FINAL ORGANIC ENRICHMENT/LOW DISSOLVED OXYGEN

TOTAL MAXIMUM DAILY LOAD (TMDL) FOR WATERS IN THE

HARPETH RIVER WATERSHED

(HUC 05130204)

September 2004

Executive Summary

The Tennessee Department of Environment and Conservation (TDEC) included several waters in the Harpeth River Basin on its §303(d) list of impaired waters for the pollutant causes, “organic enrichment/Low DO” and “Low DO” including the segments identified in the Table below. The TMDLs established in this report will address these waters and pollutant causes.

Water Quality Limited Segments and Pollutant Causes Addressed by the TMDLs

Waterbody (waterbody ID#)	Impacted Waterbody	CAUSE (Pollutant)
Harpeth River – West Harpeth River to Spencer Creek	TN05130204 016 – 1000	Organic enrichment/low dissolved oxygen
Harpeth River – Spencer Creek to Watson Creek	TN05130204 016 – 2000	Organic enrichment/low dissolved oxygen
Harpeth River – Watson Creek to Mayes Creek	TN05130204 016 – 3000	Low DO
Harpeth River – Mayes Creek to Wilson Branch	TN05130204 016 – 4000	Low DO
HARPETH RIVER TRIBUTARIES Arrington Cr, Spencer Cr, Watson Br, 5-mile Cr, Lynnwood Cr, and Starnes Cr	TN05130204 016	Organic enrichment/low dissolved oxygen
Concord Creek	TN051300204 018 – 0200	Organic enrichment/low dissolved oxygen
Kelley Creek	TN051300204 018 – 0300	Organic enrichment/low dissolved oxygen
Harpeth River – unnamed trib. To headwaters	TN051300204 018 – 3000	Low DO
HARPETH RIVER TRIBUTARIES Newsome Cr, Trace Cr, and Murray Branch are partially supporting	TN05130204 009	Organic enrichment/low dissolved oxygen
Beech Creek	TN05130204 009 – 1100	Organic enrichment/low dissolved oxygen
WEST FORK HARPETH RIVER A portion of West Harpeth, plus Cayce Branch, Polk, and Kennedy Creek are partially supporting	TN05130204 013	Organic enrichment/low dissolved oxygen
Rattlesnake Branch	TN05130204 013 – 0610	Organic enrichment/low dissolved oxygen
HARPETH RIVER From South Harpeth River to the Little Harpeth River	TN05130204009-2000	Organic enrichment/low dissolved oxygen
HARPETH RIVER From Little Harpeth River to the West Harpeth River	TN05130204009-3000	Organic enrichment/low dissolved oxygen
LITTLE HARPETH RIVER From Harpeth River to Otter Cr	TN05130204021-1000	Low DO

