4.0 TOTAL MAXIMUM DAILY LOADS

A TMDL provides a mechanism to recommend controls required to meet water quality standards. The TMDL calculation is the sum of the wasteload allocations for the point sources and the load allocations for natural background and nonpoint sources in a watershed. In the case of Sugar Creek, the major causes of impairment are habitat related and thus not easily amenable to quantification into loads. Attainment of WQS will require that both pollutant loads and other environmental conditions (such as habitat) be considered if they are identified as causes of impairment. The TMDL calculation must also include an implicit or explicit margin of safety to account for uncertainty regarding the relationship between pollutant load and water quality.

4.1 Calculation Method

Watershed Modeling

Nutrient loading in the Sugar Creek basin was simulated using the Generalized Watershed Loading Function or GWLF model (Haith et al., 1992). The complexity of this model falls between that of detailed, process-based simulation models and simple export coefficient models which do not represent temporal variability. GWLF provides a mechanistic, but simplified simulation of precipitation-driven runoff and sediment delivery. Solids load, runoff, and ground water seepage can then be used to estimate particulate and dissolved-phase pollutant delivery to a stream, based on pollutant concentrations in soil, runoff, and ground water. GWLF has been used for TMDL development in Pennsylvania, Iowa and Arizona, and is a recommended model in USEPA's Protocol for Developing Nutrient TMDLs (USEPA, 1999).

GWLF simulates runoff and streamflow by a water-balance method, based on measurements of daily precipitation and average temperature. Precipitation is partitioned into direct runoff and infiltration using a form of the Natural Resources Conservation Service's (NRCS) Curve Number method (SCS, 1986). The Curve Number determines the amount of precipitation that runs off directly, adjusted for antecedent soil moisture based on total precipitation in the preceding five days. A separate Curve Number is specified for each land use by hydrologic soil grouping. Infiltrated water is first assigned to unsaturated zone storage where it may be lost through evapotranspiration. When storage in the unsaturated zone exceeds soil water capacity, the excess percolates to the shallow saturated zone. This zone is treated as a linear reservoir that discharges to the stream or loses moisture to deep seepage, at a rate described by the product of the zone's moisture storage and a constant rate coefficient.

Flow in streams may derive from surface runoff during precipitation events or from ground water pathways. The amount of water available to the shallow ground water zone is strongly affected by evapotranspiration, which GWLF estimates from available moisture in the unsaturated zone, potential evapotranspiration, and a cover coefficient. Potential evapotranspiration is estimated from a relationship to mean daily temperature and the number of daylight hours.

The user of the GWLF model must divide land uses into "rural" and "urban" categories, which determines how the model calculates loading of sediment and nutrients. For the purposes of modeling, "rural" land uses are those with predominantly pervious surfaces, while "urban" land uses are those with predominantly impervious surfaces. It is often appropriate to divide certain land uses into pervious ("rural") and impervious ("urban") fractions for simulation. Monthly sediment delivery from each "rural" land use is computed from erosion and the transport capacity of runoff, whereas total erosion is based on the universal soil loss equation (USLE) (Wischmeier and Smith, 1978), with a modified rainfall erosivity coefficient that accounts for the precipitation energy available to detach soil particles (Haith and Merrill, 1987). Thus, erosion can occur when there is precipitation, but no surface runoff to the stream; delivery of sediment, however, depends on surface runoff volume. Sediment available for delivery is accumulated over a year, although excess sediment supply is not assumed to carry over from one year to the next. Nutrient loads from rural land uses may be dissolved (in runoff) or solid-phase (attached to sediment loading as calculated by the USLE).

For "urban" land uses, soil erosion is not calculated, and delivery of nutrients to the water bodies is based on an exponential accumulation and washoff formulation. All nutrients loaded from urban land uses are assumed to move in association with solids.

The GWLF model was calibrated to the Sugar Creek River watershed by comparing observed data from 1995 to 2000 to predicted data. The model was calibrated to predict monthly streamflows ($R^2 = 0.87$). Once the model had been calibrated, it was used to predict nutrient loadings during the 1995 to 2000 period for each of the subwatersheds listed as impaired for nutrients. The 1995 to 2000 period was selected because it includes the 1998-99 period during which a comprehensive water quality survey of the basin occurred. Five years were modeled to obtain average loadings in this period to smooth out the effects of unusually wet or dry years. The nutrient loads predicted by GWLF for each subwatershed fell within the range of loads measured by Ohio EPA in each subwatershed. The results of the estimated loadings for each subwatershed are presented in section 4.4 . Refer to Appendix A for more details on the GWLF modeling.

