APPENDIX C

RECREATION USE ANALYSIS

Method

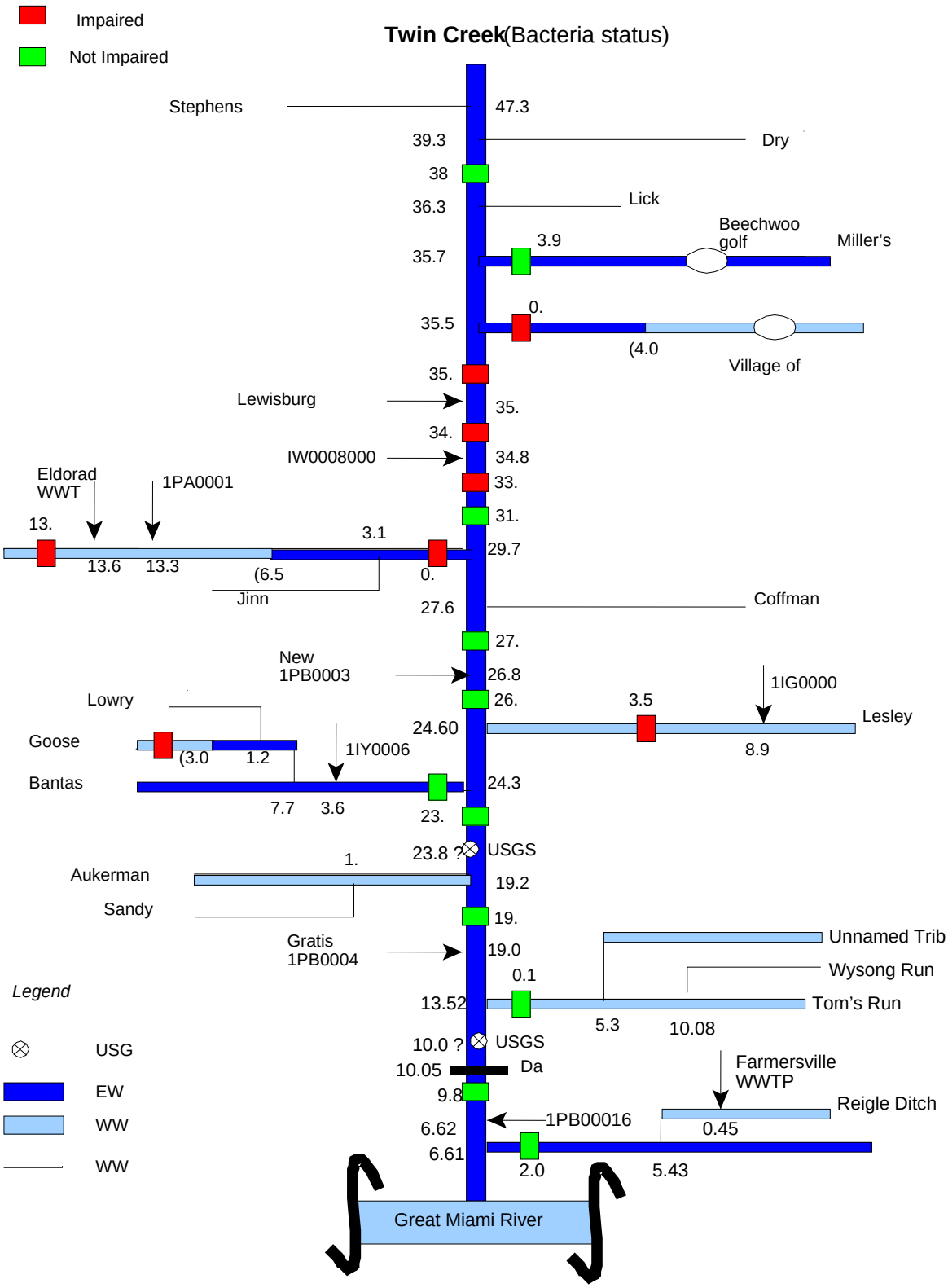

Figure 1. Schematic of the Twin Creek watershed showing bacteria sampling sites.

The literature and default values used in the load calculations are best professional judgment representations of the actual watershed conditions. Where applicable, the actual watershed data were utilized in the BIT input. In addition to error being created by default and empirical values, other sources of error may be present. For example, in the case of animal population information, the method utilized assumes that the populations from agricultural statistics are evenly distributed across the county. The density found for the county is used to obtain the population of the HUC14 areas by proportional size by the relevant land uses. Assessing the accuracy of these assumptions is beyond the scope of this study.