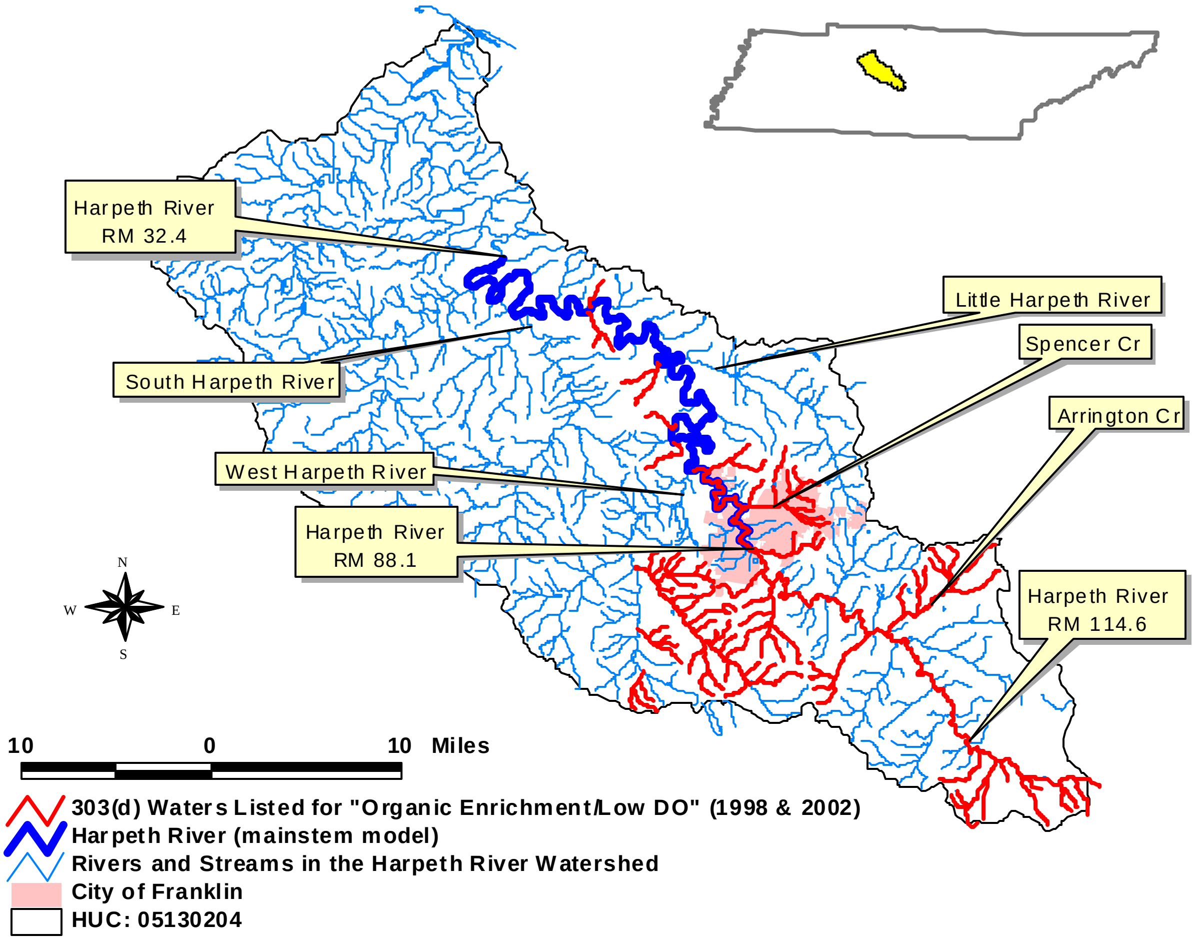

Illustration of the Impaired Waterbodies in the Harpeth River Watershed.

The TMDL report is comprised of three components. They are: 1) watershed nutrient load reduction evaluation to address the water quality impacts in the tributaries; 2) an assessment of dissolved oxygen impacts of the upper mainstem of the Harpeth River; and 3) an assessment of dissolved oxygen impacts of the lower Harpeth River from river mile 88.1 to river mile 32.4. These components contain source assessments, documentation of existing conditions, and an evaluation of the pollutant load reductions necessary to attain water quality standards. The allowable pollutant loads for each component of this TMDL report are summarized in the tables presented below.

Nutrient Reduction TMDL to Protect the Tributaries to the Harpeth River

The allowable nutrient loads for these impaired subwatersheds of the Harpeth River were calculated using an interpretation of the narrative criteria for biological integrity set forth in TDEC's water quality standards. Numeric instream target concentrations for total nitrogen and total phosphorus necessary to meet the biological integrity criteria were determined using data collected from reference sites within the eco-regions where the impaired waters in the Harpeth River watershed are located. Allowable nutrient loads are established as shown in the table below to ensure that numeric target concentrations are achieved in the tributaries to the Harpeth River.

Nutrient TMDLs for Selected Impaired Subwatersheds

HUC-12 Subwatershed (05130204)	Total Nitrogen		Total Phosphorus	
	Summer * [lbs/month]	Winter * [lbs/month]	Summer * [lbs/month]	Winter * [lbs/month]
0101	4480	12478	916	2541
0104	7335	21966	929	2709
0105	5864	18260	483	1505
0201	4062	12649	335	1042
0202	3026	9119	241	732
0301	6253	18537	489	1468
0302	5275	16425	435	1354

* Summer: 5/1 – 10/31; Winter: 11/1 – 4/30.

Estimates of Required Load Reductions for Selected Impaired Subwatersheds

HUC-12 Subwatershed (05130204)	Total Nitrogen (%)	Total Phosphorus (%)
0101	20.0	42.4
0104	20.0	42.4
0105	49.4	83.8
0201	53.1	81.3
0202	53.1	81.3
0301	44.8	82.4
0302	34.3	78.1

The Upper Harpeth River Pollutant Load Reductions

Due to the highly variable and extreme low flow conditions experienced in the upper Harpeth River, a steady state water quality model, QUAL2E, was used to evaluate pollution reduction scenarios for this portion of the Harpeth River. In this portion of the River, the principal cause for the dissolved oxygen deficit is the presence of excessive sediment oxygen demanding material. A 65% reduction of this material is necessary to achieve the 5.0 mg/l dissolved oxygen criterion. The nutrient and carbonaceous biochemical oxygen demand (CBOD) loads from nonpoint sources in the upper part of the watershed are targeted for pollutant load reductions in order to reduce the sediment oxygen demanding material sufficient to attain the dissolved oxygen criterion. It was determined that the small NPDES dischargers in the upper Harpeth River watersheds can operate at design capacity if the sediment oxygen demanding waste emanating from the storm water runoff is reduced by 65%.