Receiving Stream Modeling

In order to address possible impact of excessive nutrient loads on water quality, the Qual2E dissolved oxygen model was used to simulate the discharge of Gerber Poultry to the North Fork Sugar Creek under various scenarios. One of the scenarios includes a proposed wastewater treatment plant that would discharge to the North Fork Sugar Creek downstream of the point where Gerber Poultry discharges (through a tributary) to the North Fork. The Qual2E model was used to determine if interaction from the two dischargers would cause violations of the WQS for dissolved oxygen and ammonia. The model was calibrated using data collected by Ohio EPA during a 1993 survey. The calibrated model was validated against data collected by a consultant (URS Consultants) during a survey conducted in the North Fork during June of 1998. More details about the D.O. modeling are found in Appendix B.

4.2 Critical Conditions and Seasonality

TMDL development must define the environmental conditions that will be used when defining allowable loads. TMDLs are designed around the concept of a "critical condition." The critical condition is defined as the set of environmental conditions that, if controls are designed to protect, will ensure attainment of objectives for all other conditions. For example, the critical condition for control of a continuous point source discharge is the drought stream flow. Point source pollution controls designed to meet water quality standards for drought flow conditions will ensure compliance with standards for all other conditions. For the Sugar Creek TMDL, the 7Q10 low flow (using yields from USGS gages) was used as the critical condition in those segments where nutrient enrichment had previously been identified as causing a Dissolved Oxygen (DO) impairment. Those segments are identified in Table 1. A 50^{th} percentile annual flow was used to evaluate the impact of point source nutrient load reductions on the instream nutrient targets (phosphorus and NO_3 +NO_2).

Nutrient sources in the Sugar Creek watershed arise from a combination of continuous and wet weather-driven sources. The critical condition is expected to be the summer low-flow period because this is the period that is most conducive to algal growth. It is also during the summer when higher temperatures increase the decay rate of instream nutrients, increasing the likelihood of dissolved oxygen standard violations, as well as increased ammonia-N toxicity (because of the low flows). Therefore it is the observed summer concentrations that are compared to the targets and used to estimate the necessary loading reductions.

Seasonality is expressed in the TMDL by using the GWLF model to predict monthly loadings over a multi-year period using actual weather conditions and observed seasonal point source loadings. The estimated loads are therefore reflective of seasonal changes in weather, treatment facility operating practices, and other conditions that can vary over the course of a year (e.g. agricultural practices).

4.3 Margin of Safety (MOS)

The statute and regulations require that a TMDL include a margin of safety to account for any lack of knowledge concerning the relationship between load and wasteload allocations and water quality (CWA § 303(d)(1)(C), 40 C.F.R. § 130.7(c)(1)). EPA guidance explains that the margin of safety (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. If the MOS is implicit, the conservative assumptions in the analysis that account for the MOS must be described. If the MOS is explicit, the loading set aside for the MOS must be identified.

A margin of safety is incorporated implicitly into these TMDLs. There are several areas where an implicit margin of safety is incorporated including: the 303(d) listing process, the target development, the model inputs and application. An explanation for each of these areas is provided below.

4.3.1 TMDL priority 303(d) listing

In Ohio, one way a stream segment is listed on the 303(d) list is for failure to attain the appropriate aquatic life use as determined by direct measurement of the aquatic biological community. Many other regional or state programs rely solely on chemical samples in comparison to chemical criteria to determine water quality and designated use attainment. Relying solely on chemical data does not take into account any of the parameters or other factors for which no criteria exist but that affect stream biology, nor does it account for multiple stressor situations. Therefore, the chemical specific approach misses many biologically impaired streams and may not detect a problem until it is severe. Ohio's approach incorporates an increased level of assurance that Ohio's water quality problems are being identified. Likewise, de-listing requires attainment of the aquatic life use determined by the direct measurement of the aquatic biological community. This provides a high level of assurance (and an implicit margin of safety) that if the TMDL allocations do not lead to sufficiently improved water quality then the segments remain on the list until true attainment is achieved.

4.3.2 Target development

The use of nutrient targets that are based on data from relatively unimpacted reference sites provides an additional implicit safety factor. These data constitute a background concentration of nutrients in a stream; unimpacted streams generally have nutrient levels well below those needed to meet biological water quality standards. As the stream becomes impacted, nutrient levels can rise, but the stream can still meet water quality standards based on other factors such as the presence of good habitat. Once the nutrient levels rise high enough or other factors change which no longer mitigate the effects of nutrients then the biological community is impacted, and the stream is impaired. By using nutrient targets based on data from relatively unimpacted sites (or sites that are conservatively in attainment of biological water quality criteria) the targets themselves are set at a conservative level. In other words, water quality attainment is likely to occur at levels higher than these targets and the difference between this actual level where attainment can be achieved and the selected target is an implicit margin of safety.

