ohio EPA will continue to support the implementation process and will facilitate to the fullest extent possible restoration actions that are acceptable to the communities and stakeholders in the study area and to Ohio EPA. Ohio EPA is reluctant to rely solely on regulatory actions and encourages voluntary actions by the local stakeholders, watershed organization, and agency partners to restore the Sugar Creek watershed.

2.0 DESCRIPTION OF WATERBODIES, IMPAIRMENT STATUS AND WATER QUALITY STANDARDS

The purpose of this section of the report is to provide a brief background of Sugar Creek and its corresponding watershed. The Section 303(d) list status of the waterbody is also summarized in Table 2-1. More extensive descriptions of the watershed are available in the following reports:

- *Biological and Water Quality Study of Sugar Creek, 1998* (OEPA, 2000)
- *Total Maximum Daily Loads for the Sugar Creek Basin (Final Report)* (OEPA, 2002)
- *Recreational Use Water Quality Survey of the Sugar Creek Watershed, 2005* (OEPA, 2006)

2.1 Description of the Sugar Creek Watershed

Sugar Creek drains a 365 square mile watershed in northeast Ohio (Figure 2-1). The watershed lies in two ecoregions that are roughly defined by the southern glacial boundary in the region. The northern half of the watershed is in the glaciated Erie and Ontario Drift and Lake Plain (EOLP) and the southern half of the watershed is in the non-glaciated Western Allegheny Plateau (WAP). The glaciated portion is characterized by rolling hills and valleys whereas the non-glaciated portion has steeper topography with coal and clay deposits. The watershed is divided among four counties Holmes (26% of the watershed area), Stark (11%), Tuscarawas (35%) and Wayne (28%). Incorporated communities within the watershed include Brewster, Dover, Orrville, Smithville, Strasburg and Sugar Creek.

The mainstem of Sugar Creek is 45 miles long and flows in a northwest to southeast direction from the vicinity of Smithville in Wayne County to its confluence with the Tuscarawas River near Dover. The watershed is divided into three 11-digit assessment units (AU's):

- Sugar Creek, Headwaters to upstream of the Middle Fork (05040001100)
- South Fork Sugar Creek (05040001110)
- Sugar Creek, from Middle Fork to mouth, excluding South Fork 05040001120)

Each of the 11-digit AU's is further subdivided into 14-digit hydrologic unit code (HUC) sub-watersheds as presented in Table 2-1.

Table 2-1. Assessment Unit (AU) and 14-Digit Hydrologic Unit Code (HUC) Designations for the Sugar Creek Watershed.

11-Digit AU	14-Digit HUC	Description	Drainage Area (mi^2)
05040001100		**Sugar Creek (headwaters to above Middle Fork Sugar Creek)**	**97.33**
	010	Sugar Creek headwaters to above L. Sugar Cr.	28.17
	020	Little Sugar Creek	18.09
	030	Sugar Creek below L. Sugar Cr. to above Middle Fk. Sugar Cr. (except N. Fk. Sugar Cr.)	33.07
	040	North Fork Sugar Creek	18.00
05040001110		**South Fork Sugar Creek**	**137.69**
	010	South Fork Sugar Creek above E. Branch	34.99
	020	East Branch South Fork Sugar Creek	28.19
	030	South Fork Sugar Creek below E. Branch to above Walnut Cr.	12.66
	040	Walnut Creek (except Indian Trail Cr.)	31.65
	050	Indian Trail Creek	16.38
	060	South Fork Sugar Creek below Walnut Cr. to Sugar Cr.	13.82
05040001120		**Sugar Creek (above Middle Fork to Tuscarawas River [except South Fork])**	**121.32**
	010	Middle Fork Sugar Cr. above Crabapple Cr.	16.41
	020	Crabapple Creek	11.28
	030	Middle Fork Sugar Cr. below Crabapple Cr. to Sugar Cr.	19.52
	040	Sugar Creek below Middle Fk. Sugar Cr. to Beach City Reservoir (except S. Fk. Sugar Cr.)	17.57
	050	Sugar Creek below Beach City Reservoir to above Broad Run	13.44
	060	Broad Run	19.56
	070	Sugar Creek below Broad Run to Tuscarawas River	23.54

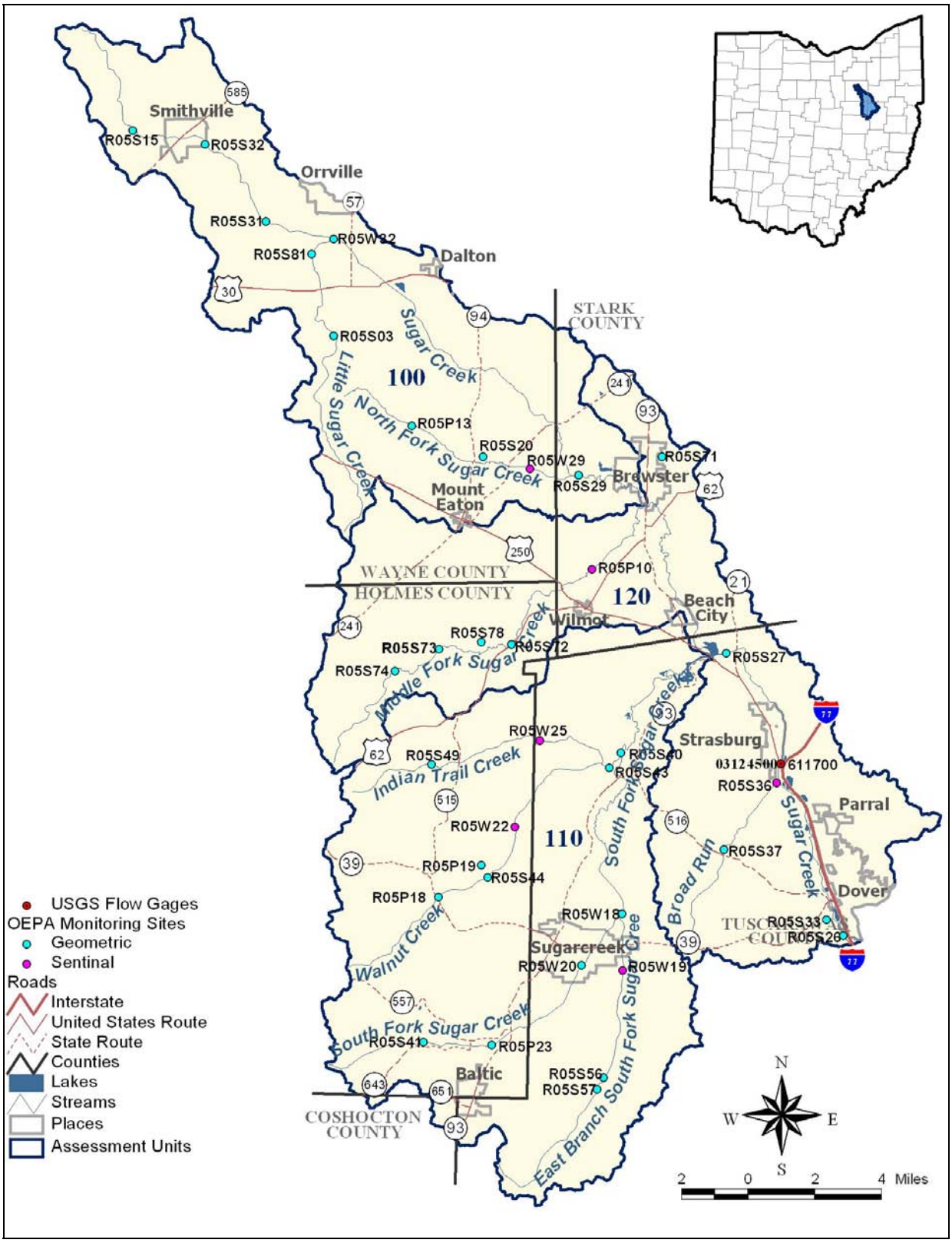

Figure 2-1. The Sugar Creek Watershed.

2.2 Land Use and Land Cover within the Sugar Creek Watershed

General land use/land cover data for the Sugar Creek watershed were extracted from a spatial database derived from satellite imagery collected during the period 1999 to 2003. This database includes the most current detailed land cover data known to be available for the watershed. Each 98-foot by 98-foot pixel contained within the satellite image was classified according to its reflective characteristics and the resulting land use and land cover characteristics of the Sugar Creek watershed are presented in Figure 2-2 and summarized in Table 2-2. The figure and the table show that agriculture is the dominant land use/land cover in the watershed and accounts for approximately 67 percent of the total area. Forested land cover accounts for nearly 28 percent of the watershed area, and is most extensive in the lower portions of the basin (AUs 110 and 120). Residential land use represents less than four percent of the total area.

Agriculture uses include: row crops, dairy cows, beef and poultry confined feeding operations, forage production, and fruit production. Farms within Holmes, Stark, Tuscarawas and Wayne Counties that incorporate the Sugar Creek watershed account for nearly 25 percent of the total milk production within the State of Ohio, averaging 1.19 x 10^9 pounds per year (USDA, 2005). Among the four counties, Wayne County has the highest density for all categories of livestock, with cattle constituting the majority of the livestock numbers. Although milk production, dairy cows, and total cattle herd sizes have remained relatively constant over the last ten years, there has been a significant decrease in hog production overall in the four county area, with the majority of the decrease observed in Holmes County.

Table 2-2. Land Use and Land Cover Characteristics of the Sugar Creek Watershed.

Land Cover / Land Use	Area (acres)	Percent of Watershed
Deciduous Forest	63,079.8	27.68
Evergreen Forest	465.0	0.20
Pasture and Hay	41,674.6	18.29
Crop	111,189.6	48.80
Open Water	479.9	0.21
Residential	7,489.3	3.29
Commercial/Industrial/Transportation	1,917.9	0.84
Bare/Mines	250.0	0.11
Urban/Recreational Grasses	195.3	0.09
Herbaceous Wetlands	146.6	0.06
Woody Wetlands	960.5	0.42
Total	**227,849**	**100.00**

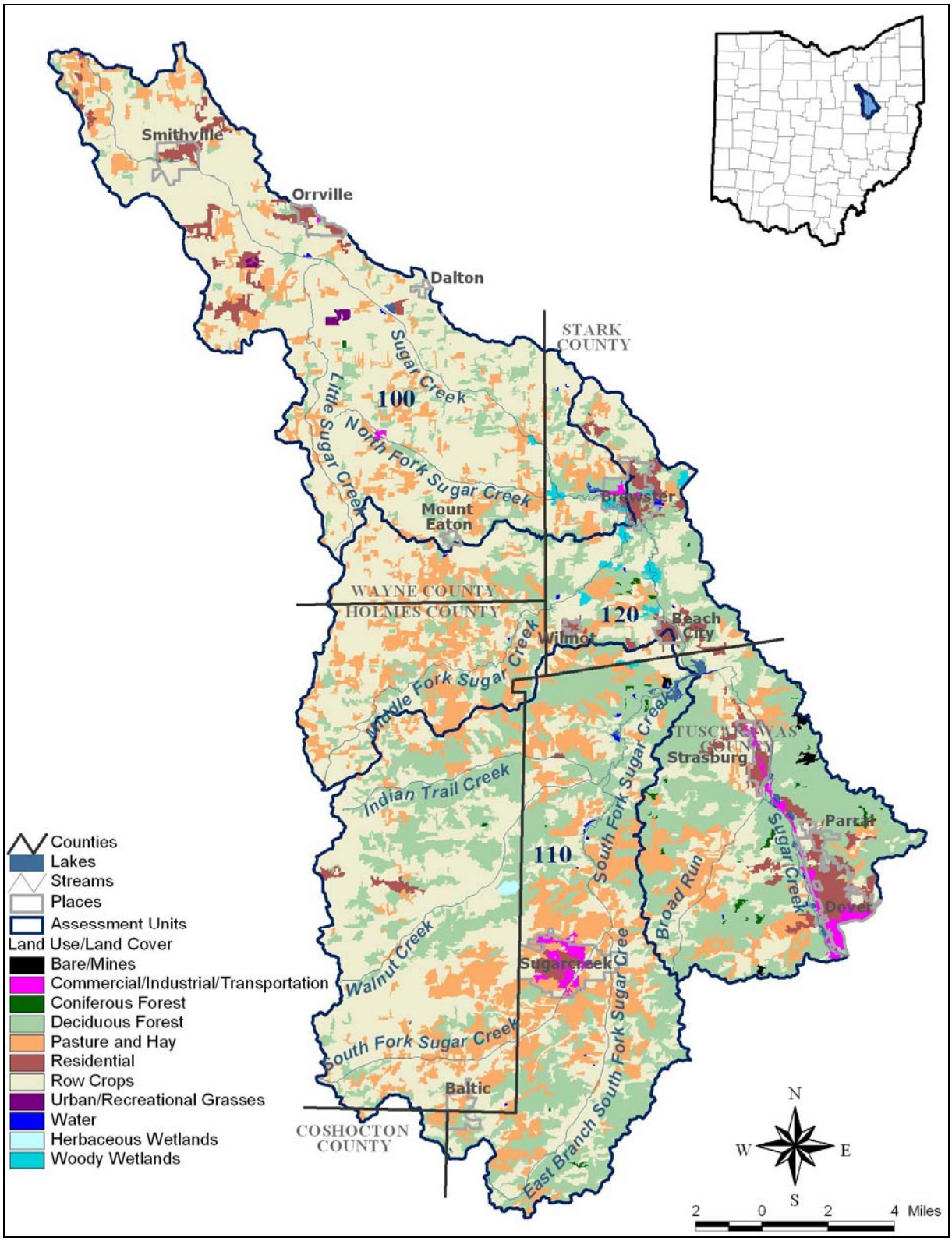

Figure 2-2. Land use and land cover within the Sugar Creek watershed.

2.3 Water Quality Standards

Interpreting Ohio's water quality standards for fecal coliform and *E. coli* is somewhat complex and the state is currently considering changing the standard. In the meantime, however, Table 2-3 shows that the primary contact *E. coli* criterion of 126 cfu/100 mL is identical to the bathing water *E. coli* criterion as a geometric mean. However, this is not the case for fecal coliforms. While the primary contact fecal coliform criterion is 1,000 cfu/100 mL, the bathing water fecal coliform criterion is 200/100 mL. For this reason, *E. coli* is not used by itself to determine if there is a violation of the primary contact recreation criteria because Ohio EPA's regulations state that:

> *"For each designation at least one of the two bacteriological standards (fecal coliform or* E. coli*) must be met (OAC 3745-1-07, Table 7-13)."*

Therefore, when both fecal coliform and *E. coli* data are available from the same sample, if at least one of the two standards is met, there is not a human health violation. If only one of the two bacteria groups are available to determine violations of recreational standards, then fecal coliform should be used, not *E. coli*, because it is very rare that a fecal coliform count of 1,000/100 mL would violate the criteria and *E. coli* would not violate the 126/100 mL criteria. For this reason, the TMDL for the Sugar Creek watershed is based on meeting the primary contact fecal coliform standard. Both the geometric mean and instantaneous portions of the standard have been assessed and the results are summarized in the companion document *Recreational Use Water Quality Survey of the Sugar Creek Watershed, 2005* (OEPA, 2006). .

Table 2-3. Fecal coliform and *E. coli* standards for Ohio. Standards only apply for the period May 1 through October 15.

Parameter	Bathing Waters		Primary Contact		Secondary Contact
	Geometric Mean[1]	Instantaneous[2]	Geometric Mean[1]	Instantaneous[2]	Instantaneous[2]
Fecal Coliform	200/100 mL	400/100 mL	1,000/100 mL	2,000/100 mL	5,000/100 mL
E. coli	126/100 mL	235/100 mL	126/100 mL	298/100 mL	576/100 mL

[1] Geometric mean fecal coliform content should not exceed this standard based on not less than five samples within a thirty-day period.
[2] Fecal coliform content should not exceed this standard in more than ten percent of the samples taken in any thirty-day period.

2.4 Impairment Status

The 303(d) listings for Sugar Creek are summarized in Table 2-4 and a comparison of the available data to the standards is presented in *Recreational Use Water Quality Survey for the Sugar Creek Watershed.*

Table 2-4. Summary of section 303(d) listings in the Sugar Creek watershed, Ohio.

Assessment Unit	Cause of Impairment	Potential Sources
05040001 100 Sugar Creek (Headwaters to Middle Fork)	Pathogens	Pasture Land Feedlots (Confined Animal Feeding Operations) Animal Holding/Management Areas Onsite Wastewater Systems (Septic Tanks)
05040001 110 South Fork Sugar Creek	Pathogens	Pasture Land
05040001 120 Sugar Creek (Middle Fork to Mouth)	Pathogens	Pasture Land

3.0 TECHNICAL APPROACH

This section of the report presents the technical approach used to estimate current and allowable fecal coliform loading to Sugar Creek and its tributary streams. As discussed below, a load duration approach was used to make these estimates.

3.1 Load Duration Curves

Load reductions for fecal coliform were determined through the use of load duration curves. This approach involves calculating the allowable loadings over the range of flow conditions expected to occur in the impaired stream by taking the following steps:

1. A flow duration curve for the stream is developed by generating a flow frequency table and plotting the data points. Since the bacteria water quality standards in Ohio are seasonal, the load duration approach employed in the Sugar Creek watershed evaluated only stream flows that occur during the recreational season of May 1 through October 15.

2. The flow curve is translated into a load duration (or TMDL) curve. To accomplish this, each flow value is multiplied by the water quality standard and by a conversion factor. The resulting points are graphed.

3. Each water quality sample is converted to a load by multiplying the water quality sample concentration by the average daily flow on the day the sample was collected. Then, the individual loads are plotted on the TMDL graph.

4. Points plotting above the curve represent deviations from the water quality standard and the daily allowable load. Those plotting below the curve represent compliance with standards and the daily allowable load.

5. The area beneath the TMDL curve is interpreted as the 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.

Both the geometric mean (1000 cfu/100 mL) and instantaneous (2000 cfu/100 mL) components of the standard were evaluated as part of this study. The TMDL is based on meeting the more strict geometric mean component of the standard and the necessary reductions from this analysis are presented in Section 4.0. The results of the instantaneous analysis are presented in Appendix C.

The stream flows displayed on a load duration curve may be grouped into various flow regimes to aid with interpretation of the load duration curves. The flow regimes are typically divided into 10 groups which can be further categorized into the following five “hydrologic zones” (Cleland, 2005):

- High flow zone: stream flows that plot in the 0 to 10 percentile range, related to flood flows.
- Moist zone: flows in the 10 to 40 percentile range, related to wet weather conditions.
- Mid-range zone: flows in the 40 to 60 percentile range, median stream flow conditions;
- Dry zone: flows in the 60 to 90 percentile range, related to dry weather flows.
- Low flow zone: flows in the 90 to 100 percentile range, related to drought conditions.

The load duration approach helps to identify the issues surrounding the impairment and to roughly differentiate between sources. Table 3-1 summarizes the relationship between the five hydrologic zones and potentially contributing source areas.

The load reduction approach also considers critical conditions and seasonal variation in the TMDL development as required by the Clean Water Act and EPA's implementing regulations. Because the approach establishes loads based on a representative flow regime, it inherently considers seasonal variations and critical conditions attributed to flow conditions.

Table 3-1. Relationship Between Load Duration Curve Zones and 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
On-site wastewater systems	M	M-H	H	H	H
Riparian areas		H	H	M	
Stormwater: Impervious		H	H	H	
Combined sewer overflow (CSO)	H	H	H		
Stormwater: Upland	H	H	M		
Field drainage: Natural condition	H	M			
Field drainage: Tile system	H	H	M-H	L-M	
Bank erosion	H	M			

Note: ***Potential relative importance of source area to contribute loads under given hydrologic condition (H: High; M: Medium; L: Low)***

3.2 Stream Flow Estimates

Daily stream flows for each monitoring site of interest are needed to apply the load duration curve. Continuous stream flow data are available for Sugar Creek at Strasburg, Ohio (U. S. Geological Survey (USGS) station 00124500) from July 7, 1931 to September 30, 2004. Additionally, provisional flow data from October 1, 2004 through September 21, 2005 were supplied by the USGS for this gage for this study. This site represents a drainage area of 311 square miles comprised mostly of agricultural row crops, pasture, and deciduous forest. However, a large reservoir is located approximately five miles upstream of the flow gage and therefore the gage does not always represent the "natural" hydrology of the watershed (e.g., the reservoir attenuates peak flow values). Consequently, the Strasburg stream gage site is not believed to represent typical flow regimes in Sugar Creek or its tributary streams. To estimate stream flows for Sugar Creek and its tributary streams, a surrogate stream gage, Mill Creek near Coshocton, OH (USGS 03140000) was identified. The Mill Creek station is located approximately 24 miles southeast of the Strasburg station and drains 27.2 square miles of land use dominated by agricultural row crop. Continuous stream flow data are available from November 1, 1936 through September 30, 2004 and provisional flow data from October 1, 2004 through September 21, 2005 were made available by the USGS for this study.

Since the load duration approach requires a stream flow time series for each site where the method is applied, stream flows were extrapolated from the Mill Creek stream flow record for each load duration site by using a multiplier based upon the ratio of the upstream drainage area for a given site to the drainage area of Mill Creek. For example, the ratio of the drainage area at the North Fork Sugar Creek

monitoring site is 16.5 square miles divided by the drainage area of Mill Creek (27.2 square miles), which equals 0.607. Thus, the daily stream flows for Mill Creek were multiplied by 0.607 to estimate the daily stream flows at the North Fork Sugar Creek monitoring site. Table 3-2 presents the drainage area ratios used to estimate stream flow for all of the load duration sites used in this TMDL; the locations of the sites are shown in Figure 3-1. A comparison between estimated stream flows and flow measurements made by OEPA are presented in Appendix B. The results indicate that the estimated flows are usually very similar to the observed flows with several exceptions. These exceptions likely result from storm events that occurred in the Sugar Creek watershed but not the Mill Creek watershed.

Table 3-2. Drainage Area Ratios Used to Estimate Stream Flow for Load Duration Analyses in the Sugar Creek Watershed.

11-Digit AU	14-Digit HUC	STORET ID	Stream Name	Location	River Mile	Upstream Drainage Area (Sq. mi.)	Drainage Area Ratio
05040001100							
	010	R05S32	Sugar Creek	County Road 502	40.18	14.4	0.529
	010	R05S31	Sugar Creek	Orr Road	36.88	25.0	0.919
	040	R05W29	North Fork Sugar Creek	W. Lebanon Road	1.35	16.5	0.607
05040001110							
	010	R05P23	South Fork Sugar Creek	Twp. Rd. 173	18.98	14.4	0.634
	010	R05W20	South Fork Sugar Creek	County Road 47	15.26	25.0	0.919
	020	R05W19	East Branch South Fork Sugar Creek	Township Road 348	1.7	25.4	0.934
	030	R05W18	South Fork Sugar Creek	Winklepleck Road	13.28	63.3	2.789
	040	R05P18	Walnut Creek	Old State Route 39	7.93	9.1	0.401
	040	R05W22	Walnut Creek	County Road 172	4.49	22.0	0.809
	050	R05W25	Indian Trail Creek	Cement Bridge Road (Township Road 66)	2.56	13.4	0.493
05040001120							
	030	R05P10	Middle Fork Sugar Creek	Northvale Avenue	3.16	41.9	1.542
	050	611700	Sugar Creek	State Route 250	7.28	311.0	1.000
	060	R05S36	Broad Run	Township Road 425	0.15	20.0	0.735

Table 3-2 and Figure 3-1 show that seven load duration sites are located within AU 110, while AUs 100 and 120 contain three sites each. This is due to the fact that there were more monitoring sites with enough data to apply the load duration curve in AU 110 compared to AU 100 and AU 120. To allow for a comparison among AU's, per acre fecal coliform loading estimates were made and are presented in Section 4.

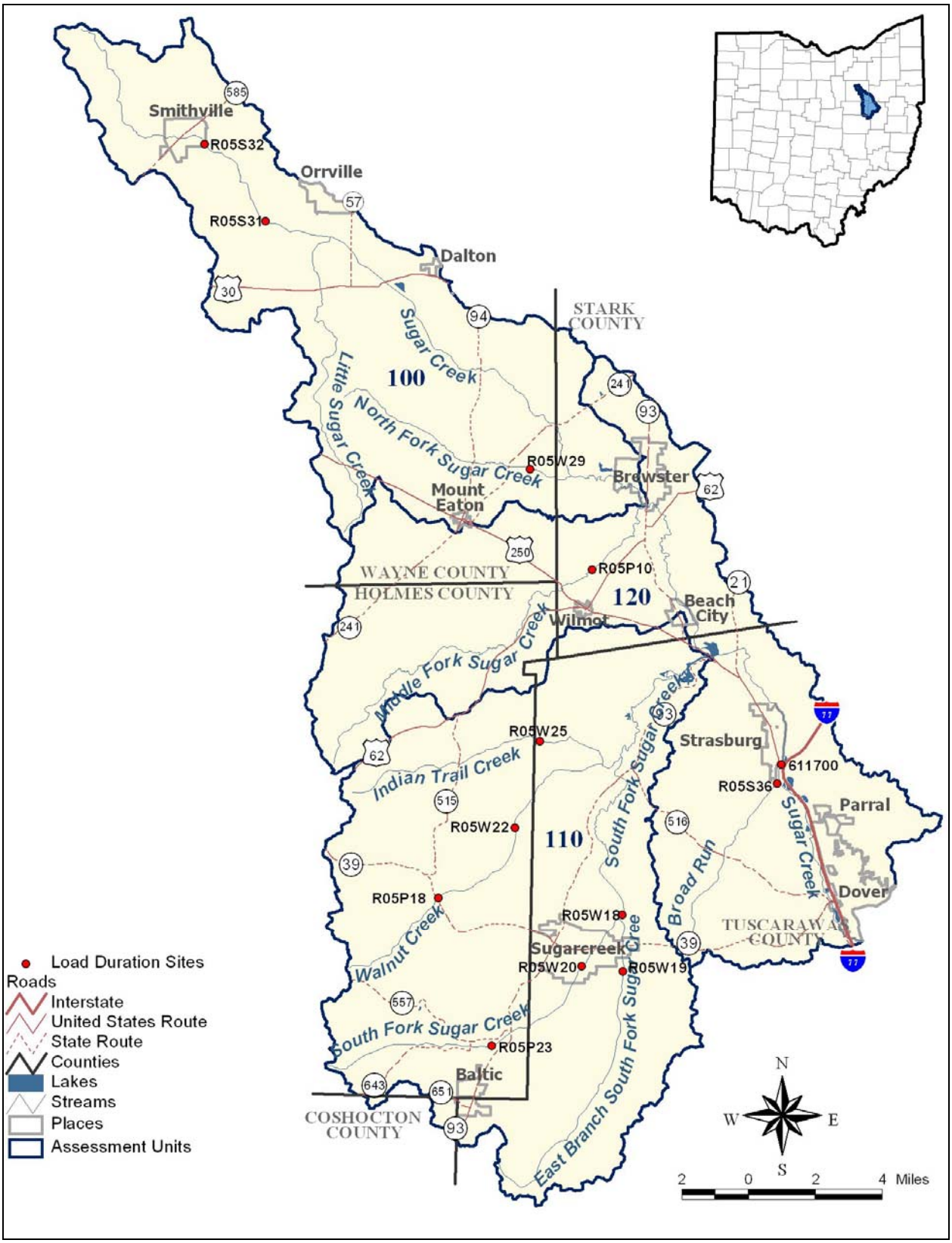

Figure 3-1. Location of load duration sites.

4.0 TMDL RESULTS

Load duration analyses were conducted for all sites with a sufficient number of samples (more than 10 typically) within each of the three major assessment units. Most of the fecal coliform data used in the analyses resulted from the extensive sampling conducted by OEPA during the summer of 2005. Additional samples were also available from sampling conducted by the Ohio Agricultural Research and Development Center (OARDC[1]) in 2002 and 2003 and some data were from the routine in-stream sampling performed by several of the larger wastewater treatment plants in the watershed. Summary statistics are presented separately for each of the data sources but the data were merged when conducting the load duration curve analysis.

4.1 Assessment Unit 100: Sugar Creek Headwaters

The load duration approach was applied to three sites located within AU100. As shown in Figure 4-1, two sites are located on Sugar Creek at OEPA stations R05S31 and R05S32 and one site is located on the North Fork Sugar Creek at OEPA station R05W29. For each load duration site, all appropriate and available fecal coliform and flow data were used.

[1] It should be noted that the specific locations of the OARDC monitoring sites were not available and therefore they could not always be included in the figures in this report.

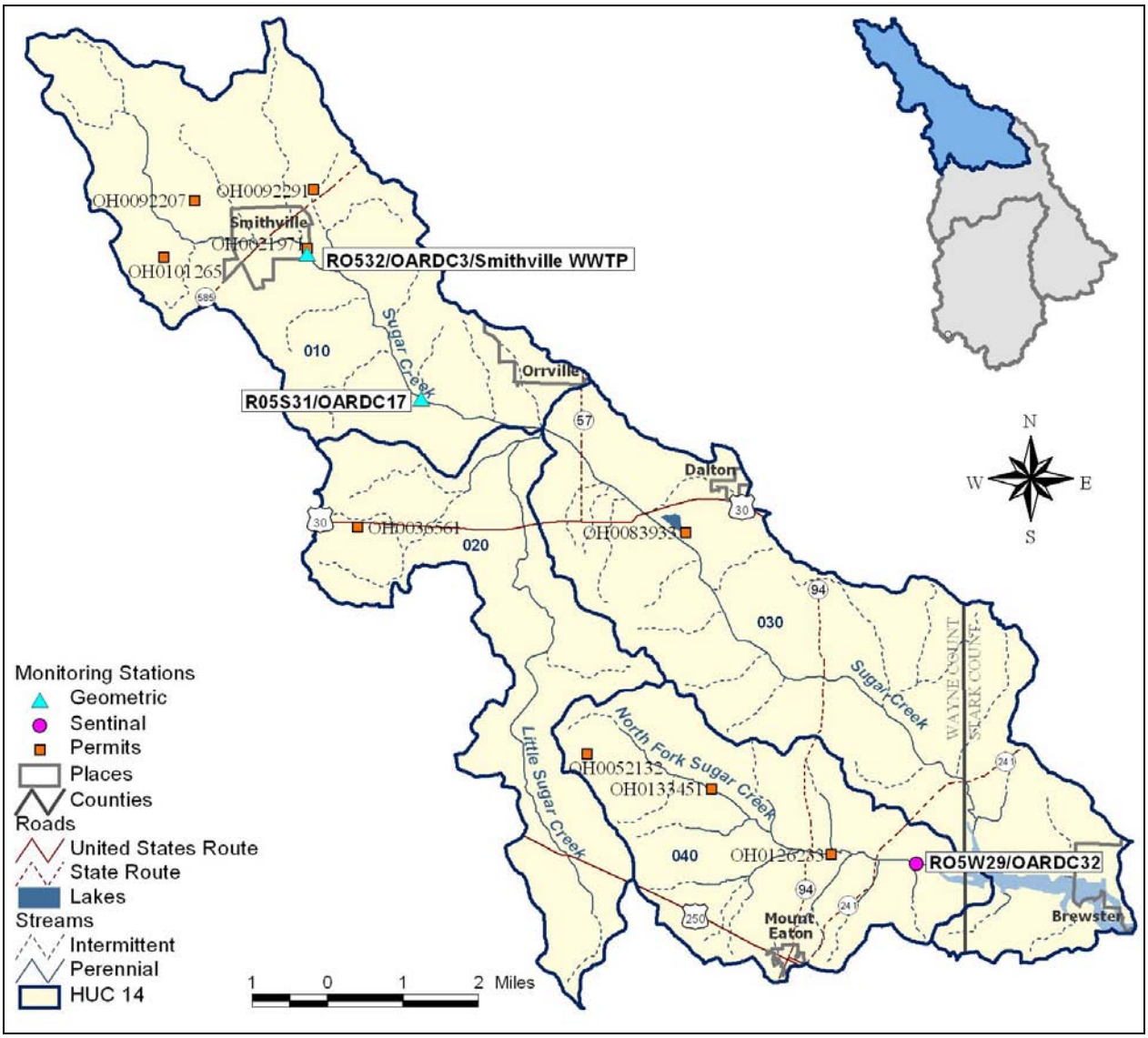

Figure 4-1. Load duration sites within the Sugar Creek Headwaters, AU 05040001100.

4.1.1 Sugar Creek (R05S31)

Monitoring site R05S31 is located on Sugar Creek at Orr Road and sixteen fecal coliform observations are available for the load duration analysis. Table 4-1 summarizes the number of observations, geometric mean, minimum and maximum values, and the period of record for each monitoring station used in the analyses of this load duration site. Figure 4-2 presents the number of observations for each of the ten flow duration percentiles. Most of the observed fecal coliform data were collected during wet weather flow conditions (moist and mid-range zones). Additionally, observed geometric mean and maximum fecal coliform values are much greater in the OARDC samples collected two to three years prior to the sampling performed by OEPA.

Table 4-1. Summary of Available Fecal Coliform Data for Load Duration Site R05S31.

Monitoring Station	Count	Geometric Mean (#/100 mL)	Min (#/100 mL)	Max (#/100 mL)	Period of Record
R05S31	5	777	310	1,300	7-26-05 to 9-13-05
OARDC 17	11	1,463	310	13,000	6-10-02 to 8-13-03

The allowable fecal coliform loads along with the observed fecal coliform loads are presented in Figure 4-3. The figure shows that eight of the fecal coliform observations exceeded the criterion of 1,000 cfu/100 mL. The greatest exceedence of the standard occurred during extreme high flow conditions. The other exceedences of the standard occurred during moist, dry, and low flow zones.

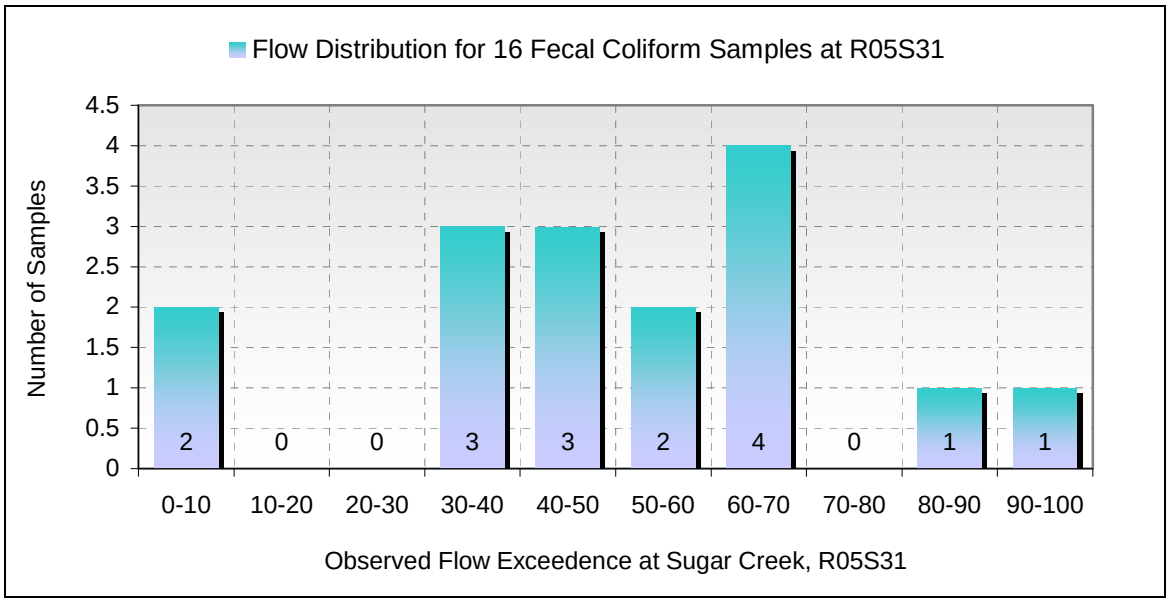

Figure 4-2. Summary of flow and fecal coliform sample distribution at load duration site R05S31.

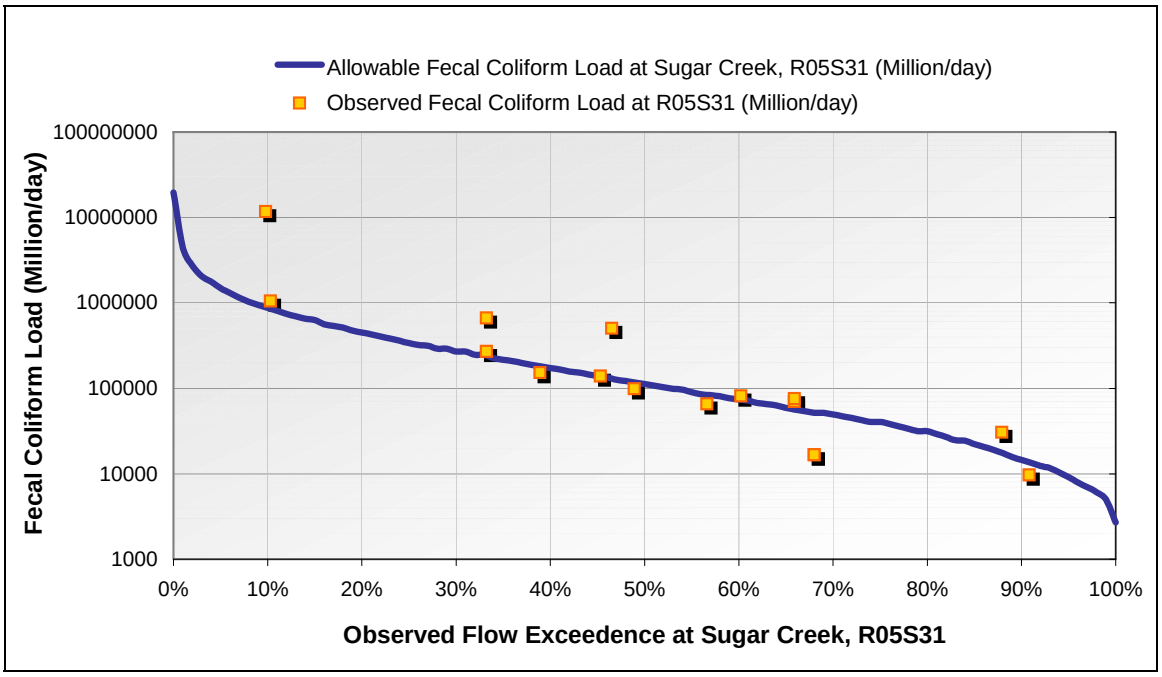

Figure 4-3. Existing fecal coliform loading and loading capacity for load duration site R05S31.

The calculated existing and allowable loads were grouped based on duration curve zones and Table 4-2 summarizes the median of existing loads for each of the duration curve zones. Table 4-2 indicates that fecal coliform loads need to be reduced by approximately 77 percent during periods of extremely high flows, 21 percent for moist conditions, 27 percent for dry conditions, and 6 percent for very low flows. Sources of fecal coliform loads appear to be associated with both wet weather and dry weather flows (see Section 5.1 for more discussion of sources).

Table 4-2. Fecal Coliform Loading Statistics for Load Duration Site R05S31.

Zone	Flow Exceedence Ranges	16-Sample Distribution	Median Observed Flow (cfs)	Allowable Load (Million/day)	Observed Load (Million/day)	Estimated Reduction (%)
High Flows	0-10	2	60.65	1,483,946	6,371,974	76.7%
Moist Conditions	10-20	0	25.73	629,553	No Data	No Data
	20-30	0	13.79	337,260	No Data	No Data
	30-40	3	8.82	215,847	272,057	20.7%
Mid-Range Flows	40-50	3	5.70	139,401	139,401	0.0%
	50-60	2	3.68	89,936	73,703	0.0%
Dry Conditions	60-70	4	2.42	59,133	43,439	0.0%
	70-80	0	1.65	40,471	No Data	No Data
	80-90	1	0.92	22,484	30,578	26.5%
Low Flows	90-100	1	0.38	9,218	9,738	5.3%

4.1.2 Sugar Creek (R05S32)

Sixteen fecal coliform observations are available for the load duration analysis at site R05S32, which is located just downstream of Smithville. Limited data are available upstream of this site. Table 4-3 summarizes the number of observations, geometric mean, minimum and maximum values, and the period of record for each monitoring station used in the analyses for this load duration site. Similar conditions were observed during the OARDC and OEPA sampling periods. Figure 4-4 presents the number of observations for each of the duration curve zones and shows that most of the observed fecal coliform data are from the moist to mid-range zones, which represent wet weather and median flow conditions.

Table 4-3. Summary of Available Fecal Coliform Data for Load Duration Site R05S32.