Wasteload Allocation to protect DO levels in the headwaters of the Harpeth River

NPDES facility	* Summer Total Nitrogen Load (lbs/month)	* Winter Total Nitrogen Load (lbs/month)	* Summer Total Phosphorus Load (lbs/month)	* Winter Total Phosphorus Load (lbs/month)	* Summer Total $CBOD_5$ Load $_a$ (lbs/month)	* Winter Total $CBOD_5$ Load $_a$ (lbs/month)
Eagleville School (TN0057789)	45.0	67.6	22.5	33.8	45.0	45.0
Page School (TN0057835)	50.0	75.1	25.0	37.5	20.0	125.1
Goose Creek Inn (TN0060216)	75.1	112.6	37.5	56.3	75.1	75.1
Oakview Elementary (TN0067873)	25.0	37.5	12.5	18.8	25.0	25.0
Trinity Elementary School (TN0064297)	32.5	48.8	16.3	24.4	32.5	32.5
Bethesda Elementary School (TN0064475)	42.5	63.8	21.3	31.9	63.8	85.1
College Grove Elementary School (TN0067164)	30.0	45.0	15.0	22.5	30.0	75.1
Hillsboro Elementary School	75.1	112.6	37.5	56.3	75.1	75.1
CAFOs	0	0	0	0	0	0
MS4s	NA	NA	NA	NA	NA	NA

Notes: a – The allowable CBOD5 load is based on the facilities permitted limits
* Summer: May 1 – October 31; Winter: November 1 – April 30

Load Allocation to protect DO levels in the headwaters of the Harpeth River

12-digit subwatershed	Total Nitrogen Load (lbs/year)	Total Phosphorus Load (lbs/year)	Total Reduction in CBOD (percent)
05130204 0101	35,700	7,350	65%

The Lower Harpeth River Pollutant Load Reductions

The lower Harpeth River from river mile 88.1 to river mile 34.2 is impaired due to low dissolved oxygen under low flow conditions. This portion of the River was modeled with a hydrodynamic model, CE-QUAL-RIV1, coupled with a water quality model, WASP6. The models were calibrated to assess existing conditions as well as predict impacts of potential pollutant sources including point sources regulated under the National Pollutant Discharge Elimination System (NPDES) program. The model documents that the most severe dissolved oxygen deficit, 1.0 mg/l dissolved oxygen, under existing conditions occurs about 40 miles downstream of the Franklin Sewage Treatment Plant (STP) discharge. The assessment of the dissolved oxygen deficit indicated that the sediment oxygen demand within the mainstem of the Harpeth River has to be reduced by 40% in order to ensure that the dissolved oxygen criterion of 5.0 mg/l will consistently be attained. EPA believes that the nutrient reductions described earlier as well as the allocations described below are sufficient to enable the lower Harpeth River to attain water quality standards.

Wasteload Allocation to STPs to protect DO levels in the lower Harpeth River

Facility	Design Flow MGD	Summer CBOD5 lbs/day	Summer Ammonia lbs/day	Winter CBOD5 lbs/day	Winter Ammonia lbs/day	Annual Total N lbs/day
Franklin STP	12.0	400 (4.0mg/l)	40 (0.4 mg/l)	1001 (10.0 mg/l)	150 (1.5 mg/l)	290 (2.9 mg/l)
Lynnwood STP	0. 4	17 (5.0 mg/l)	7 (2.0mg/l)	33 (10.0 mg/l)	17 (5.0mg/l)	22 (6.6 mg/l)
Cartwright Creek STP	0.25	10 (5.0 mg/l)	4 (2.0 mg/l)	21 (10.0 mg/l)	10 (5.0 mg/l)	15 (7.0 mg/l)

Wasteload Allocations (MS4 area) and Load Allocations to Watershed Runoff protect DO levels in the lower Harpeth River

HUC-12 Subwatershed (05130204)	Total Nitrogen Summer lbs/month	Total Nitrogen Winter lbs/month	WLA Percent Reduction in MS4 Area	LA Percent Reduction in rural area
0104	7335	21966	20.0	20.0
0105	5864	18260	49.4	49.4
0201	4062	12649	53.1	53.1
0202	3026	9119	53.1	53.1
0301	6253	18537	44.8	44.8
0302	5275	16425	34.3	34.3

Under the authority of Section 303(d) of the Clean Water Act, 33 U.S.C. 1251 et seq., as amended by the Water Quality Act of 1987, P.L. 100-4, the U.S. Environmental Protection Agency is hereby establishing TMDLs for waters in the Harpeth River watershed impaired from organic enrichment/low dissolved oxygen and low dissolved oxygen.