A further conservative assumption implicit in the target development lies in the selection of the statistic used to represent the phosphorus target which corresponds to an unimpaired biological community. Since Ohio EPA's evaluation of phosphorus data for generating target values is based on measured performance of aquatic life and since full attainment can be observed at concentrations above this target (reinforcing the concept that habitat and other factors play an important role in supporting fully functioning biological communities), it would be valid to argue that a 95^{th} percentile of these values (to exclude outliers) would be protective of the respective aquatic life use. Instead, Ohio EPA selected the median value associated with measured aquatic life performance. The selection of this statistic is an implicit margin of safety in these TMDLs. Refer to Appendix C for more information on how the nutrient targets were derived.

The habitat targets were selected using a method analogous to the nutrients method. The habitat targets and the specific aspects of the habitat that are degraded as provided with the QHEI model combine to add another layer of potential protection to achieving the WQS by providing additional guidance on an alternate means to reduce the nutrient load to the stream, mitigate the impacts of the nutrients in the stream, and directly improve an aspect of stream ecology vital to the biological community. Ohio EPA's ability to add habitat targets, and provide guidance on the improvement of the habitat is an implicit margin of safety made possible through extensive ecosystem monitoring and analysis, and should be recognized as a margin of safety in these TMDLs.

4.3.3 Model inputs and application

Conservative modeling assumptions also implicitly incorporate a margin of safety into the project for the dissolved oxygen and GWLF model simulations. Some of these conservative assumptions include:

- Setting the point source inputs at the full design or permit value for each discharger (as opposed to using the current discharge flows) or the median, whichever is higher. This incorporates an extra 20 to 30% of the total effluent flow that the system is not currently receiving. Since the Sugar Creek watershed is largely agricultural, population growth is low and it is unlikely that the additional flow will actually be in the system for several decades;

- The use of somewhat high concentrations of phosphorus and dissolved nitrogen in the groundwater contribution to streamflow. The use of this assumption, based on data collected in the mid 1980s, intends to account for impact of tiled agricultural land. Since some conservation practices have been implemented in the past 20 years, the actual groundwater concentrations are probably lower.

- Assuming a low flow condition (7Q10) which has a very small recurrence interval (water quality criteria generally do not apply to flow conditions that have a statistical recurrence interval lower than the lowest 7 day consecutive flow in any 10 year period (the 7Q10); and,

- Using moderately high instream temperatures for the dissolved oxygen simulations.

Individually, these decisions reflect conservatism; taken together, this set of circumstances is unlikely to occur concurrently and therefore, provide an additional buffer to account for uncertainty in the modeling process.

One additional aspect that decreases the uncertainty associated with the wasteload allocations and the resultant water quality is that the point sources usually achieve better quality effluent than they are allowed in their NPDES permits. This is particularly relevant for some of the smaller tributaries or headwater reaches, which are effluent dominated during low flow time periods. A random sampling of Lake Erie Basin dischargers with total phosphorus limits of 1 mg/l showed that on average these facilities discharged at 0.65 mg/l total phosphorus. This is 35% less then their allocation and represents a margin of error for the facility and a margin of safety for the stream.

4.4 TMDL Calculations

Necessary loading reductions for Sugar Creek were estimated by comparing the instream 1998-99 summer concentrations to the desired targets (see Section 3.2). For example, if the observed total phosphorus concentration was 0.38 mg/L and the target is 0.19 mg/L, it is assumed that loadings must be reduced by 50%. This approach assumes a direct relationship between loadings and concentrations and a constant assimilation factor (i.e., the instream concentrations of total phosphorus and NO3+NO2 will respond to future changes in loading in the same manner as they respond to current loads). These simplifying assumptions are warranted by the fact that it is the cumulative, rather than the acute, loadings of nutrients that are impairing the biologic communities. Please refer to *Association Between Nutrients, Habitat, and the Aquatic Biota in Ohio Rivers and Streams* (OEPA, 1999) for a full discussion of the cumulative impacts of nutrients on Ohio rivers and streams. The required load reduction needed to meet the proposed targets varied from segment to segment, as seen in Table 13.