The U.S. EPA's BIT is employed to estimate the fecal coliform load accumulated within the watershed in each 14-digit hydrologic unit. BIT estimates the monthly accumulation rate of fecal coliform bacteria on four land uses (cropland, forested, built-up or urban, and pastureland), as well as the asymptotic limit for that accumulation should no washoff occur. It also estimates the direct input of fecal coliform bacteria to streams from grazing agricultural animals and failing HSTSs (U.S. EPA 2000). No hydrologic or containment routing were considered in this model application. All loading reaching waters of the state are assumed to be completely mixed.

The BIT utilizes user-defined, default and literature values for various needed parameters. These parameters characterize the watershed and activities that occur within the watershed. User-defined values are required to be specific to the study area. These values include land use distribution, number and types of agricultural animals as well as wildlife densities. Default values are supplied by the tool; however, data from the U.S. Department of Agriculture, U.S. Census Bureau, and the local county health department were applied to the BIT model input.

Where information was available, the values were modified to reflect the study area characteristics more realistically. Default values that were used in the Twin Creek BIT simulation include the fraction of manure applied to each land use for each month, the fraction of manure type that is incorporated into the soil during land application, and the time spent grazing or confined by agricultural animals. Like default values, literature values are supplied by the tool; however, they may be replaced with user values if more accurate information is available for the study area. Literature values required by the tool are common to all drainage areas and include animal waste production rates and fecal coliform bacteria content as well as residential sewage discharge rates and raw sewage fecal coliform bacteria content. From the mass and concentration of bacteria from agricultural and wildlife animals, fecal coliform bacteria accumulation rates for each land use are determined by BIT.

Literature values are unchanged for each HUC because no watershed-specific information on these characteristics is available to better characterize the watershed in the relevant aspects. The amount of time cattle has access to streams during grazing was considered to be 100%. All other default values are left unchanged. User-defined values are determined via the following methods:

- The land use distribution is derived from the National Land Cover Dataset (NLCD) via geographic information system (GIS) analysis. The NLCD is compiled from Landsat ™ satellite imagery circa 1992 (Vogelmann, et al. 2001). NLCD information is reclassified to agree with the land use categories of BIT.

- Populations of agricultural livestock and wildlife are derived from countywide figures. Information regarding the amount of livestock is obtained from Ohio Agricultural Statistics Service published data. Information regarding wildlife populations is obtained from Ohio

Department of Natural Resource census data. In each case, the total number of animals within the county is divided by the total number of acres of relevant land use in the county. The resulting animal densities (animals per acre) are used to estimate the animal populations within each 14-digit hydrologic unit.

After the watershed area characteristics are entered, BIT predicts the maximum surface accumulation rate of fecal coliform and the asymptotic limit of accumulation should no washoff occur. Additionally, BIT predicts the fecal coliform load contributed directly to the stream from livestock with stream access as well as home septic system discharge load.

To complement BIT, a spreadsheet method was developed to estimate the pollutant loads from bacteria washoff utilizing runoff. Soil Conservation Service (SCS) runoff curve-numbers are used to calculate the runoff. To appropriately determine the hydrology using the SCS method, Hydrologic Response Units (HRU) were developed by overlaying the NCLD land use with the STATSGO soil coverage. Utilizing GIS analysis, HRUs for each land use with each soil type combination was determined. With the combined data set, the SCS curve-number method was employed for each of these areas within each modeled HUC14 unit. These methods use a combination of known land use data and empirically-derived runoff functions in each calculation.

Bacteria washoff is estimated using the daily land-surface accumulation rate generated by BIT, and a washoff equation common to SWMM, HSPF and GWLF (other models). This equation assumes the percent washoff is proportioned to the rainfall amount produced within one day. The proportion exponentially increases with rainfall amount and the rate of increase is considered to be greater in urban areas than in non-urban areas.

Urban area $$\%washoff = 1 - e^{\frac{\ln 0.1}{0.5}Q}$$

Non-urban area $$\%washoff = 1 - e^{\frac{\ln 0.1}{0.65}Q}$$

where Q is the rainfall runoff (inches per unit area of land surface) from the SCS curve-number method. In addition to the daily bacteria accumulation rate, the washoff equation requires daily precipitation and a washoff coefficient as inputs. Daily runoff is estimated using the SCS curve-number method.

Results

The following tables show existing loads of fecal coliform bacteria, organized by 14-digit HUC.