Monitoring Station	Count	Geometric Mean (#/100 mL)	Min (#/100 mL)	Max (#/100 mL)	Period of Record
R05S32	5	1,266	440	11,000	7-26-05 to 9-13-05
OARDC 3	11	1,412	320	10,000	6-10-02 to 8-13-03

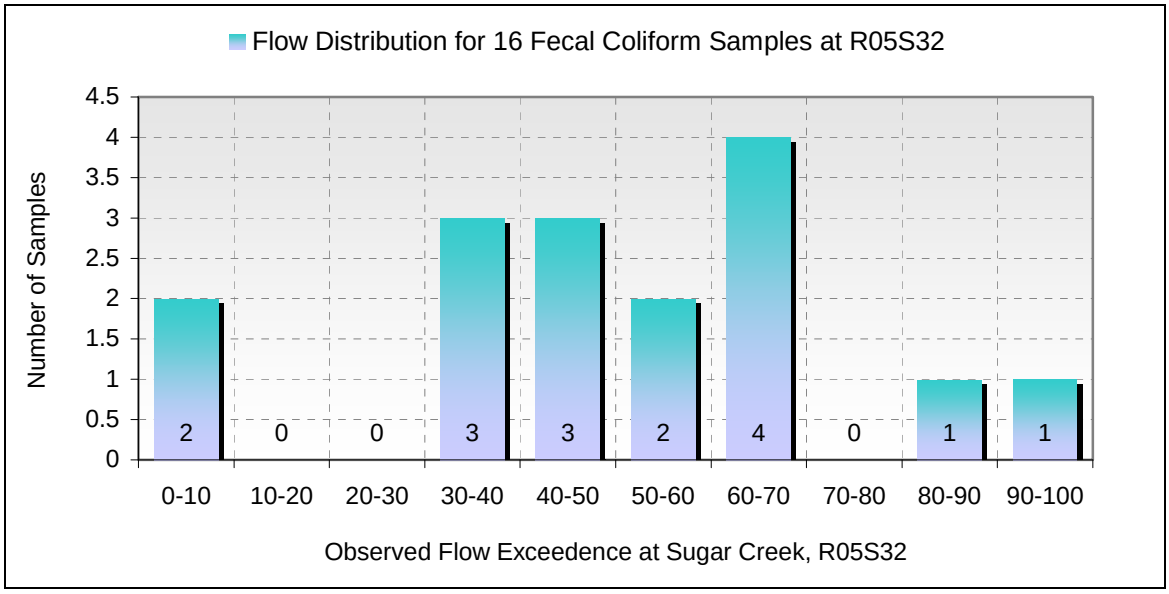

Figure 4-4. Summary of flow and fecal coliform sample distribution at load duration site R05S32.

The allowable and observed fecal coliform loads are presented in Figure 4-5. The figure shows that nine of the fecal coliform observations exceed the 1000 cfu/100 mL criterion and exceedances occur in all five hydrologic zones. The most significant reductions are needed for high flow conditions. The calculated existing loads were grouped based on duration curve hydrologic zones and are summarized in Table 4-4. Significant load reductions are needed for wet weather flow regimes.

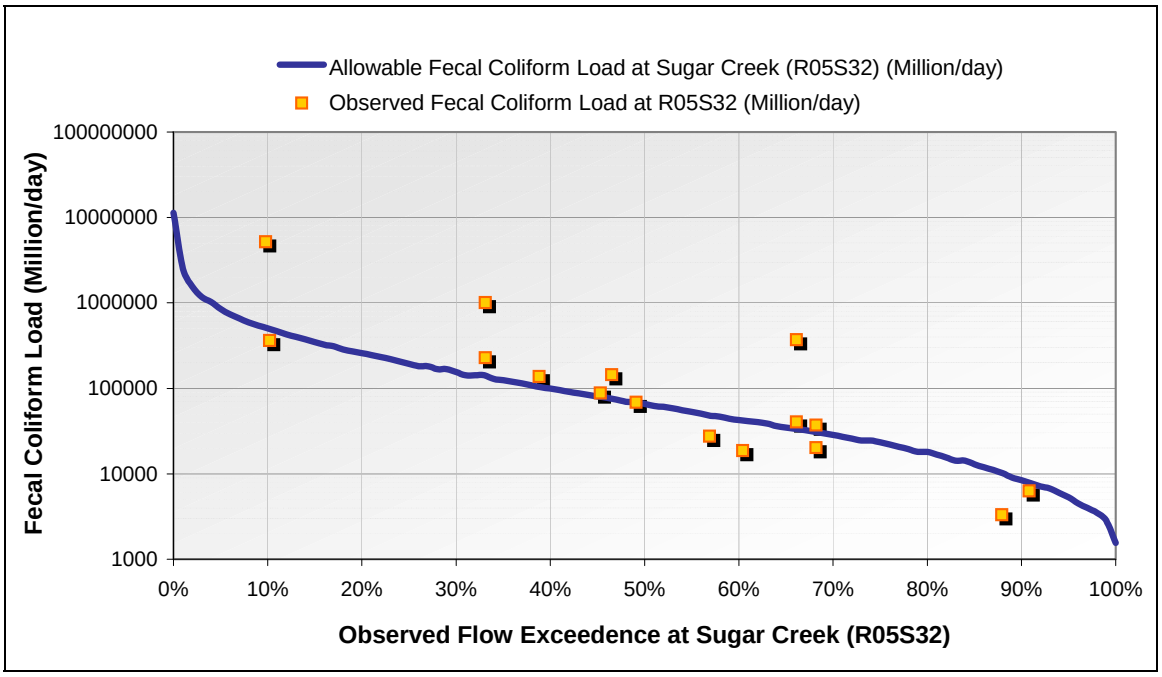

Figure 4-5. Existing fecal coliform loading and loading capacity for load duration site R05S32.

Table 4-4. Summary of Available Fecal Coliform Data for Load Duration Site R05S32.

Zone	Flow Exceedence Ranges	16-Sample Distribution	Median Observed Flow (cfs)	Allowable Load (Million/day)	Observed Load (Million/day)	Estimated Reduction (%)
High Flows	0-10	2	34.91	854,197	2,770,188	69.2%
Moist Conditions	10-20	0	14.81	362,387	No Data	No Data
	20-30	0	7.94	194,136	No Data	No Data
	30-40	3	5.08	124,247	227,786	45.5%
Mid-Range Flows	40-50	3	3.28	80,243	88,267	9.1%
	50-60	2	2.12	51,770	23,167	0.0%
Dry Conditions	60-70	4	1.43	34,944	38,827	10.0%
	70-80	0	0.95	23,296	No Data	No Data
	80-90	1	0.53	12,942	3,313	0.0%
Low Flows	90-100	1	0.22	5,306	6,316	16.0%

4.1.3 North Fork Sugar Creek (R05W29)

A total of twenty-four fecal coliform samples[2] were available for the load duration analysis at site R05W29, which is located on the North Fork of Sugar Creek at West Lebanon Road. Table 4-5 summarizes the number of observations, geometric mean, minimum and maximum values, and the period of record for each monitoring station used in the analyses. Figure 4-6 presents the number of observations for each of the duration curve hydrologic zones and shows that most data are from the mid-range to high flow conditions. Additionally, the geometric mean, minimum and maximum of fecal coliform samples are much greater in the OEPA data set collected two to three years after sampling was performed by the OARDC.

Table 4-5. Summary of Available Fecal Coliform Data for Load Duration Site R05W29.

Monitoring Station	Count	Geometric Mean (#/100 mL)	Min (#/100 mL)	Max (#/100 mL)	Period of Record
R05W29	13	7,323	1,200	160,000	7-21-05 to 10-11-05
OARDC 32	11	3,434	200	20,000	6-10-02 to 8-13-03

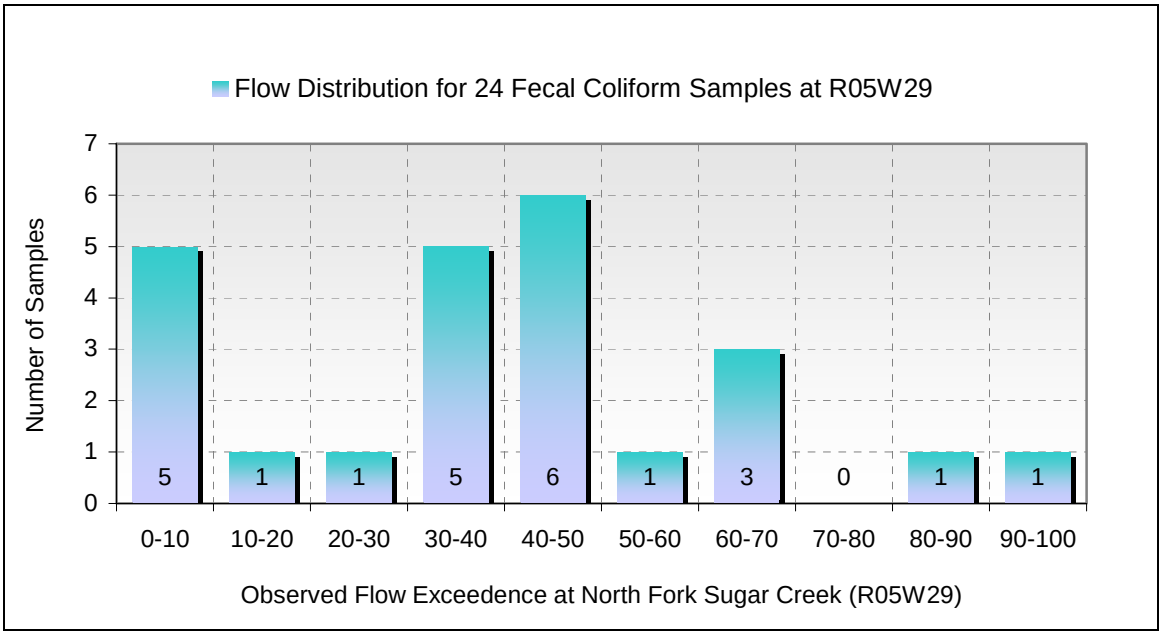

Figure 4-6. Summary of flow and fecal coliform sample distribution at load duration site R05W29.

Figure 4-7 shows that twenty-three of the twenty-four fecal coliform observations exceed the loading limit. The loading limit is exceeded within each hydrologic zone for which observed data are available. The greatest exceedence of the standard occurs in the high flow zone, which represents extreme high flow conditions. Furthermore, loading limits are exceeded in the dry and low flow hydrologic zones. These zones represent low flow conditions, and such loading limit exceedences suggest a persistent source of fecal coliform such as failing onsite wastewater systems or livestock with direct access to the stream.

[2] Two fecal coliform samples were collected at two different times at R05W29 on October 11, 2005. These two samples were averaged and the mean value was used in the load duration analysis.

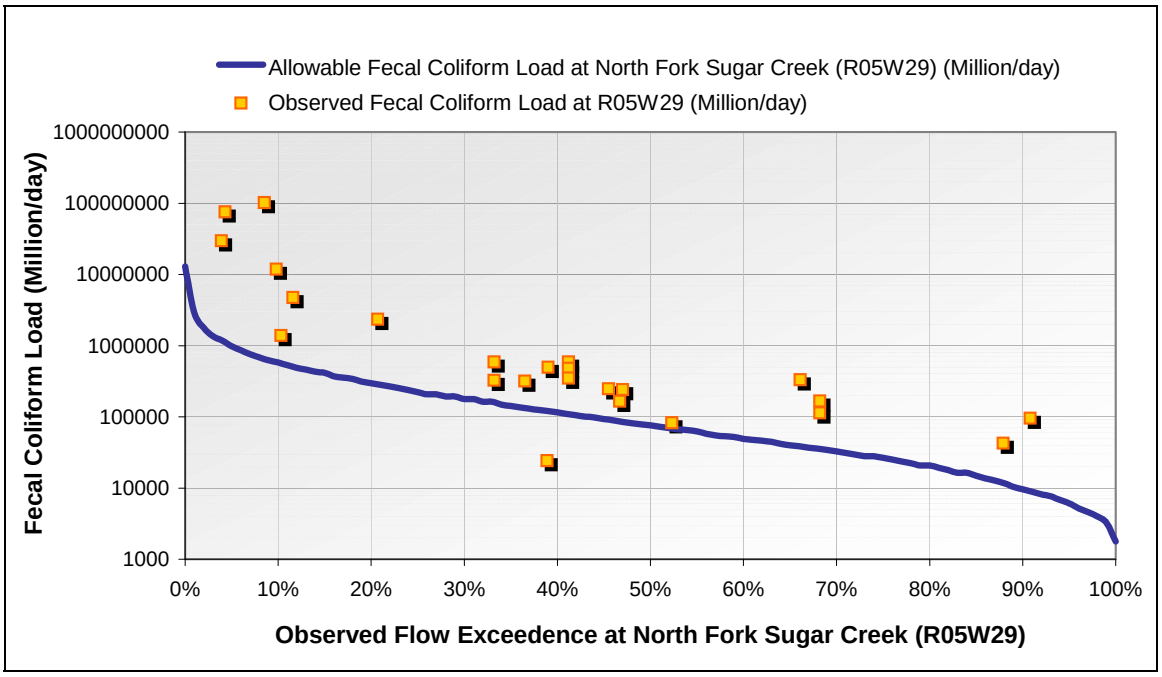

Figure 4-7. Existing fecal coliform loading and loading capacity for load duration site R05W29.

The calculated existing loads were grouped based on duration curve hydrologic zones and are summarized in Table 4-6. Significant load reductions are needed across all flow regimes.

Table 4-6. Summary of Available Fecal Coliform Data for Load Duration Site R05W29.

Zone	Flow Exceedence Ranges	24-Sample Distribution	Median Observed Flow (cfs)	Allowable Load (Million/day)	Observed Load (Million/day)	Estimated Reduction (%)
High Flows	0-10	5	40.06	980,147	29,719,372	96.7%
Moist Conditions	10-20	1	17.00	415,820	4,746,034	91.2%
	20-30	1	9.11	222,761	2,338,645	90.5%
	30-40	5	5.83	142,567	326,716	56.4%
Mid-Range Flows	40-50	6	3.82	93,559	298,790	68.7%
	50-60	1	2.55	62,373	82,892	24.8%
Dry Conditions	60-70	3	1.64	40,097	167,516	76.1%
	70-80	0	1.09	26,731	No Data	No Data
	80-90	1	0.61	14,851	42,770	65.3%
Low Flows	90-100	1	0.25	6,089	96,025	93.7%

It should be noted that two monitoring sites located upstream of R05W29 recorded much lower fecal coliform levels compared to R05W29, as presented in Figure 4-8. In fact, the upper reaches of the North Fork Sugar Creek, showed marked improvement since sampling conducted in 1998, with both sites in the vicinity of the Village of Kidron in full attainment for the recreational use criteria. Construction of a wastewater treatment plant serving the Village of Kidron appears to have successfully addressed bacteria pollution issues in this reach of the North Fork Sugar Creek (OEPA, 2006).

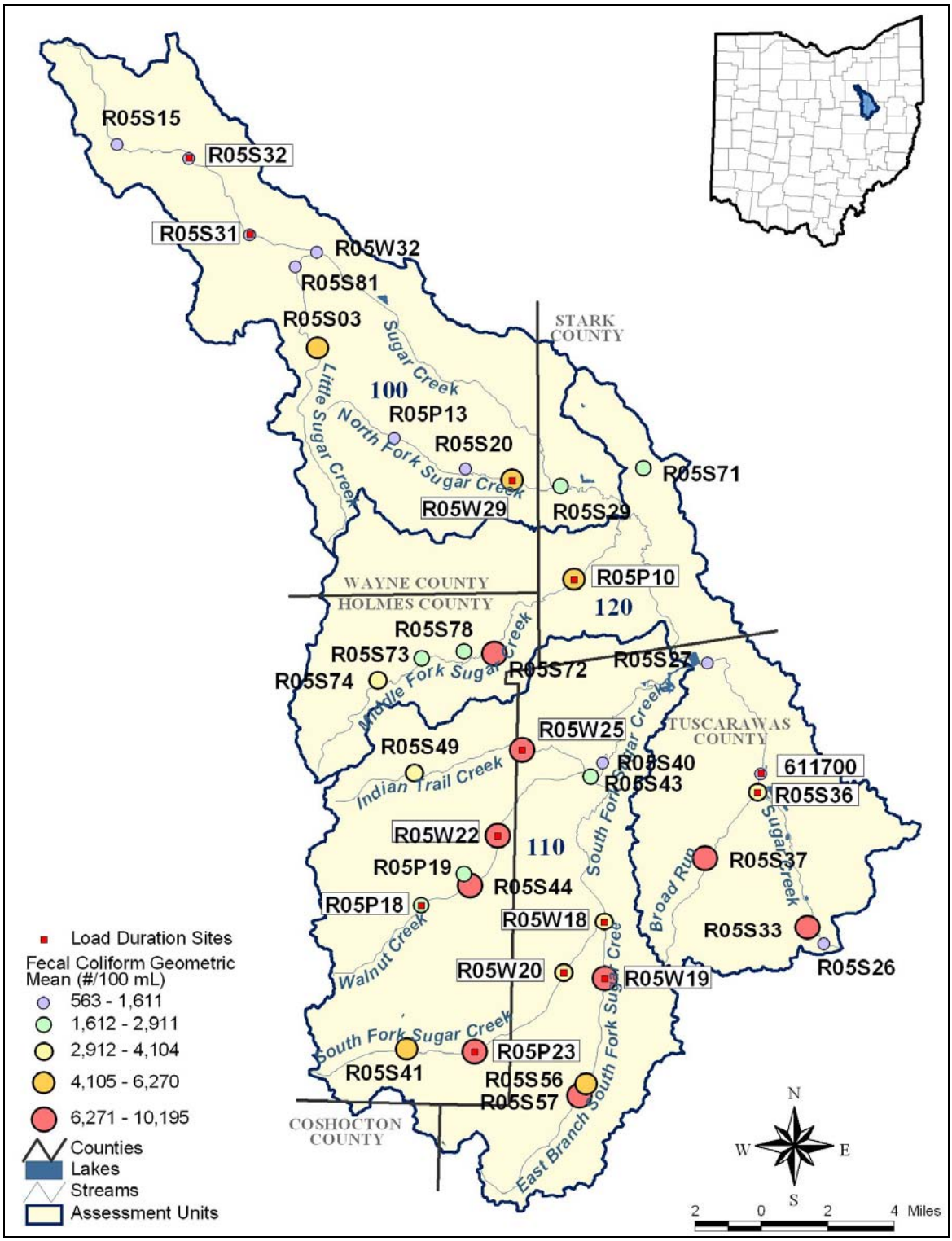

Figure 4-8. Fecal coliform geometric means for load duration curve sites within the Sugar Creek watershed.

4.1.4 Assessment Unit 100 Allocations

The allocations of loads for the assessment unit 100 TMDLs are summarized in Table 4-7. Loads are expressed for the May 1 to October 15 time period to be consistent with Ohio's water quality standards. Since there are 167 days between May 1 and October 15, the current load and the loading capacity are based on the daily loads from the load duration curve analysis multiplied by 16.7 days for each of the 10 flow percentiles. The 10 flow percentile loads are then summed to get a load per recreation season[3].

The wasteload allocations shown in Table 4-7 are based on the design flows of each facility upstream of a given load duration site multiplied by its permit limit; the individual WLAs are shown in Table 4-8. Table 4-7 also presents the current fecal coliform loads at each monitoring site on a per unit area or "normalized" basis. This information has been used to derive an estimated average loading rate of 2.75E+10 cfu/acre/recreation season for this assessment unit. This rate is lower than the rates in assessment units 110 and 120 (see Sections 4.2.8 and 4.3.4 for more details).

The Clean Water Act requires that a TMDL include a margin of safety (MOS) to account for any lack of knowledge concerning the relationship between load and wasteload allocations and water quality. USEPA guidance explains that the MOS may be implicit (i.e., incorporated into the TMDL through conservative assumptions in the analysis) or explicit (i.e., expressed in the TMDL as loadings set aside for the MOS). An explicit MOS of 10 percent has been applied as part of this TMDL and is shown in Table 4-7. USEPA has not published any guidance on how to set an explicit MOS and 10 percent is generally used when the uncertainty in the analysis is considered typical.

Table 4-7. TMDL Summary for AU100.

Category	Load Duration Site		
	R05S31	R05S32	R05W29
Current Load (cfu/rec season)	2.01E+14	9.14E+13	6.33E+14
Loading Capacity (cfu/rec season)	5.06E+13	2.91E+13	3.35E+13
Wasteload Allocation (cfu/rec season)	2.53E+12	2.53E+12	2.89E+12
Margin of Safety (cfu/rec season)	5.06E+12	2.91E+12	3.35E+12
Load Allocation (cfu/rec season)	4.30E+13	2.37E+13	2.72E+13
Point Source Reductions (percent)	0%	0%	0%
Nonpoint Source Reductions (percent)	78%	73%	96%
Normalized Current Load (cfu/acre/rec season)	1.26E+10	9.91E+09	6.00E+10

[3] In some cases current loads and loading capacities had to be estimated for flow percentiles for which fecal coliform data were not available. In these cases the loads were based on the loads for the next highest and next lowest flow percentile.

Table 4-8. WLAs for facilities within AU100.

Facility	US EPA ID	Design Flow (mgd)	Design Flow (Liters from May 1 to Oct 15)	FC Limit (#/100 mL)	WLA (#/rec season)
Wayne County Airport	OH0092207	0.002	1,271,760	1000	1.27E+10
Smithville Western	OH0101265	0.090	57,229,200	1000	5.72E+11
Smithville MHP	OH0092291	0.006	3,815,280	1000	3.82E+10
Smithville WWTP	OH0021971	0.300	190,764,000	1000	1.91E+12
Gerber's Poultry Inc	OH0052132	0.250	158,970,000	1000	1.59E+12
Kidron WWTP	OH0133451	0.160	101,740,800	1000	1.02E+12
Mount Eaton WWTP	OH0126233	0.045	28,614,600	1000	2.86E+11
Lake Harmony Subdivision	OH0083933	0.036	22,891,680	1000	2.29E+11
Wayne Co. Eastwood Subdivision STP	OH0036561	0.060	38,152,800	1000	3.82E+11

The Clean Water Act also requires that TMDLs take into account critical conditions for stream flow, loading, and water quality parameters as part of the analysis of loading capacity. Through the load duration curve approach the critical conditions (the periods when the greatest reductions are required) have been identified for each load duration site. The allocation of point source loads (i.e., the WLA) takes into account critical conditions by assuming the point sources will always discharge at the facility's maximum design flows and right at their permit limits. In reality, the loads from these facilities are usually much less.

The Clean Water Act also requires that TMDLs be established with consideration of seasonal variations. Seasonal variations are addressed in this TMDL by only assessing conditions during the season when the water quality standard applies (May through October). The load duration approach also accounts for seasonality by evaluating allowable loads over the entire range of observed flows.

4.2 Assessment Unit 110: South Fork Sugar Creek

The load duration approach was applied to seven sites located within AU100. As shown in Figure 4-9, three sites are located on South Fork Sugar Creek at OEPA stations R05P23, R05W20, and R05W18. One site is located on East Branch South Fork Sugar Creek at OEPA station R05W19, and two sites are located on Walnut Creek at OEPA stations R05P18 and R05W22. Additionally, one site is located on Indian Trail Creek at OEPA station R05W25. For each load duration site, all appropriate and available fecal coliform and flow data were used.

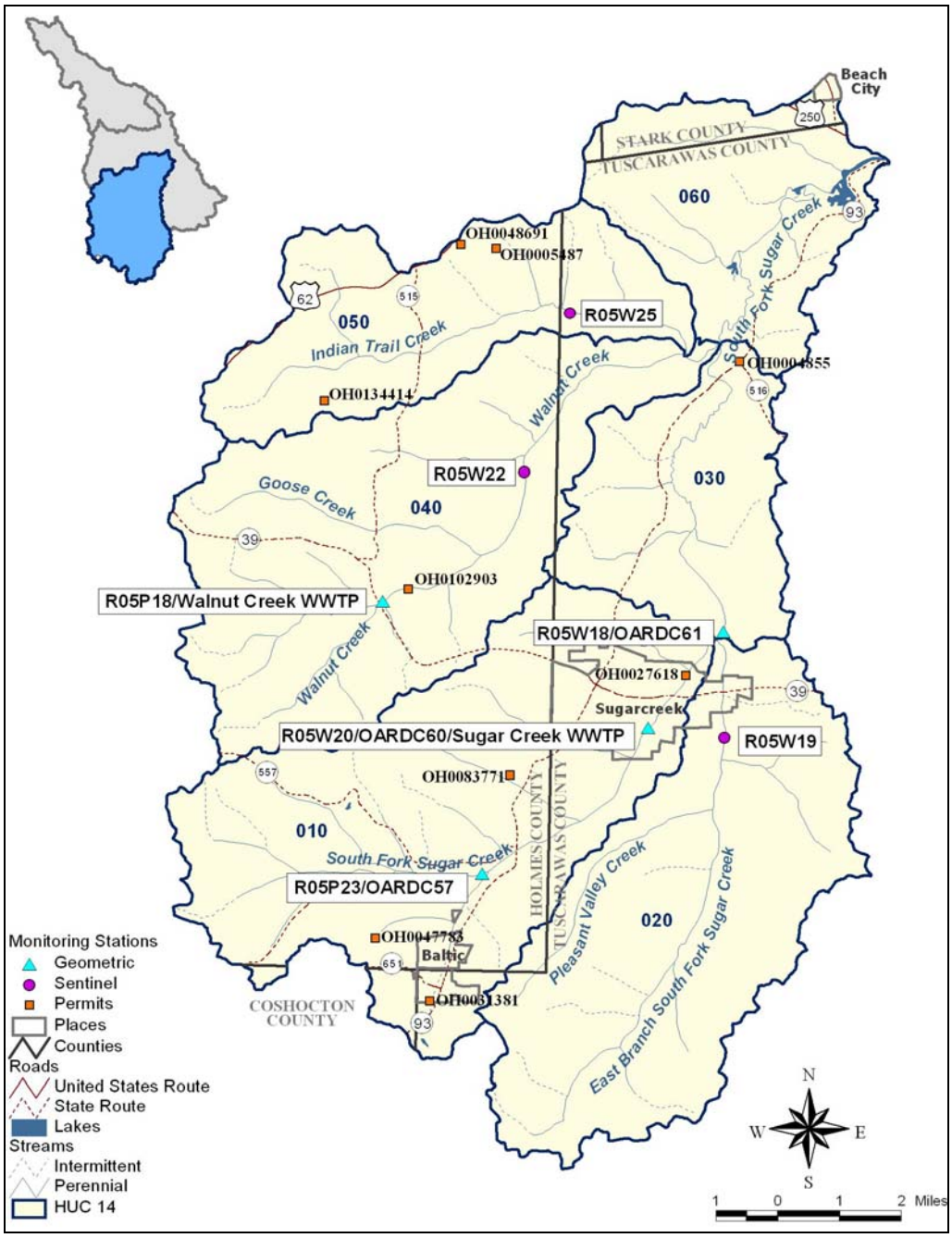

Figure 4-9. Load duration sites within the Sugar Creek Headwaters, AU 05040001110.

4.2.1 South Fork Sugar Creek (R05P23)

A total of fifteen fecal coliform observations are available for the load duration analysis at site R05P23. Five samples were collected by OEPA at station R05P23, and ten samples were collected at OARDC site 57, which is located approximately 0.67 miles upstream of R05P23. Table 4-9 summarizes the number of observations, geometric mean, minimum and maximum values, and the period of record for each monitoring station used in the analyses for this load duration site. The OEPA and the OARDC observed very similar geometric mean, minimum and maximum fecal coliform levels during their respective

sampling periods. Figure 4-10 presents the number of observations for each of the duration curve zones and shows that most of the observed fecal coliform data were collected during average flow conditions.

Table 4-9. Summary of Available Fecal Coliform Data for Load Duration Site R05P23.

Monitoring Station	Count	Geometric Mean (#/100 mL)	Min (#/100 mL)	Max (#/100 mL)	Period of Record
R05P23	5	8,169	3,300	19,000	7-26-05 to 9-12-05
OARDC 57	10	7,427	3,300	20,000	6-10-02 to 8-13-03

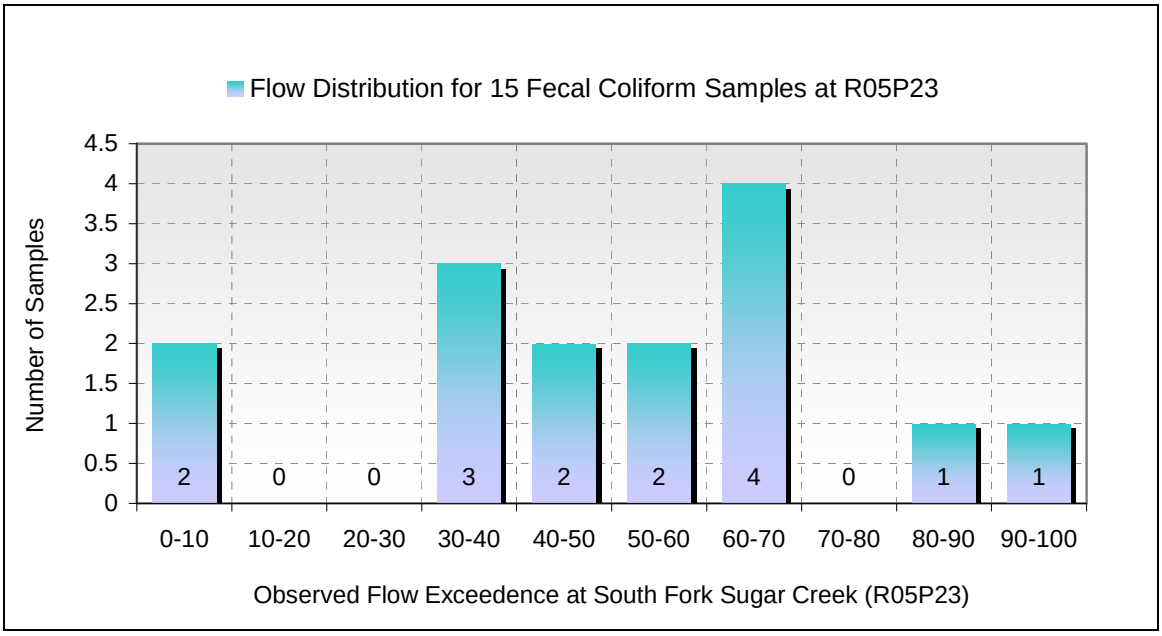

Figure 4-10. Summary of flow and fecal coliform sample distribution at load duration site R05P23.

The allowable and observed fecal coliform loads are presented in Figure 4-11. The figure shows that all of the observed coliform observations exceed the 1000 cfu/100 mL criterion. Table 4-10 summarizes the median of existing allowable loads for each of the duration curve zones. The table shows that significant levels of reduction are required for all observed flow conditions, and that the greatest level of reduction (nearly 95 percent) is needed for the low flow condition. Such a large reduction in this flow zone suggests a persistent source of fecal coliform such as failing onsite wastewater systems or livestock with direct access to the stream.

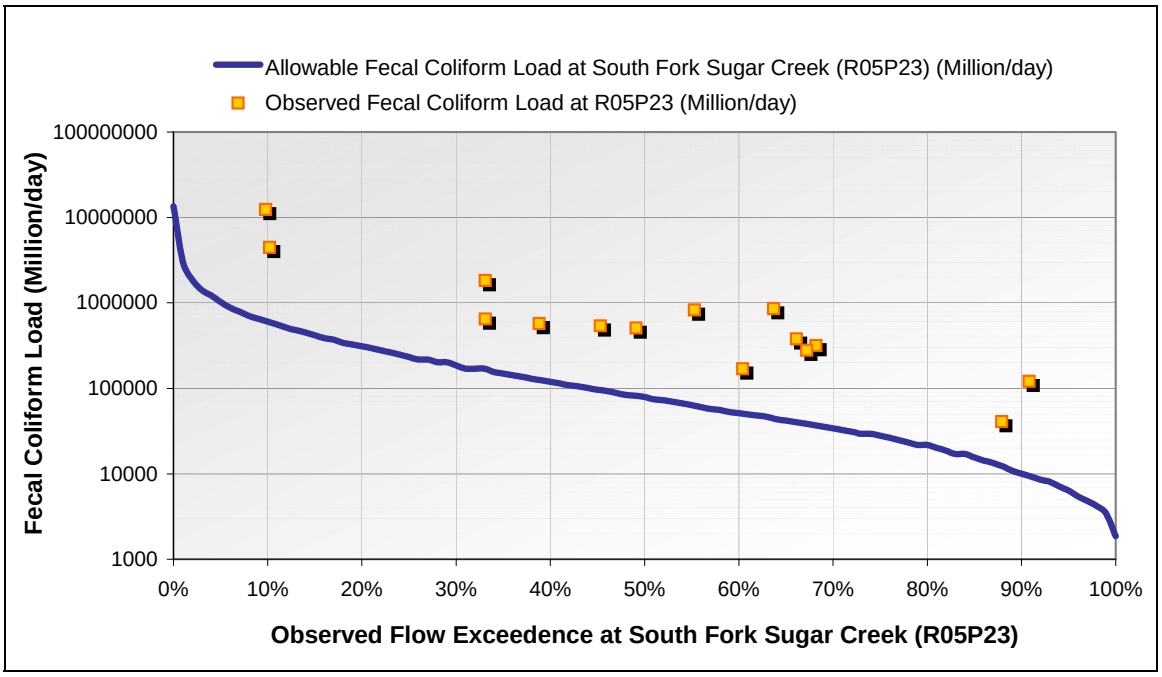

Figure 4-11. Existing fecal coliform loading and loading capacity for load duration site R05P23.

Table 4-10. Summary of Available Fecal Coliform Data for Load Duration Site R05P23.

Zone	Flow Exceedence Ranges	15-Sample Distribution	Median Observed Flow (cfs)	Allowable Load (Million/day)	Observed Load (Million/day)	Estimated Reduction (%)
High Flows	0-10	2	41.78	1,022,194	8,442,795	87.9%
Moist Conditions	10-20	0	17.12	418,805	No Data	No Data
	20-30	0	9.51	232,669	No Data	No Data
	30-40	3	6.09	148,908	648,372	77.0%
Mid-Range Flows	40-50	2	3.93	96,170	524,126	81.7%
	50-60	2	2.60	63,596	497,835	87.2%
Dry Conditions	60-70	4	1.71	41,880	347,763	88.0%
	70-80	0	1.14	27,920	No Data	No Data
	80-90	1	0.63	15,511	40,950	62.1%
Low Flows	90-100	1	0.26	6,360	121,112	94.7%

Four monitoring stations, located on the South Fork Sugar Creek approximately 2.0 and 1.45 miles upstream of R05P23 and OARDC 57, respectively (see Figure 4-8), have sampled fecal coliform and these data are summarized in Table 4-11. The table shows that geometric means, and minimum and maximum fecal coliform levels, are similar to those observed at R05P23 and OARDC 57, which suggests that high levels of fecal coliform are present throughout this reach of the South Fork Sugar Creek.

Table 4-11. Summary of Available Fecal Coliform Data Upstream of Site R05P23.

Monitoring Station	Count	Geometric Mean (#/100 mL)	Min (#/100 mL)	Max (#/100 mL)	Period of Record
OEPA R05S41	5	6,270	3,300	28,000	7-26-05 to 9-12-05
OARDC 52	11	6,019	3,400	20,000	6-10-02 to 8-13-03
OARDC 53	11	6,780	3,800	20,000	6-10-02 to 8-13-03
OARDC 54	11	7,576	980	20,000	6-10-02 to 8-13-03

4.2.2 South Fork Sugar Creek (R05W20)

A total of twenty-eight fecal coliform observations are available for the load duration analysis at site R05W20. Limited data are available upstream of this site. Table 4-12 summarizes the number of observations, geometric mean, minimum and maximum values, and the period of record for each monitoring station used in the analyses for this load duration site. The geometric mean and maximum of fecal coliform samples are greater in the OARDC data set collected two to three years prior to the sampling performed by the OEPA. The OEPA and the Sugar Creek wastewater treatment plant observed similar fecal coliform levels during their respective sampling periods. Figure 4-12 presents the number of observations for each of the duration curve zones and shows that the observed fecal coliform data are fairly well distributed across the entire flow regime.

Table 4-12. Summary of Available Fecal Coliform Data for Load Duration Site R05W20.

Monitoring Station	Count	Geometric Mean (#/100 mL)	Min (#/100 mL)	Max (#/100 mL)	Period of Record
R05W20	5	4,251	1,800	8,700	7-26-05 to 9-12-05
OARDC 60	11	5,387	1,800	20,000	6-10-02 to 8-13-03
Sugar Creek WWTP	12	2,161	282	9,500	6-23-99 to 8-08-04

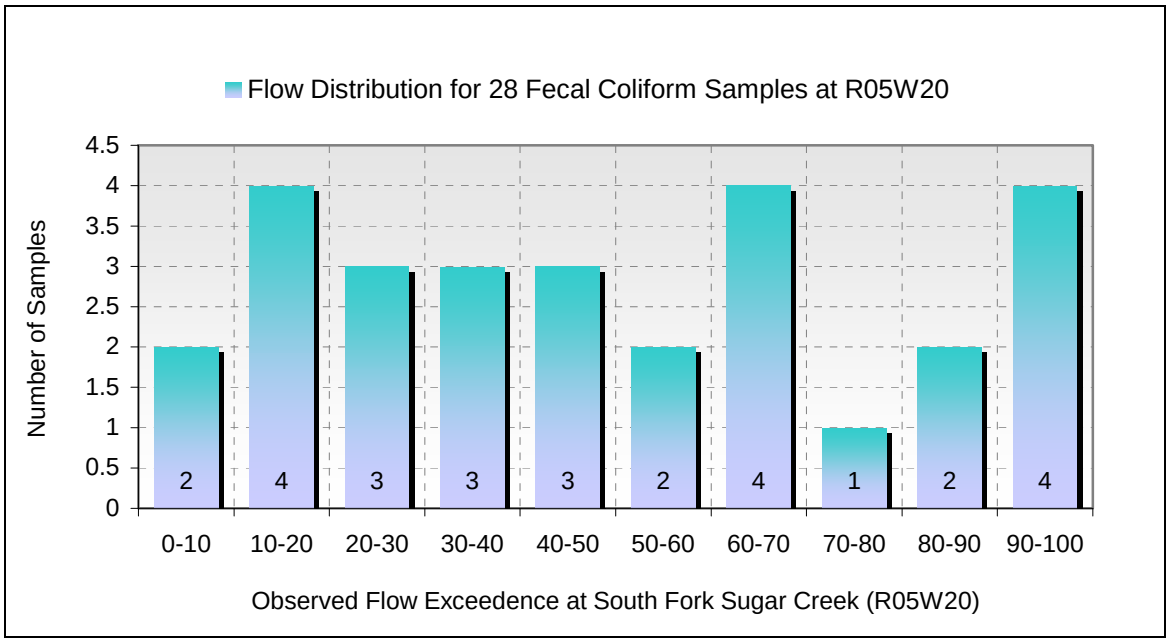

Figure 4-12. Summary of flow and fecal coliform sample distribution at load duration site R05W20.

The allowable and observed fecal coliform loads are presented in Figure 4-13. The figure shows that twenty-six of the twenty-eight fecal coliform observations exceed the 1000 cfu/100 mL criterion, and exceedances occur in all five hydrologic zones. Table 4-13 summarizes the median of existing allowable loads for each of the duration curve zones, and suggests that the greatest levels of reduction are needed for the mid-range through high flow conditions. Furthermore, Table 4-13 shows that a 54 percent reduction is required for the low flow hydrologic zone. Such a large reduction in this flow zone suggests a persistent source of fecal coliform such as failing onsite wastewater systems or livestock with direct access to the stream.