Another important assumption used for these TMDLs deals with the relationship between measures of dissolved nitrogen and NO3+NO2 nitrogen. The instream targets are expressed as NO3+NO2, but the GWLF model outputs loadings as dissolved nitrogen (which includes NO3+NO2, NH4+, and NH3). Since dissolved nitrogen is typically comprised primarily of NO3+NO2 (usually 80-90% based on observed Sugar Creek data), the allowable loads for these TMDLs will be expressed in terms of dissolved nitrogen. However, the estimate of the necessary loading reductions are obtained by comparing the observed instream NO3+NO2 concentrations to the target NO3+NO2 concentrations.

Table 14 shows the existing loads determined using the GWLF model for each subwatershed for dissolved nitrogen, total phosphorus and sediments. Under "existing conditions" the Nonpoint Source (NPS) column includes groundwater, urban, agricultural and natural background loads. The Point Source (PS) column includes the sum of known point source loads in the watershed. The TMDL was determined by multiplying the existing total load by the recommended percent reduction. The TMDL was divided among background conditions, wasteload allocation for point sources (WLA) and load allocations (LA) for nonpoint sources. To determine the background load, the GWLF model was run assuming the watershed was completely covered by forests, instead of cropland, pastureland, and other urban land uses. All the point sources and septic tanks were also excluded, to determine the pollutant loads under "pristine" or pre-settlement conditions. The remaining load was allocated to Nonpoint sources. The percent reductions for nitrogen and phosphorus were set to an appropriate percentage, based on the average reduction needed to meet the nutrient targets shown in Tables 11 and 12.

A 30% reduction in sediment load is viewed as a feasible goal for the Sugar Creek watershed, once the recommendations from the TMDL report (e.g increasing conservation tillage, establish riparian buffers, fence livestock, etc) are funded and implemented. This level of sediment reduction should significantly boost biological scores in the watershed, based on experience with the Auglaize river basin. Information from the USGS indicates that there was a 49.8% reduction in suspended- sediment discharge in the Auglaize River (northwest Ohio) between 1970 and 1998. The report indicates that the reduction in sediment yields may be the result of widespread

Table 14. TMDLs and Allocations For the Sugar Creek Basin

Subwatershed	Existing Conditions			Percent Reduction	TMDL	TMDL Allocations		
	NPS	PS	Total			Natural	WLA	LA
Dissolved Nitrogen (kg/day)								
E Branch	103	0	103	40%	62	13	0	49
Upper Sugar	426	27.3	453	70%	136	37	27.3	72
Lower Sugar	253	102.6	356	0%	356	35	102.6	218
North Fork	77	36.4	113	70%	34	8	21.2	5
Middle Fork	186	13.6	200	25%	150	22	13.6	114
South Fork	338	40.1	378	30%	265	29	28.5	207
Walnut/Indian Tr	222	30.3	252	30%	176	22	26.0	128
Total Phosphorus (kg/day)								
E Branch	24	0	24	60%	10	4	0	6
Upper Sugar	39	5.6	45	60%	18	3	2.6	12
Lower Sugar	47	33	80	50%	40	6	6.2	28
North Fork	14	5.4	19	50%	10	2	3.6	4
Middle Fork	39	11.2	50	40%	30	5	1.0	24
South Fork	59	24.7	84	60%	34	5	2.7	26
Walnut/Indian Tr	30	12.9	43	60%	17	8	2.3	7
Sediments (metric tons/year)								
E Branch	4798	0	4798	30%	3359	896	0	2463
Upper Sugar	3657	13.3	3670	30%	2569	408	13.3	2148
Lower Sugar	9774	115.2	9889	30%	6922	1270	115.2	5537
North Fork	2040	15.4	2055	30%	1439	356	15.4	1067
Middle Fork	6981	4.9	6985	30%	4890	1305	4.9	3580
South Fork	8690	17.0	8707	30%	6095	1158	17.0	4920
Walnut/Indian Tr	5025	15.2	5040	30%	3528	2047	15.2	1466

adoption of conservation tillage (USGS, 2000). Preliminary results from Ohio EPA's biological survey of the Auglaize River basin indicates that most mainstem sites are attaining their use designation.. It should be noted that GWLF simulates sheet and rill erosion, and a multiplier (sediment delivery ratio) determines what percent of that sediment reaches the stream. Bank and gully erosion are not simulated by GWLF, but are taken into account by the QHEI index. The QHEI will be used to guide implementation actions to address bank and gully erosion.