Table 1. Existing nonpoint source fecal coliform loads (total seasonal values from 1996 through 2006, 11 years).

HUC 14 (05080002)	Narrative	Crop[a]	Forest[b]	Urban Green[c]	Pasture	Urban buildup[d]	Water	Wetland[e]	Total NPS
030 030	Twin Cr. below Millers Fk. to above Price Cr. (except Swamp Cr.)	9.46E+14	1.94E+13	3.96E+13	1.68E+15	6.36E+11	0	1.56E+12	2.69E+15
030 040	Swamp Cr.	1.27E+15	8.48E+12	1.13E+13	2E+15	2.85E+11	0	0	3.29E+15
030 050	Price Cr @ Pence-Sherman RD	2.04E+15	2.69E+13	5.4E+13	3.25E+15	2.21E+11	0	0	5.37E+15
030 060	Twin Cr. below Price Cr. to above Bantas Fk.	2.21E+15	3.58E+13	2.25E+13	3.49E+15	6.35E+11	0	1.38E+12	5.76E+15
040 020	Goose Cr	9.2E+14	6.78E+13	0	1.53E+15	2.41E+11	0	0	2.52E+15

[a] The “crop” designation includes row crops, small grain and fallow fields.
[b] The “forest” designation includes deciduous, evergreen and mixed forests as well as shrubland.
[c] The “urban green” designation includes bare rock/sand/clay, quarries/strip mines/gravel pits, transitional areas, orchards and vineyards, grassland/herbaceous areas and urban/recreational grasses.
[d] The “urban buildup” designation includes low- and high-density residential areas and commercial/industrial and transportation areas.
[e] The “wetland” designation includes woody wetlands and emergent herbaceous wetlands.

Table 2. Total existing fecal coliform load (total seasonal values from 1996 through 2006, 11 years).

HUC 14 (05080002)	Narrative	Total NPS	Septics	Livestock	Total Load	Reduction	Load reduction	Total load (11 years)
030 030	Twin Cr. below Millers Fk. to above Price Cr. (except Swamp Cr.)	2.69E+15	1.38E+17	3.72E+16	1.78E+17	88%	1.57E+17	4.05E+16
030 040	Swamp Cr.	3.29E+15	2.73E+17	4.43E+16	3.20E+17	83%	2.66E+17	1.06E+17
030 050	Price Cr @ Pence-Sherman Rd	5.37E+15	4.05E+17	7.26E+16	4.83E+17	90%	4.35E+17	9.38E+16
030 060	Twin Cr. below Price Cr. to above Bantas Fk.	5.76E+15	2.57E+17	6.45E+16	3.27E+17	69%	2.26E+17	1.01E+17
040 020	Goose Cr.	2.52E+15	5.54E+17	2.81E+16	5.85E+17	88%	5.15E+17	1.42E+17

Table 3. Existing nonpoint source fecal coliform load (average seasonal values from 1996 through 2006).

HUC 14 (05080002)	Narrative	Crop[a]	Forest[b]	Urban Green[c]	Pasture	Urban buildup[d]	Water	Wetland[e]	Total NPS
030 030	Twin Cr. below Millers Fk. to above Price Cr. (except Swamp Cr.)	8.60E+13	1.78E+12	3.60E+12	1.53E+14	5.78E+10	0	1.42E+11	2.45E+14
030 040	Swamp Cr.	1.16E+14	7.71E+11	1.02E+12	1.82E+14	2.59E+10	0	0	2.99E+14
030 050	Price Cr @ Pence-Sherman Rd	1.86E+14	2.45E+12	4.91E+12	2.96E+14	2.01+10	0	0	4.88E+14
030 060	Twin Cr. below Price Cr. to above Bantas Fk.	2.01E+14	3.26E+12	2.05E+12	3.17E+14	5.78E+10	0	1.25E+11	5.23E+14
040 020	Goose Cr.	8.36E+13	6.17E+12	0	1.40E+14	2.19E+10	0	0	2.29E+14

[a] The “crop” designation includes row crops, small grain and fallow fields.
[b] The “forest” designation includes deciduous, evergreen and mixed forests as well as shrubland.
[c] The “urban green” designation includes bare rock/sand/clay, quarries/strip mines/gravel pits, transitional areas, orchards and vineyards, grassland/herbaceous areas and urban/recreational grasses.
[d] The “urban buildup” designation includes low- and high-density residential areas and commercial/industrial and transportation areas.
[e] The “wetland” designation includes woody wetlands and emergent herbaceous wetlands.