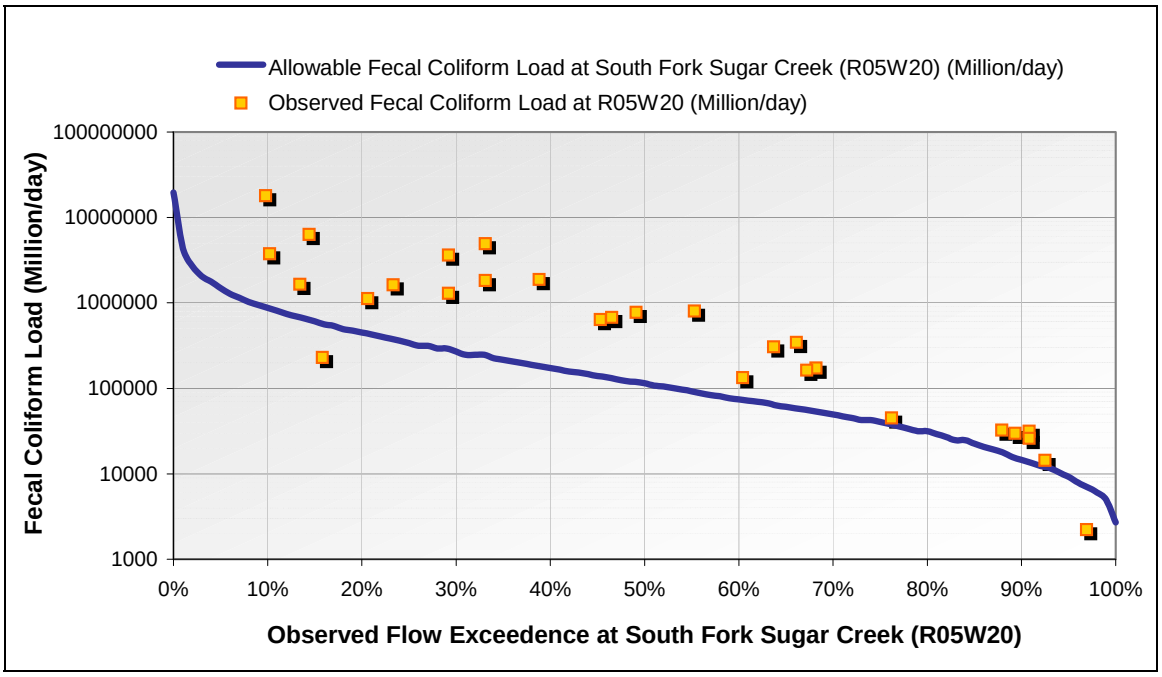

Figure 4-13. Existing fecal coliform loading and loading capacity for load duration site R05W20.

Table 4-13. Summary of Available Fecal Coliform Data for Load Duration Site R05W20.

Zone	Flow Exceedence Ranges	28-Sample Distribution	Median Observed Flow (cfs)	Allowable Load (Million/day)	Observed Load (Million/day)	Estimated Reduction (%)
High Flows	0-10	2	60.57	1,481,859	10,880,081	86.4%
Moist Conditions	10-20	4	24.82	607,135	1,386,808	56.2%
	20-30	3	13.79	337,297	1,624,648	79.2%
	30-40	3	8.82	215,870	1,880,769	88.5%
Mid-Range Flows	40-50	3	5.70	139,416	676,618	79.4%
	50-60	2	3.77	92,195	467,831	80.3%
Dry Conditions	60-70	4	2.48	60,713	239,593	74.7%
	70-80	1	1.65	40,476	45,108	10.3%
	80-90	2	0.92	22,486	31,144	27.8%
Low Flows	90-100	4	0.38	9,219	20,195	54.3%

Monitoring data show that although fecal coliform bacteria levels are high at station R05W20, they are lower relative to those sampled upstream at R05P23 and R05S41 (see Table 4-9 and Figure 4-8). This suggests that the primary sources of fecal coliform are located upstream and some die-off has occurred by the time the stream reaches site R05W20.

4.2.3 East Branch South Fork Sugar Creek (R05W19)

A total of twelve fecal coliform observations are available for the load duration analysis at site R05W19. Table 4-14 summarizes the geometric mean, minimum and maximum values, and the period of record for the monitoring station used in the analyses for this load duration site. Figure 4-14 presents the number of observations for each of the duration curve zones. The figure shows that no fecal coliform data have been collected during periods corresponding to dry and low flow conditions.

Table 4-14. Summary of Available Fecal Coliform Data for Load Duration Site R05W19.

Monitoring Station	Count	Geometric Mean (#/100 mL)	Min (#/100 mL)	Max (#/100 mL)	Period of Record
R05W19	12	10,195	2,400	24,000	7-21-05 to 10-11-05

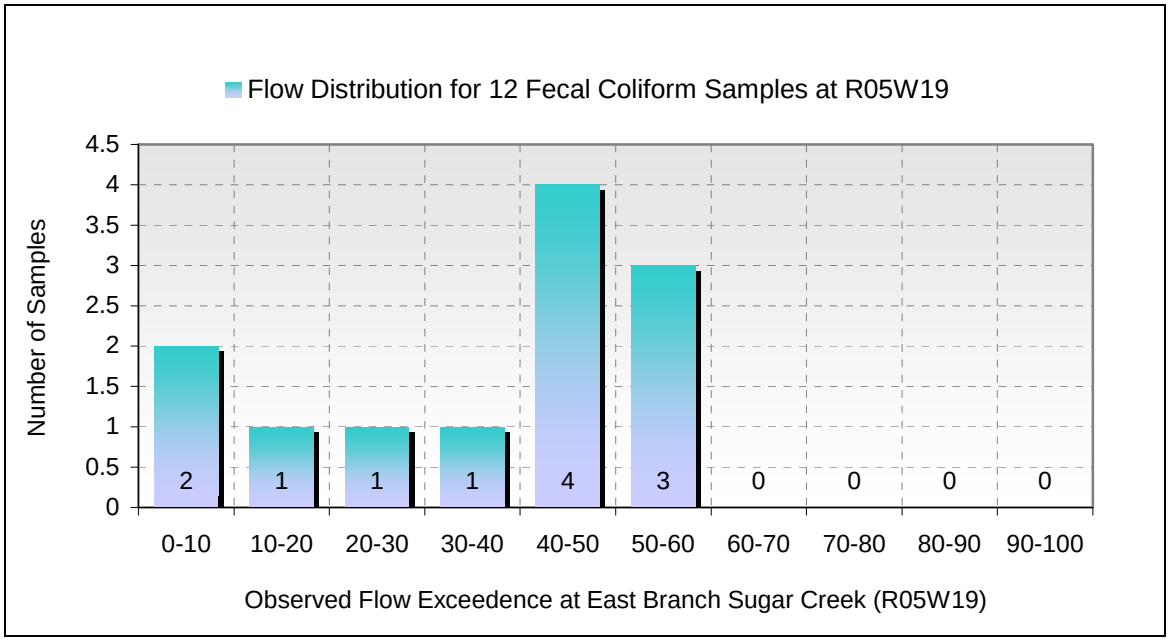

Figure 4-14. Summary of flow and fecal coliform sample distribution at load duration site R05W19.

Figure 4-15 shows that all of the fecal coliform observations exceed the loading limit. The loading limit is exceeded within each hydrologic zone for which observed data are available. The greatest exceedence of the standard occurs in the moist condition zone, which represents wet weather flow conditions. The calculated existing loads were grouped based on duration curve hydrologic zones and are summarized in Table 4-15. Table 4-15 shows that significant load reductions are needed for mid-range flow through high flow conditions.

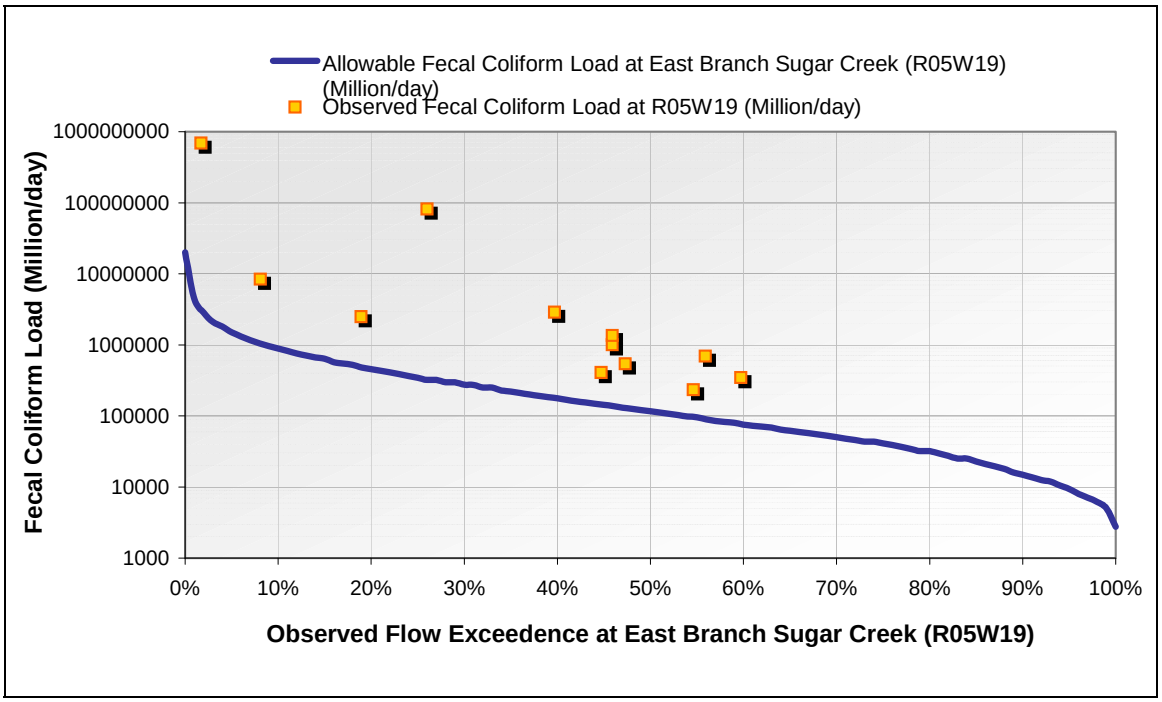

Figure 4-15. Existing fecal coliform loading and loading capacity for load duration site R05W19.

Table 4-15. Summary of Available Fecal Coliform Data for Load Duration Site R05W19.

Zone	Flow Exceedence Ranges	12-Sample Distribution	Median Observed Flow (cfs)	Allowable Load (Million/day)	Observed Load (Million/day)	Estimated Reduction (%)
High Flows	0-10	2	61.64	1,508,167	350,602,939	99.6%
Moist Conditions	10-20	1	26.15	639,828	2,496,218	74.4%
	20-30	1	14.01	342,765	82,054,151	99.6%
	30-40	1	8.97	219,370	2,886,923	92.4%
Mid-Range Flows	40-50	4	5.88	143,961	772,012	81.4%
	50-60	3	3.91	95,746	346,897	72.4%
Dry Conditions	60-70	0	2.52	61,698	No Data	No Data
	70-80	0	1.68	41,132	No Data	No Data
	80-90	0	0.93	22,851	No Data	No Data
Low Flows	90-100	0	0.38	9,369	No Data	No Data

Two OEPA monitoring sites, R05S56 and R05S57, are located upstream of R05W19 and five fecal coliform samples were collected at both stations during the summer of 2005. Fecal coliform levels at R05S56 and R05S57 (geometric means of 4,847 and 8,814, respectively) are high but still lower than the geometric mean observed at site R05W19. This suggests that there are significant sources of fecal coliform throughout the East Branch South Fork Sugar Creek.

4.2.4 South Fork Sugar Creek (R05W18)

OEPA site R05W18 is co-located with the OARDC 61 sampling station. A total of sixteen fecal coliform observations are available for the load duration analysis at site R05W19. Five samples were collected by OEPA, and 11 samples were collected by OARDC. Table 4-16 summarizes the geometric mean, minimum and maximum values, and the period of record for the monitoring station used in the analyses for this load duration site. The OEPA and the OARDC data sets have very similar geometric mean values, however minimum and maximum fecal coliform levels are lower in the OEPA data.
Figure 4-16 presents the number of observations for each of the duration curve zones. The figure shows that most of the observed fecal coliform data coincide with mid-range to low flow conditions.

Table 4-16. Summary of Available Fecal Coliform Data for Load Duration Site R05W18.

Monitoring Station	Count	Geometric Mean (#/100 mL)	Min (#/100 mL)	Max (#/100 mL)	Period of Record
R05W18	5	3,893	780	8,200	7-26-05 to 9-12-05
OARDC 61	11	3,754	1,300	20,000	6-30-99 to 8-13-2004

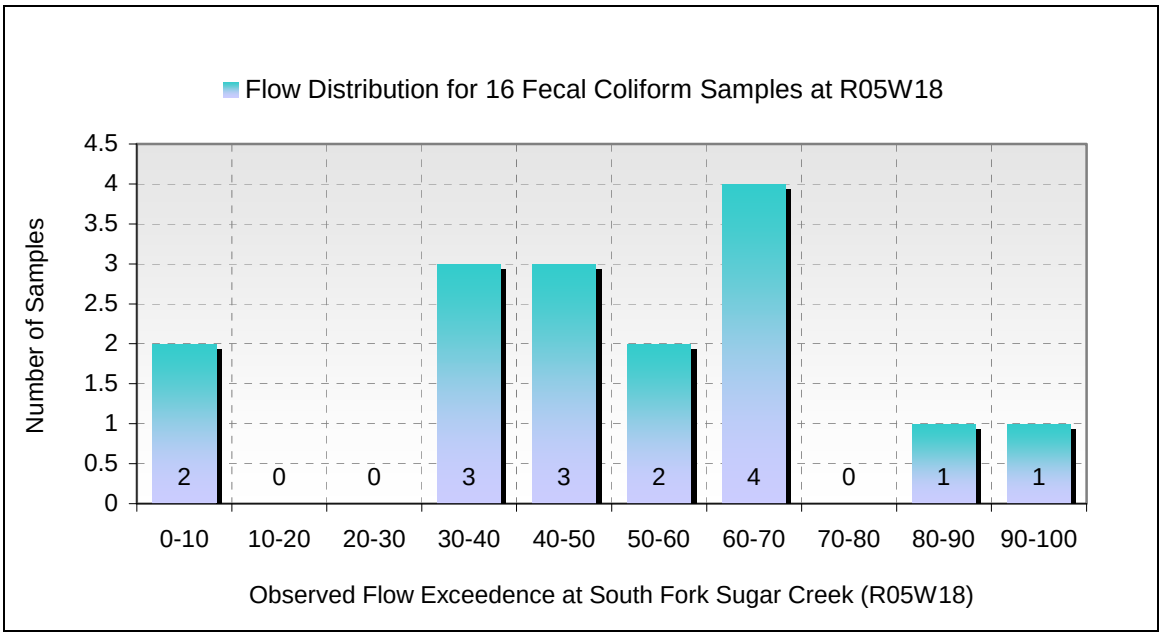

Figure 4-16. Summary of flow and fecal coliform sample distribution at load duration site R05W18.

The allowable and observed fecal coliform loads are presented in Figure 4-17. The figure shows that fifteen of the sixteen observed coliform observations exceed the 1000 cfu/100 mL criterion. Table 4-17 summarizes the median of existing allowable loads for each of the duration curve zones. The table shows that significant levels of reduction are required for all observed flow conditions, and that the greatest level of reduction, 84 percent, is needed for the high flow condition.

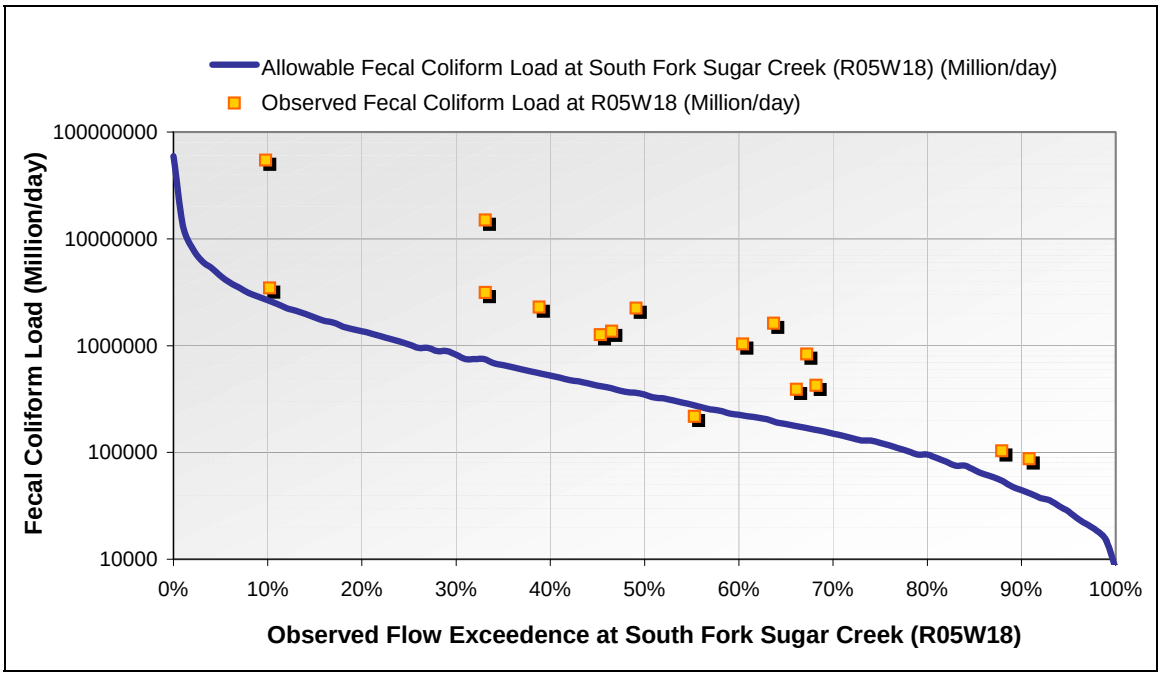

Figure 4-17. Existing fecal coliform loading and loading capacity for load duration site R05W18.

Table 4-17. Summary of Available Fecal Coliform Data for Load Duration Site R05W18.

Zone	Flow Exceedence Ranges	16-Sample Distribution	Median Observed Flow (cfs)	Allowable Load (Million/day)	Observed Load (Million/day)	Estimated Reduction (%)
High Flows	0-10	2	183.80	4,496,686	29,023,754	84.5%
Moist Conditions	10-20	0	75.30	1,842,345	No Data	No Data
	20-30	0	41.84	1,023,525	No Data	No Data
	30-40	3	26.77	655,056	3,152,457	79.2%
Mid-Range Flows	40-50	3	17.29	423,057	1,368,794	69.1%
	50-60	2	11.43	279,763	627,011	55.4%
Dry Conditions	60-70	4	7.53	184,234	630,833	70.8%
	70-80	0	5.02	122,823	No Data	No Data
	80-90	1	2.79	68,235	103,717	34.2%
Low Flows	90-100	1	1.14	27,976	87,409	68.0%

Two monitoring load duration sites, R05W20 and R05W19, are located upstream of R05W18. R05W20 is located upstream of R05W18 on the South Fork Sugar Creek, while R05W19 is located upstream on the East Branch South Fork Sugar Creek. A comparison of Table 4-16 to Tables 4-12 and 4-14 (see also Figure 4-8) reveals a decrease in the geometric mean of the fecal coliform samples downstream of both R05W19 and R05W20. Likewise, minimum observed levels decrease downstream of R05W19 and R05W20. However, observed maximum fecal coliform samples are similar among the three sampling stations.

4.2.5 Walnut Creek (R05P18)

A total of sixteen fecal coliform observations are available for the load duration analysis at site R05P18. Five samples were collected by OEPA at station R05P18, and the Walnut Creek wastewater treatment plant collected 11 samples immediately downstream of the facility. There are no fecal coliform monitoring sites upstream of R05P18. Table 4-18 summarizes the geometric mean, minimum and maximum values, and the period of record for the monitoring station used in the analyses for this load duration site. Figure 4-18 presents the number of observations for each of the duration curve zones. The figure shows that no fecal coliform data have been collected during periods corresponding to low flow conditions.

Table 4-18. Summary of Available Fecal Coliform Data for Load Duration Site R05P18.

Monitoring Station	Count	Geometric Mean (#/100 mL)	Min (#/100 mL)	Max (#/100 mL)	Period of Record
R05P18	5	10,403	2,400	24,000	7-26-05 to 9-12-05
Walnut Creek WWTP	11	1,175	1	12,000	6-30-99 to 8-24-2004

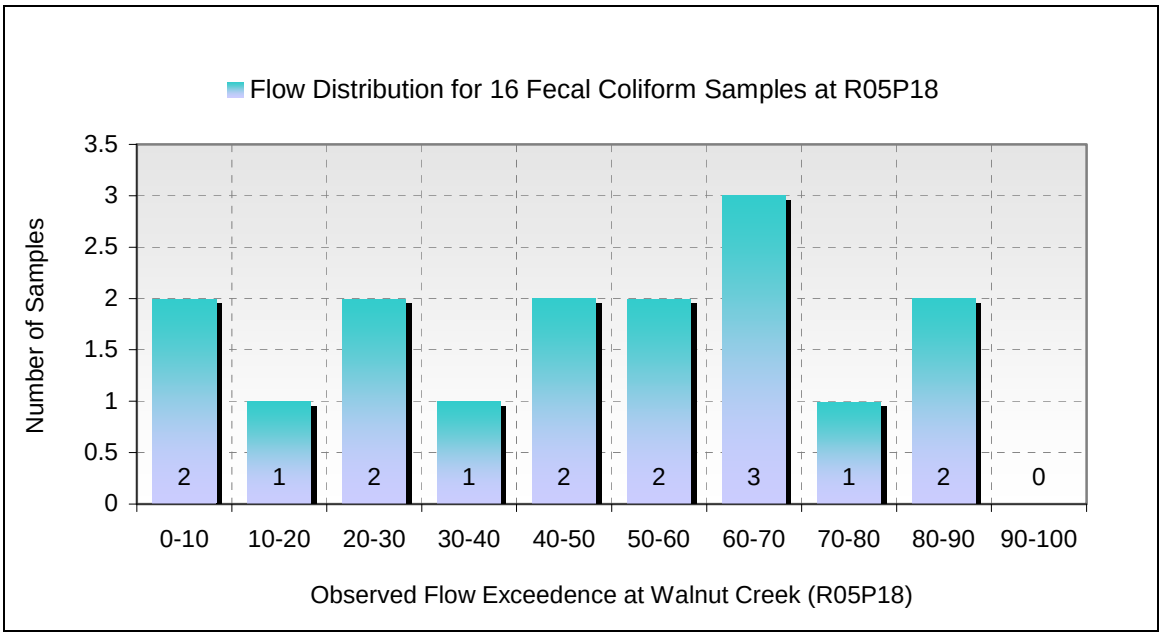

Figure 4-18. Summary of flow and fecal coliform sample distribution at load duration site R05P18.

The allowable and observed fecal coliform loads are presented in Figure 4-19. The figure shows that 12 of the 16 fecal coliform observations exceed the 1000 cfu/100 mL criterion. Table 4-19 summarizes the median of existing allowable loads for each of the duration curve zones, and shows that the greatest levels of reduction are needed for the mid-range flow conditions. The dispersion of data points in Figure 4-19 suggests that exceedences of allowable fecal coliform loads are associated with wet weather through dry weather flows.

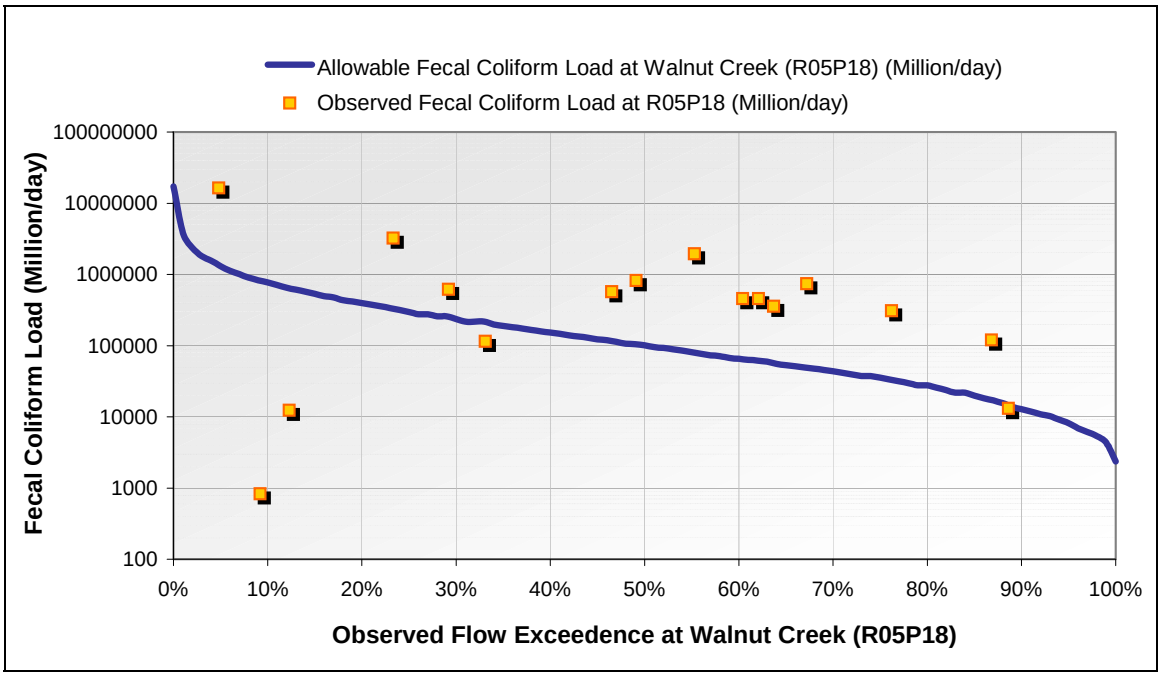

Figure 4-19. Existing fecal coliform loading and loading capacity for load duration site R05P18.

Table 4-19. Summary of Available Fecal Coliform Data for Load Duration Site R05P18.

Zone	Flow Exceedence Ranges	16-Sample Distribution	Median Observed Flow (cfs)	Allowable Load (Million/day)	Observed Load (Million/day)	Estimated Reduction (%)
High Flows	0-10	2	53.31	1,304,345	8,194,633	84.1%
Moist Conditions	10-20	1	21.84	534,405	12,410	0.0%
	20-30	2	12.14	296,892	1,923,860	84.6%
	30-40	1	7.77	190,011	115,392	0.0%
Mid-Range Flows	40-50	2	5.02	122,715	695,222	82.3%
	50-60	2	3.32	81,150	1,202,412	93.3%
Dry Conditions	60-70	3	2.18	53,441	460,183	88.4%
	70-80	1	1.46	35,627	309,559	88.5%
	80-90	2	0.81	19,793	66,665	70.3%
Low Flows	90-100	0	0.33	8,115	No Data	No Data

4.2.6 Walnut Creek (R05W22)

R05W22 is located approximately 3.5 miles downstream of site R05P18. A total of twelve fecal coliform observations are available for the load duration analysis at site R05W22, and these data are summarized in Table 4-20. Figure 4-20 presents the number of observations for each of the duration curve zones. The figure shows that most of the fecal coliform data have been collected during periods corresponding to lower mid-range flows through low flow conditions.

Table 4-20. Summary of Available Fecal Coliform Data for Load Duration Site R05W22.

Monitoring Station	Count	Geometric Mean (#/100 mL)	Min (#/100 mL)	Max (#/100 mL)	Period of Record
R05W22	12	9,308	1,200	20,000	7-21-05 to 9-26-05

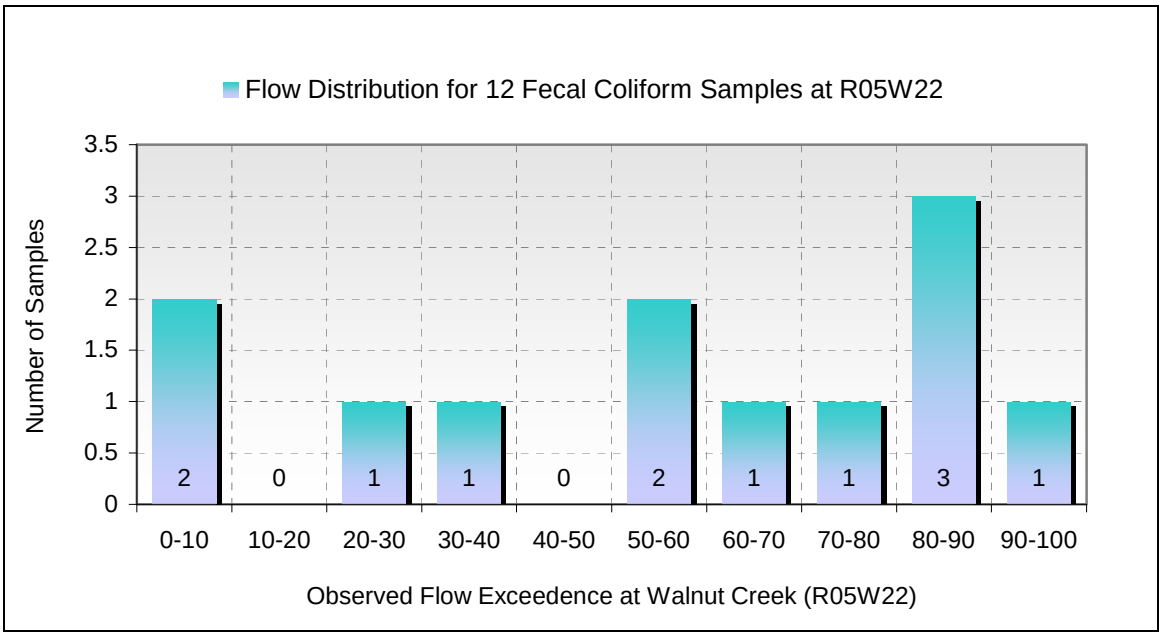

Figure 4-20. Summary of flow and fecal coliform sample distribution at load duration site R05W22.

The allowable and observed fecal coliform loads are presented in Figure 4-21. The figure shows that all of the 12 fecal coliform observations exceed the 1000 cfu/100 mL criterion. Table 4-21 summarizes the median of existing allowable loads for each of the duration curve zones, and shows that the greatest levels of reduction are needed for the high flow condition. With the exception of the low flow zone, all flow zones for which fecal coliform data are available require very large load reductions. Furthermore, the pattern of the data points in Figure 4-21 suggests that exceedences of allowable fecal coliform loads are associated with wet weather flows and dry weather flows. As presented in Figure 4-8, the geometric mean of sampled fecal coliform data is greater in magnitude compared to those data collected upstream at site R05P18.

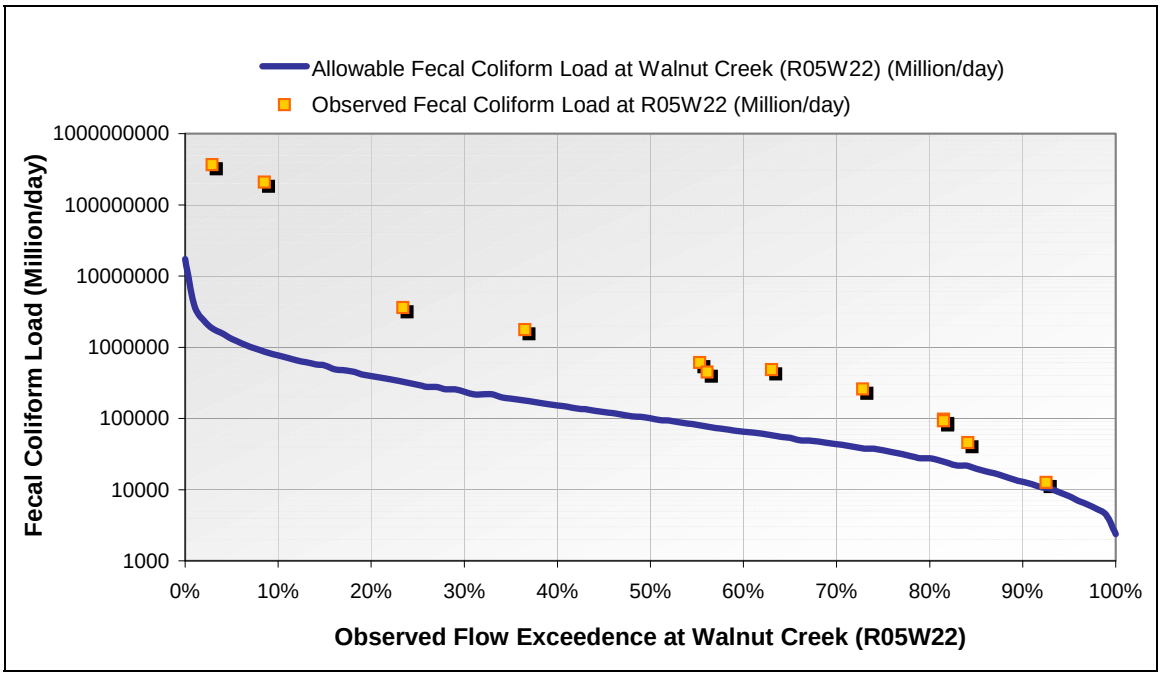

Figure 4-21. Existing fecal coliform loading and loading capacity for load duration site R05W22.

Table 4-21. Summary of Available Fecal Coliform Data for Load Duration Site R05W22.

Zone	Flow Exceedence Ranges	12-Sample Distribution	Median Observed Flow (cfs)	Allowable Load (Million/day)	Observed Load (Million/day)	Estimated Reduction (%)
High Flows	0-10	2	53.39	1,306,325	286,791,463	99.5%
Moist Conditions	10-20	0	22.65	554,198	No Data	No Data
	20-30	1	12.14	296,892	3,615,398	91.8%
	30-40	1	7.77	190,011	1,762,308	89.2%
Mid-Range Flows	40-50	0	5.02	122,913	No Data	No Data
	50-60	2	3.32	81,150	529,208	84.7%
Dry Conditions	60-70	1	2.18	53,441	485,325	89.0%
	70-80	1	1.46	35,627	259,096	86.2%
	80-90	3	0.81	19,793	92,796	78.7%
Low Flows	90-100	1	0.33	8,115	12,679	36.0%

4.2.7 Indian Trail Creek (R05W25)

A total of twelve fecal coliform observations are available for the load duration analysis at site R05W25, and these data are summarized in Table 4-22. Figure 4-22 presents the number of observations for each of the duration curve zones. The figure shows that the fecal coliform sampling distribution tends to be clustered in the moist flow zone; seven of the twelve samples coincide with the moist flow zone. Furthermore, no fecal coliform samples were collected during dry or low flow conditions.

Table 4-22. Summary of Available Fecal Coliform Data for Load Duration Site R05W25.

Monitoring Station	Count	Geometric Mean (#/100 mL)	Min (#/100 mL)	Max (#/100 mL)	Period of Record
R05W25	12	6,934	1,200	140,000	7-21-05 to 10-11-05

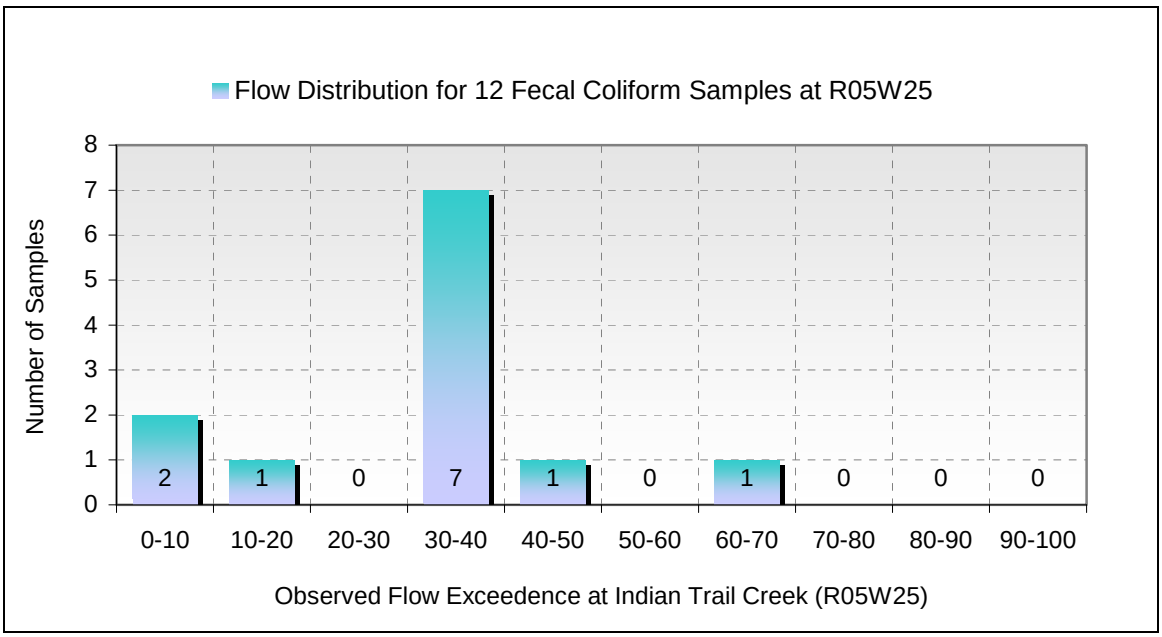

Figure 4-22. Summary of flow and fecal coliform sample distribution at load duration site R05W25.

The allowable and observed fecal coliform loads are presented in Figure 4-23. The figure shows that all of the 12 fecal coliform observations exceed the 1000 cfu/100 mL criterion. Table 4-23 summarizes the median of existing allowable loads for each of the duration curve zones, and shows that the greatest levels of reduction are needed for the high flow condition. As presented in Table 4-23, large reductions are required in each flow zone for which fecal coliform data are available. Additionally, the greatest reductions are associated with higher flow conditions, which suggests that fecal coliform loading is related to wet weather flows in Indian Trail Creek.

Five fecal coliform samples were collected upstream at station R05S49 and yielded a geometric mean of 3,462, a minimum value of 1,600, and a maximum value of 10,000. Comparisons of these upstream data to those observed at R05W25 (see Figure 4-8) suggest that a significant source of fecal coliform loading occurs between these two sampling stations.

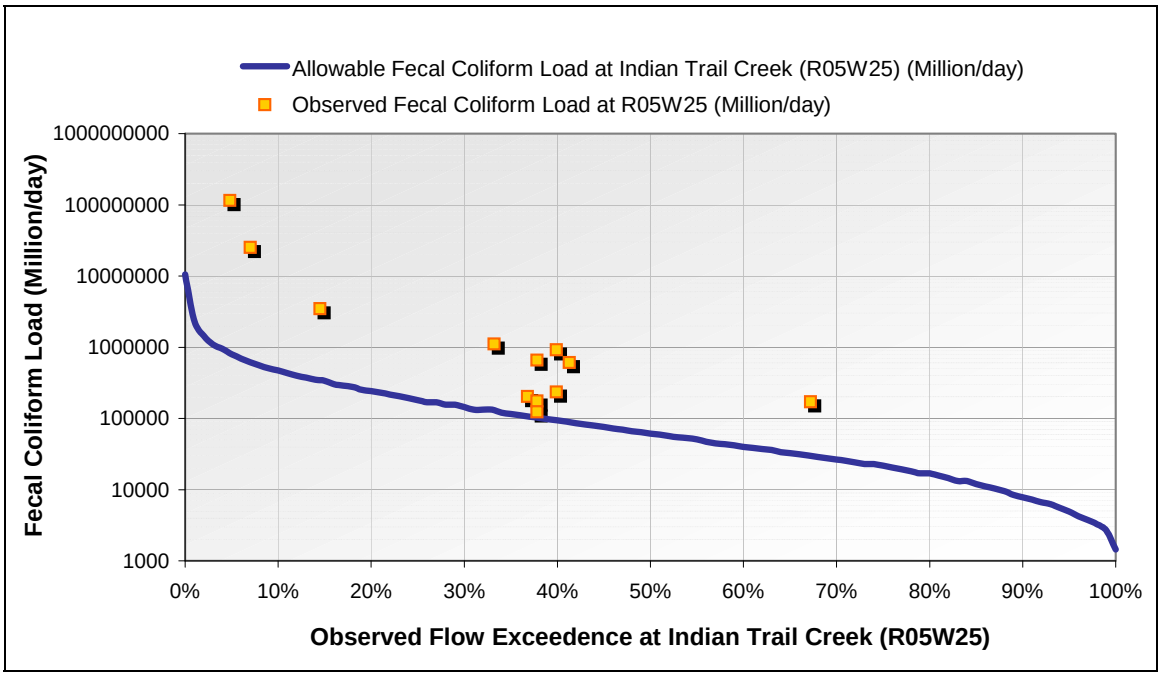

Figure 4-23. Existing fecal coliform loading and loading capacity for load duration site R05W25.

Table 4-23. Summary of Available Fecal Coliform Data for Load Duration Site R05W25.

Zone	Flow Exceedence Ranges	12-Sample Distribution	Median Observed Flow (cfs)	Allowable Load (Million/day)	Observed Load (Million/day)	Estimated Reduction (%)
High Flows	0-10	2	32.54	796,067	70,370,230	98.9%
Moist Conditions	10-20	1	13.80	337,725	3,485,544	90.3%
	20-30	0	7.40	180,924	No Data	No Data
	30-40	7	4.73	115,792	235,249	50.8%
Mid-Range Flows	40-50	1	3.11	75,988	613,007	87.6%
	50-60	0	2.07	50,659	No Data	No Data
Dry Conditions	60-70	1	1.33	32,566	171,878	81.1%
	70-80	0	0.89	21,711	No Data	No Data
	80-90	0	0.49	12,062	No Data	No Data
Low Flows	90-100	0	0.20	4,945	No Data	No Data

4.2.8 AU110 Allocations

The allocations of loads for the AU110 TMDLs are summarized in Table 4-24 and indicate that significant nonpoint source load reductions are needed at each of the seven load duration analysis points. Loads are expressed for the May 1 to October 15 time period to be consistent with Ohio's water quality standards. Since there are 167 days between May 1 and October 15, the current load and the loading capacity are based on the daily loads from the load duration curve analysis multiplied by 16.7 days for

each of the 10 flow percentiles. The 10 flow percentile loads are then summed to get a load per recreation season[4].