/s/ September 28, 2004

James D. Giattina, Water Management Division Director Date

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Introduction

Section 303(d) of the Clean Water Act (CWA) requires each state to list those waters within its boundaries for which technology based effluent limitations are not stringent enough to protect any water quality standard applicable to such waters. Listed waters are prioritized with respect to designated use classifications and the severity of pollution. In accordance with this prioritization, states are required to develop Total Maximum Daily Loads (TMDLs) for those water bodies that are not attaining water quality standards. State water quality standards consist of designated use(s) for individual waterbodies, appropriate numeric and narrative water quality criteria protective of the designated uses, and an antidegradation statement. The TMDL process establishes the maximum allowable loadings of pollutants for a waterbody that will allow the waterbody to maintain water quality standards. The TMDL may then be used to develop controls for reducing pollution from both point and nonpoint sources in order to restore and maintain the quality of water resources.

The Tennessee Department of Environment and Conservation (TDEC) included several waters in the Harpeth River Basin on its 1998 §303(d) list of impaired waters for the pollutant cause, "organic enrichment/DO." On September 30, 2003, TMDLs were proposed for public review and comment to address these impairments. In addition, TMDLs were also proposed on September 30, 2003 for public review and comment to address 3 segments that were identified on the State's Draft 2002 §303(d) list as impaired from the pollutant causes of "Organic enrichment/Low DO" and "Low DO."

On January 15, 2004, the U.S. Environmental Protection Agency (EPA) approved TDEC's 2002 §303(d) list of impaired waters. Several of the waters on the State's 2002 list were resegmented and/or renamed. Therefore, TMDLs are being established for waters in the Harpeth River watershed that are on the State's 2002 §303(d) list and identified as impaired for "Organic Enrichment/Low DO" and "Low DO." Table 1 shows the relationship between the waters addressed in this final TMDL report and the waters that were addressed by the TMDLs proposed on September 30, 2003.

Table 1 Relationship between segments addressed by TMDLs proposed on 9/30/2003 and segments addressed by the final TMDLs

Waterbody (waterbody ID#) Addressed by TMDLs proposed on 9/30/2003	Waterbody (waterbody ID#) Addressed by final TMDLs established in this report
HARPETH RIVER From W Fk Harpeth to headwaters is partially supporting (TN05130204 016)	Harpeth River – West Harpeth River to Spencer Creek (TN05130204 016 – 1000)
	Harpeth River – Spencer Creek to Watson Creek (TN05130204 016 – 2000)
	Harpeth River – Watson Creek to Mayes Creek (TN05130204 016 – 3000)
	Harpeth River – Mayes Creek to Wilson Branch (TN05130204 016 – 4000)
	Harpeth River – unnamed trib. To headwaters (TN051300204 018 – 3000)

HARPETH RIVER TRIBUTARIES Arrington Cr, Spencer Cr, Watson Br, 5-mile Cr, Lynnwood Cr, and Starnes Cr (TN05130204 016)	HARPETH RIVER TRIBUTARIES Arrington Cr, Spencer Cr, Watson Br, 5-mile Cr, Lynnwood Cr, and Starnes Cr (TN05130204 016)
HARPETH RIVER TRIBUTARIES Concord Cr, Puckett, Cheatham, Kelley, portion of Harpeth headwaters (TN05130204 016)	Concord Creek (TN051300204 018 – 0200) Kelley Creek (TN051300204 018 – 0300)
HARPETH RIVER TRIBUTARIES Newsome Cr, Trace Cr, and Murray Branch are partially supporting (TN05130204 009)	HARPETH RIVER TRIBUTARIES Newsome Cr, Trace Cr, and Murray Branch are partially supporting (TN05130204 009)
HARPETH RIVER TRIBUTARIES Beech and unn. Trib to Harpeth are not supporting (TN05130204 009)	Beech Creek (TN05130204 009 – 1100)
WEST FORK HARPETH RIVER A portion of West Harpeth, plus Cayce Branch, Polk, and Kennedy Creek are partially supporting (TN05130204 013)	WEST FORK HARPETH RIVER A portion of West Harpeth, plus Cayce Branch, Polk, and Kennedy Creek are partially supporting (TN05130204 013)
W. FORK HARPETH TRIBUTARIES Rattlesnake Branch is not supporting (TN05130204 013)	Rattlesnake Branch (TN05130204 013 – 0610)
HARPETH RIVER From South Harpeth River to the Little Harpeth River (TN05130204009-2000)	HARPETH RIVER From South Harpeth River to the Little Harpeth River (TN05130204009-2000)
HARPETH RIVER From Little Harpeth River to the West Harpeth River (TN05130204009-3000)	HARPETH RIVER From Little Harpeth River to the West Harpeth River (TN05130204009-3000)
LITTLE HARPETH RIVER From Harpeth River to Otter Cr (TN05130204021-1000)	LITTLE HARPETH RIVER From Harpeth River to Otter Cr (TN05130204021-1000)