Table 4. Existing fecal coliform load (average seasonal values from 1996 through 2006).

HUC 14 (05080002)	Narrative	Total NPS	Septics	Livestock	Total Load	Reduction	Load reduction	Average annual load
030 030	Twin Cr. below Millers Fk. to above Price Cr. (except Swamp Cr.)	2.45E+14	1.26E+16	3.38E+15	1.62E+16	88%	1.42E+16	1.94E+15
030 040	Swamp Cr.	2.99E+14	2.48E+16	4.03E+15	2.91E+16	83%	2.42E+16	4.95E+15
030 050	Price Cr @ Pence-Sherman Rd	4.88E+14	3.68E+16	6.6E+15	4.39E+16	90%	3.95E+16	4.39E+15
030 060	Twin Cr. below Price Cr. to above Bantas Fk.	5.23E+14	2.33E+16	5.86E+15	2.97E+16	69%	1.46E+16	1.52E+16
040 020	Goose Cr.	2.29E+14	5.04E+16	2.55E+15	5.32E+16	88%	4.68E+16	6.38E+15

Table 5. Existing nonpoint source fecal coliform load (average daily load).

HUC 14 (05080002)	Narrative	Crop[a]	Forest[b]	Urban Green[c]	Pasture	Urban buildup[d]	Water	Wetland[e]	Total NPS
030 030	Twin Cr. below Millers Fk. to above Price Cr. (except Swamp Cr.)	5.12E+11	1.05E+10	2.14E+10	9.11E+11	3.44E+08	0	8.43E+08	1.46E+12
030 040	Swamp Cr.	6.89E+11	4.59E+09	6.09E+09	1.08E+12	1.54E+08	0	0	1.78E+12
030 050	Price Cr @ Pence-Sherman Rd	1.11E+12	1.45E+10	2.92+10	1.76E+12	1.20E+08	0	0	2.91E+12
030 060	Twin Cr. below Price Cr. to above Bantas Fk.	1.20E+12	1.94E+10	1.22+10	1.89E+12	3.44E+08	0	7.44E+08	3.11E+12
040 020	Goose Cr.	4.98E+11	3.67E+10	0	8.30E+11	1.30E+08	0	0	1.36E+12

[a] The “crop” designation includes row crops, small grain and fallow fields.
[b] The “forest” designation includes deciduous, evergreen and mixed forests as well as shrubland.
[c] The “urban green” designation includes bare rock/sand/clay, quarries/strip mines/gravel pits, transitional areas, orchards and vineyards, grassland/herbaceous areas and urban/recreational grasses.
[d] The “urban buildup” designation includes low- and high-density residential areas and commercial/industrial and transportation areas.
[e] The “wetland” designation includes woody wetlands and emergent herbaceous wetlands.

Table 6. Existing fecal coliform total load and TMDLs.

HUC 14 (05080002)	Narrative	Total NPS	PS*	Septics	Livestock	Total load	Reduction	Load reduction	TMDL
030 030	Twin Cr. below Millers Fk. to above Price Cr. (except Swamp Cr.)	1.46E+12	1.49E+10	7.47E+13	2.01E+13	9.63E+13	88%	8.47E+13	1.16E+13
030 040	Swamp Cr.	1.78E+12	3.22E+09	1.48E+14	2.4E+13	1.73E+14	83%	1.44E+14	2.95E+13
030 050	Price Cr @ Pence-Sherman Rd	2.91E+12	3.79E+09	2.19E+14	3.93E+13	2.61E+14	90%	2.35E+14	2.61E+13
030 060	Twin Cr. below Price Cr. to above Bantas Fk.	3.11E+12	1.15E+10	1.39E+14	3.49E+13	1.77E+14	69%	1.22E+14	5.49E+13
040 020	Goose Cr.	1.36E+12	1.51E+09	3E+14	1.52E+13	3.17E+14	88%	2.79E+14	3.80E+13

* For a list of the point source dischargers and their fecal coliform loadings, see Table 10 of the main report.

References

U.S. EPA. 2000. *Bacterial Indicator Tool User Guide*. U.S. Environmental Protection Agency, Office of Water.

Vogelmann, J.E., S.M. Howard, L. Yang, C.R. Larson, B.K. Wylie, and J.N. Van Driel. 2001. Completion of the 1990s National Land Cover Data Set for the Conterminous United States. *Photogrammetric Engineering and Remote Sensing* **67**: 650-662.