The wasteload allocations shown in Table 4-24 are based on the design flows of each facility upstream of a given load duration site multiplied by its permit limit; the individual WLAs are shown in Table 4-25Table 4-8. Table 4-24Table 4-7 also presents the current fecal coliform loads at each monitoring site on a per unit area or "normalized" basis. This information has been used to derive an estimated average loading rate of 1.75E+11 cfu/acre/recreation season for this assessment unit. This rate is the highest of the three assessment units (see Sections 4.1.4 and Sections 4.3.4 for more details).

The discussion of margin of safety, critical conditions, and seasonable presented in Section 4.1.4 also applies to the TMDLs presented in Table 4-24.

Table 4-24. TMDL Summary for AU110.

Category	Load Duration Site						
	R05P23	R05W20	R05W19	R05W18	R05P18	R05W22	R05W25
Current Load (cfu/rec season)	2.45E+14	2.90E+14	7.34E+15	8.11E+14	2.17E+14	7.35E+15	1.30E+15
Loading Capacity (cfu/rec season)	3.46E+13	5.02E+13	5.15E+13	1.52E+14	4.42E+13	4.46E+13	2.72E+13
Wasteload Allocation (cfu/rec season)	1.91E+11	2.80E+11	0.00E+00	3.46E+12	0.00E+00	5.72E+11	3.27E+12
Margin of Safety (cfu/rec season)	3.46E+12	5.02E+12	5.15E+12	1.52E+13	4.42E+12	4.46E+12	2.72E+12
Load Allocation (cfu/rec season)	3.10E+13	4.49E+13	4.64E+13	1.34E+14	3.98E+13	3.95E+13	2.12E+13
Point Source Reductions (percent)	0%	0%	0%	0%	0%	0%	0%
Nonpoint Source Reductions (percent)	87%	84%	99%	83%	82%	99%	98%
Normalized Current Load (cfu/acre/rec season)	2.66E+10	1.81E+10	4.52E+11	2.00E+10	3.73E+10	5.22E+11	1.51E+11

[4] In some cases current loads and loading capacities had to be estimated for flow percentiles for which fecal coliform data were not available. In these cases the loads were based on the loads for the next highest and next lowest flow percentile.

Table 4-25. WLAs for facilities within AU110.

Facility	US EPA ID	Design Flow (mgd)	Design Flow (Liters from May 1 to Oct 15)	FC Limit (#/100 mL)	WLA (#/yr)
Baltic Rubber	OH0031381	0.020	12,717,600	1000	1.27E+11
Baltic WWTP	OH0047783	0.010	6,358,800	1000	6.36E+10
Case Farms Inc.	OH0005487	0.500	317,940,000	1000	3.18E+12
Guggisberg Cheese Inc.	OH0083771	0.014	8,902,320	1000	8.90E+10
Holmes Co. Health Dept.	OH0048691	0.015	9,538,200	1000	9.54E+10
Sugarcreek WWTP	OH0027618	0.500	317,940,000	1000	3.18E+12
Troyer's Trail Bologna Inc.	OH0004855	0.005	3,179,400	1000	3.18E+10
Walnut Creek WWTP	OH0102903	0.090	57,229,200	1000	5.72E+11

4.3 Assessment Unit 120: Middle Fork Sugar Creek to Mouth

The load duration approach was applied to three sites located within AU120. As shown in Figure 4-24, one site is located on Middle Fork Sugar Creek at OEPA station R05P10, one site is located on Sugar Creek at OEPA/USGS station 611700, and one site is located on Broad Run at OEPA station R05S36. For each load duration site, all appropriate and available fecal coliform and flow data were used.

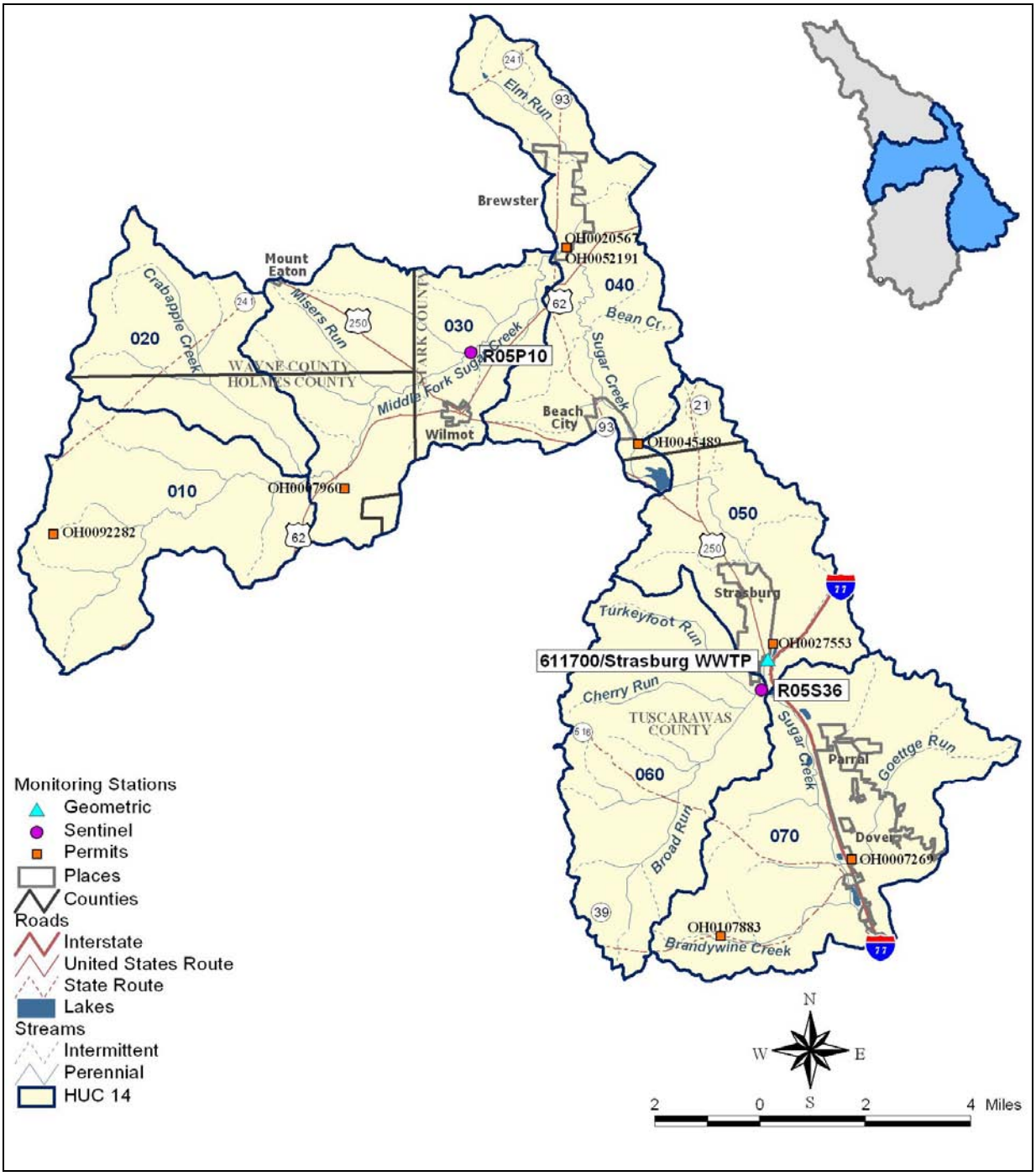

Figure 4-24. Load duration sites within the Sugar Creek Headwaters, AU 05040001120.

4.3.1 Middle Fork Sugar Creek (R05P10)

A total of twelve fecal coliform observations are available for the load duration analysis at site R05P10, and these data are summarized in Table 4-26. Figure 4-25 presents the number of observations for each of the duration curve zones. Of the thirteen samples, five correspond to mid-range flow conditions, and four samples correspond to higher flow moist conditions. The figure shows that no fecal coliform samples were collected during low flow conditions.

Table 4-26. Summary of Available Fecal Coliform Data for Load Duration Site R05P10.

Monitoring Station	Count	Geometric Mean (#/100 mL)	Min (#/100 mL)	Max (#/100 mL)	Period of Record
R05P10	13	4,789	1,065	150,000	7-21-05 to 10-11-05

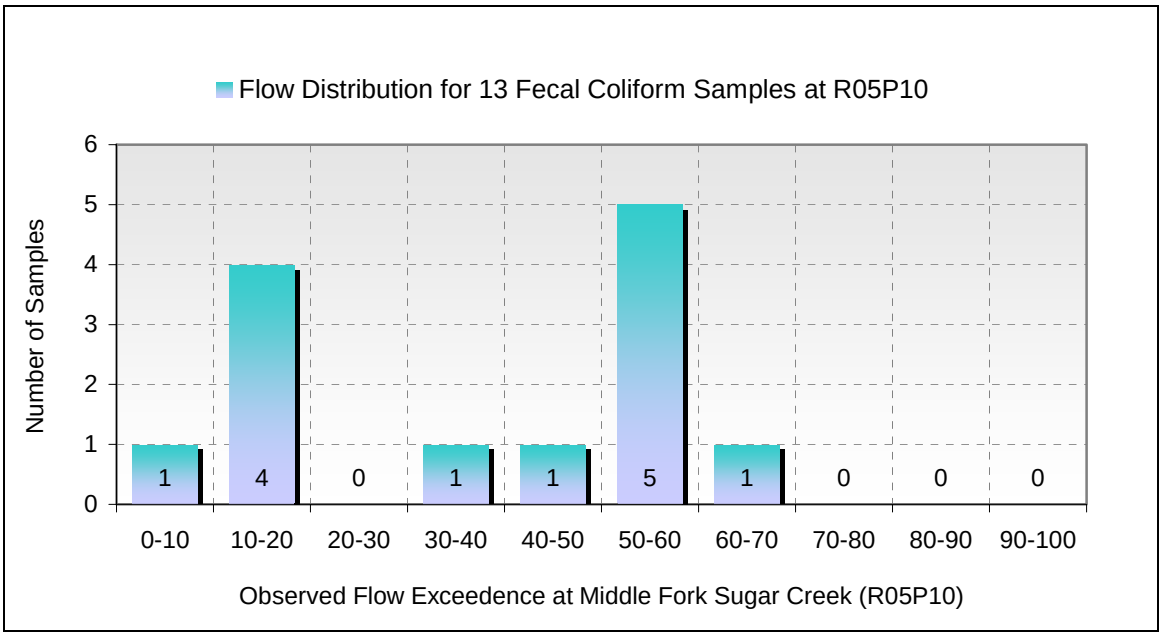

Figure 4-25. Summary of flow and fecal coliform sample distribution at load duration site R05P10.

The allowable and observed fecal coliform loads are presented in Figure 4-26. The figure shows that exceedences the 1000 cfu/100 mL criterion occurs with higher flow conditions. Table 4-27 summarizes the median of existing allowable loads for each of the duration curve zones, and shows that the greatest levels of reduction are needed for the high flow condition. As presented in Table 4-27, large reductions are required in almost every flow zone for which fecal coliform data are available.

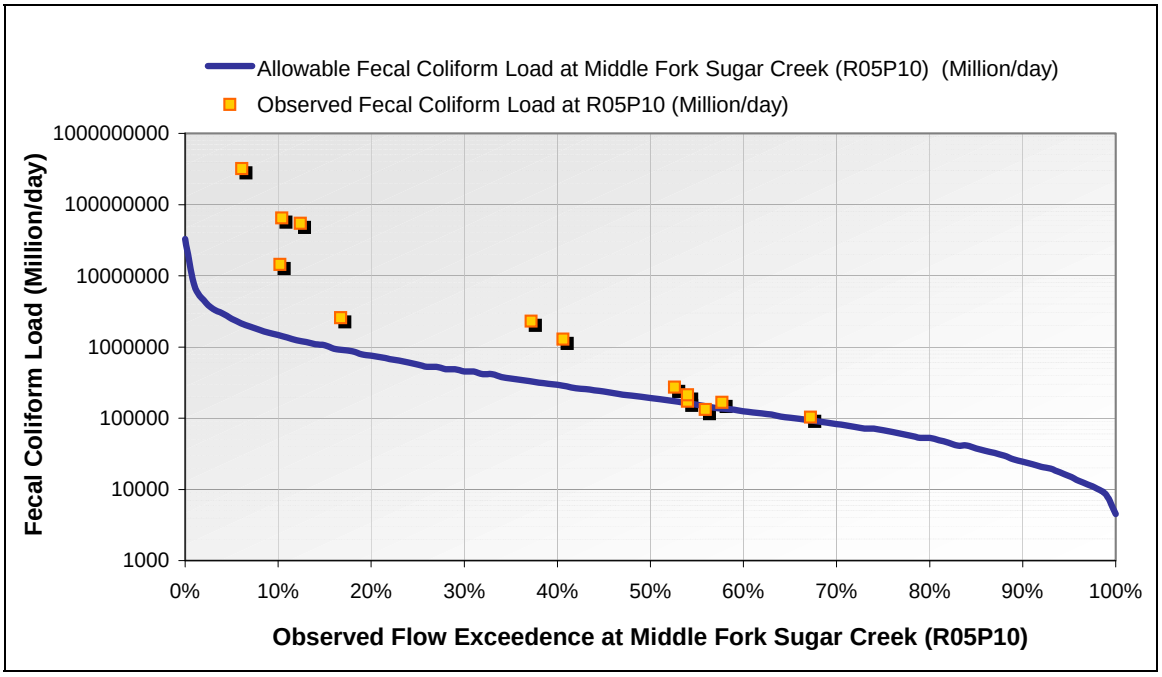

Figure 4-26. Existing fecal coliform loading and loading capacity for load duration site R05P10.

Table 4-27. Summary of Available Fecal Coliform Data for Load Duration Site R05P10.

Zone	Flow Exceedence Ranges	13-Sample Distribution	Median Observed Flow (cfs)	Allowable Load (Million/day)	Observed Load (Million/day)	Estimated Reduction (%)
High Flows	0-10	1	101.62	2,486,156	319,512,745	99.2%
Moist Conditions	10-20	4	43.18	1,056,333	34,552,449	96.9%
	20-30	0	23.13	565,893	No Data	No Data
	30-40	1	14.80	362,171	2,307,701	84.3%
Mid-Range Flows	40-50	1	9.71	237,675	1,289,683	81.6%
	50-60	5	6.32	154,677	173,590	10.9%
Dry Conditions	60-70	1	4.16	101,861	103,747	1.8%
	70-80	0	2.78	67,907	No Data	No Data
	80-90	0	1.54	37,726	No Data	No Data
Low Flows	90-100	0	0.63	15,468	No Data	No Data

Limited fecal coliform data are available at upstream sites R05S72, R05S73, and R05S74, which are located approximately 4.2, 6.7, and 8.6 miles upstream, respectively, of R05P10. The data for these three sites are summarized in Table 4-28. The table shows that maximum fecal coliform samples vary widely among the four sites. However, geometric mean data and minimum fecal coliform samples are similar to those observed at R05P10 (see Figure 4-8). This suggests that high levels of fecal coliform are present throughout this reach of the Middle Fork Sugar Creek.

Table 4-28. Summary of Available Fecal Coliform Data Upstream of Site R05P10.

Monitoring Station	Count	Geometric Mean (#/100 mL)	Min (#/100 mL)	Max (#/100 mL)	Period of Record
R05S72	5	7,638	2,400	240,000	7-26-05 to 9-12-05
R05S73	5	2,859	1,800	5,400	7-26-05 to 9-12-05
R05S74	5	4,104	1,700	180,000	7-26-05 to 9-12-05

4.3.2 Sugar Creek (611700)

Twenty-five fecal coliform observations are available for the load duration analysis at site 611700. Thirteen samples were collected by OEPA during the summer of 2005 and 12 additional samples were available from the Strasburg wastewater treatment plant. Table 4-29 summarizes the number of observations, geometric mean, minimum and maximum values, and the period of record for each monitoring station used in the analyses for this load duration site. The geometric mean and minimum of the fecal coliform samples are greater in the OEPA sample set than those sampled by the Strasburg WWTP. The maximum observed value is similar between the sample data sets. Figure 4-27 presents the number of observations for each of the duration curve zones and shows that the observed fecal coliform data are fairly well distributed across the entire flow regime. No fecal coliform data were sampled in the middle (20-30 percentile flow) of the moist flow zone.

Table 4-29. Summary of Available Fecal Coliform Data for Load Duration Site 611700.

Monitoring Station	Count	Geometric Mean (#/100 mL)	Min (#/100 mL)	Max (#/100 mL)	Period of Record
611700	13	1,136	200	21,000	7-21-05 to 10-11-05
Strasburg WWTP	12	633	121	20,000	6-08-99 to 8-12-04

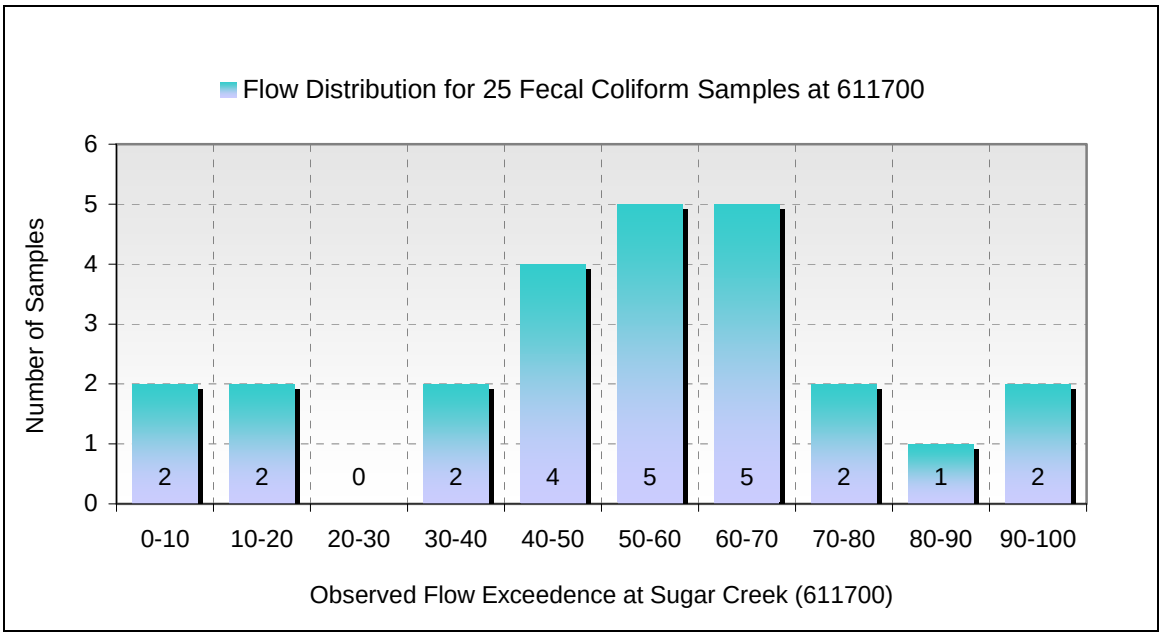

Figure 4-27. Summary of flow and fecal coliform sample distribution at load duration site 611700.

The allowable and observed fecal coliform loads are presented in Figure 4-28. The figure shows that exceedences the 1000 cfu/100 mL criterion generally occurs with higher flow conditions, from mid-range flows through high flows. One exceedence does occur in the low flow hydrologic condition. Table 4-30 summarizes the median of existing allowable loads for each of the duration curve zones, and shows that the greatest levels of reduction are needed for the high flow condition. As presented in Table 4-30, very large reductions are required in high flow and moist flow zones, and a moderate reduction is required in the low flow zone. The data suggest that excessive loading of fecal coliform are mainly a consequence of wet weather storm flows. All other hydrologic zones for which fecal coliform data are available do not require load reductions.

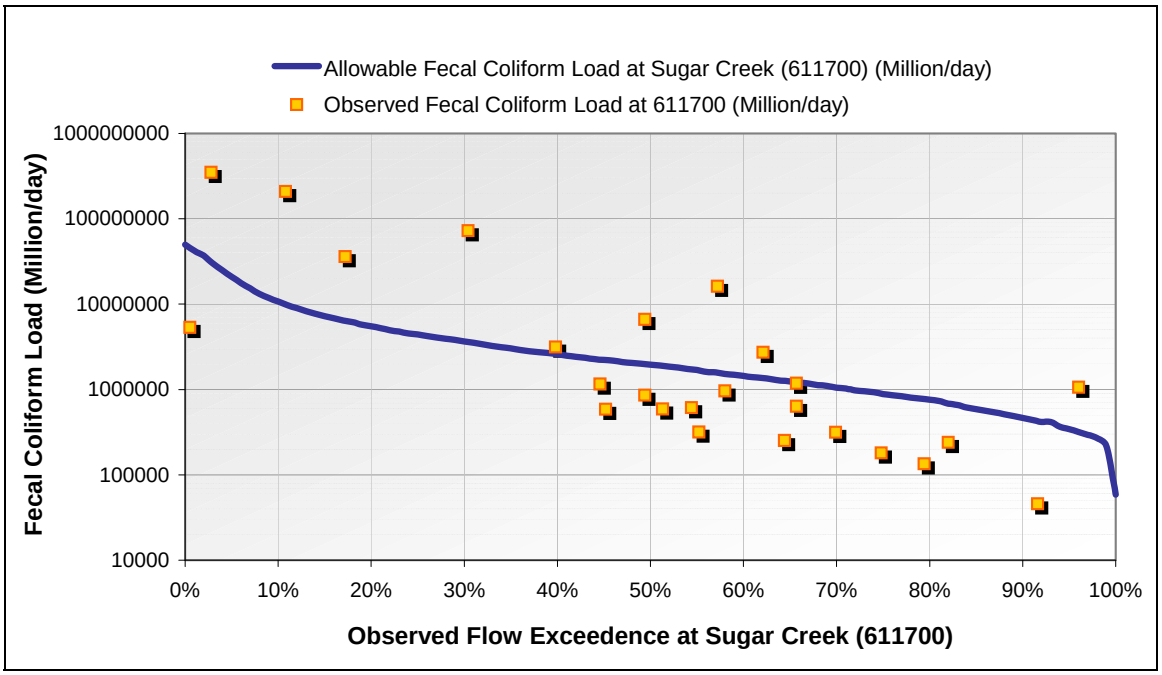

Figure 4-28. Existing fecal coliform loading and loading capacity for load duration site 611700.

Table 4-30. Summary of Available Fecal Coliform Data for Load Duration Site 611700.

Zone	Flow Exceedence Ranges	25-Sample Distribution	Median Observed Flow (cfs)	Allowable Load (Million/day)	Observed Load (Million/day)	Estimated Reduction (%)
High Flows	0-10	2	855.80	20,937,794	177,609,274	88.2%
Moist Conditions	10-20	2	296.00	7,241,864	122,827,879	94.1%
	20-30	0	180.00	4,403,836	No Data	No Data
	30-40	2	124.00	3,033,754	37,780,020	92.0%
Mid-Range Flows	40-50	4	91.00	2,226,384	1,009,457	0.0%
	50-60	5	69.00	1,688,137	611,448	0.0%
Dry Conditions	60-70	5	51.00	1,247,754	633,565	0.0%
	70-80	2	36.00	880,767	157,364	0.0%
	80-90	1	24.00	587,178	241,232	0.0%
Low Flows	90-100	2	14.10	344,967	553,807	37.7%

OEPA monitoring site R05S27 is located approximately 4.8 miles upstream of site 611700, and just a short distance downstream of the Beach City Reservoir (see Figure 4-8). Nine samples were collected at R05S27 during the summer of 2005. The samples yielded a geometric mean of 765, a minimum value of 200, and a maximum of 5,500. The geometric mean and maximum fecal coliform values are much lower for this upstream fecal sampling site compared to 611700 (see Table 4-27, station 611700). This suggests that the Beach City Reservoir likely serves as a fecal coliform "sink" and that sources of fecal coliform discharge into Sugar Creek between station R05S27 and station 611700.

4.3.3 Broad Run (R05S36)

A total of thirteen fecal coliform observations are available for the load duration analysis at site R05S36, and these data are summarized in Table 4-31. Figure 4-29 presents the number of observations for each of the duration curve zones. Six of the samples correspond to high flow mid-range flow conditions, five samples correspond to lower mid-range and dry conditions, while two sample correspond to dry

conditions. The figure shows that fecal coliform samples were not collected during mid and lower moist flow conditions, nor in low flow conditions.

Table 4-31. Summary of Available Fecal Coliform Data for Load Duration Site R05S36.

Monitoring Station	Count	Geometric Mean (#/100 mL)	Min (#/100 mL)	Max (#/100 mL)	Period of Record
R05S36	13	3,811	410	63,000	7-21-05 to 10-11-05

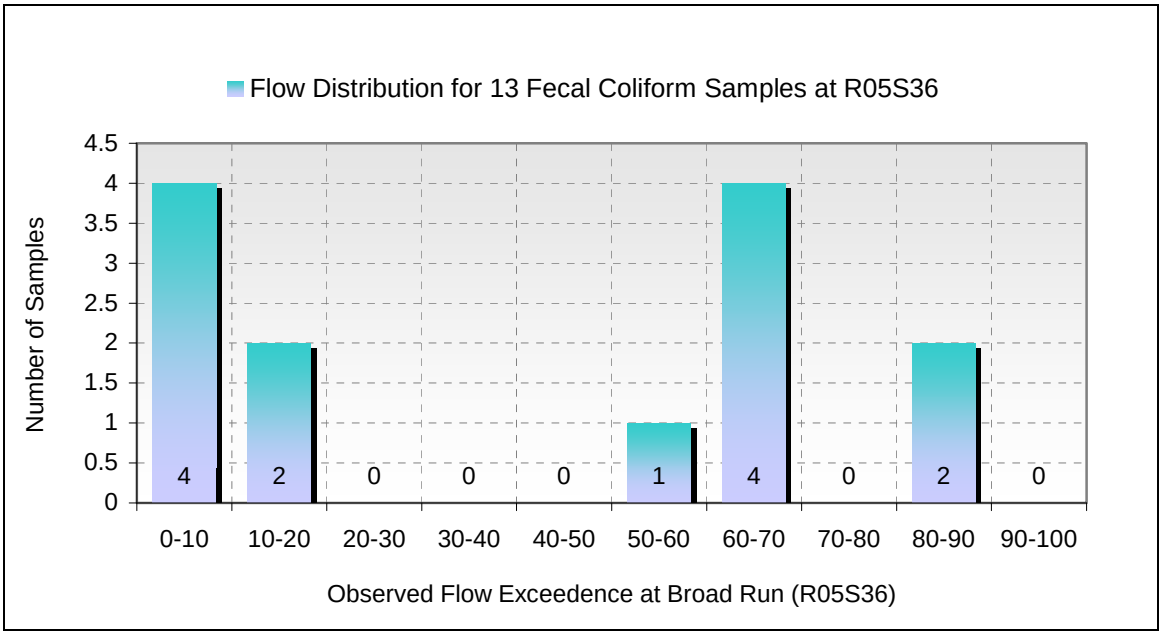

Figure 4-29. Summary of flow and fecal coliform sample distribution at load duration site R05S36.

The allowable and observed fecal coliform loads are presented in Figure 4-30. The figure shows that exceedences the 1000 cfu/100 mL criterion occurs in each flow condition where fecal coliform data are available. Table 4-32 summarizes the median of existing allowable loads for each of the duration curve zones, and shows that the greatest levels of reduction are needed for the high flow condition. As presented in Table 4-32, large reductions are required in each flow zone for which fecal coliform data are available.

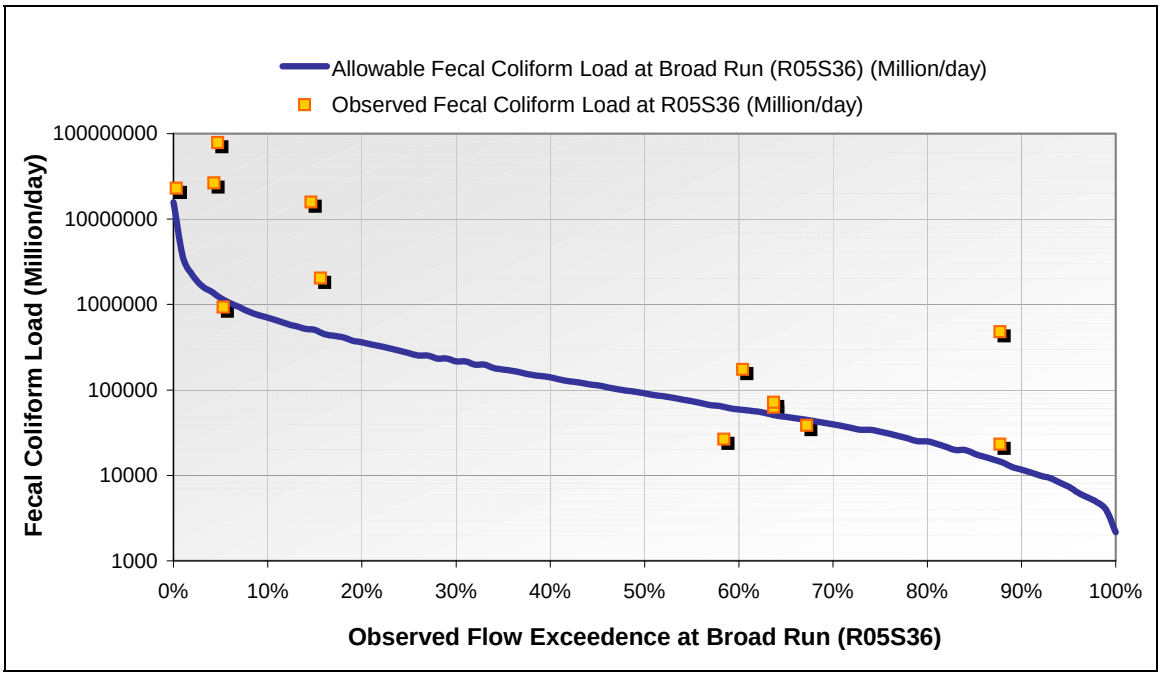

Figure 4-30. Existing fecal coliform loading and loading capacity for load duration site R05S36.

Table 4-32. Summary of Available Fecal Coliform Data for Load Duration Site R05S36.

Zone	Flow Exceedence Ranges	13-Sample Distribution	Median Observed Flow (cfs)	Allowable Load (Million/day)	Observed Load (Million/day)	Estimated Reduction (%)
High Flows	0-10	4	48.51	1,186,834	24,667,458	95.2%
Moist Conditions	10-20	2	20.58	503,505	8,923,367	94.4%
	20-30	0	11.03	269,735	No Data	No Data
	30-40	0	7.06	172,630	No Data	No Data
Mid-Range Flows	40-50	0	4.63	113,289	No Data	No Data
	50-60	1	3.01	73,728	26,539	0.0%
Dry Conditions	60-70	4	1.98	48,552	67,194	27.7%
	70-80	0	1.32	32,368	No Data	No Data
	80-90	2	0.74	17,982	251,466	92.8%
Low Flows	90-100	0	0.30	7,373	No Data	No Data

OEPA monitoring site R05S37 is located approximately 2.7 miles upstream of site R05S36. Six samples were collected at R05S37 during the summer of 2005. The samples yielded a geometric mean of 9,610 cfu/100 mL compared to a geometric mean of 3,811 cfu/100 mL at site R05S36 (see Figure 4-8). This suggests that the primary sources of fecal coliform are located upstream and considerable die-off may have occurred between the two sites.

4.3.4 Assessment Unit 120 Allocations

The allocations of loads for the AU120 TMDLs are summarized in Table 4-33 and indicate that significant nonpoint source load reductions are needed at each of the three load duration analysis points. Loads are expressed for the May 1 to October 15 time period to be consistent with Ohio's water quality standards. Since there are 167 days between May 1 and October 15, the current load and the loading capacity are based on the daily loads from the load duration curve analysis multiplied by 16.7 days for each of the 10 flow percentiles. The 10 flow percentile loads are then summed to get a load per recreation season[5].

The wasteload allocations shown in Table 4-33 are based on the design flows of each facility upstream of a given load duration site multiplied by its permit limit; the individual WLAs are shown in Table 4-34. Table 4-33 also presents the current fecal coliform loads at each monitoring site on a per unit area or "normalized" basis. This information has been used to derive an estimated average loading rate of 1.04E+11 cfu/acre/recreation season for this assessment unit, which is higher than assessment unit 100 but less than assessment unit 110.

The discussion of margin of safety, critical conditions, and seasonable presented in Section 4.1.4 also applies to the TMDLs presented in Table 4-33.

Table 4-33. TMDL Summary for AU120.

Category	Load Duration Site		
	R05P10	611700	R05S36
Current Load (cfu/rec season)	6.10E+15	7.04E+15	6.23E+14
Loading Capacity (cfu/rec season)	8.49E+13	7.11E+14	4.05E+13
Wasteload Allocation (cfu/rec season)	2.80E+12	1.16E+13	0.00E+00
Margin of Safety (cfu/rec season)	8.49E+12	7.11E+13	4.05E+12
Load Allocation (cfu/rec season)	7.36E+13	6.29E+14	3.65E+13
Point Source Reductions (percent)	0%	0%	0%
Nonpoint Source Reductions (percent)	99%	91%	94%
Normalized Current Load (cfu/acre/rec season)	2.28E+11	3.54E+10	4.87E+10

Table 4-34. WLAs for facilities within AU120.

Facility	US EPA ID	Design Flow (mgd)	Design Flow (Liters from May 1 to Oct 15)	FC Limit (#/100 mL)	WLA (#/yr)
Alpine Cheese Co.	OH0007960	0.220	139,893,600	1000	1.40E+12
Beach City Wilmont STP	OH0045489	0.200	127,176,000	1000	1.27E+12
Brewster Dairy	OH00052191	0.300	190,764,000	1000	1.91E+12
Brewster STP.	OH0020567	0.665	422,860,200	1000	4.23E+12
Mt. Hope WWTP	OH0092282	0.220	139,893,600	1000	1.40E+12
Strasburg WWTP	OH0027553	0.225	143,073,000	1000	1.43E+12

[5] In some cases current loads and loading capacities had to be estimated for flow percentiles for which fecal coliform data were not available. In these cases the loads were based on the loads for the next highest and next lowest flow percentile.

5.0 SOURCE ASSESSMENT

The most likely sources of fecal coliform within each assessment unit are identified in the following sections. Although specific loads from all sources have not been estimated due to resource and data constraints, the most likely sources have been identified using a weight-of-evidence approach based on an evaluation of the following data:

- Land use/land cover
- Population
- Point Sources
- Number of licensed dairy farms
- Stream channel and riparian corridor conditions
- Best professional judgment

5.1 Assessment Unit 100: Sugar Creek Headwaters

This section of the report discusses the most likely bacteria sources for AU100 (Sugar Creek Headwaters).

5.1.1 Land Use and Land Cover

Land use and land cover within assessment unit 100 are summarized in 0 and presented in Figure 5-1. The table and figure show that the vast majority (85.4 percent) of the assessment unit is devoted to agricultural activities; row crops account for 70.6 percent of the total assessment unit area, while pasture accounts for 14.8 percent of the total area. Sources of bacteria and potential pathogens associated with agricultural activities include poorly managed or uncontrolled runoff from animal rearing and feeding operations, barn yards and milk houses, spills or releases from manure handling operations, runoff from manure applied used as fertilizer for farm fields, and direct access of streams by grazing animals.

Table 5-1. Land Use and Land Cover within AU 05040001100, Sugar Creek Headwaters.

Land Use and Land Cover	Area (acres)	Percent
Deciduous Forest	6,043.6	9.7
Coniferous Forest	18.5	0.0
Pasture and Hay	9,235.1	14.8
Row Crops	43,940.4	70.6
Water	101.4	0.2
Residential	2,232.2	3.6
Commercial/Industrial/Transportation	134.3	0.2
Urban/Recreational Grasses	195.5	0.3
Woody Wetlands	312.0	0.5
Total	**62,212.9**	**100.0**

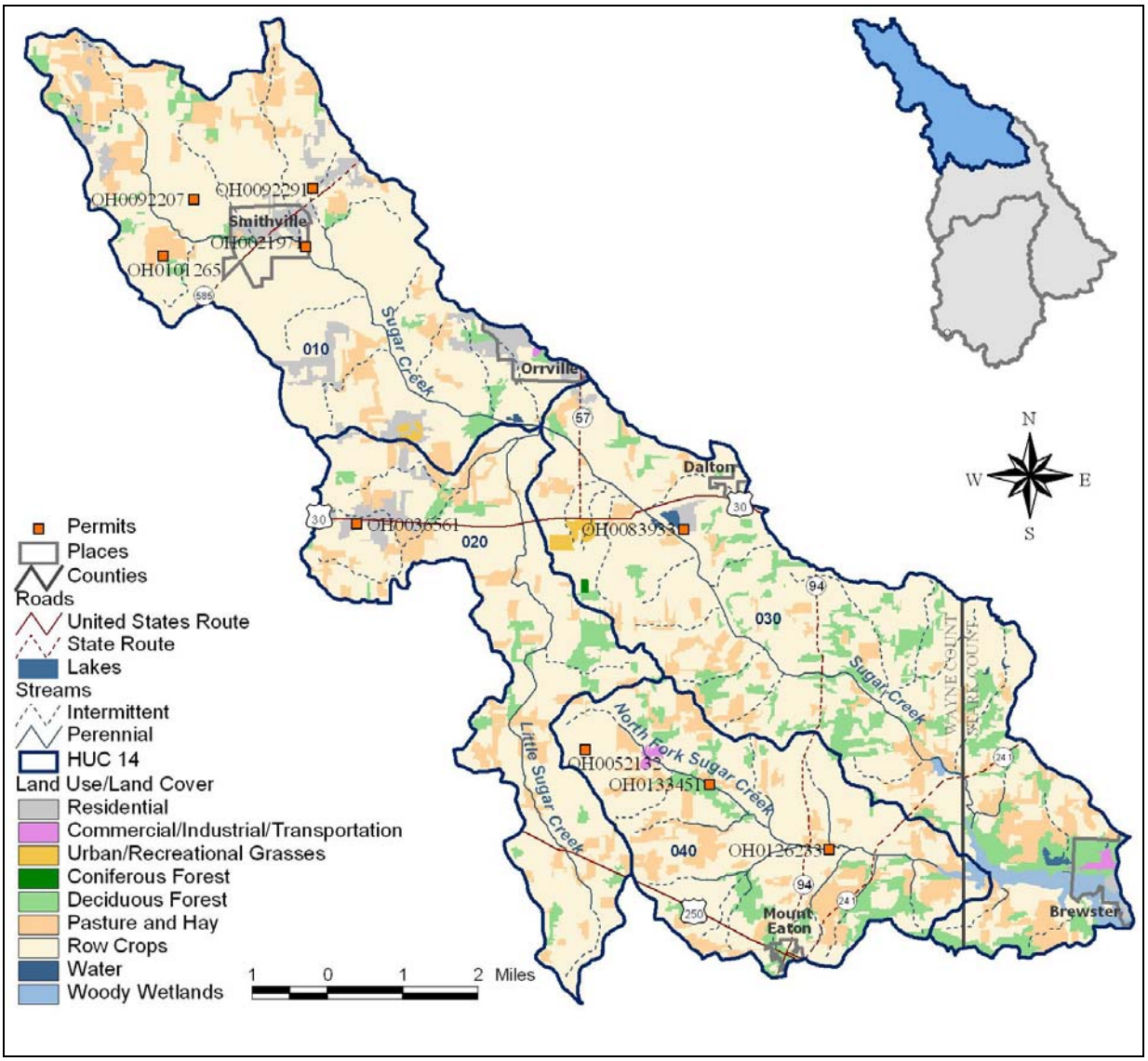

Figure 5-1. Land use/land cover and point sources within AU 05040001100, Sugar Creek headwaters.

5.1.2 On-Site Wastewater Systems

Table 5-2 presents the population characteristics of Sugar Creek headwaters. Major towns and their corresponding populations are listed in the table, as well as the total rural residents and total population within the headwaters. The population of the assessment unit is predominantly rural in character (66 percent) with the major towns of Smithville and Orville only accounting for 9 and 8 percent of the total headwaters population, respectively.