The WLA loads are based on permitted loads at design flow for the point sources in the basin. For total phosphorus, the effluent limits for all point sources were set to 1 mg/l (summer only). "Summer" is defined as the period from March through November. For dissolved nitrogen, only the WLA loads for the North Fork were adjusted by lowering the nitrogen loads, because the point source NO3 + NO2 load is very high compared to all other Sugar Creek subwatersheds. Other dischargers elsewhere in the Sugar Creek basin should monitor their effluent concentration of NO3 + NO2. The existing and proposed phosphorus point source (summer) loads for dischargers in the Sugar creek watershed are shown in table 15.

Table 15. Phosphorus Summer [A] Loads for Point Source Dischargers in the Sugar Creek Basin

Discharger	Design Flow (MGD)	Existing Flow (MGD)	Existing P Load (kg/day)	P Load* @ 1 mg/l (kg/day)	Subwatershed
Smithville WWTP	0.30	0.3	1.2	1.1	Upper Sugar
Eastwood WWTP	0.2 [B]	0.06	0.7	0.76	Upper Sugar
Harmony Lake WWTP	0.036	0.036	0.41	0.14	Upper Sugar
Gerber Poultry	0.80 [B]	0.16	4.6	3.0	North Fork
Kidron WWTP (proposed)	0.1	None	none	0.38	North Fork
Mt. Hope WWTP	0.022	0.022	0.25	0.08	Middle Fork
Alpine Cheese Co.	0.022	0.022	8.35	0.08	Middle Fork
Brewster WWTP	0.665	0.391	4.28	2.52	Sugar Creek
Brewster Dairy	0.30	0.30	18.6	1.14	Sugar Creek
Beach City WWTP	0.297	0.15	2.8	1.12	Sugar Creek
Baltic Rubber Co.	0.02	0.02	NA	NA	South Fork
Baltic WWTP	0.1	0.1	2.8	0.38	South Fork
Guggisberg Cheese	0.04 [B]	0.014	9.6	0.15	South Fork
Sugarcreek WWTP	0.50	0.5	9.4	1.9	South Fork
American Whey	0.065	0.065	2.88	0.25	South Fork
Walnut Creek WWTP	0.090	0.09	1.0	0.3	Walnut Ck
Holmes By-Products	NA	NA			Indian Trail Ck
Troyer's Trail Bologna	0.005	0.005	0.05	0.02	Indian Trail Ck
Case Farms Inc	0.50	0.50	11.9	1.9	Indian Trail Ck
Strasburg WWTP	0.225	0.225	4.0	1.3	Sugar Creek
Alpine Hills (camp)	NA	NA	0.06	0.02	Sugar Creek
Broad Run Cheese	NA	NA	0.06	0.02	Sugar Creek
Dover Chemical Co.	4.0 [B]	1.45	NA	NA	Sugar Creek

[A] March through November

[B] Proposed expansion flow

* At proposed expansion flow or design flow

By request of one of the watershed groups, table 16 has been added to this report, showing the nutrient loads normalized by drainage area. Although this approach may help compare across subwatersheds, it ignores important factors such as habitat, ecoregion, spatial location of point sources in watershed, etc. However, it indicates that the point source nitrogen load per unit of area is highest for the North Fork subwatershed. Details about the allocations for each listed subwatershed are shown following Table 16.

Table 16. Nutrient Loads per Square Mile of Drainage Area for Sugar Creek Subwatersheds

Subwatershed	Existing Conditions				TMDL	TMDL Allocations		
	NPS	PS	Total			Natural	WLA	LA
Dissolved Nitrogen (kg/day/mi^2)								
E Branch	3.65	0	3.65		2.19	0.46	0	1.73
Upper Sugar	5.36	0.34	5.71		1.71	0.47	0.34	0.90
Lower Sugar	4.49	0.70	5.2		3.30	0.46	0.61	2.22
North Fork	4.26	2.02	6.28		1.88	0.44	1.18	0.26
Middle Fork	3.94	0.29	4.23		3.17	0.47	0.29	2.42
South Fork	5.48	0.65	6.13		4.29	0.46	0.46	3.36
Walnut/Indian Tr	4.61	0.63	5.24		3.67	0.46	0.54	2.67
Total Phosphorus (kg/day/mi^2)								
E Branch	0.85	0	0.85		0.34	0.14	0	0.20
Upper Sugar	0.50	0.07	0.57		0.23	0.04	0.03	0.16
Lower Sugar	0.71	0.26	0.97		0.44	0.09	0.05	0.30
North Fork	0.76	0.30	1.06		0.53	0.08	0.20	0.22
Middle Fork	0.82	0.24	1.06		0.63	0.11	0.02	0.51
South Fork	0.96	0.40	1.36		0.54	0.08	0.04	0.42
Walnut/Indian Tr	0.63	0.27	0.89		0.36	0.17	0.05	0.14