WWTPs serve Mount Eaton, Smithville, and Kidron. However, most of the population in this assessment unit relies on onsite wastewater treatment (i.e., septic systems). OEPA estimated that approximately 67 percent of the septic systems were failing (60 percent ponded (surfacing of effluent); 5 percent short-circuited (less than 50 feet from a stream); 2 percent were illegal direct discharging systems) (OEPA, 2002).

Table 5-2. Population Characteristics within AU 05040001100, Sugar Creek Headwaters.

Place	2000 Population	Percent
Brewster	871	6%
Dalton	189	1%
Mount Eaton	223	2%
Orrville	1,189	8%
Smithville	1,333	9%
Rural	10649	74%
Total	14454	100%

5.1.3 Point Source Dischargers

Facilities with National Pollutant Discharge Elimination System (NPDES) permits to discharge wastewater within the Sugar Creek watershed include small to large publicly owned wastewater treatment facilities as well as industrial dischargers. Permitted industrial dischargers fall within several different categories including cheese manufacturing, poultry processing, meatpacking, rendering, and chemical manufacturing. Information regarding the location, receiving streams, and design flows for NPDES permitted facilities within the Sugar Creek headwaters assessment unit is provided in Table 5-3 and the locations of the facilities are shown in Figure 5-1.

Effluent limitations for fecal coliform bacteria at all permitted point source dischargers are required to be maintained at or below the applicable water quality criteria during the recreation season (May 1 - October 15). Therefore, if an NPDES regulated facility is meeting its effluent limitations, there should be no contribution to violations of the water quality criteria downstream of the discharge. Exceedances of effluent limitations for fecal coliform bacteria determined from monthly operating report data submitted to the Ohio EPA are summarized in OEPA, 2006. Although some temporal problems are noted for individual facilities, the compliance rate among NPDES dischargers is generally high, especially when the data for 2005 are considered. Analysis of the data supports a conclusion that NPDES regulated facilities are not responsible for the violations of the water quality criteria for fecal coliform bacteria and *E. coli* in assessment unit 100.

Table 5-3. NPDES Permitted Wastewater Dischargers within AU 05040001100, Sugar Creek Headwaters.

11-Digit AU/ Facility	County	Ohio Permit	US EPA ID	Expiration	Receiving Stream	River Mile	Sugar Creek RM	Design Flow (MGD)
Gerber's Poultry Inc.	Wayne	3IH00049	OH0052132	1/31/2007	RM 5.85 Trib. North Fork Sugar Creek	0.83	23.22	0.250
Kidron WWTP	Wayne	3PG00159	OH0133451	11/30/2008	North Fork Sugar Creek	5.15	23.22	0.160
Lake Harmony Subdivision	Wayne	3PG00078	OH0083933	10/31/2005	Sugar Creek	32.15	32.15	0.036
Mount Eaton WWTP	Wayne	3PA00033	OH0126233	11/30/2009	North Fork Sugar Creek	2.90	23.22	0.045
Smithville Mobile Home Park	Wayne	3PG00139	OH0092291	7/31/2010	RM 39.66 Trib. Sugar Creek	1.25	39.66	0.006
Smithville Western	Wayne	3PS00010	OH0101265	5/31/2006	RM 0.31 Trib. To RM 42.42 Trib. to Sugar Creek	0.20	42.42	0.090
Smithville WWTP	Wayne	3PB00046	OH0021971	5/31/2005	Sugar Creek	40.33	40.33	0.300
Wayne Co. Airport	Wayne	3PG00132	OH0092207	2/28/2010	RM 41.85 Trib. Sugar Creek	0.70	41.85	0.002
Wayne Co. Eastwood Subdivision STP	Wayne	3PG00133	OH0036561	12/31/2007	Little Sugar Creek	0.80	34.79	0.060

5.1.4 Livestock

A total of 62 licensed Grade A dairy farms are located within AU100, which yields a density of 0.64 farms per square mile. Additionally, a total of 67 Manufacture grade dairy farms are licensed within the assessment unit, which yields a density of 0.69 facilities per square mile (Figure 5-2). There are an estimated 800 beef cows within the assessment unit based upon the 2002 Agricultural Census and a GIS analysis (see Appendix D for more details).

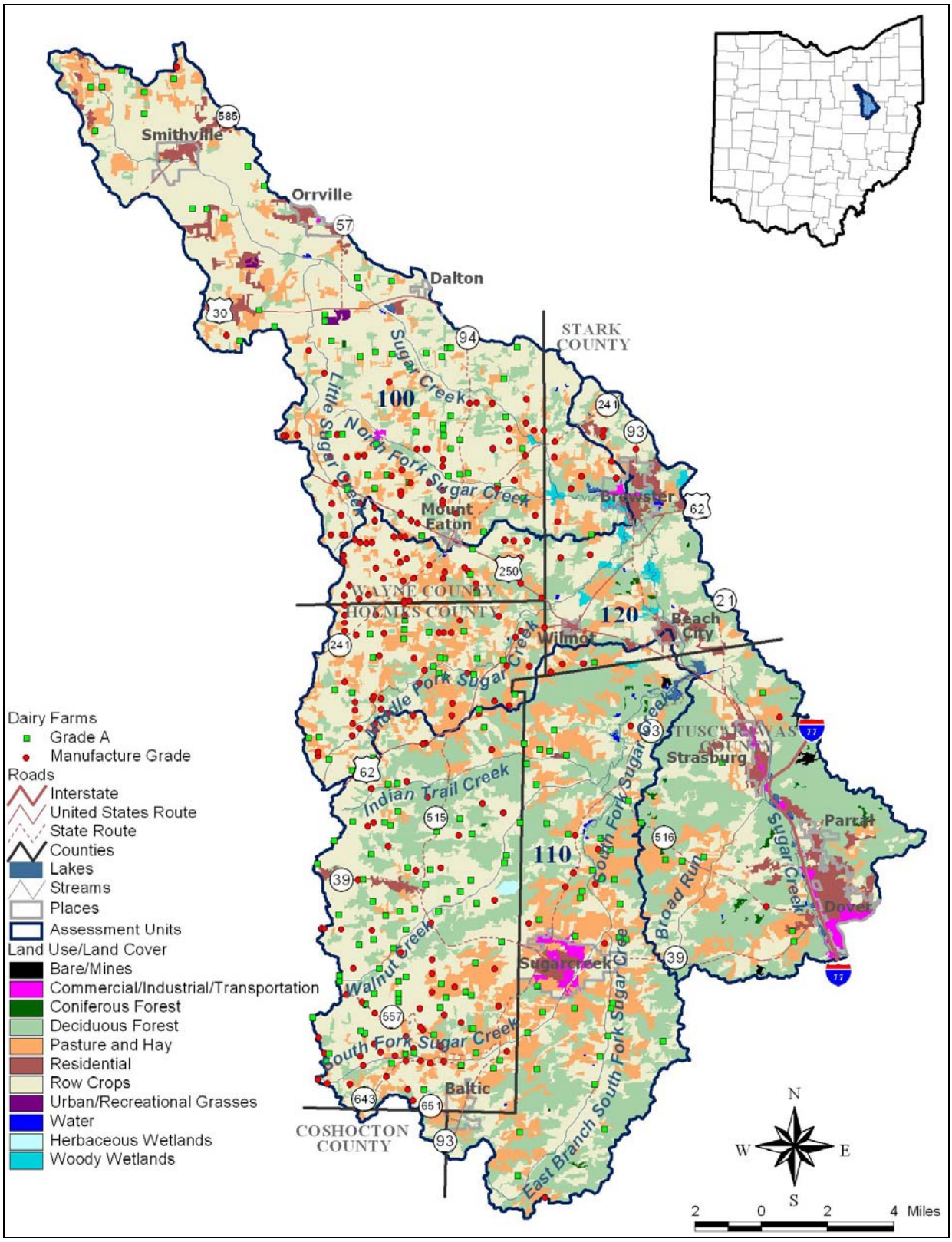

Figure 5-2. Locations of dairy farms within the Sugar Creek watershed.

5.1.5 Stream Channel and Riparian Corridor Conditions

Stream channel morphology and floodplain quality are believed to play an important role in the extremely high fecal coliform and *E. coli* densities observed throughout the Sugar Creek watershed. High TSS concentrations have been correlated to high fecal coliform counts (OEPA, 2006), as have low QHEI scores (Appendix B). Channel conditions within AU100 are relatively poor, with an overall QHEI score of 48 observed at Site R05W29 in 1998. The substrate and channel indices of the QHEI were also marginal at this site (11.5 and 13.0, respectively).

To evaluate riparian corridor conditions in assessment unit 100, a 98-foot (30-meter) buffer zone around all the perennial streams was created within GIS and overlain on the land cover spatial data layer. The land cover types occurring within the buffer zone were extracted and are summarized in Table 5-4. The table shows that the riparian corridor is largely comprised of agricultural land uses with 68 percent of the buffer categorized as cropland and 12 percent categorized as pasture. The relative lack of forest cover suggests that livestock may have relatively unrestricted access to streams in many areas.

Table 5-4. Land Cover and Land Use within the Riparian Buffer of the Sugar Creek Headwaters.

Land Cover / Land Use	Area (acres)	Percentage of Riparian Buffer
Deciduous Forest	134.3	12.3
Evergreen Forest	0.0	0.0
Pasture and Hay	126.3	11.5
Crop	744.6	68.0
Open Water	0.2	0.0
Residential	13.3	1.2
Commercial/Industrial/Transportation	6.2	0.6
Woody Wetlands	70.7	6.5
Total	**1095.7**	**100.0**

5.1.6 Sugar Creek Headwaters -- Summary

The weight-of-evidence suggests that agricultural activities are the most significant source of pathogens and indicator organisms in the Sugar Creek Headwaters Assessment unit. This conclusion is based on the following supporting information:

- The vast majority (85.4 percent) of the assessment unit is devoted to agricultural activities; row crops account for 70.6 percent of the total assessment unit area, while pasture accounts for 14.8 percent of the total area.
- The Agricultural Census indicates there are numerous beef and dairy cattle in the watershed. There is a dairy farm located approximately every 1.5 square miles within the assessment unit.
- A majority (70 percent) of the riparian corridor within the assessment unit is devoted to agricultural activities, suggesting that livestock may have relatively unrestricted access to streams in many areas.
- Monitoring data indicate that the wastewater treatment plants and other point sources in the watershed are largely in compliance with their permits.
- The results of the load duration curve analysis for the two stations in the headwaters (R05S32 and R05S31) are consistent with the primary source of bacteria being runoff from crop and pasture lands (i.e., exceedances occur during wet weather events). The results of the load duration curve for

station R0SW29 in the North Fork of Sugar Creek suggest that livestock access to streams and/or directly discharging onsite wastewater systems could be significant sources (i.e., exceedances occur during both wet weather and dry conditions).

- A screening-level estimate of sources suggests that runoff from pasture lands and direct livestock access to streams are the primary sources even when applying the most conservative (high) estimates of loads from other sources (Figure 5-3). Additional details of the screening-level source assessment are provided in Appendix D.

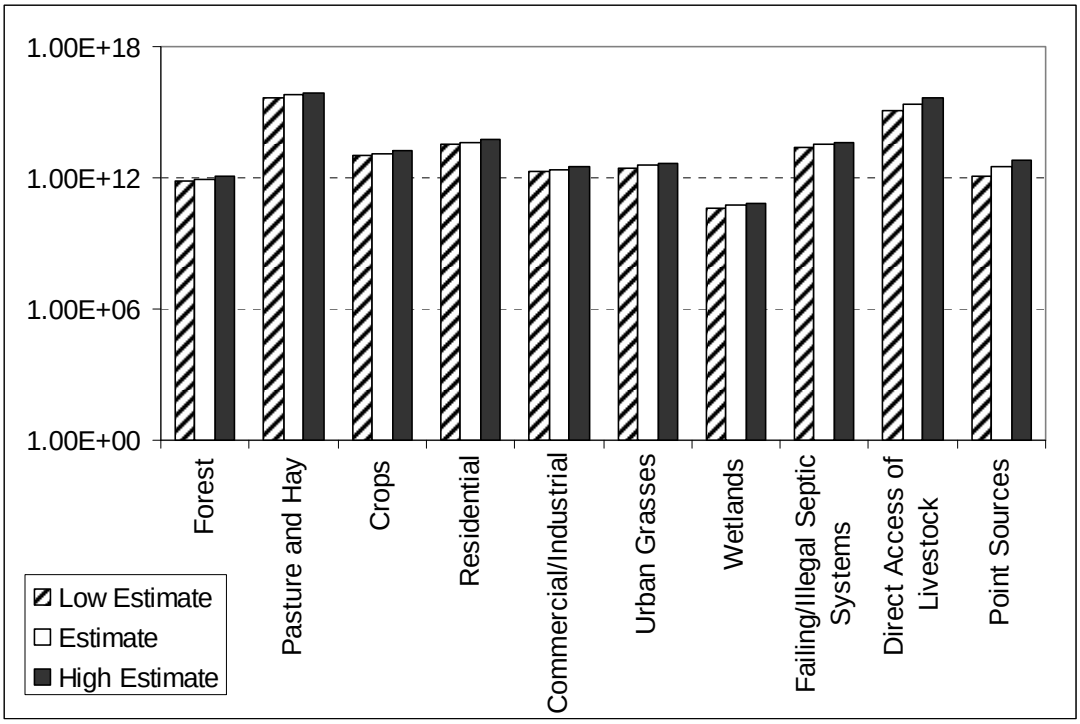

Figure 5-3. Results of screening-level source assessment for Sugar Creek assessment unit 100. Note that the Y-axis is a logarithmic scale and the difference between the highest and lowest sources is greater than it appears.

5.2 Assessment Unit 110: South Fork Sugar Creek

This section of the report discusses the most likely bacteria sources for assessment unit 110 (South Fork Sugar Creek).

5.2.1 Land Use and Land Cover

Land use and land cover within assessment unit 110 are summarized in Table 5-5 and presented in Figure 5-4. The table and figure show that the vast majority (64.4 percent) of the assessment unit is devoted to agricultural activities; row crops account for 43.3 percent of the total assessment unit area, while pasture and hay account for 21.1 percent of the total area. Additionally, deciduous forest accounts for 33.3 percent of the assessment unit area.

Table 5-5. Land Use and Land Cover within AU 05040001110, South Fork Sugar Creek.

Land Use and Land Cover	Area (acres)	Percent
Deciduous Forest	29,292.8	33.3
Coniferous Forest	97.6	0.1
Pasture and Hay	18,578.6	21.1
Row Crops	38,171.0	43.3
Water	173.0	0.2
Residential	873.3	1.0
Commercial/Industrial/Transportation	649.4	0.7
Bare/Mines	39.1	<0.1
Herbaceous Wetlands	146.6	0.2
Woody Wetlands	74.5	0.1
Total	**88,096.0**	**100.0**

5.2.2 On-Site Wastewater Systems

Table 5-6 presents the population characteristics of South Fork Sugar Creek assessment unit. Major towns and their corresponding populations are listed in the table, as well as the total rural residents and total population within the subbasin. The population of the assessment unit is predominantly rural in character (nearly 73 percent) with the major towns of Baltic and Sugarcreek accounting for 10 and 15 percent of the total assessment unit population, respectively.

WWTPs serve Baltic, Sugarcreek, and Walnut Creek. However, most of the population in this assessment unit relies on onsite wastewater treatment (e.g., septic systems). OEPA estimated that approximately 67 percent of the septic systems were failing (60 percent ponded (surfacing of effluent); 5 percent short-circuited (less than 50 feet from a stream); 2 percent were illegal direct discharging systems) (OEPA, 2002).

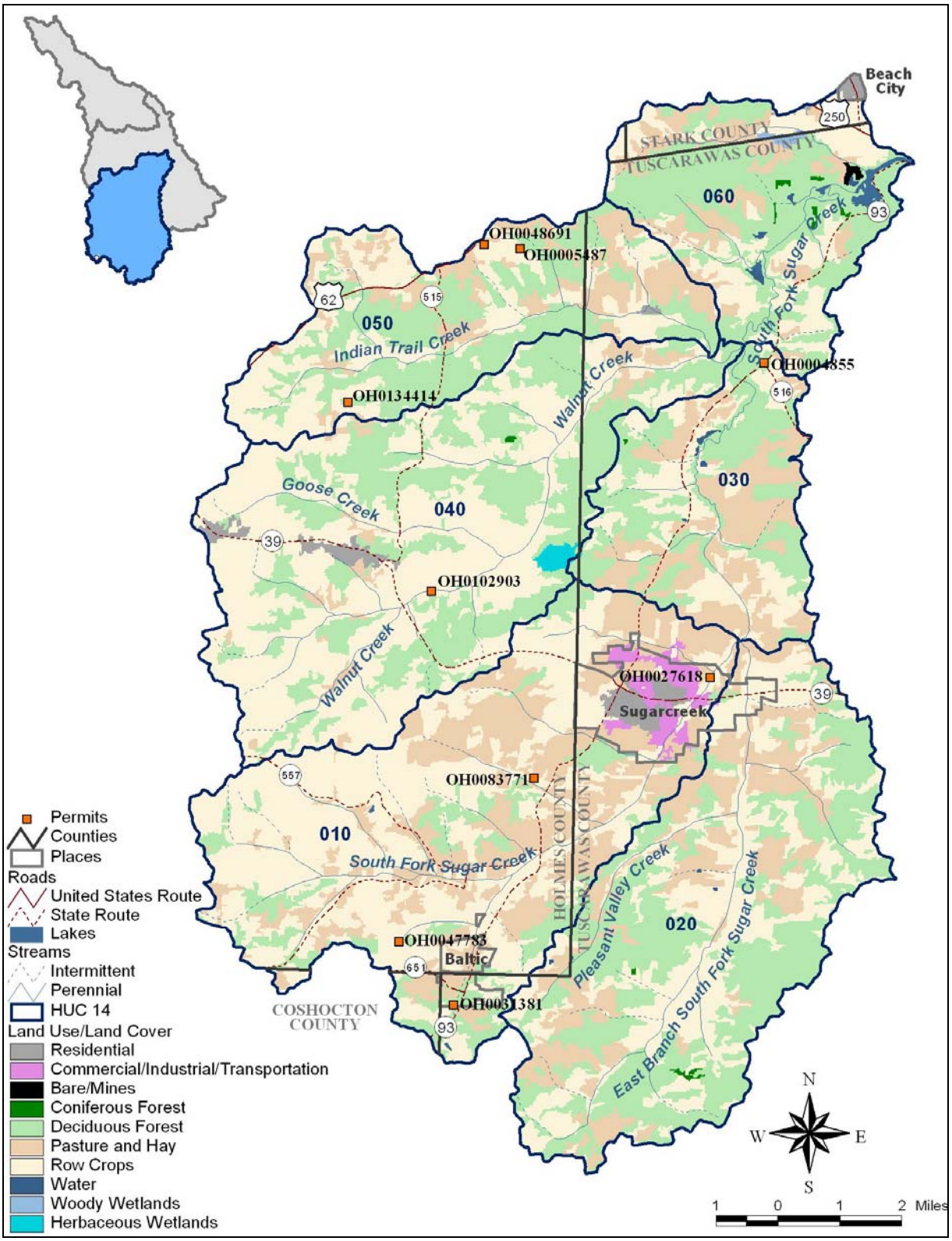

Figure 5-4. Land use/land cover and point sources within AU 05040001110, South Fork Sugar Creek.

Table 5-6. Population Characteristics within AU 05040001110, South Fork Sugar Creek.

Place	2000 Population	Percent
Baltic	1,465	10%
Beach City	350	2%
Sugarcreek	2,174	15%
Rural	10,816	73%
Total	14,805	100%

5.2.3 Point Source Dischargers

Facilities with National Pollutant Discharge Elimination System (NPDES) permits to discharge wastewater within the Sugar Creek watershed include small to large publicly owned wastewater treatment facilities as well as industrial dischargers. Permitted industrial dischargers fall within several different categories including cheese manufacturing, poultry processing, meatpacking, rendering, and chemical manufacturing. Information regarding the location, receiving streams, and design flows for NPDES permitted facilities within the Sugar Creek headwaters assessment unit is provided in Table 5-7 and the locations of the facilities are shown in Figure 5-4.

Effluent limitations for fecal coliform bacteria at all permitted point source dischargers are required to be maintained at or below the applicable water quality criteria during the recreation season (May 1 - October 15). Therefore, if an NPDES regulated facility is meeting its effluent limitations, there should be no contribution to violations of the water quality criteria downstream of the discharge. Exceedances of effluent limitations for fecal coliform bacteria determined from monthly operating report data submitted to the Ohio EPA are summarized in OEPA, 2006. Although some temporal problems are noted for individual facilities, the compliance rate among NPDES dischargers is generally high, especially when the data for 2005 are considered. Analysis of the data supports a conclusion that NPDES regulated facilities are not responsible for the violations of the water quality criteria for fecal coliform bacteria and *E. coli* in Assessment Unit 110.

Table 5-7. NPDES Permitted Wastewater Dischargers within AU 05040001110, South Fork Sugar Creek.

11-Digit AU/ Facility	County	Ohio Permit	US EPA ID	Expiration	Receiving Stream	River Mile	Sugar Creek RM	Design Flow (MGD)
Baltic Rubber	Tuscarawas	NA	OH0031381	NA	Brush Run	2.00	12.3	0.020
Baltic WWTP	Tuscarawas	0PB00067	OH0047783	5/31/2009	Brush Run	0.95	12.3	0.010
Case Farms Inc.	Holmes	3IH00103	OH0005487	6/30/2007	RM 3.2 Trib. Indian Trail Creek	1.40	12.3	0.500
Guggisberg Cheese Inc.	Holmes	3IH00065	OH0083771	7/28/2001	Troyer Valley Creek	1.47	12.3	0.014
Holmes Co. Health Dept.	Holmes	3PG00138	OH0048691	1/31/2007	RM 26.34 Trib. Indian Trail Creek	1.30	12.3	0.015
Sugarcreek WWTP	Tuscarawas	0PB00070	OH0027618	3/31/2006	South Fork Sugar Creek	14.13	12.3	0.500
Troyer's Trail Bologna Inc.	Holmes	3IH00104	OH0004855	9/30/2006	RM 5.42 Trib. Indian Trail Creek	0.25	12.3	0.005
Walnut Creek WWTP	Holmes	3PH00058	OH0102903	10/31/2008	Walnut Creek	7.88	12.3	0.090

5.2.4 Livestock

A total of 111 licensed Grade A dairy farms are located within AU110, which yields a density of 0.81 farms per square mile. Additionally, a total of 82 Manufacture grade dairy farms are licensed within the assessment unit, which yields a density of 0.60 facilities per square mile (Figure 5-2). There are an estimated 1,600 beef cows within the assessment unit based upon the 2002 Agricultural Census and a GIS analysis (see Appendix D for details). Livestock are estimated to be one of the largest sources of bacteria within the assessment unit.

5.2.5 Stream Channel and Riparian Corridor Conditions

Stream channel morphology and floodplain quality are believed to play an important role in the extremely high fecal coliform and *E. coli* densities observed throughout the Sugar Creek watershed. High TSS concentrations have been correlated to high fecal coliform counts (OEPA, 2006), as have low QHEI scores (Appendix B). Within AU110, channel conditions are relatively poor in Walnut Creek and East Branch South Fork Sugar Creek, with overall QHEI scores of 25.5 and 23.0 observed in 1998 at sites R05W22 and R05W19, respectively. Substrate and channel indices of the QHEI were also low at these sites. Substrate scores for Walnut Creek (R05W22) and East Branch South Fork Sugar Creek (R05W19) were 4.5 and 4.0, respectively. Scores of channel indices for these two sites were 1.0 and 5.0, respectively. In contrast, the overall QHEI score of Indian Trail Creek, measured at site R05W25, was much greater with a value of 67.5. Similarly, substrate and channel indices scores for this site were 11.0 and 14.5.

To evaluate riparian corridor conditions in assessment unit 110, a 98-foot (30-meter) buffer zone around all the perennial streams was created within GIS and overlain on the land cover spatial data layer. The land cover types occurring within the buffer zone were extracted and are summarized in Table 5-8. The table shows that the riparian corridor is largely comprised of agricultural land uses with 53 percent of the buffer categorized as cropland and 12 percent categorized as pasture and hay. Thirty-one percent of the riparian corridor is comprised of deciduous forest, and is mainly concentrated in the lower-most portion of South Fork Sugar Creek. The large amount of agricultural cover, widely found adjacent to streams in the upper portion of the assessment unit, suggests that livestock may have relatively unrestricted access to streams in many areas.

Table 5-8. Land Cover and Land Use within the Riparian Buffer of the South Fork Sugar Creek.

Land Cover / Land Use	Area (acres)	Percentage of Riparian Buffer
Deciduous Forest	405.2	31.2
Pasture and Hay	161.7	12.4
Crop	693.4	53.3
Open Water	15.3	1.2
Residential	9.6	0.7
Commercial/Industrial/Transportation	15.3	1.2
Total	**1300.5**	**100.0**

5.2.6 South Fork Sugar Creek -- Summary

The weight-of-evidence suggests that agricultural activities are the most significant source of pathogens and indicator organisms in the South Fork Sugar Creek assessment unit. This conclusion is based on the following supporting information:

- The vast majority (64 percent) of the assessment unit is devoted to agricultural activities; row crops account for 43.3 percent of the total assessment unit area, while pasture accounts for 21.1 percent of the total area.
- The Agricultural Census indicates there are numerous beef and dairy cattle in the watershed. There is a dairy farm located approximately every 1.25 square miles within the assessment unit.
- A majority (65 percent) of the riparian corridor within the assessment unit is devoted to agricultural activities, suggesting that livestock may have relatively unrestricted access to streams in many areas.
- Monitoring data indicate that the wastewater treatment plants and other point sources in the watershed are largely in compliance with their permits.
- A screening-level estimate of sources suggests that runoff from pasture lands and direct livestock access to streams are the primary sources even when applying the most conservative (high) estimates of loads from other sources (Figure 5-5). Additional details of the screening-level source assessment are provided in Appendix D.

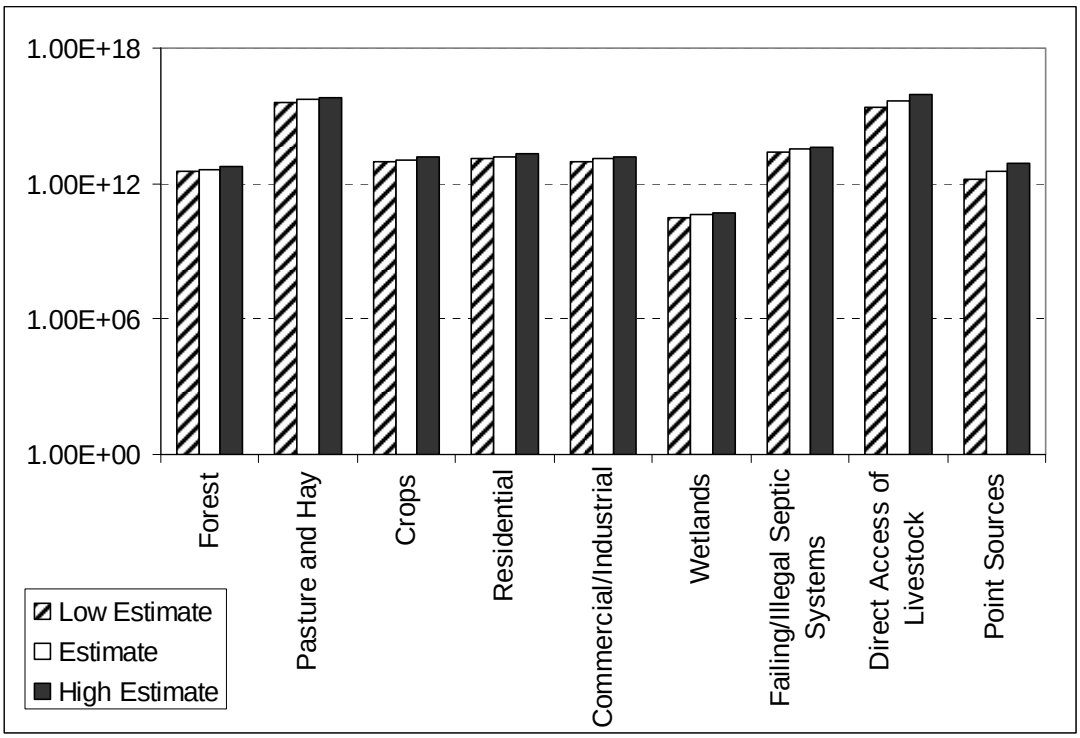

Figure 5-5. Results of screening-level source assessment for Sugar Creek assessment unit 110. Note that the Y-axis is a logarithmic scale and the difference between the highest and lowest sources is greater than it appears.

5.3 Assessment Unit 120: Middle Fork Sugar Creek to Mouth

This section of the report discusses the most likely bacteria sources for assessment unit 110 (Middle Fork Sugar Creek to Mouth).

5.3.1 Land Use and Land Cover

Land use and land cover within assessment unit 120 are summarized in Table 5-9 and presented in Figure 5-6. The table and figure show that most (55.4 percent) of the assessment unit is devoted to agricultural activities; row crops account for 37.5 percent of the total assessment unit area, while pasture and hay account for 17.9 percent of the total area. Deciduous forest and residential land cover types are also important, accounting for 35.8 percent and 5.7 percent of the assessment unit area, respectively.

Table 5-9. Land Use and Land Cover within AU 05040001120, Middle Fork Sugar Creek to Mouth.

Land Use and Land Cover	Area (acres)	Percent
Deciduous Forest	27,743.9	35.8
Coniferous Forest	348.9	0.4
Pasture and Hay	13,867.2	17.9
Row Crops	29,086.2	37.5
Water	205.0	0.3
Residential	4,386.9	5.7
Commercial/Industrial/Transportation	1,134.4	1.5
Bare/Mines	210.8	0.3
Woody Wetlands	574.4	0.7
Total	**77,558.0**	**100.0**

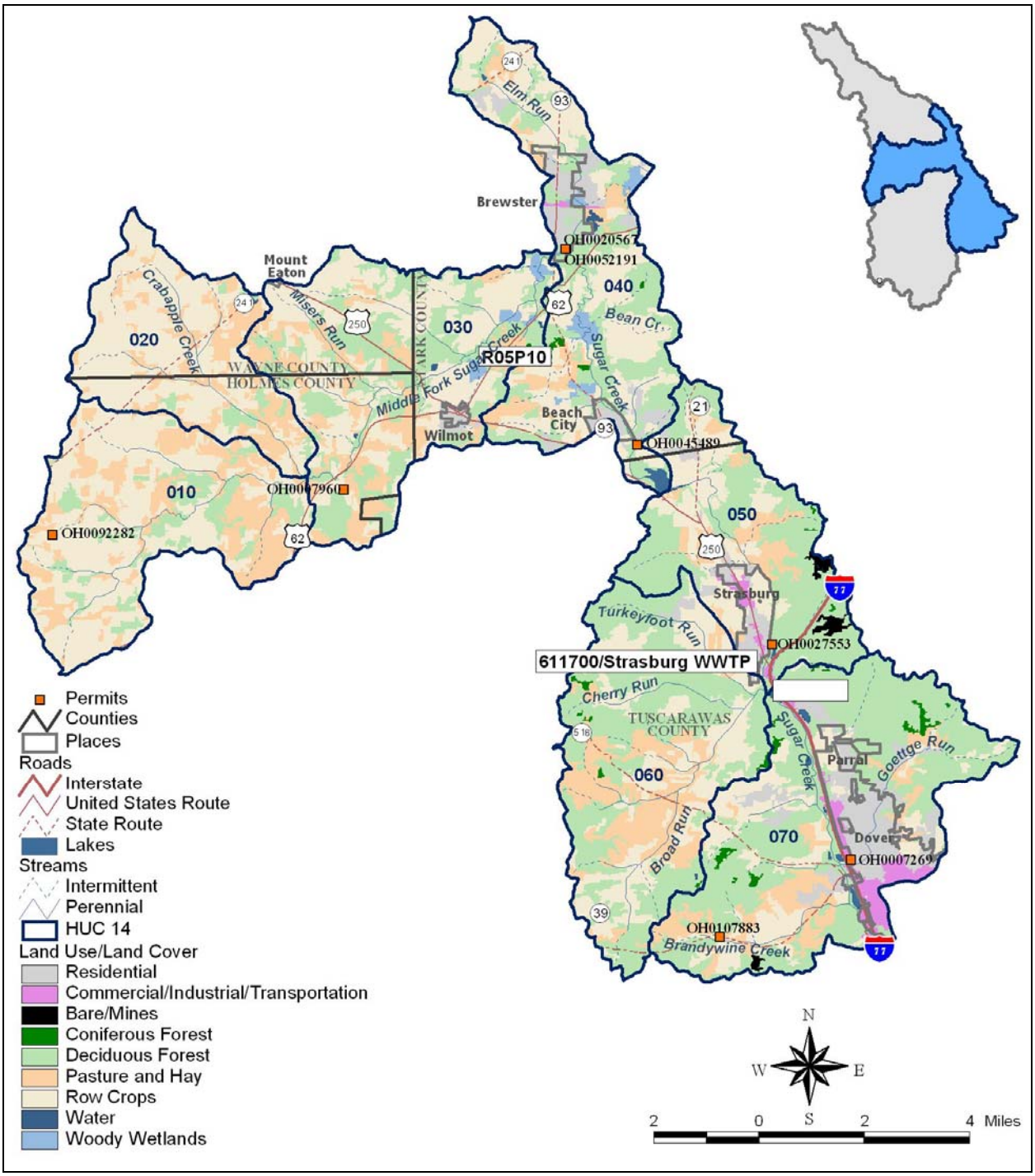

Figure 5-6. Land use/land cover and point sources within AU 05040001120, Middle Fork Sugar Creek to Mouth.

5.3.2 On-Site Wastewater Systems

Table 5-10 presents the population characteristics of the Middle Fork Sugar Creek. Major towns and their corresponding populations are listed in the table, as well as the total rural residents and total population within the headwaters. The population of the assessment unit is approximately evenly split between urban and rural with the major towns of Dover, Strasburg, and Brewster accounting for almost 40 percent of the total population. WWTPs serve Beach City, Brewster, Mount Hope, and Strasburg.

Table 5-10. Population Characteristics within AU 05040001120, Middle Fork Sugar Creek to Mouth.

Place	2000 Population	Percent
Beach City	787	3%
Brewster	1,453	6%
Dover	8,072	32%
Mount Eaton	23	0%
Parral	241	1%
Strasburg	2,310	9%
Wilmont	335	1%
Rural	12,005	48%
Total	25,226	100%

5.3.3 Point Source Dischargers

Facilities with National Pollutant Discharge Elimination System (NPDES) permits to discharge wastewater within the Sugar Creek watershed include small to large publicly owned wastewater treatment facilities as well as industrial dischargers. Permitted industrial dischargers fall within several different categories including cheese manufacturing, poultry processing, meatpacking, rendering, and chemical manufacturing. Information regarding the location, receiving streams, and design flows for NPDES permitted facilities within the Sugar Creek headwaters assessment unit is provided in Table 5-11 and the locations of the facilities are shown in Figure 5-6.

Effluent limitations for fecal coliform bacteria at all permitted point source dischargers are required to be maintained at or below the applicable water quality criteria during the recreation season (May 1 - October 15). Therefore, if an NPDES regulated facility is meeting its effluent limitations, there should be no contribution to violations of the water quality criteria downstream of the discharge. Exceedances of effluent limitations for fecal coliform bacteria determined from monthly operating report data submitted to the Ohio EPA are summarized in OEPA, 2006. Although some temporal problems are noted for individual facilities, the compliance rate among NPDES dischargers is generally high, especially when the data for 2005 are considered. Analysis of the data supports a conclusion that NPDES regulated facilities are not responsible for the violations of the water quality criteria for fecal coliform bacteria and *E. coli* in assessment unit 10.

Table 5-11. NPDES Permitted Wastewater Dischargers within AU 05040001120, Middle Fork Sugar Creek.

11-Digit AU/ Facility	County	Ohio Permit	US EPA ID	Expiration	Receiving Stream	River Mile	Sugar Creek RM	Design Flow (MGD)
Alpine Cheese Co.	Holmes	3IH00100	OH0007960	1/28/2004	Middle Fork Sugar Creek	8.50	19.38	0.220
Beach City Wilmont STP	Stark	3PB00036	OH0045489	12/31/2006	Sugar Creek	13.80	13.80	0.200
Brewster Dairy	Stark	3IH00051	OH00052191	2/28/2007	Sugar Creek	19.04	19.04	0.300
Brewster STP.	Stark	3PB00006	OH0020567	2/28/2007	Sugar Creek	19.05	19.05	0.665
Mount Hope WWTP	Holmes	3PG00135	OH0092282	11/30/2004	Middle Fork Sugar Creek	2.20	19.38	0.220
Strasburg WWTP	Tuscarawas	0PB00043	OH0027553	7/31/2006	Sugar Creek	7.45	7.45	0.225

5.3.4 Livestock

A total of 34 licensed Grade A dairy farms are located within AU120, which yields a density of 0.28 farms per square mile. Additionally, a total of 94 Manufacture grade dairy farms are licensed within the assessment unit, which yields a density of 0.77 facilities per square mile (Figure 5-2). There are an estimated 1100 beef cows within the assessment unit based upon the 2002 Agricultural Census and a GIS analysis (see Appendix D for details).

5.3.5 Stream Channel and Riparian Corridor Conditions

Stream channel morphology and floodplain quality are believed to play an important role in the extremely high fecal coliform and *E. coli* densities observed throughout the Sugar Creek watershed. High TSS concentrations have been correlated to high fecal coliform counts (OEPA, 2006), as have low QHEI scores (Appendix B). Channel conditions within AU120 range from slightly poor to good, as measured in Middle Fork Sugar Creek at site R05P10, and in Broad Run at site R05S36. Overall QHEI scores of 44.5 and 70.0 were calculated for Middle Fork Sugar Creek and Broad Run, respectively. The substrate and channel indices of the QHEI were marginal at R05P10 (11.0 and 9.5, respectively), while R05S36 scored higher in both categories with a substrate score of 12.0 and a channel indices score of 16.0.

To evaluate riparian corridor conditions in AU120, a 98-foot (30-meter) buffer zone around all the perennial streams was created within GIS and overlain on the land cover spatial data layer. The land cover types occurring within the buffer zone were extracted and are summarized in Table 5-12. The table shows that the riparian corridor is mainly comprised of agricultural land uses and deciduous forest. Approximately 31 percent and 16 percent of the corridor is devoted to row crop and pasture/hay land use, respectively, while, and additional 46 percent of the corridor cover is comprised of deciduous forest. Much of the agricultural cover in the riparian corridor is found along the upper portions of Middle Fork Sugar Creek, Broad Run, and Brandywine Creek. The relative lack of forest cover along these riparian corridor segments may allow livestock to have relatively unrestricted access to these stream reaches.

Table 5-12. Land Cover and Land Use within the Riparian Buffer of the Middle Fork Sugar Creek.

Land Cover / Land Use	Area (acres)	Percentage of Riparian Buffer
Deciduous Forest	582.0	45.6
Evergreen Forest	0.4	<0.1
Pasture and Hay	202.2	15.8
Crop	394.7	30.9
Open Water	10.5	0.8
Residential	30.5	2.4
Commercial/Industrial/Transportation	7.1	0.6
Woody Wetlands	49.6	3.9
Total	**1277.0**	**100.0**

5.3.6 Middle Fork Sugar Creek -- Summary

The weight-of-evidence suggests that agricultural activities are the most significant source of pathogens and indicator organisms in the Middle Fork Sugar Creek assessment unit, although other sources might also be significant. This conclusion is based on the following supporting information:

- Most of the land use/land cover (55.4 percent) of the assessment unit is devoted to agricultural activities; however, a significant portion of the assessment unit also consists of forested land uses.
- There is a high density of dairy farms located along the Middle Fork Sugar Creek (see Figure 5-2).
- The riparian corridor along the Middle Fork Sugar Creek is largely devoted to agricultural activities, suggesting that livestock may have relatively unrestricted access to streams in many areas.
- Monitoring data indicate that the wastewater treatment plants and other point sources in the watershed are largely in compliance with their permits.
- A screening-level estimate of sources suggests that runoff from pasture lands and direct livestock access to streams are the primary sources even when applying the most conservative (high) estimates of loads from other sources (Figure 5-7). Additional details of the screening-level source assessment are provided in Appendix D.