4.4.1 Sugar Creek (Headwaters to Middle Fork)

Nonpoint source modeling was performed using the GWLF model (see Appendix A for details). Table 17 shows the annual loads of total phosphorus, dissolved nitrogen, and sediments contributed by various land uses and sources in the Upper Sugar Creek subwatershed (based on model simulation from 1995-2000). Agricultural lands are the main contributors of total phosphorus, suspended sediments (and probably dissolved nitrogen) in this segment. There is insufficient data to determine what portion of the dissolved nitrogen is intercepted by agricultural tiles and routed to the streams (instead of to groundwater). Septic systems are estimated to contribute about 28% of the total phosphorus and 20% of the dissolved nitrogen in this subwatershed. Ohio EPA estimates that a population of approximately 7822 inhabitants is served by residential septic systems in this subwatershed. (See Table 10 of Appendix A for more details). Point source loads contribute about 10% of the total phosphorus, and nearly 7% of the dissolved nitrogen generated in this subwatershed (including dischargers in Little Sugar Creek), based on annual loads.

Table 17. Simulated Distribution of Annual Nutrient Loads and Erosion in Upper Sugar Creek Subwatershed (1995-2000) According to Results of GWLF Nonpoint Source Model

Source	Area (ha)	Dissolved N (t)	Percent N	Total P (t)	Percent P	Sediments (tons/yr)	Sediments %
Row Crop	5742	13.69	8.4%	5.72	35.4%	3100.07	84.5%
Pasture	11388	5.77	3.5%	1.27	7.9%	495.89	13.5%
Forest	2569	0.10	0.1%	0.07	0.4%	51.95	1.4%
Barren	4.3	0.00	0.0%	0.01	0.1%	9.30	0.3%
Open Water	88.8	0.18	0.1%	0.01	0.0%	0	0
Wetland	193.7	0.40	0.2%	0.02	0.1%	0	0
Residential	466.8	0.00	0.0%	0.07	0.5%	0	0
Commercial	87.4	0.00	0.0%	0.10	0.6%	0	0
Groundwater		99.75	61.2%	2.78	17.2%	0	0
Point Source		10.76	6.6%	1.61	10.0%	13.3	0.4%
Septic Systems		32.24	19.8%	4.49	27.8%	0	0
TOTAL		162.90		16.16		3670.51	

(t) = metric ton = 1000 kg
Percentages may not = 100% due to rounding.
Dissolved N = Sum of ammonia-N, NO3+NO2
Total P = Total phosphorus

4.4.2 North Fork Sugar Creek

Table 18 shows the annual loads of total phosphorus, dissolved nitrogen, and sediments contributed by various land uses and sources in the North Fork subwatershed. These loads are based on GWLF simulations for the period 1995-2000. The table provides insight about where the implementation activities should be focused to achieve maximum load reductions. Point sources are providing about 34% of the nitrogen and 22% of the phosphorus load. Septic systems are also a major source of nutrients. This subwatershed also has the highest median concentration of NO2 + NO3 and the largest nitrogen point source load per square mile in the Sugar Creek basin.

Table 18. Simulated Distribution of Annual Nutrient Loads and Erosion in North Fork Sugar Creek Subwatershed (1995-2000) According to Results of Nonpoint Source Model (GWLF)*

Source	Area (ha)	Dis. N (t)	Percent N	Tot. P (t)	Percent P	Sediments	% Sediments
Row Crop	1001.2	2.39	5.9%	2.40	34.3%	1635.53	79.6%
Pasture	2978.7	1.32	3.2%	0.60	8.6%	358.27	17.4%
Forest	594.2	0.02	0.1%	0.06	0.9%	46.27	2.3%
Barren	0	0.00	0.0%	0.00	0.0%	0.00	0.0%
Open Water	3.2	0.01	0.0%	0.00	0.0%	0	
Wetland	13.4	0.03	0.1%	0.00	0.0%	0	
Residential	64.3	0.00	0.0%	0.01	0.2%	0.00	
Commercial	12.5	0.00	0.0%	0.01	0.2%	0.00	
Groundwater		10.98	27.0%	0.62	8.9%		
Point Source		13.91	34.2%	1.56	22.4%	15.4	0.7%
Septic Systems		12.07	29.6%	1.71	24.5%		
TOTAL		40.72		6.98		2055.5	