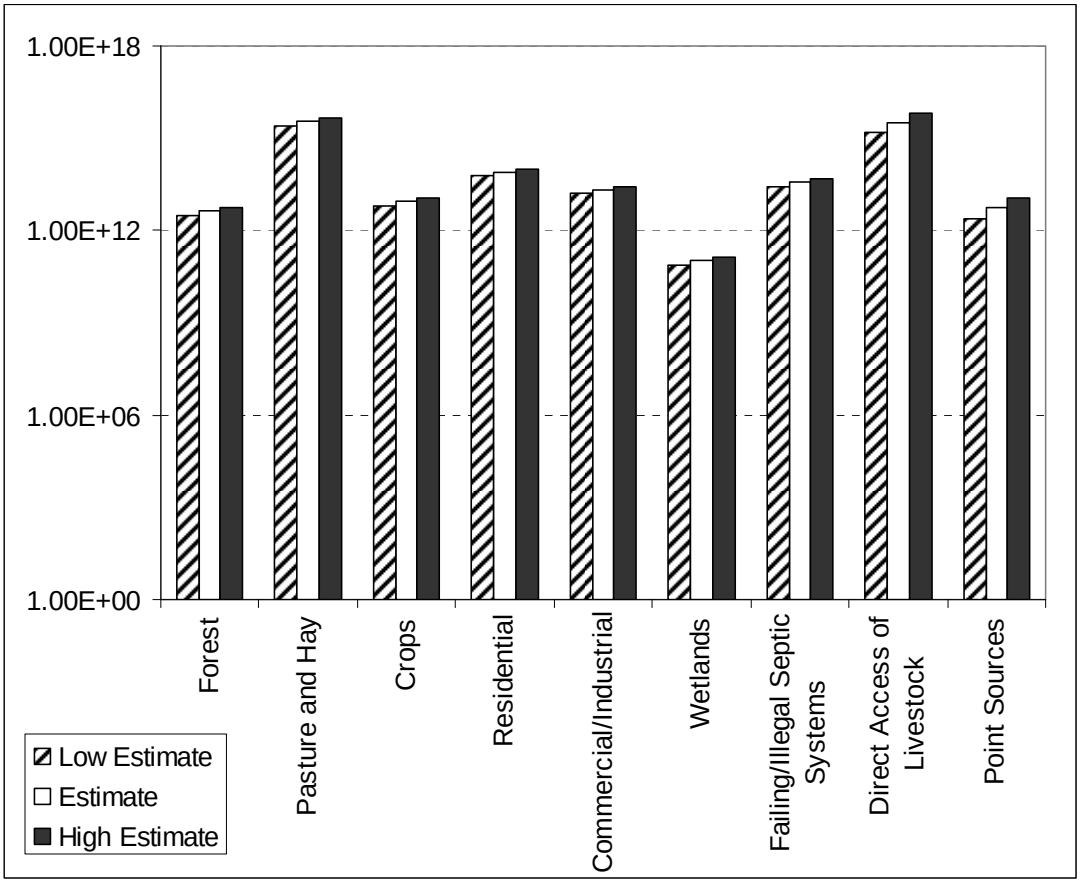

Figure 5-7. Results of screening-level source assessment for Sugar Creek assessment unit 120. Note that the Y-axis is a logarithmic scale and the difference between the highest and lowest sources is greater than it appears.

6.0 IMPLEMENTATION AND MONITORING RECOMMENDATIONS

Restoration methods to bring an impaired water body into attainment with water quality standards through the TMDL process generally involves an increase in the water body's capacity to assimilate pollutants, a reduction of pollutant loads, or some combination of both. With respect to the protection of recreational uses through the reduction of indicator bacteria counts in the Sugar Creek watershed, pollutant "assimilation" as that term is normally used in the TMDL context is not an option. However, as discussed in the report "Recreational Use Water Quality Survey for the Sugar Creek Watershed 2005" (Ohio EPA, 2006), habitat rehabilitation, especially the re-connection of streams with their flood plains, can play an important role in removing bacteria sequestered within fine sediments from streams so that sediment resuspension does not cause elevated bacteria counts and the associated risk of pathogen exposure. Therefore, an effective restoration strategy includes habitat and flood plain improvements in conjunction with reductions in pollutant loads in order to meet the recreational use criteria within the watershed.

Potential restoration strategies used to achieve the TMDL restoration targets to protect recreational uses in the Sugar Creek watershed include:

1) Improvements in livestock pasturing practices to exclude animals from streams
2) Riparian buffer initiatives
3) Habitat and flood plain restoration efforts
4) Flood plain management
5) Sediment and erosion control practices in agricultural and urban areas
6) Conservation farming practices
7) Livestock waste management plans including milk house wastes
8) Home sewage treatment system management and maintenance
9) Implementation of House Bill 110 programs for semi-public waterwater treatment plants in counties not yet participating in the program
10) Storm water management plans
11) Centralized treatment for unsewered communities with high rates of system failures
12) Wastewater treatment planning for high growth areas
13) Public education for awareness of watersheds and water quality

6.1 Implementation Actions and Management Measures

To maximize usefulness, a TMDL implementation plan should address the following:

- Implementation actions and management measures
- Time line
- Reasonable assurances
- Legal or regulatory controls
- Time required to attain water quality standards
- Monitoring plan
- Milestones for attaining water quality standards
- TMDL revision procedures

Ohio EPA is taking an iterative, adaptive approach to implementation for this TMDL project. Point sources regulated under NPDES permits have not been found to be a significant source of bacteria loading that require reductions. Therefore, loading reductions for bacteria in the Sugar Creek watershed will need to address non-point sources such as by excluding livestock from direct contact with surface waters,

eliminating or controlling un-permitted, direct discharges to streams, and the identification and repairing of failing on-site home sewage treatment systems. Ohio EPA does not have direct regulatory mechanisms to implement these remedies, therefore significant local efforts will be necessary to address the water quality degradation and meet applicable water quality criteria.

TMDLs have been approved for the Sugar Creek watershed that address non-attainment of biological water quality criteria (Ohio EPA, 2002). The report sets TMDL targets for dissolved nitrogen, total phosphorus, and sediment and provides loading allocations for seven sub-watershed units within the watershed. The implementation strategy established in the 2002 TMDL report identifies 10 examples of measures necessary to meet the TMDL targeted loads for these pollutants. Several of these measures relate to controls of non-point pollutant loadings that will also result in significant reductions in fecal coliform and *E. Coli* bacteria loadings. The implementation strategy for Sugar Creek re-affirms the need to implement the strategies found in the approved 2002 TMDL and builds upon these recommendations to specifically address water quality impairments to recreational uses found within the watershed.

6.2 Specific Recommendations

Specific implementation recommendations for the reductions of non-point loadings of pathogens in the Sugar Creek watershed are as follows:

1. Develop a Watershed Management Plan for the Sugar Creek watershed

In 2000, the Northeast Ohio Four County Regional Planning and Development Organization (NEFCO) developed a watershed management plan for the Wayne and Stark County portions of the Sugar Creek watershed (NEFCO, 2000). This plan has not been formally endorsed. Later, in coordination with the Ohio Department of Natural Resources (ODNR), funding for a Watershed Coordinator position was made available to the Wayne Soil and Water Conservation District (SWCD) to produce an endorsable watershed management plan for the entire Sugar Creek Watershed. However, this Watershed Coordinator position became vacant in May of 2006, and it is not clear at the time of this writing whether the position will be re-filled. ODNR should prioritize the funding and hiring of a new watershed coordinator housed within an appropriate local agency or watershed group to complete the process of generating an endorsable watershed management plan. Completion of the watershed management planning process is crucial for obtaining funding for pollution abatement and environmental restoration programs such as the 319 Non-Point Source program. Additionally, locally driven planning efforts are generally more likely to be acceptable to watershed residents and may result in greater voluntary participation in the water resource improvement efforts.

2. Fence livestock off the stream

A program of identifying locations where livestock have free access to streams should be carried out by the local soil and water conservation districts and the Natural Resources Conservation Service. These efforts should focus on headwater streams where livestock densities are high in order to prioritize stream reaches targeted for livestock exclusion. Once these locations have been identified, landowner education and a targeted use of incentives within existing state and federal programs should be used to provide alternative livestock water supplies, animal stream crossing structures, and fencing to exclude livestock from the stream. This program will be most effective when it can be implemented in conjunction with habitat and flood plain restoration efforts and the establishment of buffer strips or riparian forest buffers.

3. Improve manure management practices

The most critical aspect of minimizing water quality impacts from any size animal feeding operation is the proper management of manure. All operations should have updated manure management plans and make every effort to avoid land application of their manure during wet weather and during the winter when runoff is more likely to occur. An important aspect of manure application plans should be the provision of adequate isolation distances from streams, preferably within areas with adequate buffer strips or forested riparian buffers (see item 5 below). Continued efforts by local Soil Water Conservation District (SWCD) and Natural Resource Conservation Service (NRCS) staff to work with producers and update plans will be critical. Ohio EPA is committed to working in partnership with local agencies, to respond promptly to complaints as appropriate, and to work with our partners to inform producers about emerging technology and BMPs as well as updates to the technical standards for manure handling and application.

4. Create flood plain in previously channelized stream reaches, improve Qualitative Habitat Evaluation Index scores in accordance with the approved 2002 TMDL for the Sugar Creek Watershed

Agricultural land use and crop productivity throughout large portions of the Sugar Creek watershed depend upon adequate soil drainage. A large percentage of the stream network within the watershed has been significantly entrenched and channelized to alleviate flooding and enhance agricultural productivity, especially along the mainstem of Sugar Creek and in the lower reaches of the main tributaries. These ditched streams have their outlets within large areas designated for innundation behind the Beach City Dam. These altered stream reaches are isolated from their flood plains except during extreme flood events. Many of the smaller tributaries to these stream reaches have also been channelized and entrenched as the result of and in response to the downcutting and erosion of the stream channels as they adjusted to the reduced channel elevations downstream.

On a watershed scale, practices involving agricultural drainage, stream channelization, and flood reduction degrade the ecological health of the Sugar Creek watershed. The cumulative impacts of high flow rates and the associated relative increase in stream power, as well as elevated sediment delivery on Sugar Creek and its tributaries, contributes to water quality degradation, declining biological integrity, and high counts of pathogen indicator bacteria. Additional stress to the system has been added by the activities of private landowners and public projects to control stream bank erosion and flooding in localized areas.

Altered stream channel morphology, poor flood plain quality, and disconnection of stream channels from their flood plains play an important part in the extremely high fecal coliform and *E. coli* densities observed in the Sugar Creek watershed. Sediments in aquatic systems can be a significant reservoir for pathogenic organisms and indicator bacteria. Sediment resuspension can significantly increase bacteria counts in overlying waters (Byappanahalli, et al., 2003;Craig et al., 2003; Francy et al., 2003; Francy et al., 2005; Jamieson, et al., 2005). The linkage of total suspended solids to bacterial counts indicates that pollution abatement efforts to reduce water column bacteria counts will also have to consider not only non-point loadings of TSS and bacteria (external loads to the stream) but also factors that address bacteria laden sediments within the stream channel (internal loading).

The approved 2002 nutrient, sediment, and habitat alteration TMDL for the Sugar Creek watershed calls for restoration of stream habitat to meet a score of 60 using the Qualitative Habitat Evaluation Index (QHEI). Although this target does provide a measurable goal for fish habitat restoration, it may not go far enough towards the creation of active flood plain along the many miles of entrenched, channelized streams found in the watershed where fine pollutant and bacteria laden sediments become entrapped for

later resuspension. A program to create flood plain areas where fine sediments and attached bacteria can be deposited along the margins of the stream will result in reductions in the bacteria counts during high flow events. The mortality rate for bacteria deposited in flood plains is higher since they are exposed to drying conditions and direct sunlight. Reestablishment of flood plains will also result in coincident reductions in nutrient concentrations and total suspended solids through the same depositional processes. As fine sediments are removed from the stream channel, and the stream course is allowed to meander naturally, habitat for aquatic life will also improve.

The challenge of meeting the TMDL goals, specifically those associated with the habitat and flood plain width targets established in this report and the approved 2002 nutrient, sediment and habitat TMDLs will be to find acceptable methods that simultaneously accommodate agricultural drainage, erosion protection and flood reduction work and the ecological needs of the Sugar Creek system. Recent scientific evidence suggests that these objectives can be compatible (Ward et al., 2002). Ohio EPA has identified implementation strategies that will provide for long-term improvement in stream channel condition, flood plain connectivity, and habitat quality that will provide for significant reductions in fecal coliform and *E. coli* bacteria.

First, in some circumstances, the United States Army Corps of Engineers (US ACOE) issues permits for dredging and placement of fill in a stream below the ordinary high water mark. The determination of when a Section 404 permit is needed is made by the US ACOE and may involve the consideration of comments from Ohio EPA and others. When a 404 permit is needed, Ohio EPA is responsible for reviewing Section 401 water quality certifications and isolated wetland applications for this activity and certifying that the activity will meet water quality standards. Future 401 and isolated wetland certifications by Ohio EPA should include a review for attainment of water quality standards in light of these targets, and where attainment is not possible, the certification should seek mitigation of the proposed activity. Downstream mitigation within the same sub-watershed is highly preferable because it helps the system absorb the increased amount of flood water and erosional energy created when projects fall short of attaining on-site the sediment loading reduction, habitat and flood plain width allocations and recommendations found in this report. Where appropriate, Ohio EPA should require, as part of the mitigation plan, natural channel design or flood plain excavation to allow the stream channel access to the flood plain.

The second means of implementing the sediment loading, habitat and flood plain width recommendations of this report and the 2002 TMDL is possible through action by local government entities. Local jurisdictions through zoning and through their authority to enact flood plain regulations have the ability to protect existing flood plains and to make wooded riparian corridors a preferred land use in those areas. There are a number of locally-derived benefits associated with reaching the sediment loading, habitat and flood plain width targets provided in this report and the 2002 TMDL. Meeting these targets will improve and preserve the water resources and will also keep or restore landscape features that could add to local land values. In addition, zoning and flood plain regulations that keep new development out of the stream setbacks, within which the stream channel itself is likely to move over the course of time, will reduce public and private costs associated with flood damage and loss of property when stream banks erode.

The third and primary implementation mechanism is to maintain agricultural drainage through environmentally sound means. An ongoing step along this path has been Ohio EPA's participation on a Rural Drainage Advisory Committee convened by Ohio DNR Division of Soil and Water Conservation. Other committee participants include environmental groups, county engineers, academia, and federal, state, and local soil and water conservationists. The committee is looking at the current laws and regulations related to ditch construction and maintenance and looking for practical solutions that effectively address drainage needs and protection of water quality. Additional specific outcomes might

include State-wide guidelines to assess drainage needs, ditch reconstruction needs and methods, and BMPs for construction and maintenance.

Upon development of additional guidelines, the bacteria, sediment loading, habitat and flood plain width targets found in this report and the approved 2002 TMDL will allow for a systematic approach to improving conditions within each sub-watershed area of the Sugar Creek watershed. Petition ditch maintenance work and privately maintained drainage projects on waters designated as Warmwater Habitat should be performed with an eye towards installing BMPs that will reduce sediment loads, and improve habitat and flood plain width characteristics within the tributary network. Conversion of traditional ditch design and maintenance practices to innovative two stage channel and over-widened ditch design to create flood plain, flood plain excavation, or natural channel design features should also be encouraged. Strategies for watershed action that target cost sharing or other mechanisms of funding these efforts should be prioritized by local, state and federal agencies.

5. Establish buffer strips and/or riparian forest buffers

Riparian buffers, also known as vegetated buffer zones or conservation buffers, are lands adjacent to streams that protect surface waters from polluted runoff and other stressors to the aquatic ecosystem. Runoff traveling through riparian buffers is slowed and particles transported by overland flows are more readily deposited in these areas. Additionally, vegetated buffer zones have higher rates of infiltration and reduce the volume of runoff reaching surface waters and thereby further reduce pollutant loading to surface waters. Major vegetation types used as buffers are trees, shrubs, native warm-season grasses and non-native cool-season grasses.

Forested riparian buffers have the advantage of a deeper root zone which often facilitates relatively more infiltration and also provides an excellent source of shade to small and medium sized streams. Shading is beneficial to stream systems because it moderates water temperatures (i.e., reduces daytime peak and increases over-night low temperatures) as well as retards excessive algae production by limiting sunlight. Shrubs and warm season grasses are more deeply rooted than cool season grasses and, in addition, provide superior upland wildlife habitat (especially for ground nesting birds), which may provide ancillary benefits to local residents. Small stream ecosystems also utilize detritus and debris originating from riparian zones for food subsidies and habitat structure, especially from forested riparian zones.

Riparian buffers can also provide valuable habitat for wildlife. In addition to providing food and cover they are an important corridor or travel way for a variety of wildlife. Forested stream corridors benefit game species and non-game species like migratory songbirds.

Flood plain vegetation slows flood waters, thereby helping to maintain stable streambanks and protect downstream property. By slowing down flood waters and rainwater runoff, the flood plain vegetation allows water to soak into the ground and recharge groundwater. Slowing flood waters allows the flood plain to function as a site of sediment deposition, trapping sediments that build stream banks and would otherwise degrade resulting in stream bank erosion and downstream degradation through sediment deposition. Buffers also trap pathogens, nutrients, fertilizers, pesticides, and heavy metals, and they help trap snow and cut down on blowing soil in areas with strong winds. If properly installed and maintained, they have the capacity to:

- remove up to 60 percent or more of certain pathogens.
- remove up to 50 percent or more of nutrients and pesticides.
- remove up to 75 percent or more of sediment.

Riparian buffer creation and restoration efforts should be coordinated with other implementation efforts relating to habitat quality and the creation of flood plain listed in this report to provide the greatest benefit to reduce bacteria counts in the stream network. Targeted use of state and federal incentive programs to encourage integrated approaches to habitat and flood plain improvement efforts should be developed in order to meet these objectives. A preferred mechanism for achieving this coordination of effort is through the development of an endorsed watershed management plan.

6. Identify discharges from animal management operations such as milk houses and animal feeding operations and provide incentives and controls to eliminate these sources

Ohio EPA is currently responsible for issuing NPDES permits to animal feeding operations (AFO) that meet the definition of a concentrated animal feeding operation (CAFO). There is only one CAFO (e.g., greater than 700 dairy cows) that is required to obtain an NPDES CAFO permit in the Sugar Creek watershed at this time. However, medium sized operations may be required to apply for a permit in the future if they have a discharge from their production area. Ohio EPA will make every effort to investigate operations where discharges are alleged, and determine if an NPDES permit is needed. Once issued, these permits are expected to result in nutrient and bacteria reductions since both the production area and land application activities will be more closely regulated. In addition, most permittees will be required to attend training related to water quality and manure handling as a condition of their permit.

Permit conditions and requirements are not expected to change significantly when the NPDES authority for CAFOs is transferred to the Ohio Department of Agriculture. Ohio EPA will continue to work closely with the Department of Agriculture in establishing requirements to protect water quality, especially in critical watersheds such as Sugar Creek.

Given the large number of dairy farms in the Sugar Creek watershed, it is possible that numerous direct discharges exist from smaller operations not subject to NPDES permit requirements that contribute significantly to the loading of bacteria to adjacent waterways. Identification and elimination of these "milk house" waste discharges is important not only to meet recreational use water quality criteria related to pathogens, but also for the reduction of nutrient loadings to streams within the watershed. The Alpine Cheese Company nutrient trading program has made this a priority item for addressing phosphorus loading to targeted areas within the watershed (see section 6.3 for a description of this program). This phosphorus reduction strategy will have coincident benefits for the reduction of bacterial loadings as well. This strategy should be expanded to address runoff from smaller animal feeding operations as well.

7. Identify and upgrade or eliminate faulty septic systems and/or off-lot discharging home sewage treatment systems in unsewered areas:

Identification of specific problem areas affected by failing on-site home sewage treatment systems (HSTSs) was not within the scope of the 2005 recreational use water quality survey. However, given the large number of homes within the watershed that are not served by central sewer systems, correction of failing on-site HSTSs must be considered as an important component of TMDL implementation. Ohio EPA estimates that approximately 67 percent of the on-site HSTSs within the Sugar Creek watershed are failing (Ohio EPA, 2002), and these systems may be significant localized sources of bacteria loading contributing to water quality violations, especially in areas where housing densities are concentrated.

Current known problem areas that should be considered for connection to centralized sewage systems are the communities of Columbia and Lowdon located to the north of Dover in Tuscarawas County (AU 05040001120). These communities have high housing densities located within an area of shallow depths to groundwater. The City of Dover has submitted a general plan to provide sewers to these areas and is

currently in the process of developing engineering drawings to upgrade their wastewater treatment plant. Once the treatment plant has been upgraded, sewers should be extended to these communities in order to protect human health and provide for adequate sewage treatment.

Other potential problem areas have not been fully assessed, but may require the installation of centralized wastewater treatment facilities if significant rates of HSTS failure are found include the following communities in Tuscarawas County:

AU 05040001110:
Ragersville (Auburn Township)
Unsewered areas in the vicinity of Baltic (Bucks Township)
Barrs Mill (Sugar Creek Township)

AU 05040001120:
Dundee (Wayne Township)
Winfield (Dover Township)

It is recommended that the Tuscarawas County Health Department, in conjunction with Ohio EPA, conduct studies to determine the degree of impact failing HSTSs in these communities are having with respect to bacterial loadings and that corrective actions be taken as necessary in order to repair or replace failing systems or to provide for alternative wastewater treatment as appropriate.

8. Implement HB 110 for small commercial wastewater dischargers in Wayne and Tuscarawas Counties

Bacteria loads from permitted NPDES dischargers in the Sugar Creek watershed were determined not to be a significant source of NON-attainment of the recreational use water quality criteria. However, there are a significant number of small commercial sanitary waste treatment/disposal systems discharging between 0 to 25,000 gallons per day (also known as semi-publics) in the watershed that are not yet permitted under NPDES that have traditionally been regulated through Local Health Districts (LHDs). Many of these small systems have had a history of poor operation and maintenance. A program was created by the Ohio General Assembly in 1984 under House Bill 110 (HB110) to address pollution controls for these small wastewater systems. The program is a contractual partnership between LHDs and Ohio EPA, whereby LHDs conduct, on behalf of the Agency, inspection and enforcement services for these semi-public wastewater treatment facilities. To offset costs of local oversight, State law (Revised Code 3709.085) authorizes LHDs to charge fees for inspection services to be paid by the facility owners.

Ohio EPA operates the HB110 program to better protect the public health and welfare, and to protect the environment. Ohio EPA believes that due to the proximity, the multitude of facilities, and the availability of resources, oversight of operations for sanitary waste disposal at semi-publics may best be accomplished locally by qualified personnel. Ohio EPA provides technical and enforcement support to the program in order to enable LHDs to take on this task. Ohio EPA also provides training programs for LHDs that focus on sanitary waste disposal for Semi-Public facilities, technical assistance, inspection issues, and enforcement case development.

In accordance with Ohio EPA's HB110 contracts, LHDs regularly inspect sanitary facilities at semi-publics for compliance with Ohio's water pollution control laws and regulations. Investigations of complaints regarding waste disposal by semi-publics are also accomplished locally. Ohio EPA also consults with LHDs on the approval of plans and issuance of permits-to-install (PTIs) for semi-publics. Installation inspections may be performed locally to ensure compliance with Ohio EPA's PTI conditions.

In coordination with Ohio EPA, LHDs may notify entities of noncompliance with Ohio's water pollution control regulations. LHDs are also instrumental in identifying semi-publics installed without PTIs, of which Ohio EPA may not be aware. Where noncompliance notification and informal requests fail to correct violations, entities may be referred to Ohio EPA for enforcement or the County Prosecutor may bring an action under local nuisance ordinances. All discharges of pollutants which are unpermitted or in discharge in excess of permitted loadings are statutory nuisances under Revised Code 6111.04. Holmes and Stark Counties have both entered into HB110 contracts with Ohio EPA to oversee semi-public wastewater treatment operations. These programs have worked well to alleviate problems typically encountered in the operation of these small systems. Wayne and Tuscarawas Counties have not yet entered into contracts with Ohio EPA to implement the HB110 program. Although the specific nature and degree of problems relating to improperly operated semi-public wastewater systems in these portions of the watershed is unknown, they may be having significant impacts on recreational use attainment in specific stream reaches. It is recommended that Ohio EPA work with both Wayne and Tuscarawas Counties to develop HB 110 programs in order to address this issue and provide better oversight of semi-public wastewater facilities.

9. Update Areawide Waste Treatment Management Plans (208 plans)

The 208 (Areawide Waste Treatment Management Plan prepared pursuant to Section 208 of the Clean Water Act) plan for the Muskingum River basin area was completed in 1979. The purpose of the plan is to address municipal wastewater treatment issues and nonpoint source pollution. Resources are needed to sustain the Water Quality Management planning efforts at the area-wide level so that plan recommendations will be acted on and adopted by local communities. Identifying an action in the 208 Plan for local government attention is only the first step towards implementation. The updated NEFCO 208 plan which covers Stark and Wayne Counties is scheduled to be certified in the near future. The NEFCO plan addresses seven areas including wastewater management, home sewage disposal systems, and nonpoint source pollution.

Table 6-1. Description of Implementation Actions and Measures

#	Implementation Actions & Management Measure	Affected Stream / Party	Parameters Effected / Benefits	Estimated Effectiveness
1	Develop a Watershed Management Plan for the Sugar Creek watershed	Sugar Creek watershed area	Establish stream protection and restoration targets, provide watershed education, possible source of funding.	Very good when implemented.
2	Fence livestock off the stream	Sugar Creek watershed area	Reduction in bacteria and nutrient loadings, improvement of riparian habitat and reduction in suspended solids.	Very good when implemented
3	Improve manure management practices	Sugar Creek watershed area	Reduction in bacteria and nutrient loadings.	Very good when implemented
4	Create flood plain in previously channelized stream reaches, improve Qualitative Habitat Evaluation Index scores in accordance with the approved 2002 TMDL for the Sugar Creek Watershed	Sugar Creek watershed area	Reduction in suspended solids loadings, reduction in bacteria resuspension, connection of stream with flood plain to provide addition nutrient and bacteria reductions.	Very good when implemented
5	Establish buffer strips and/or riparian forest buffers	Sugar Creek watershed area	Reduction in bacteria and nutrient loadings, protection of riparian habitat and reduction in suspended solids.	Very good when implemented
6	Identify discharges from animal management operations such as milk houses and animal feeding operations and provide incentives and controls to eliminate these sources	Sugar Creek watershed area	Reduction in bacteria and nutrient loadings	Very good when implemented
7	Identify and upgrade or eliminate faulty septic systems and/or off-lot discharging home sewage treatment systems in unsewered areas	Sugar Creek watershed area	Reduction in bacteria and nutrient loadings	Very good when implemented
8	Implement HB 110 for small commercial wastewater dischargers in Wayne and Tuscarawas Counties	Sugar Creek watershed area	Reduction in bacteria and nutrient loadings	Very good when implemented
9	208 updates	Sugar Creek watershed area (part of Muskingum River watershed)	Comprehensive planning will help to promote better land use decisions and provide guidance to Ohio EPA and local sewer authorities. Storm water controls will help to reduce impacts associated with development.	Very good, if the guidance is followed.

6.3 Time Line

Significant progress has been made in addressing water quality issues in the Sugar Creek watershed since the 2002 TMDL was finalized. For example, in 2003, a wastewater treatment facility was constructed to service Kidron in Wayne County. Failing on-site sewage systems in this community were a significant source of non-attainment of water quality criteria in the North Fork of Sugar Creek. Construction of this

facility has resulted in significant improvements in water quality in the upstream portions of the North Fork (Ohio EPA, 2006). The upstream portion of the North Fork was the only stream segment in the watershed found to be in full attainment of the recreational use water quality criteria for bacteria in the 2005 water quality survey.

In 2001, a group of local farmers partnered with researchers associated with the Agroecosystems Management Program (AMP) of the Ohio Agricultural Research and Development Center (OARDC) to begin a headwaters initiative in the North Fork Sugar Creek watershed to assess and address water quality issues identified by in the approved nutrient, sediment, and habitat TMDL. The Sugar Creek Headwaters Project used a new approach for grassroots farmer led pollution identification and abatement through a partnership teaming the landowners with researchers, and technicians from the local Soil and Water Conservation Districts and NRCS. "Project goals include understanding the ecology of agricultural pollution; generating an entrepreneurial mechanism that catalyzes stewardship values and synergy between farmers and industry to lower pollution levels while mutually increasing profitability and social capital; and creating ways for farmers to transition toward more ecological farming while increasing earnings." (http://oardc.ohio-state.edu/story.php?id=3161 , OARDC, 2005). The cooperative effort has secured funding through a 319 Non-Point Source grant for the collection adequate data to target pollution abatement and habitat restoration efforts, as well as implementation of several recommendations found in the approved 2002 TMDL report such as the installation of livestock exclusion fencing and the creation of riparian corridors along streamways. Although these activities were targeted primarily toward meeting the nutrient loading, sediment reduction and habitat restoration targets set in the 2002 TMDL, these efforts should have also significant benefits in the reduction of bacteria loading to the targeted streams.

The experience gained in efforts to address water quality concerns in the Sugar Creek Headwaters Project has lead to the development of an approach dubbed the "Sugar Creek Method". This concept seeks to use community-based efforts to approach watershed management that emphasizes local decision making and actions based upon scientific data (http://sugarcreekmethod.osu.edu/index.html).

The Sugar Creek Method has six main characteristics (quoted from the Sugar Creek method web page):

1) Treat each stream as unique physically, biologically, and socially.
2) Focus on headwaters and benchmark water quality.
3) Catalyze participatory learning communities at the local level that seek their own sub-watershed visions.
4) Collaborate with downstream teams with the help of Extension and Soil and Water Quality professionals.
5) Build on the concept that a healthy environment leads to healthy people and profitable agriculture.
6) Seek to find more sustainable approaches at the family, property parcel, sub-watershed community, and watershed levels through a holistic approach.

The Sugar Creek method approach has resulted in significant levels of participation by local farmers, including farmers from the Amish religious community who have taken the lead on efforts to improve their local watersheds. Successful efforts in the upper Sugar Creek and North Fork watersheds (AU 05040001100) have led to interest by farmers and land owners in the South Fork watershed (AU 05040001110) to begin similar activities.

NPDES permit nutrient reduction targets for total phosphorus in the 2002 TMDL have also created a program for non-point source pollution implementation in the Sugar Creek watershed that will have a positive effect upon the reduction of bacteria loads. The Alpine Cheese Co., a cheese manufacturer with a permitted NPDES discharge to the Middle Fork (AU 050400001100), when faced with a 1 mg/l total

phosphorus limit in their permit, requested permission to expand their flow, reduce total phosphorus concentrations to 3.2 mg/l and to implement a nutrient trading program in cooperation with the Holmes SWCD and the Ohio State University AMP and OARDC. Upon approval by Ohio EPA through the NPDES permit for this facility, the nutrient trading program will implement total phosphorus load reduction programs through the installation of traditional and innovative best management practices (BMPs). Many of these BMPs will also provide significant controls for bacteria loading and will be highly compatible with the goals of this report. For more information regarding this program, see the following URL: http://www.ohiodnr.com/soilandwater/docs/AnnualReport/2005CPAnnualReport.pdf.

6.4 Reasonable Assurances

As part of an implementation plan, reasonable assurances provide a level of confidence that the waste load allocations and load allocations in TMDLs will be implemented by Federal, State, or local authorities and/or by voluntary action. Reasonable assurances for enforceable point source controls, such as wastewater treatment plant upgrades, combined sewer overflow control and changes to NPDES permits are not necessary for the Sugar Creek watershed. For certain non-point source activities assurances must include 1) demonstration of adequate funding; 2) process by which agreements/arrangements between appropriate parties (e.g., governmental bodies, private landowners) will be reached; 3) assessment of the future of government programs which contribute to implementation actions; and 4) demonstration of anticipated effectiveness of the actions.

The 2002 USDA Farm Bill provides funding for several incentives-based cost share programs for farmers to promote resource conservation, agricultural improvements, and environmental protection and restoration. These programs which are managed by NRCS and the Farm Service Agency (FSA) are designed to reduced agricultural contributions of nutrients and sediment to streams and rivers. Continued adoption of these conservation practices on new farmland acres in the smaller tributary streams and the headwaters of Sugar Creek will contribute to water quality improvements in the whole watershed and will be a vital part of reducing bacteria loadings in order to meet the recreational use water quality criteria. Information regarding these programs can be obtained through the NRCS Ohio office web site http://www.oh.nrcs.usda.gov/ . Funding levels and priorities for NRCS programs implemented under the 2002 Farm Bill change periodically based upon budgets and implementation strategies set by the State Conservationist and the Department of Agriculture. Special emphasis is often set to meet TMDL goals and priorities in order to align strategies within the NRCS programs with Clean Water Act goals.

Section 319 of the 1987 Clean Water Act created a national program to control and prevent non-point source pollution of the Nation's surface and ground water resources. The Ohio EPA, Ohio's designated water quality agency, is responsible for administering the program in Ohio. A goal of 80% aquatic life use attainment for Ohio waters by 2010 is a state priority. In concert with this goal, the Section 319 Implementation Grant program is designed to provide financial assistance to projects that eliminate or reduce water quality impairments caused by non-point source pollution (NPS) and prevent future NPS related impairments. The latest Ohio EPA 319 Grant program Request for Proposals and Application Package can be found on the Agency's website: http://www.epa.state.oh.us/dsw/index.html .

The Ohio EPA's Division of Environmental and Financial Assistance (DEFA) administers the Water Pollution Control Loan Fund. The WPCLF provides financial and technical assistance for numerous types of non-point source pollution control actions, and for treatment works improvements, such as wastewater treatment plant expansions and upgrades, new and replacement sewers, correction of clean water inflow and infiltration into sewers, combined sewer overflows (CSOs), and sewer separation projects. Ohio EPA will continue to prioritize attainment of TMDL goals in the Sugar Creek watershed through WPCLF projects to protect or improve the quality of ground water, rivers, streams, lakes, and other water resources as opportunities arise.

DEFA also administers the Water Resources Restoration Sponsorship Program (WRRSP) and the Linked Deposit Loans program to help provide funding for environmental improvement and pollution abatement activities. The WRRSP funds the reasonable cost of non-point source projects that fully protect and/or restore critical surface water and wetland habitats. This may include several kinds of actions that may be specified within a TMDL. By advancing a portion of the estimated amount of interest due from the loan of a sponsoring WPCLF recipient, Ohio EPA can provide assistance to the WRRSP project which, unlike a loan, is not required to be repaid.

The linked deposit program is a mechanism for financing non-point source projects to be implemented by private organizations and individuals. Linked deposits are a different type of loan, because instead of borrowing directly from the WPCLF, a borrower receives the loan through a private lending institution at a below market interest rate. The interest rate for the loan is reduced through a subsidy provided by a WPCLF funded certificate of deposit placed with the lender. Linked deposits can be used with a wide variety of projects, such as source water protection, agriculture best management practices, animal feeding operations, urban storm water runoff control, stream corridor restoration, non-discharging home sewage treatment system replacements, and forestry/ land development best management practices.

Information regarding all of the financial assistance programs administered by Ohio EPA can be obtained via the Division of Environmental Financial Assistance web site: http://www.epa.state.oh.us/defa/.

Several other incentive based programs exist through state and local agencies that can be used to meet TMDL loading reduction and stream protection goals. An summary index of available programs can be obtained from the Ohio State University Extension web page: http://ohioline.osu.edu/ae-fact/0001.html .

Table 6-2. Time line and Reasonable Assurances

#	Action	Managing Party	Schedule	Reasonable Assurance Description/Specifics
1	Develop a Watershed Management Plan for the Sugar Creek watershed	Ohio DNR/Local Watershed coordinator	Initiate further development following TMDL approval, work with NEFCO and OEPA	319 Funding obligations
2	Fence livestock off the stream	Local SCWDs, landowners	Ongoing	BMP development, cooperative agreements
3	Improve manure management practices	Local SCWDs, landowners	Ongoing	BMP development, cooperative agreements
4	Create flood plain in previously channelized stream reaches, improve Qualitative Habitat Evaluation Index scores in accordance with the approved 2002 TMDL for the Sugar Creek Watershed	Local SWCDs, ACOE, Ohio EPA	Ongoing, additional work following TMDL approval	BMP development, cooperative agreements
5	Establish buffer strips and/or riparian forest buffers	Local Governments, ODNR, NRCS and FSA through the Conservation Reserve Program (CRP)	Ongoing, additional work following TMDL approval	Local zoning, BMP development, cooperative agreements. Ancillary assurances may be tied to Phase II storm water regulations and comprehensive planning for local communities.
6	Identify discharges from animal management operations such as milk houses and animal feeding operations and provide incentives and controls to eliminate these sources	ODA, OEPA, Local SWCDs	Ongoing	NPDES permits for direct discharges, BMP development, cooperative agreements
7	Identify and upgrade or eliminate faulty septic systems and/or off-lot discharging home sewage treatment systems in unsewered areas	Local Health Departments, Ohio Department of Health	Ongoing	State and local home sewage treatment system regulations.
8	Implement HB 110 for small commercial wastewater dischargers in Wayne and Tuscarawas Counties	Local Health Departments, Ohio EPA	Stark and Holmes currently participating	House Bill 110 allows health departments and Ohio EPA to enter into contract for the purpose of licensing and inspecting semipublic sewage disposal systems. Existing regulations are utilized (ORC 6111)
9	208 updates	Ohio EPA, NEFCO	208's completed in 1979	Section 208 of the Clean Water Act

6.5 Time required to attain water quality standards

Water quality standards for bacteria will be met when two stages of restoration have occurred. Initially a reduction in the current load is needed, and if the measures discussed in Section 6.2 are implemented it should result in a reduction over the next five years. Following the implementation of load reductions, additional time is needed to complete a flushing of the system, removing material and bacteria

sequestered in the sediment. Both processes should occur somewhat simultaneously with load reductions allowing flushing to occur more successfully.

Completion of livestock fencing and floodplain restoration may take longer based on the amount of financial aid available to local farmers.

6.6 Monitoring plan

Monitoring will be done to determine whether implementation of the TMDL recommendations has resulted in attainment of water quality standards and to provide support for revisions to the TMDL. This sampling will be done at a minimum by NPDES permit holders at locations upstream and downstream of their outfalls. The Ohio EPA currently has no routine ambient monitoring stations within the Sugar Creek watershed.

An extensive monitoring program has been developed in partnership between the Ohio State University, local watershed groups and local agencies in response to the 2002 TMDL for nutrients, sedimentation and habitat alteration. Biweekly sampling is conducted at over 100 sampling stations in order to track water quality changes over time. Funding for this sampling effort is provided by various grants, including funds provided via a Section 319 grant, and funding provided through a nutrient trading program initiated in the watershed in 2005. The sampling program does not currently include bacteriological analyses, but this monitoring could be added to the program if funding is secured. Researchers from OSU have recently applied for funding through the U.S. Department of Agriculture to determine linkages between water-borne illnesses resulting from consumption of drinking water and pathogen contamination in surface and ground waters. If funded, this study could provide valuable insight into the measures needed to protect human health through the use of groundwater as a drinking water supply and through recreational contact with streams within the watershed. A revised water quality monitoring program for bacteria could include assessments to determine whether actions identified in the implementation plan are actually being carried out and criteria for determining whether these actions are effective in reaching the TMDL targets. It is recommended that Ohio EPA continue to work closely with OSU, the local SWCD's and watershed groups to expand and continue the monitoring activities currently being carried out.

Biological and water quality studies of the Sugar Creek watershed, similar to those conducted by the Ohio EPA in 1998 and 2005 will be scheduled when there are indications that major changes in the watershed have occurred. In addition, interim and/or surrogate measures that document progress in water quality improvement are recommended. Consideration must be given to the lag time between source control actions (habitat improvements and loading reductions) and observable/measurable in-stream effects, especially for non-point sources.

6.7 Milestones for attaining water quality standards

The milestones for attaining water quality standards addressed in this TMDL will be those outlined in Ohio Administrative Code Chapter 3745-01-07 included as Table 6-3.

Table 6-3. Sugar Creek water quality milestones.

	Bathing waters
Fecal coliform -	geometric mean fecal coliform content (either MPN or MF), based on not less than five samples within a thirty-day period, shall not exceed 200 per 100 ml and fecal coliform content (either MPN or MF) shall not exceed 400 per 100 ml in more than ten per cent of the samples taken during any thirty-day period.
E. coli -	geometric mean E. coli content (either MPN or MF), based on not less than five samples within a thirty-day period, shall not exceed 126 per 100 ml and E. coli content (either MPN or MF) shall not exceed 235 per 100 ml in more than ten per cent of the samples taken during any thirty-day period.
	Primary contact
Fecal coliform -	geometric mean fecal coliform content (either MPN or MF), based on not less than five samples within a thirty-day period, shall not exceed 1,000 per 100 ml and fecal coliform content (either MPN or MF) shall not exceed 2,000 per 100 ml in more than ten per cent of the samples taken during any thirty-day period.
E. coli -	geometric mean E. coli content (either MPN or MF), based on not less than five samples within a thirty-day period, shall not exceed 126 per 100 ml and E. coli content (either MPN or MF) shall not exceed 298 per 100 ml in more than ten per cent of the samples taken during any thirty-day period.
	Secondary contact
Fecal coliform -	shall not exceed 5,000 per 100 ml (either MPN or MF) in more than ten per cent of the samples taken during any thirty-day period.
E. coli -	shall not exceed 576 per 100 ml in more than ten per cent of the samples taken during any thirty-day period.

A tiered approach to monitoring progress and validating the TMDL will be followed; the tiered progression includes:

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

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

7.0 REFERENCES

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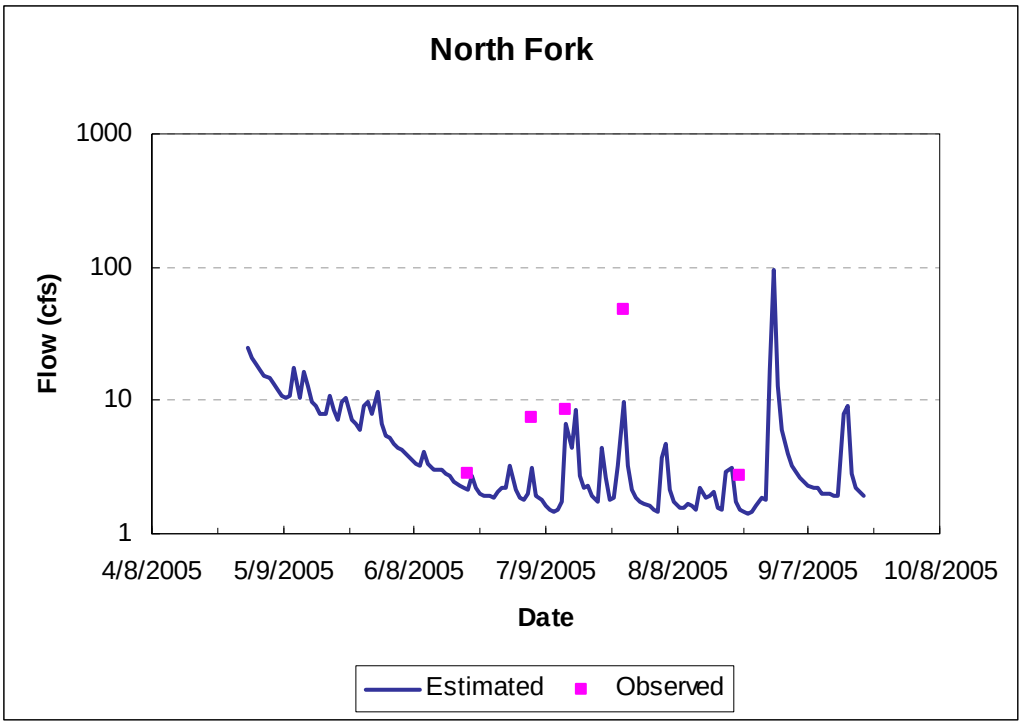
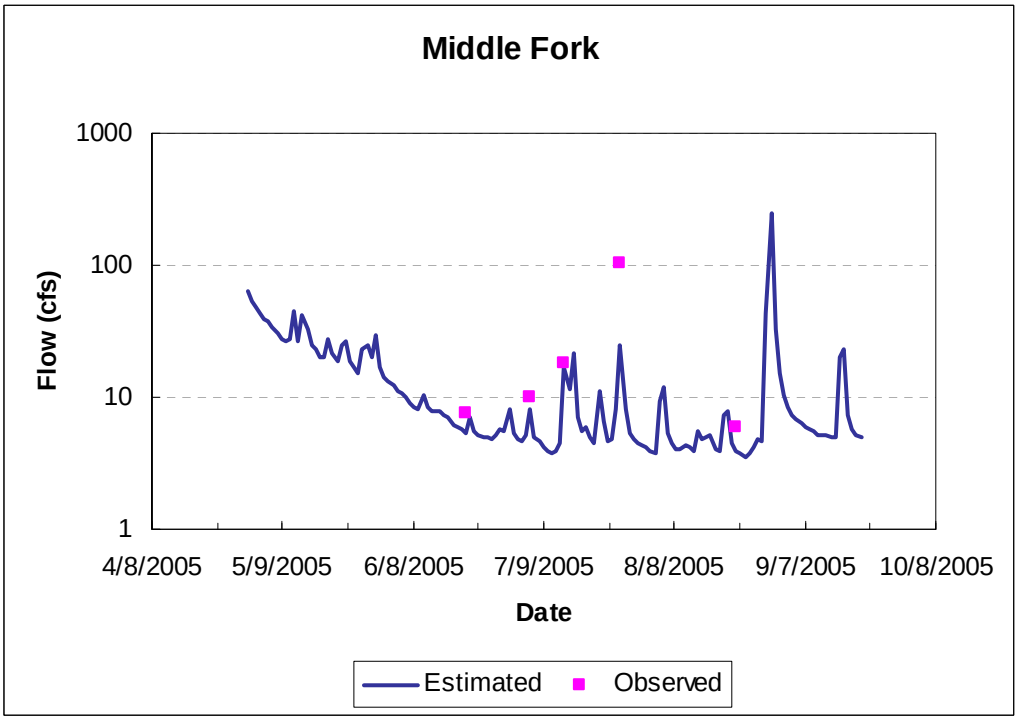
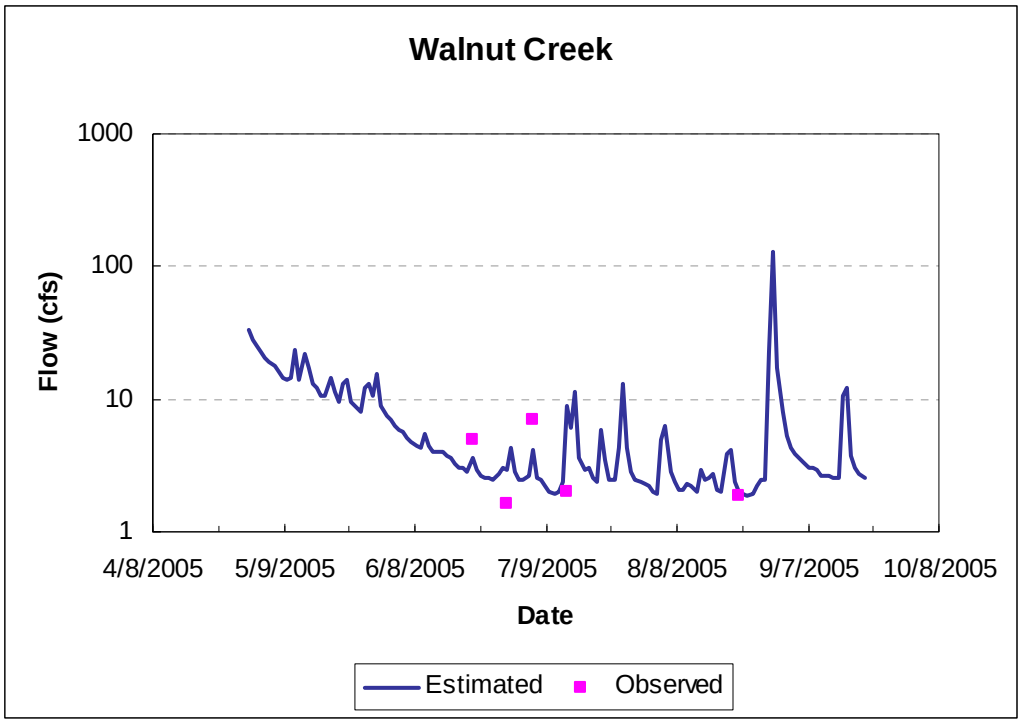
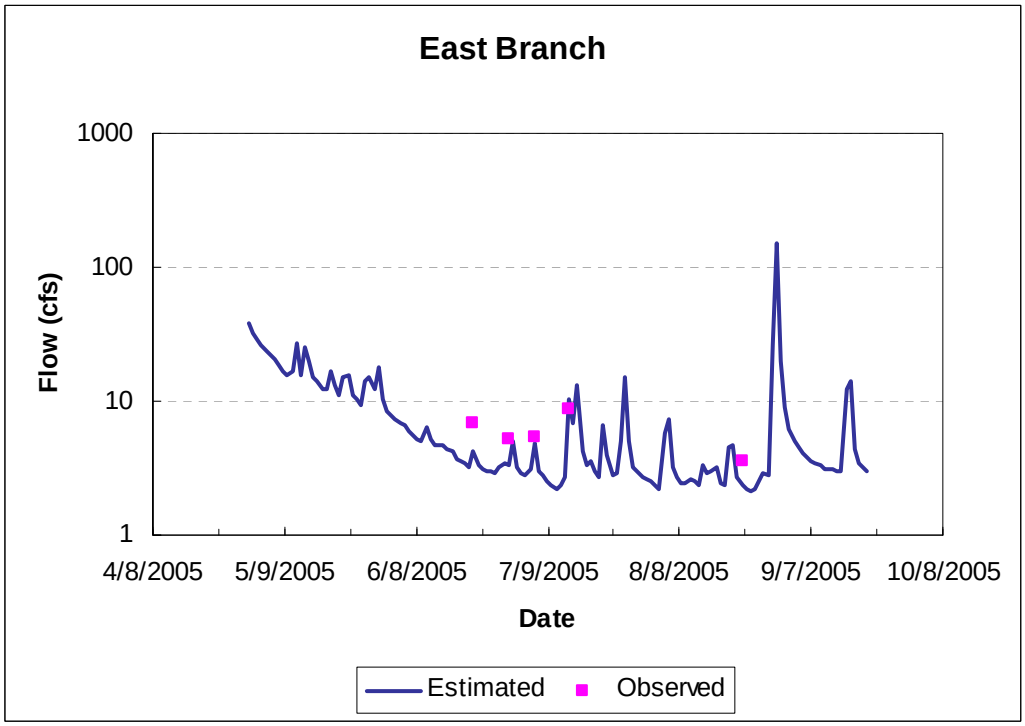
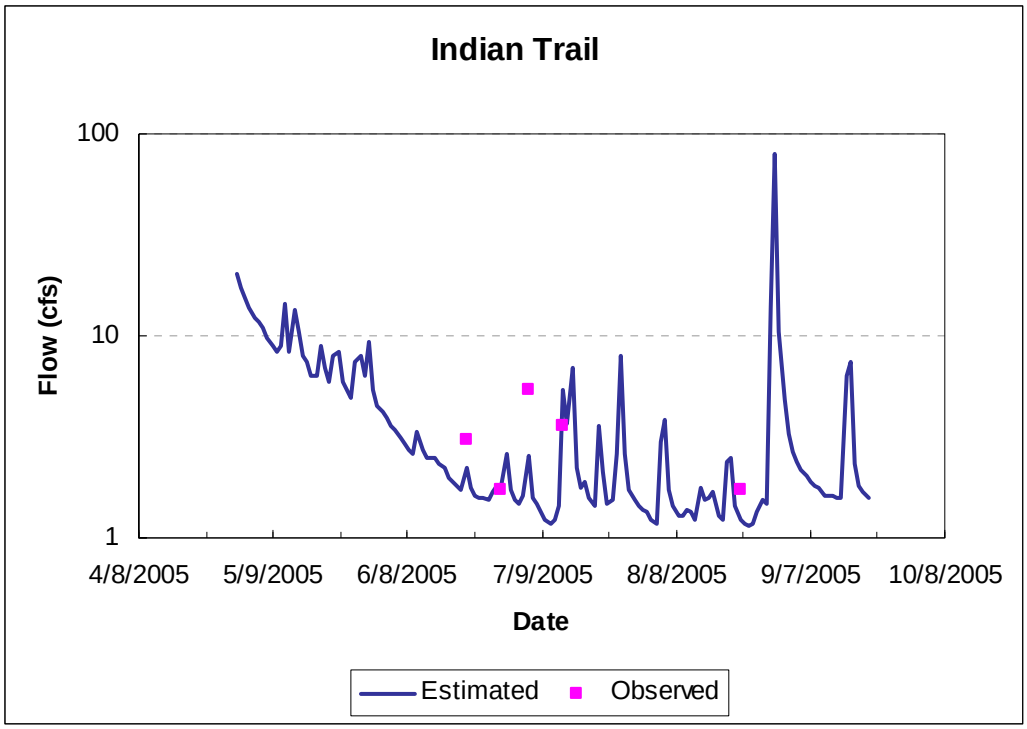
Appendix A: Comparison of Estimated Stream Flows and Stream Flows Measured by Ohio EPA


North Fork
1000
100
10
1
Flow (cfs)
4/8/2005
5/9/2005
6/8/2005
7/9/2005
8/8/2005
9/7/2005
10/8/2005
Date
Estimated
Observed


Middle Fork
1000
100
10
1
Flow (cfs)
4/8/2005
5/9/2005
6/8/2005
7/9/2005
8/8/2005
9/7/2005
10/8/2005
Date
Estimated
Observed


Walnut Creek
1000
100
10
1
Flow (cfs)
4/8/2005
5/9/2005
6/8/2005
7/9/2005
8/8/2005
9/7/2005
10/8/2005
Date
Estimated
Observed


East Branch
1000
100
10
1
Flow (cfs)
4/8/2005
5/9/2005
6/8/2005
7/9/2005
8/8/2005
9/7/2005
10/8/2005
Date
Estimated
Observed


Indian Trail
100
10
1
Flow (cfs)
4/8/2005
5/9/2005
6/8/2005
7/9/2005
8/8/2005
9/7/2005
10/8/2005
Date
Estimated
Observed

Appendix B: Correlation Between Qualitative Habitat Evaluation Index (QHEI) Scores and Fecal Coliform Counts

The QHEI is composed of an array of metrics that evaluate stream substrate and gradient, instream cover, and stream channel, pool/riffle and riparian quality (Rankin, 1989). These physical habitat attributes are important in explaining the species presence, absence, and composition of fish communities and other aquatic life (e.g. invertebrates) in a stream. The QHEI is a macro-scale approach that measures emergent properties of habitat (sinuosity, pool/riffle development) rather than individual factors that shape these characteristics (current velocity, depth, substrate size).

The relationship between fecal coliform levels and QHEI scores were examined for each of the five sentinel monitoring sites in the Sugar Creek watershed. The observed geometric mean fecal coliform versus the total QHEI score for each sentinel monitoring site are plotted in Figure B-1. In general, Figure B-1 shows that as the geometric mean of fecal coliform levels increase, the total QHEI score decreases. East Branch South Fork and Walnut Creek sites were observed to have the greatest fecal coliform geometric means and the lowest total QHEI scores. Conversely, the Broad Run site was observed to have the smallest fecal coliform geometric mean and the greatest total QHEI score. Figure B-1 suggests that the total QHEI score for a sentinel monitoring site is inversely related to the geometric mean of observed fecal coliform.

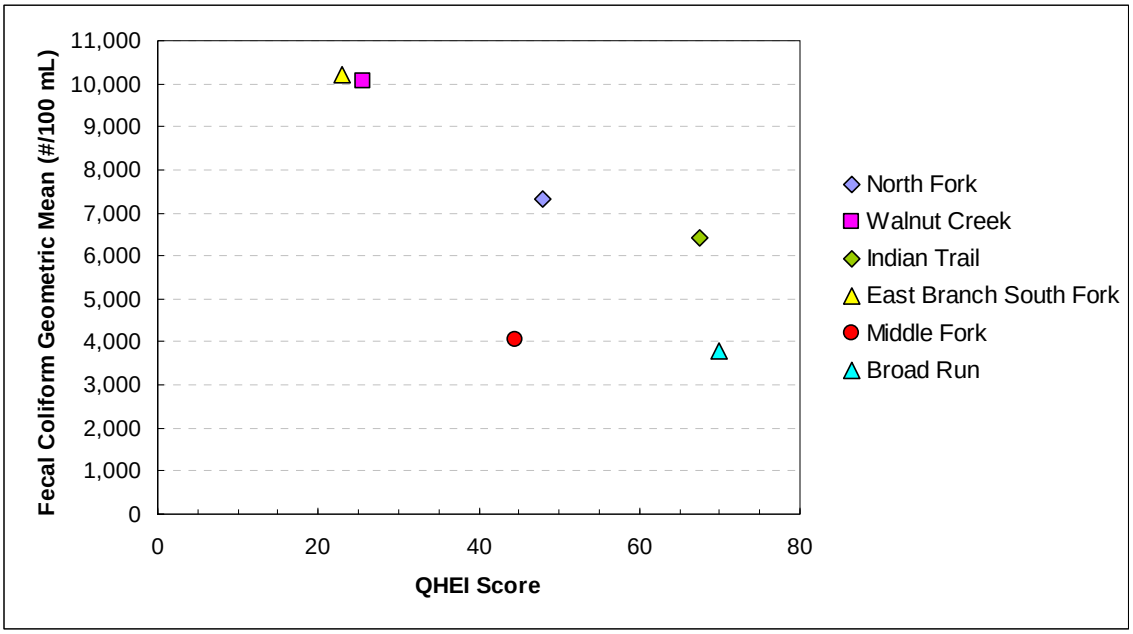


Figure B-1. Comparison of fecal coliform geometric means and total QHEI scores for the sentinel monitoring sites in the Sugar Creek watershed.

Figures B-2 and B-3 present fecal coliform geometric mean values plotted against channel score and substrate score, respectively. Channel score and substrate score are components of the total QHEI score. Figures B-2 and B-3 show that the East Brach South Fork and Walnut Creek monitoring sites were observed to have the greatest fecal coliform geometric means and the lowest total channel and substrate scores. Conversely, the Broad Run site was observed to have the smallest fecal coliform geometric mean and the greatest channel and substrate scores. Channel score and substrate score are inversely related to the geometric mean value of observed fecal coliform levels.

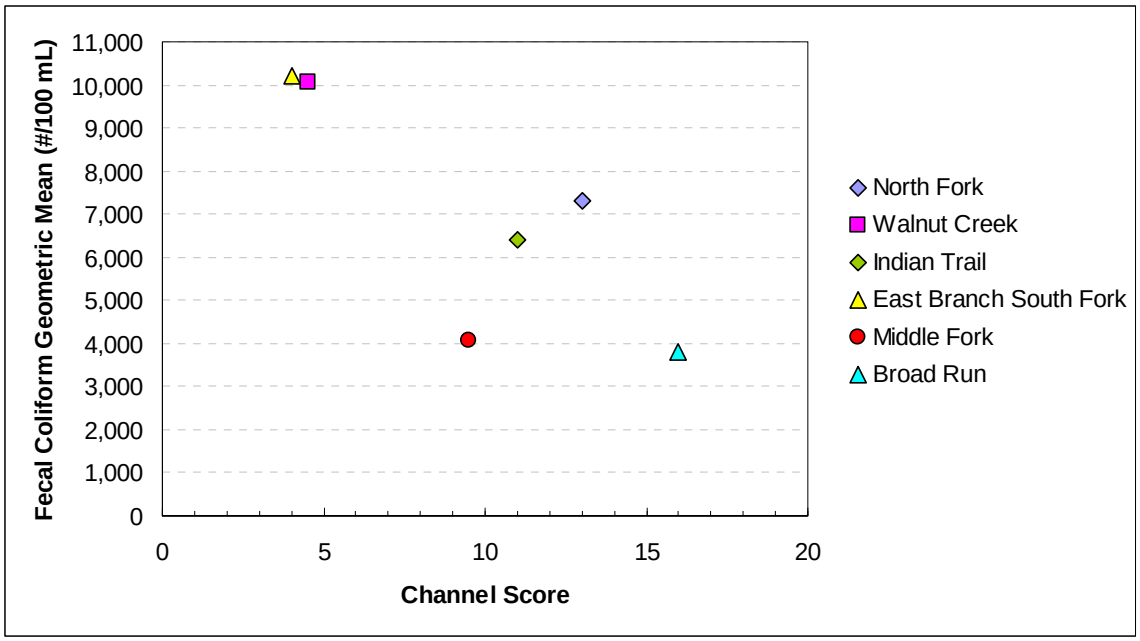


Figure B-2. Comparison of fecal coliform geometric means and QHEI channel scores for the sentinel monitoring sites in the Sugar Creek watershed.

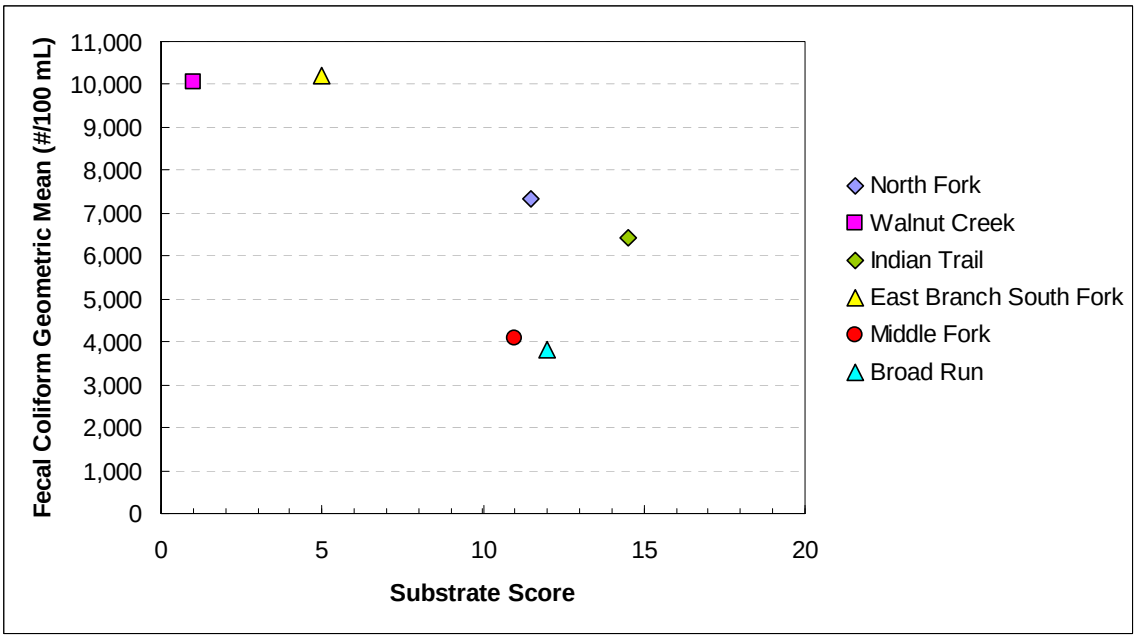


Figure B-3. Comparison of fecal coliform geometric means and QHEI substrate scores for the sentinel monitoring sites in the Sugar Creek watershed.

Appendix C: Load Duration Analyses with Fecal Coliform Criteria of 2000 cfu/100 mL

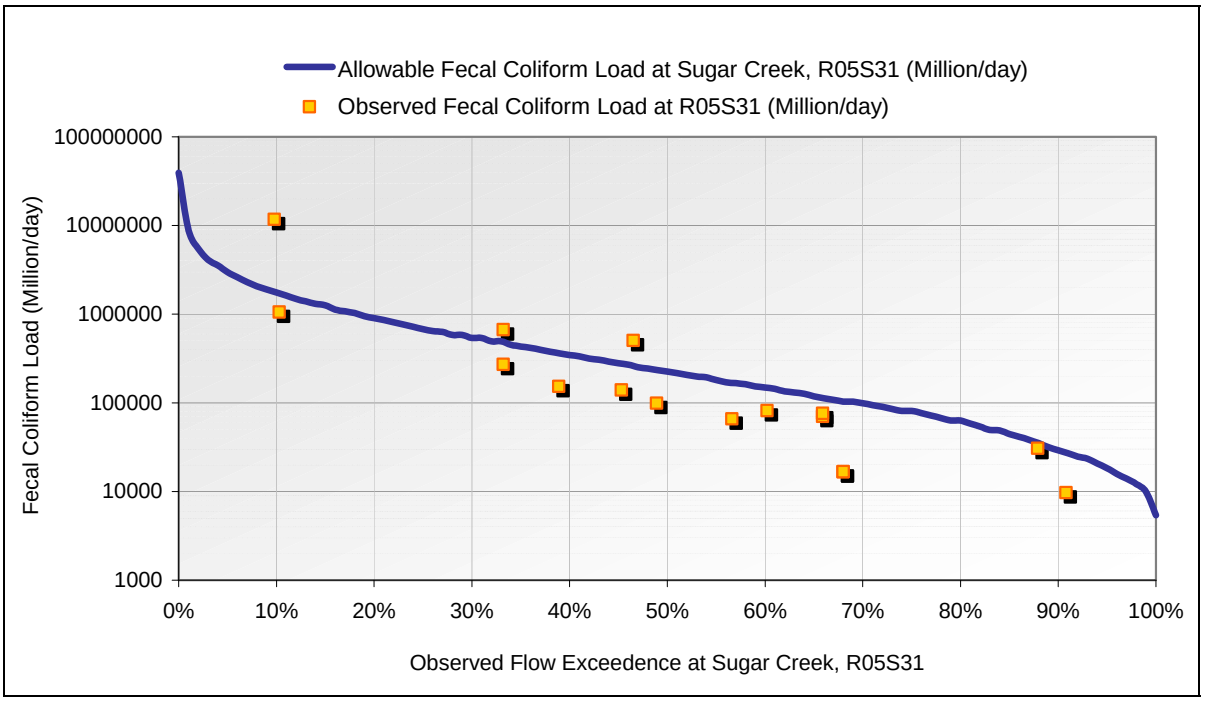


Figure C-1. Existing fecal coliform loading and loading capacity for load duration site R05S31.

Table C-1. Summary of Available Fecal Coliform Data for Load Duration Site R05S31.

Zone	Flow Exceedence Ranges	16-Sample Distribution	Median Observed Flow (cfs)	Allowable Load (Million/day)	Observed Load (Million/day)	Necessary Reduction (%)
High Flows	0-10	2	60.65	2,967,892	6,371,974	53.4%
Moist Conditions	10-20	0	25.73	1,259,106	No Data	No Data
	20-30	0	13.79	674,521	No Data	No Data
	30-40	3	8.82	431,693	272,057	0.0%
Mid-Range Flows	40-50	3	5.70	278,802	139,401	0.0%
	50-60	2	3.68	179,872	73,703	0.0%
Dry Conditions	60-70	4	2.42	118,266	43,439	0.0%
	70-80	0	1.65	80,943	No Data	No Data
	80-90	1	0.91	44,518	30,578	0.0%
Low Flows	90-100	1	0.38	18,392	9,738	0.0%

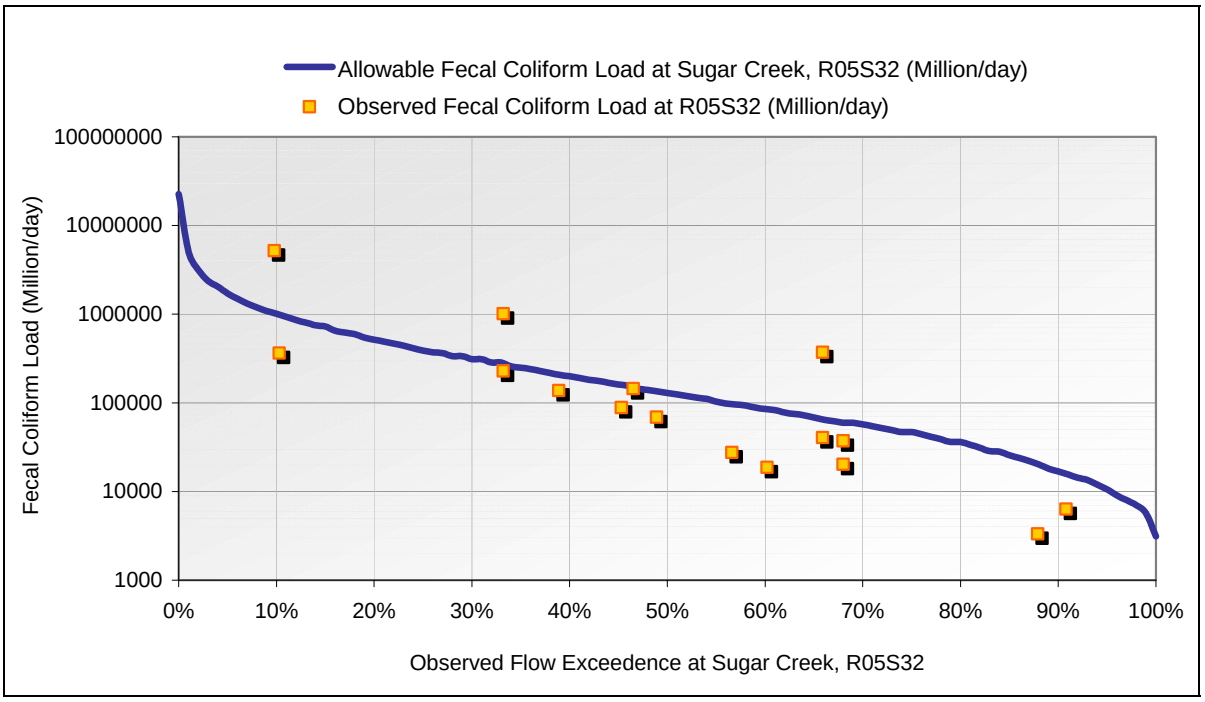


Figure C-2. Existing fecal coliform loading and loading capacity for load duration site R05S32.

Table C-2. Summary of Available Fecal Coliform Data for Load Duration Site R05S32.

Zone	Flow Exceedence Ranges	16-Sample Distribution	Median Observed Flow (cfs)	Allowable Load (Million/day)	Observed Load (Million/day)	Necessary Reduction (%)
High Flows	0-10	2	34.91	1,708,395	2,770,188	38.3%
Moist Conditions	10-20	0	14.81	724,774	No Data	No Data
	20-30	0	7.94	388,272	No Data	No Data
	30-40	3	5.08	248,494	227,786	0.0%
Mid-Range Flows	40-50	3	3.28	160,486	88,267	0.0%
	50-60	2	2.12	103,539	23,167	0.0%
Dry Conditions	60-70	4	1.39	68,077	38,827	0.0%
	70-80	0	0.95	46,593	No Data	No Data
	80-90	1	0.52	25,626	3,313	0.0%
Low Flows	90-100	1	0.22	10,587	6,316	0.0%

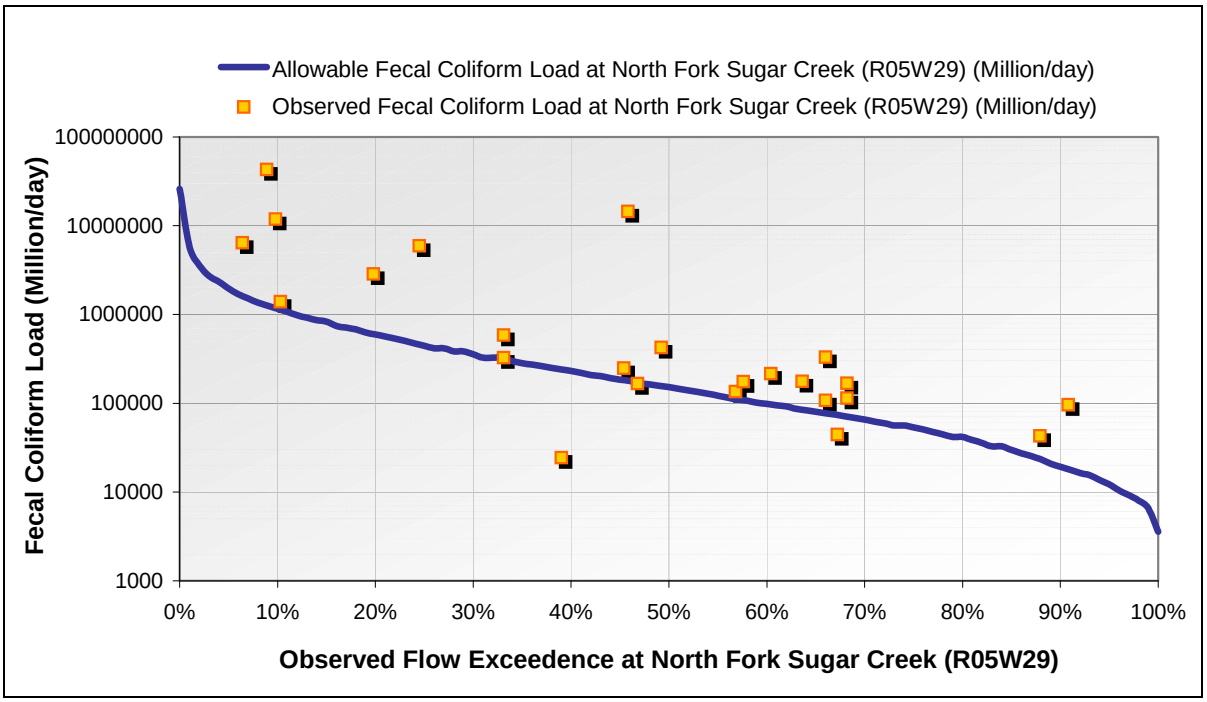


Figure C-3. Existing fecal coliform loading and loading capacity for load duration site R05W29.

Table C-3. Summary of Available Fecal Coliform Data for Load Duration Site R05W29.

Zone	Flow Exceedence Ranges	21-Sample Distribution	Median Observed Flow (cfs)	Allowable Load (Million/day)	Observed Load (Million/day)	Necessary Reduction (%)
High Flows	0-10	4	40.06	1,960,294	9,148,725	78.6%
Moist Conditions	10-20	1	17.00	831,640	2,869,158	71.0%
	20-30	1	9.11	445,521	5,940,285	92.5%
	30-40	3	5.77	282,164	326,716	13.6%
Mid-Range Flows	40-50	4	3.76	184,149	336,814	45.3%
	50-60	3	2.49	121,776	175,832	30.7%
Dry Conditions	60-70	6	1.64	80,194	140,785	43.0%
	70-80	0	1.09	53,463	No Data	No Data
	80-90	1	0.61	29,701	42,770	30.6%
Low Flows	90-100	1	0.25	12,178	96,025	87.3%

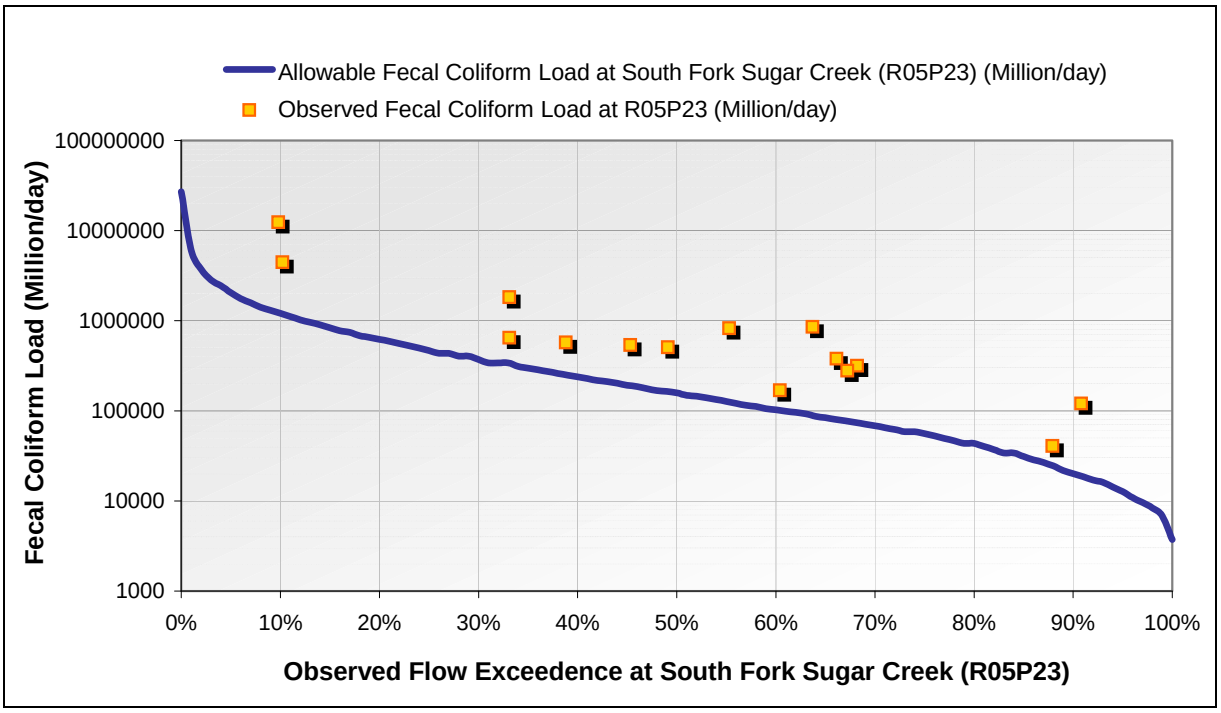


Figure C-4. Existing fecal coliform loading and loading capacity for load duration site R05P23.

Table C-4. Summary of Available Fecal Coliform Data for Load Duration Site R05P23.

Zone	Flow Exceedence Ranges	21-Sample Distribution	Median Observed Flow (cfs)	Allowable Load (Million/day)	Observed Load (Million/day)	Necessary Reduction (%)
High Flows	0-10	2	41.78	2,044,388	8,442,795	75.8%
Moist Conditions	10-20	0	17.12	837,610	No Data	No Data
	20-30	0	9.51	465,339	No Data	No Data
	30-40	3	6.09	297,817	648,372	54.1%
Mid-Range Flows	40-50	2	3.93	192,340	524,126	63.3%
	50-60	2	2.60	127,193	497,835	74.5%
Dry Conditions	60-70	4	1.71	83,761	347,763	75.9%
	70-80	0	1.14	55,841	No Data	No Data
	80-90	1	0.63	31,023	40,950	24.2%
Low Flows	90-100	1	0.26	12,719	121,112	89.5%

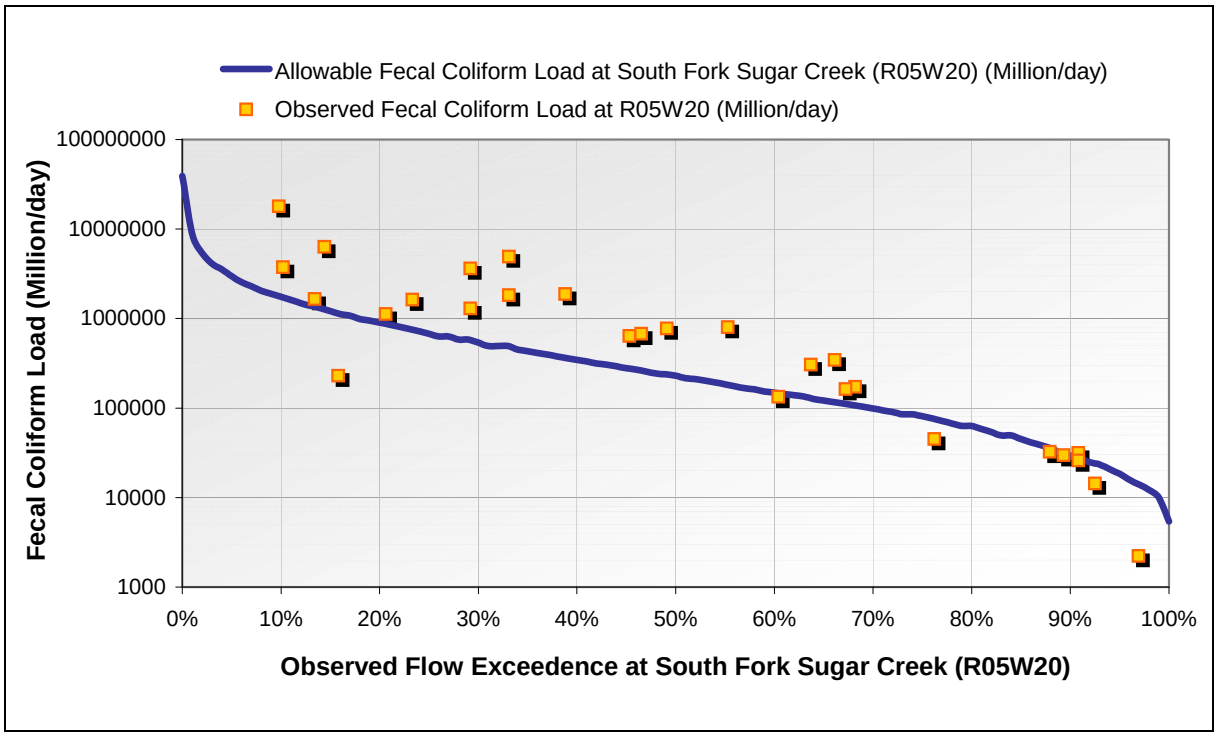


Figure C-5. Existing fecal coliform loading and loading capacity for load duration site R05W20.

Table C-5. Summary of Available Fecal Coliform Data for Load Duration Site R05W20.