*All loads as metric tons/year (1000 kg/year)
Dis. N = Sum of ammonia-N, NO3+NO2   Tot. P = Total phosphorus

4.4.3 Little Sugar Creek

There was no specific nonpoint source simulation performed for this subwatershed, as it is included under the upper Sugar Creek segment discussed under subsection 4.4.1. Although insufficient data was available to adequately quantify bacteria, the available information shows indication of bacteria problems. Many of the recommendations given in Section 6 will reduce the bacteria as well as the sediment and total phosphorus loads to the creek. Dissolved nitrogen concentrations do not seem to be a problem in this segment (are within the recommended target of 1 mg/l).

4.4.4 Sugar Creek: South Fork to Tuscarawas River (RM 12.3 to 0.0)

The GWLF nonpoint source model was used to simulate annual nutrient and sediment loads in a reach that includes this segment, as well as the portion of Sugar Creek downstream of Brewster. There are two significant point sources discharging to Sugar Creek in Brewster. Although they are located in a segment not listed in the 1998 303(d) list, these dischargers are having an impact in the creek. About one third of the annual dissolved nitrogen and total phosphorus load is estimated to come from waste water treatment plants. Despite the considerable nitrogen loads from the point sources, the NO3 + NO2 concentrations in this reach of Sugar Creek are within the recommended target of 1.5 mg/l. Table 19 shows the annual loads of total phosphorus, dissolved nitrogen, and sediments contributed by various land uses and sources in the lower Sugar Creek subwatershed, including the point sources mentioned above.

Table 19. Simulated Distribution of Annual Nutrient Loads and Erosion in Lower Sugar Creek Subwatershed (1995-2000) According to Results of GWLF Nonpoint Source Model

Source	Area (ha)	Dis. N (t)	Percent N	Tot. P (t)	Percent P	Sediments (tons/yr)	% Sediments
Row Crop	3819	7.03	5.5%	10.91	37.7%	7849.44	79.4%
Pasture	6396	2.48	1.9%	1.69	5.9%	1117.29	11.3%
Forest	7144.8	0.22	0.2%	0.42	1.5%	324.15	3.3%
Barren	124.4	0.03	0.0%	0.62	2.1%	482.59	4.9%
Open Water	228.3	0.47	0.4%	0.02	0.1%	0	
Wetland	303.7	0.63	0.5%	0.03	0.1%	0	
Residential	1013.8	0.00	0.0%	0.11	0.4%	0.00	
Commercial	168.7	0.00	0.0%	0.20	0.7%	0.00	
Groundwater		49.19	38.4%	1.46	5.1%		
Point Source		40.12	31.3%	9.49	32.8%	115.00	1.2%
Septic Systems		27.97	21.8%	3.96	13.7%		
TOTAL		128.13		28.92		9888.47	

*All loads as metric tons/year (1000 kg/year)
Dis. N = Sum of ammonia-N, NO3+NO2   Tot. P = Total phosphorus

4.4.5 Goettge Run

There was no specific nonpoint source simulation performed for this small (5 mi^2)subwatershed. It is included under the lower Sugar Creek segment discussed under subsection 4.4.5.

4.4.6 Brandywine Creek

Due to its small size (less than 6 mi^2) no individual modeling was done for this subwatershed, although it is included in the nonpoint source simulation performed for the lower Sugar Creek subwatershed. Although insufficient data was available to adequately quantify bacteria, the available information shows indication of bacteria problems. Many of the recommendations given in Section 6 will reduce the bacteria as well as the sediment loads to the creek.

4.4.7 Unnamed tributary to South Fork Sugar Creek at RM 14.15

Due to its small drainage area (about 3 square miles) no individual NPS modeling was done for this subwatershed. However, the GWLF nonpoint source model was used to simulate annual nutrient and sediment loads in the South Fork Sugar Creek, which includes this segment. Table 20 shows the annual loads of total phosphorus, dissolved nitrogen, and sediments contributed by various land uses and sources in the South Fork subwatershed. A point source (American Whey) located in this segment is included in the modeling done for the South Fork subwatershed.

Table 20. Simulated Distribution of Annual Nutrient Loads and Erosion in South Fork Subwatershed (1995-2000) According to Results of GWLF Nonpoint Source Model

Source	Area (ha)	Dis. N (t)	Percent N	Tot. P (t)	Percent P	Sediments (tons/yr)	% Sediments
Row Crop	2500.7	5.24	3.8%	8.31	27.6%	5987.13	68.8%
Pasture	8727.9	4.42	3.2%	3.03	10.1%	1991.37	22.9%
Forest	3680.3	0.15	0.1%	0.19	0.6%	146.28	1.7%
Barren	141.4	0.03	0.0%	0.72	2.4%	565.36	6.5%
Open Water	165.5	0.34	0.3%	0.01	0.0%	0	
Wetland	347.8	0.72	0.5%	0.03	0.1%	0	
Residential	320.2	0.00	0.0%	0.05	0.2%	0.00	
Commercial	51.7	0.00	0.0%	0.06	0.2%	0.00	
Groundwater		89.36	65.6%	7.69	25.5%		
Point Source		15.64	11.5%	7.12	23.6%	17.00	0.2%
Septic Systems		20.34	14.9%	2.88	9.6%		
TOTAL		136.24		30.10		8707.13	

(t) = metric ton = 1000 kg
Percentages may not = 100% due to rounding.
Dissolved N = Sum of ammonia-N, NO3+NO2
Total P = Total phosphorus

5.0 PUBLIC PARTICIPATION

The Sugar Creek basin is split among four counties (Holmes, Stark, Tuscarawas and Wayne). On May 31, 2000, an informational meeting was held in Wooster (Wayne County) Ohio. Representatives from Soil & Water Conservation Districts (SWCD), Natural Resources Conservation Service (NRCS), and Health Departments from the four counties were invited. Other entities represented were the Northeast Ohio Four County Regional Planning & Development Organization (NEFCO), Ohio Department of Natural Resources (ODNR), Ohio Agricultural Research and Development Center (OARDC), East Branch Sugar Creek watershed task force, North Fork Sugar Creek watershed task force and several members of the farming community. The meeting was sponsored by Ohio EPA's Division of Surface Water to share the results of the biological and water quality surveys performed in the Sugar Creek basin during 1998-99, provide information about the TMDL process, and request that the four counties collaborate in applying for a watershed coordinator grant for the whole basin. The meeting was very successful in several ways:

- The OARDC "adopted" the Sugar Creek basin as a pilot project to test its "participatory approach" to organize watershed groups. This approach was subsequently applied successfully in the upper Sugar Creek (Smithville) area and will be tried in other subwatersheds in the basin.

- Although the four counties could not agree on having a single watershed coordinator, two applications were submitted for the position. The application from Wayne county was approved, and a watershed coordinator for the upper Sugar Creek subwatershed (HUC05040001-100) was funded. The coordinator is working on development of an implementation plan.

- Ohio EPA received valuable feedback from those attending the meeting, which was useful in developing presentations brought to watershed groups later on.

Ohio EPA has stayed in touch with the existing watershed groups, providing information and asking for feedback on the draft TMDL report. The following watershed groups meet regularly:

East Branch Sugar Creek watershed task force: Ohio EPA has stayed in touch with this group by phone and e-mail through Alice McKenney, a Tuscarawas county SWCD watershed specialist that facilitates the group's meetings. Ohio EPA staff has met with the group (March 5, 2001) to discuss the draft TMDL report and listen to group members' concerns regarding implementation of the TMDL report recommendations. This group meets regularly and is in the process of completing a watershed plan for the East Branch.

North Fork Sugar Creek watershed task force: Ohio EPA stays in touch with this group through Eric Schultz, the watershed coordinator (Wayne county SWCD) for the upper Sugar Creek subwatershed. Ohio EPA staff attended a meeting (March 9, 2001) with the watershed coordinator and representatives from Wayne and Stark SWCD, NRCS, Health departments, and other regional organizations. Among the topics discussed were the draft TMDL report recommendations, sources of funds for implementation of management alternatives, and coordination among state and local agencies.

Upper Sugar creek (Smithville) watershed group (Sugar Creek Partners): Ohio EPA has stayed in touch with this group by phone and e-mail through Richard Moore, an Ohio State University professor who's leading the OARDC team that facilitated the formation of this group. This group is promoting environmental stewardship by organizing family activities that include biological and water quality monitoring demonstrations to educate stakeholders. These activities also build fellowship among neighbors, thus improving the group's ability to reach consensus on watershed planning decisions. A Sugar Creek "Family Day" was held on July 23, 2002 and included a biological sampling demonstration offered by Ohio EPA staff.

Plate 4. Robert Davic (Ohio EPA-NWDO) gives a stream biology presentation at Sugar Creek Partners "Family Day" activity.