Zone	Flow Exceedence Ranges	28-Sample Distribution	Median Observed Flow (cfs)	Allowable Load (Million/day)	Observed Load (Million/day)	Estimated Reduction (%)
High Flows	0-10	2	60.57	2,963,718	10,880,081	72.8%
Moist Conditions	10-20	4	24.82	1,214,270	1,386,808	12.4%
	20-30	3	13.79	674,594	1,624,648	58.5%
	30-40	3	8.82	431,740	1,880,769	77.0%
Mid-Range Flows	40-50	3	5.70	278,832	676,618	58.8%
	50-60	2	3.77	184,389	467,831	60.6%
Dry Conditions	60-70	4	2.48	121,427	239,593	49.3%
	70-80	1	1.65	80,951	45,108	0.0%
	80-90	2	0.92	44,973	31,144	0.0%
Low Flows	90-100	4	0.38	18,439	20,195	8.7%

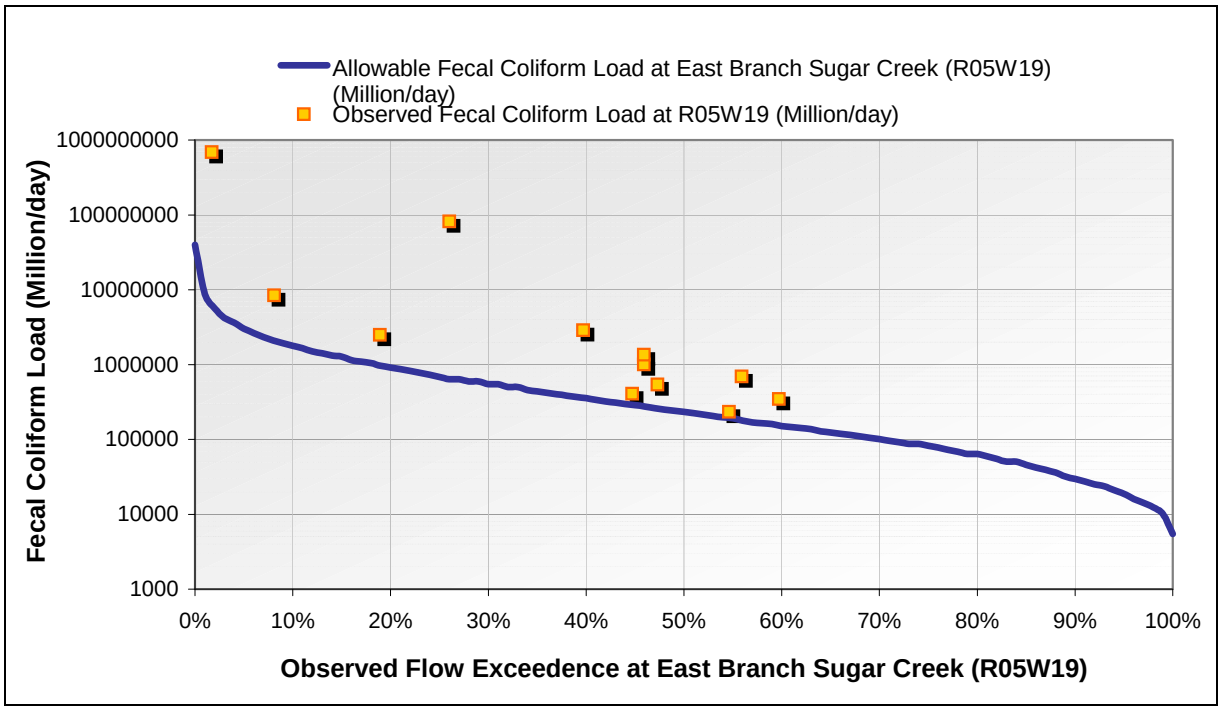


Figure C-6. Existing fecal coliform loading and loading capacity for load duration site R05W19.

Table C-6. Summary of Available Fecal Coliform Data for Load Duration Site R05W19.

Zone	Flow Exceedence Ranges	12-Sample Distribution	Median Observed Flow (cfs)	Allowable Load (Million/day)	Observed Load (Million/day)	Estimated Reduction (%)
High Flows	0-10	2	61.64	3,016,334	350,602,939	99.1%
Moist Conditions	10-20	1	26.15	1,279,657	2,496,218	48.7%
	20-30	1	14.01	685,530	82,054,151	99.2%
	30-40	1	8.97	438,739	2,886,923	84.8%
Mid-Range Flows	40-50	4	5.88	287,923	772,012	62.7%
	50-60	3	3.91	191,492	346,897	44.8%
Dry Conditions	60-70	0	2.52	123,395	No Data	No Data
	70-80	0	1.68	82,264	No Data	No Data
	80-90	0	0.93	45,702	No Data	No Data
Low Flows	90-100	0	0.38	18,738	No Data	No Data

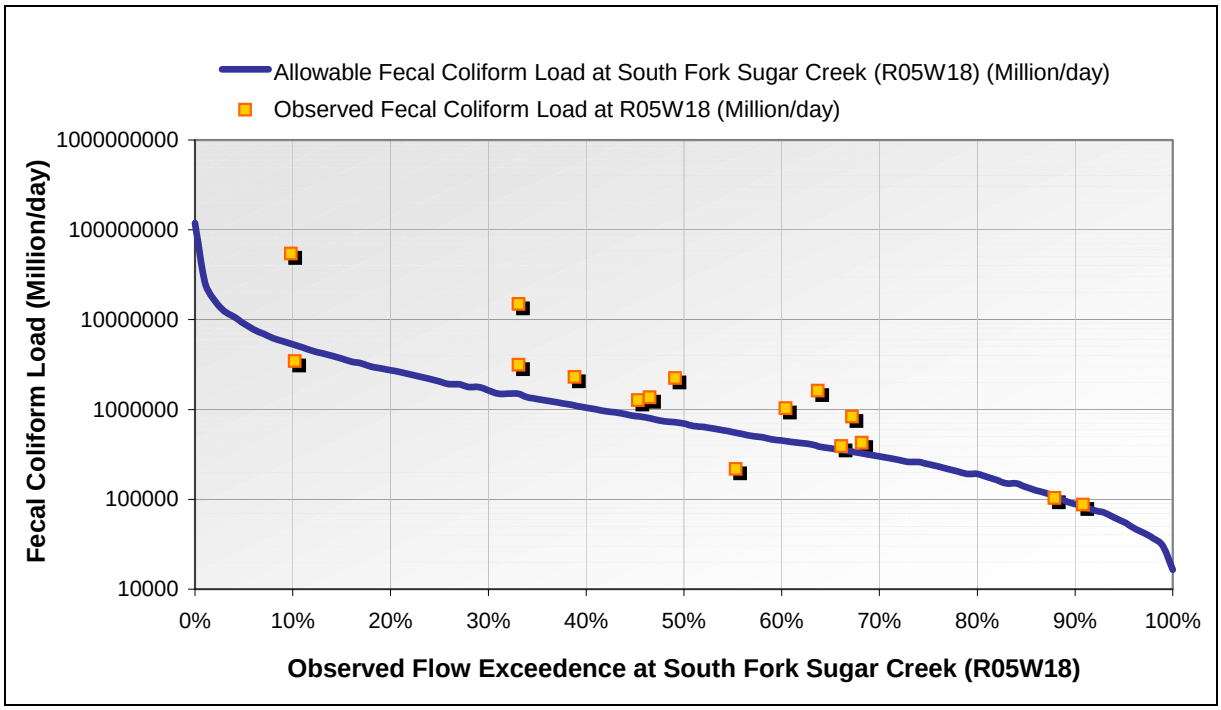


Figure C-7. Existing fecal coliform loading and loading capacity for load duration site R05W18.

Table C-7. Summary of Available Fecal Coliform Data for Load Duration Site R05W18.

Zone	Flow Exceedence Ranges	16-Sample Distribution	Median Observed Flow (cfs)	Allowable Load (Million/day)	Observed Load (Million/day)	Estimated Reduction (%)
High Flows	0-10	2	183.80	8,993,372	29,023,754	69.0%
Moist Conditions	10-20	0	75.30	3,684,690	No Data	No Data
	20-30	0	41.84	2,047,050	No Data	No Data
	30-40	3	26.77	1,310,112	3,152,457	58.4%
Mid-Range Flows	40-50	3	17.29	846,114	1,368,794	38.2%
	50-60	2	11.43	559,527	627,011	10.8%
Dry Conditions	60-70	4	7.53	368,469	630,833	41.6%
	70-80	0	5.02	245,646	No Data	No Data
	80-90	1	2.79	136,470	103,717	0.0%
Low Flows	90-100	1	1.14	55,953	87,409	36.0%

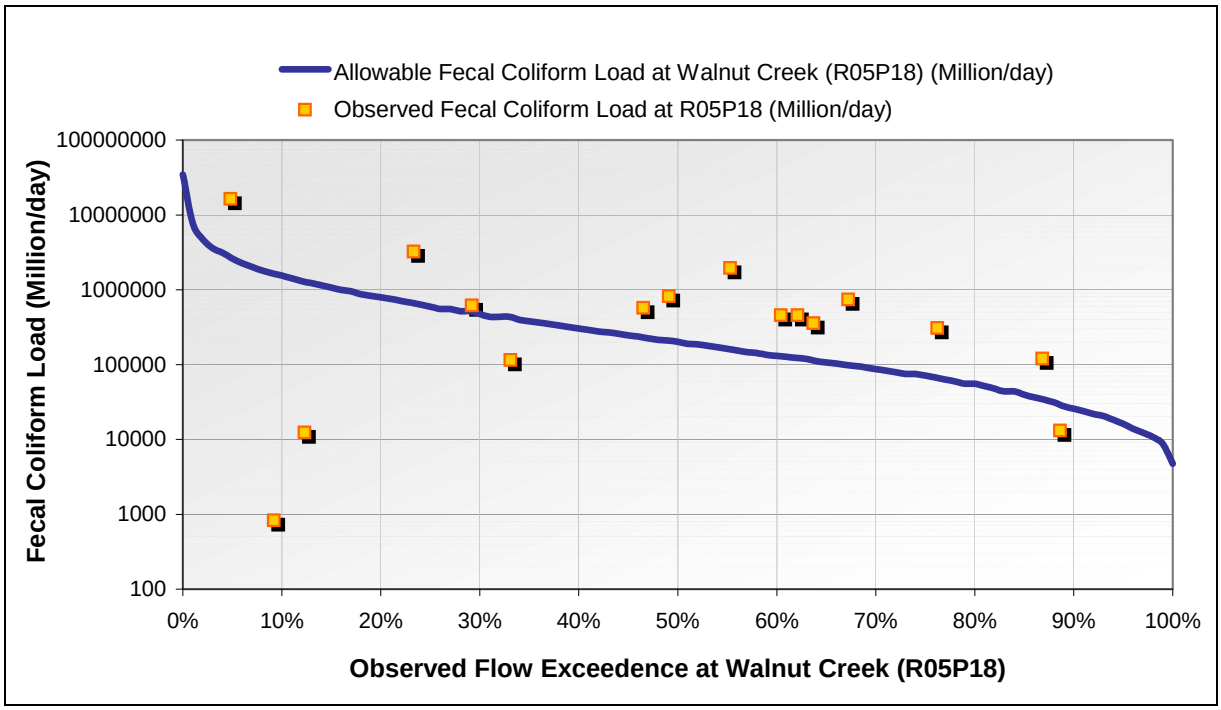


Figure C-8. Existing fecal coliform loading and loading capacity for load duration site R05P18.

Table C-8. Summary of Available Fecal Coliform Data for Load Duration Site R05P18.

Zone	Flow Exceedence Ranges	16-Sample Distribution	Median Observed Flow (cfs)	Allowable Load (Million/day)	Observed Load (Million/day)	Estimated Reduction (%)
High Flows	0-10	2	53.31	2,608,691	8,194,633	68.2%
Moist Conditions	10-20	1	21.84	1,068,811	12,410	0.0%
	20-30	2	12.14	593,784	1,923,860	69.1%
	30-40	1	7.77	380,022	115,392	0.0%
Mid-Range Flows	40-50	2	5.02	245,431	695,222	64.7%
	50-60	2	3.32	162,301	1,202,412	86.5%
Dry Conditions	60-70	3	2.18	106,881	460,183	76.8%
	70-80	1	1.46	71,254	309,559	77.0%
	80-90	2	0.81	39,586	66,665	40.6%
Low Flows	90-100	0	0.33	16,230	No Data	No Data

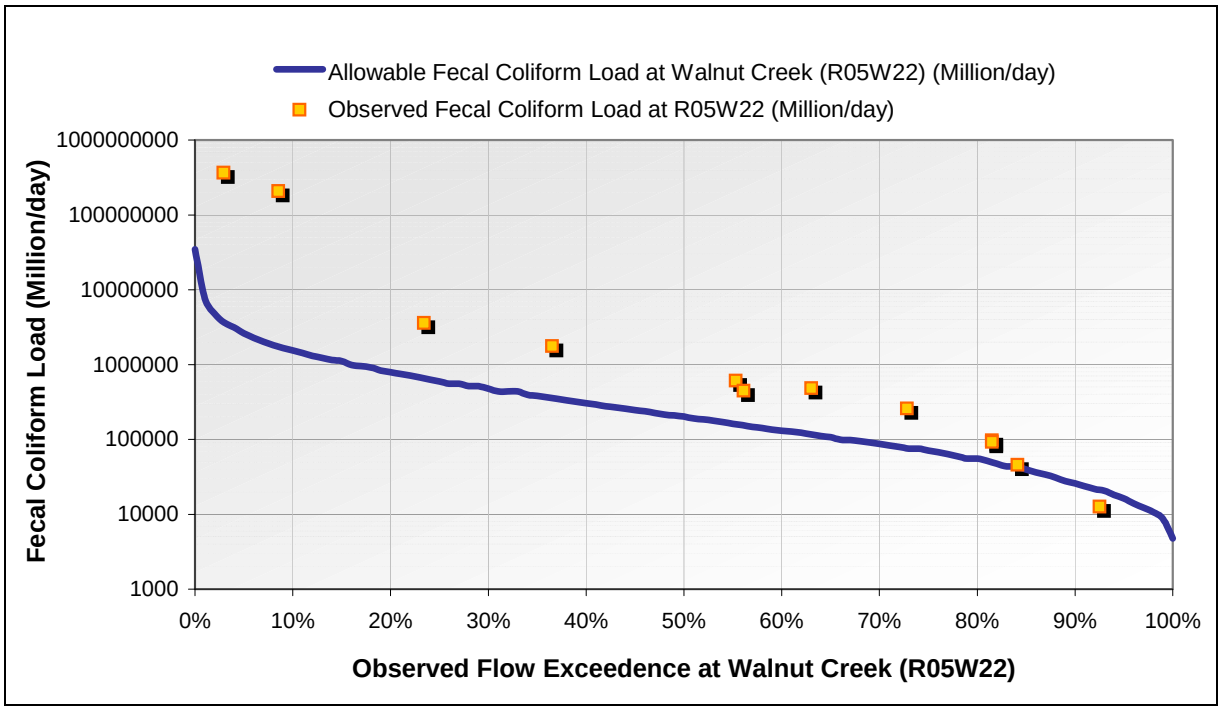


Figure C-9. Existing fecal coliform loading and loading capacity for load duration site R05W22.

Table C-9. Summary of Available Fecal Coliform Data for Load Duration Site R05W22.

Zone	Flow Exceedence Ranges	12-Sample Distribution	Median Observed Flow (cfs)	Allowable Load (Million/day)	Observed Load (Million/day)	Estimated Reduction (%)
High Flows	0-10	2	53.39	2,612,649	286,791,463	99.1%
Moist Conditions	10-20	0	22.65	1,108,397	No Data	No Data
	20-30	1	12.14	593,784	3,615,398	83.6%
	30-40	1	7.77	380,022	1,762,308	78.4%
Mid-Range Flows	40-50	0	5.02	245,827	No Data	No Data
	50-60	2	3.32	162,301	529,208	69.3%
Dry Conditions	60-70	1	2.18	106,881	485,325	78.0%
	70-80	1	1.46	71,254	259,096	72.5%
	80-90	3	0.81	39,586	92,796	57.3%
Low Flows	90-100	1	0.33	16,230	12,679	0.0%

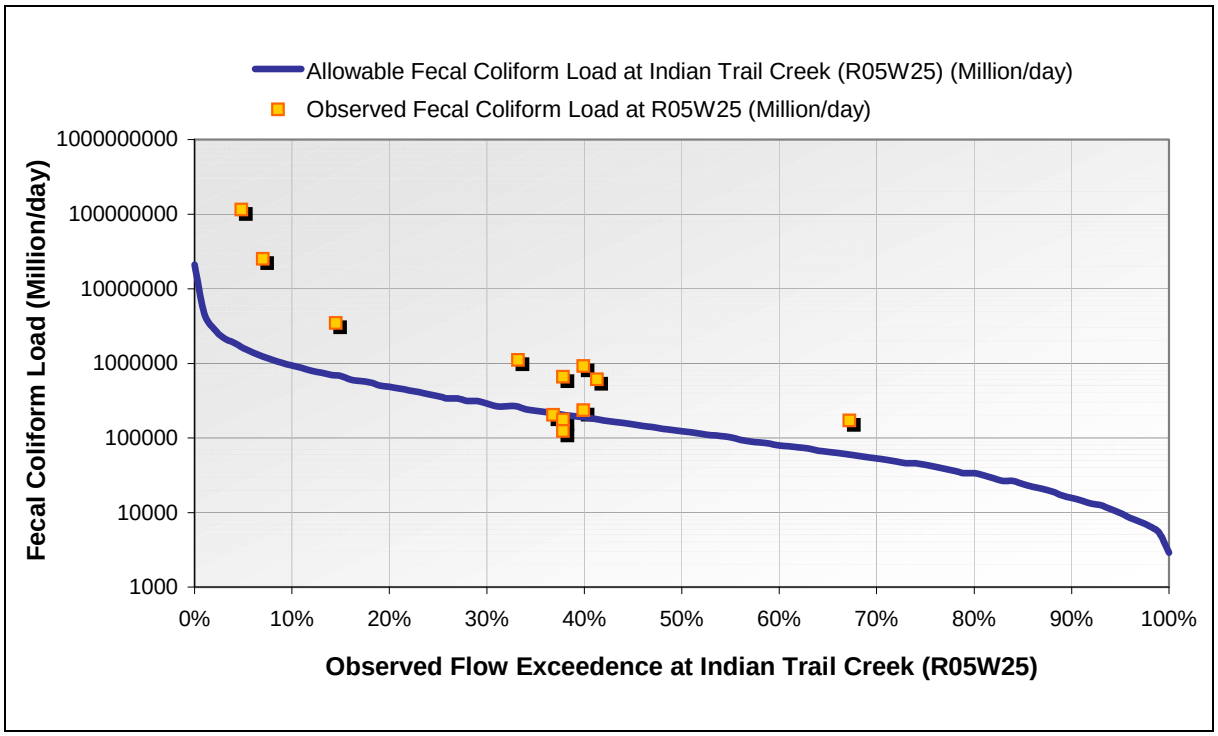


Figure C-10. Existing fecal coliform loading and loading capacity for load duration site R05W25.

Table C-10. Summary of Available Fecal Coliform Data for Load Duration Site R05W25.

Zone	Flow Exceedence Ranges	12-Sample Distribution	Median Observed Flow (cfs)	Allowable Load (Million/day)	Observed Load (Million/day)	Estimated Reduction (%)
High Flows	0-10	2	32.54	1,592,134	70,370,230	97.7%
Moist Conditions	10-20	1	13.80	675,451	3,485,544	80.6%
	20-30	0	7.40	361,849	No Data	No Data
	30-40	7	4.73	231,583	235,249	1.6%
Mid-Range Flows	40-50	1	3.11	151,976	613,007	75.2%
	50-60	0	2.07	101,318	No Data	No Data
Dry Conditions	60-70	1	1.33	65,133	171,878	62.1%
	70-80	0	0.89	43,422	No Data	No Data
	80-90	0	0.49	24,123	No Data	No Data
Low Flows	90-100	0	0.20	9,891	No Data	No Data

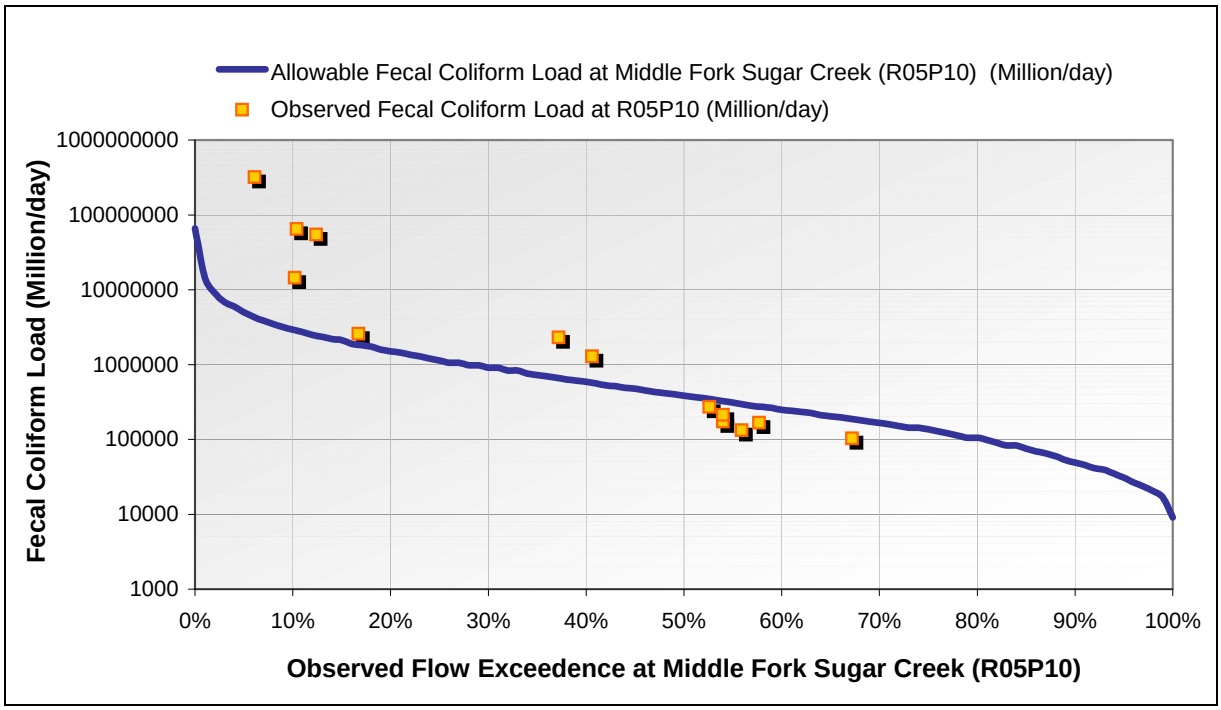


Figure C-11. Existing fecal coliform loading and loading capacity for load duration site R05P10.

Table C-11. Summary of Available Fecal Coliform Data for Load Duration Site R05P10.

Zone	Flow Exceedence Ranges	13-Sample Distribution	Median Observed Flow (cfs)	Allowable Load (Million/day)	Observed Load (Million/day)	Estimated Reduction (%)
High Flows	0-10	1	101.62	4,972,312	319,512,745	98.4%
Moist Conditions	10-20	4	43.18	2,112,667	34,552,449	93.9%
	20-30	0	23.13	1,131,786	No Data	No Data
	30-40	1	14.80	724,343	2,307,701	68.6%
Mid-Range Flows	40-50	1	9.71	475,350	1,289,683	63.1%
	50-60	5	6.32	309,355	173,590	0.0%
Dry Conditions	60-70	1	4.16	203,721	103,747	0.0%
	70-80	0	2.78	135,814	No Data	No Data
	80-90	0	1.54	75,452	No Data	No Data
Low Flows	90-100	0	0.63	30,935	No Data	No Data

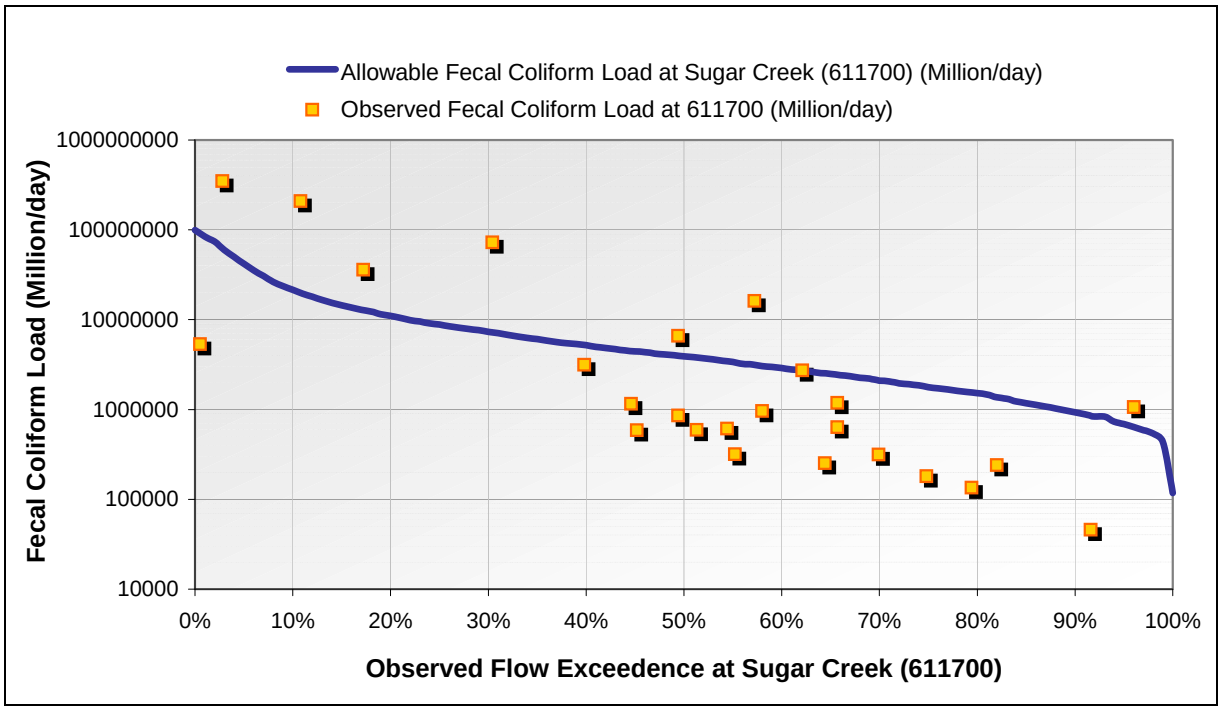


Figure C-12. Existing fecal coliform loading and loading capacity for load duration site 611700.

Table C-12. Summary of Available Fecal Coliform Data for Load Duration Site 611700.

Zone	Flow Exceedence Ranges	25-Sample Distribution	Median Observed Flow (cfs)	Allowable Load (Million/day)	Observed Load (Million/day)	Estimated Reduction (%)
High Flows	0-10	2	855.80	41,875,587	177,609,274	76.4%
Moist Conditions	10-20	2	296.00	14,483,727	122,827,879	88.2%
	20-30	0	180.00	8,807,672	No Data	No Data
	30-40	2	124.00	6,067,507	37,780,020	83.9%
Mid-Range Flows	40-50	4	91.00	4,452,767	1,009,457	0.0%
	50-60	5	69.00	3,376,274	611,448	0.0%
Dry Conditions	60-70	5	51.00	2,495,507	633,565	0.0%
	70-80	2	36.00	1,761,534	157,364	0.0%
	80-90	1	24.00	1,174,356	241,232	0.0%
Low Flows	90-100	2	14.10	689,934	553,807	0.0%

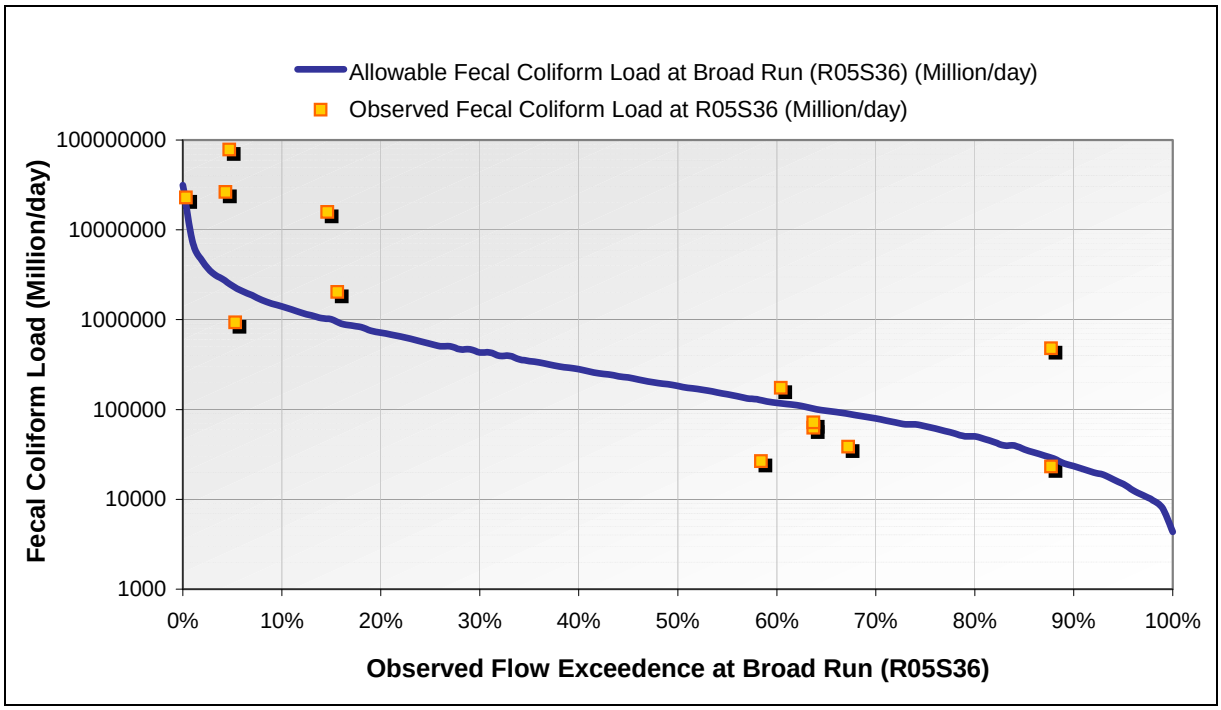


Figure C-13. Existing fecal coliform loading and loading capacity for load duration site R05S36.

Table C-13. Summary of Available Fecal Coliform Data for Load Duration Site R05S36.

Zone	Flow Exceedence Ranges	13-Sample Distribution	Median Observed Flow (cfs)	Allowable Load (Million/day)	Observed Load (Million/day)	Estimated Reduction (%)
High Flows	0-10	4	48.51	2,373,668	24,667,458	90.4%
Moist Conditions	10-20	2	20.58	1,007,010	8,923,367	88.7%
	20-30	0	11.03	539,470	No Data	No Data
	30-40	0	7.06	345,261	No Data	No Data
Mid-Range Flows	40-50	0	4.63	226,577	No Data	No Data
	50-60	1	3.01	147,455	26,539	0.0%
Dry Conditions	60-70	4	1.98	97,105	67,194	0.0%
	70-80	0	1.32	64,736	No Data	No Data
	80-90	2	0.74	35,965	251,466	85.7%
Low Flows	90-100	0	0.30	14,746	No Data	No Data

Appendix D: Screening Level Assessment of Fecal Coliform Sources within the Sugar Creek Watershed

A screening-level assessment of the most likely sources of fecal coliform within the Sugar Creek watershed was made as part of this TMDL analysis. The purpose of the screening-level assessment was to be used as one component of the weight-of-evidence approach presented in Section 5. Several different methodologies, described below, were used to estimate the potential load of fecal coliform from each of the potential source categories into the streams within each assessment unit. Resource constraints prevented an integrated modeling analysis that would have used a consistent methodology to evaluate each source and would have also accounted for in-stream processes (e.g., die-off and re-suspension). Nevertheless, the approach described below is believed to be useful in determining the relative importance of the various key sources even if the magnitude of the estimated loads is prone to errors. Low, medium, and high estimates were made for each source to try and bracket the potential range of expected loadings.

Land Use and Land Cover

Potential fecal coliform loads from each of the land use/land cover categories were made based on unit area loading rates derived from previous Hydrologic Simulation Program in Fortran (HSPF) modeling applications. HSPF is a comprehensive watershed and receiving water quality modeling framework that was originally developed in the mid-1970's and is generally considered one of the most advanced hydrologic and watershed loading models available. Calibrated HSPF models for the Eagle Creek[1] watershed located in Portage County, Ohio (USEPA, 2004) and the Upper Menomonee River watershed located in Washington County, Wisconsin (Tetra Tech, 2005) were used to derive representative loading rates for each of the following land use/land cover categories:

- Forest (based on Upper Menomonee River model)
- Pasture and Hay (based on Eagle Creek model)
- Crops (based on Upper Menomonee River model)
- Residential (based on Eagle Creek model)
- Commercial/Industrial (based on Eagle Creek model)
- Wetlands (based on Upper Menomonee River model)

The pasture and hay loading rate derived from the Eagle Creek model was adjusted to account for the larger dairy herds in the Sugar Creek watershed. The number of milk cows reported by USDA for the various counties in the Sugar Creek and Eagle Creek watersheds was used to determine different adjustment rates for each assessment unit as shown in Table D-1.

Table D-1. Number of milk cows in Sugar Creek and Eagle Creek counties.

Sugar Creek Assessment Unit	# of Milk Cows	Adjustment Factor
100	Wayne County: 33420 Portage County: 1962	17.03
110	Average of Holmes and Tuscarawas Counties: 15102 Portage County: 1962	7.70
120	Average of Holmes, Tuscarawas, and Stark Counties: 13052 Portage County: 1962	6.65

The final unit area fecal coliform loading rates for each land use/land cover category are presented in Table D-2. It is acknowledged that there is a very large degree of uncertainty associated with these rates. These uncertainties are associated with differences in climate, soils, stream characteristics, number of dairy operations, and land use practices among the Sugar Creek, Eagle Creek, and Upper Menomonee

[1] The Eagle Creek application was performed using the Loading Simulation Program in C++, a re-coded version of HSPF.

River watersheds that likely result in highly varying loading rates. To partially account for this uncertainty, the low and high estimated loads presented in Section 5 are based on using 75 percent and 125 percent of the values presented in Table D-2.

Table D-2. Estimated fecal coliform unit area loading rates for Sugar Creek land use/land cover categories.

Land Use/Land Cover	AU 100 Unit Area Loading Rate (#/ac/yr)	AU 110 Unit Area Loading Rate (#/ac/yr)	AU 120 Unit Area Loading Rate (#/ac/yr)
Forest	3.30E+08	3.30E+08	3.30E+08
Pasture and Hay	1.40E+12	6.31E+11	5.45E+11
Crops	6.56E+08	6.56E+08	6.56E+08
Residential	4.07E+10	4.07E+10	4.07E+10
Commercial/Industrial	4.07E+10	4.07E+10	4.07E+10
Urban Grasses	4.07E+10	4.07E+10	4.07E+10
Wetlands	3.90E+08	3.90E+08	3.90E+08

Failing/Illegal Septic Systems

Septic systems provide the potential to deliver bacteria loads to surface waters due to system failures caused by improper maintenance and/or malfunctions. In some cases, human waste is directly deposited into surface waters from houses without septic systems. The number of septic systems in each assessment unit was based on estimates made by OEPA for a previous nutrient and sediment modeling application in the watershed (OEPA, 2002). The proportion of failing septic systems was also based on this previous study. Houses considered to have a normal functioning septic system were assumed to have no contribution of fecal bacteria to surface waters. Houses with failing systems were assumed to discharge 70 gallons per person per day with an average fecal coliform concentration reaching the stream of 10,000 cfu/100 mL (Horsely & Whitten, 1996). Assuming there are 2.5 people, on average, per house this results in a daily load of 6.62E+7 cfu/house/day.

Low and high estimates for on-site wastewater system loads were made by multiplying the number of failing systems by 75 percent and 125 percent respectively.

Point Source Dischargers

Loads from point sources were based on the design flows of each facility multiplied by an estimated fecal coliform count of 500 cfu/100 mL for each facility. Low estimates were made assuming an average fecal coliform count of 200 cfu/100 mL and high estimates were made using 1000 cfu/100 mL. The results are presented in Table D-3.

Table D-3. Estimated point source loads.

Facility	US EPA ID	Design Flow (mgd)	Low Estimate (cfu/rec season)	Estimate (cfu/rec season)	High Estimate (cfu/rec season)
Alpine Cheese Co.	OH0007960	0.220	2.78E+11	6.95E+11	1.39E+12
Baltic Rubber	OH0031381	0.020	2.53E+10	6.32E+10	1.26E+11
Baltic WWTP	OH0047783	0.010	2.53E+10	6.32E+10	1.26E+11
Beach City Wilmont STP	OH0045489	0.200	2.53E+11	6.32E+11	1.26E+12
Brewster Dairy	OH00052191	0.300	3.79E+11	9.48E+11	1.90E+12
Brewster STP	OH0020567	0.665	8.41E+11	2.10E+12	4.20E+12
Case Farms Inc.	OH0005487	0.500	1.26E+10	3.16E+10	6.32E+10
Gerber's Poultry Inc	OH0052132	0.250	3.16E+11	7.90E+11	1.58E+12
Guggisberg Cheese Inc.	OH0083771	0.014	6.32E+11	1.58E+12	3.16E+12
Holmes County Health Dept.	OH0048691	0.015	1.77E+10	4.42E+10	8.85E+10
Kidron WWTP	OH0133451	0.160	2.02E+11	5.06E+11	1.01E+12
Lake Harmony Subdivision	OH0083933	0.036	4.55E+10	1.14E+11	2.28E+11
Mount Eaton WWTP	OH0126233	0.045	5.69E+10	1.42E+11	2.84E+11
Mt. Hope WWTP	OH0092282	0.220	2.78E+11	6.95E+11	1.39E+12
Smithville MHP	OH0092291	0.006	7.59E+09	1.90E+10	3.79E+10
Smithville Western	OH0101265	0.090	1.14E+11	2.84E+11	5.69E+11
Smithville WWTP	OH0021971	0.300	3.79E+11	9.48E+11	1.90E+12
Strasburg WWTP	OH0027553	0.225	2.84E+11	7.11E+11	1.42E+12
Sugar Creek WWTP	OH0027618	0.500	1.90E+10	4.74E+10	9.48E+10
Troyer's Trail Bologna Inc.	OH0004855	0.005	6.32E+11	1.58E+12	3.16E+12
Walnut Creek WWTP	OH0102903	0.090	6.32E+09	1.58E+10	3.16E+10
Wayne Co. Eastwood Subdivision STP	OH0036561	0.060	7.59E+10	1.90E+11	3.79E+11
Wayne County Airport	OH0092207	0.002	2.53E+09	6.32E+09	1.26E+10

Livestock with Direct Access to Streams

Pathogens produced by livestock can be directly deposited in a stream when grazing animals have stream access. Loads from this potential source were calculated based on the estimated number of beef cattle in each assessment unit multiplied by a daily fecal coliform production rate and the estimated number of hours spent in the stream. The number of beef cattle in each assessment unit was based on animal densities calculated from the 2002 Agricultural Census (USDA, 2006). For example, the Census reported 4,009 beef cattle in Wayne County and 267,169 acres in farms. This resulted in a beef cattle density of approximately 0.015 beef cattle per acre, which was multiplied by the number of pasture, hay, and cropland acres in assessment unit 100. Similar calculations were made for other assessment units as shown in Table D-4.

A daily beef cattle fecal coliform production rate of 1.04E+11 cfu/day was used based on a literature value (ASAE, 1998). All of the beef cattle in each assessment unit were assumed to spend 4 hours per day in the stream during the summer recreation season. The low estimated loads were based on an assumption of cattle spending 2 hours per day in the stream and the high estimate assumed 8 hours per day.

Table D-4. Beef cattle densities in Sugar Creek counties.

Description	Wayne County	Holmes County	Tuscarawas County	Stark County
# beef cows	4009	4669	5180	3161
land in farms (acres)	267,169	206,603	159,665	145,163
# beef cows/farm acre	0.015	0.023	0.032	0.022

Table D-5. Estimated number of beef cattle in Sugar Creek assessment units.

Assessment Unit	# acres cropland, pasture, and hay	Beef Cattle Density	Estimated Number of Beef Cattle (Rounded)
100	53,175	0.015	800
110	56,749	0.028	1600
120	42,953	0.026	1100

Notes: AU100 density based on Wayne County; AU110 density based on average of Holmes and Tuscarawas counties; AU120 density based on average of Holmes, Stark, and Tuscarawas counties.

References for Appendix D

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