The resegmentation conducted by TDEC as part of its 2002 §303(d) listing process resulted in a refinement of the identification of impairment. Therefore, there were portions of some of the 1998 §303(d) listed segments that were removed during the State's 2002 §303(d) list process in an effort to more accurately define the scope of impairment. However, this refinement did not result in any changes to the identification of sources of the impairment nor did it result in any changes to the allocations provided to these sources to ensure the attainment of water quality standards. The waters and associated pollutant causes addressed by the TMDLs are identified inTable 2 below.

Table 2 Waters and pollutant causes addressed by the TMDL

Waterbody (waterbody ID#)	Impacted Waterbody	CAUSE (Pollutant)
Harpeth River – West Harpeth River to Spencer Creek	TN05130204 016 – 1000	Organic enrichment/low dissolved oxygen

Harpeth River – Spencer Creek to Watson Creek	TN05130204 016 – 2000	Organic enrichment/low dissolved oxygen
Harpeth River – Watson Creek to Mayes Creek	TN05130204 016 – 3000	Low DO
Harpeth River – Mayes Creek to Wilson Branch	TN05130204 016 – 4000	Low DO
HARPETH RIVER TRIBUTARIES Arrington Cr, Spencer Cr, Watson Br, 5-mile Cr, Lynnwood Cr, and Starnes Cr	TN05130204 016	Organic enrichment/low dissolved oxygen
Concord Creek	TN051300204 018 – 0200	Organic enrichment/low dissolved oxygen
Kelley Creek	TN051300204 018 – 0300	Organic enrichment/low dissolved oxygen
Harpeth River – unnamed trib. To headwaters	TN051300204 018 – 3000	Low DO
HARPETH RIVER TRIBUTARIES Newsome Cr, Trace Cr, and Murray Branch are partially supporting	TN05130204 009	Organic enrichment/low dissolved oxygen
Beech Creek	TN05130204 009 – 1100	Organic enrichment/low dissolved oxygen
WEST FORK HARPETH RIVER A portion of West Harpeth, plus Cayce Branch, Polk, and Kennedy Creek are partially supporting	TN05130204 013	Organic enrichment/low dissolved oxygen
Rattlesnake Branch	TN05130204 013 – 0610	Organic enrichment/low dissolved oxygen
HARPETH RIVER From South Harpeth River to the Little Harpeth River	TN05130204009-2000	Organic enrichment/low dissolved oxygen
HARPETH RIVER From Little Harpeth River to the West Harpeth River	TN05130204009-3000	Organic enrichment/low dissolved oxygen
LITTLE HARPETH RIVER From Harpeth River to Otter Cr	TN05130204021-1000	Low DO

As part of the process for developing TMDLs for the Harpeth River waters to address organic enrichment/DO, EPA has worked closely with TDEC during the past five years in water quality data collection efforts, water quality assessments, and the development of technical tools to develop TMDLs including water quality models. On July 31, 2002, EPA coordinated an effort with TDEC to complete a report entitled, "Harpeth River Watershed Modeling Effort: A Tool for TMDL Development", which documented a system of four models representing physical, chemical, and biological processes in the Harpeth River watershed. Specifically, the models include: 1) an application of the watershed model, Loading Simulation Program in C++ (LSPC), to the Harpeth River watershed as defined by the hydrologic unit code (HUC) 05130204; 2) an application of the steady-state, one-dimensional dissolved oxygen model, QUAL2E, to the upper portion of the mainstem of the Harpeth River (i.e., upstream from River Mile 89.2); 3) an application of the one-dimensional, hydrodynamic model CE-QUAL-RIV1 to the lower portion of the mainstem of the Harpeth River (i.e., from River Mile 88.1 to 32.4); and 4) a linkage of the Water Quality Analysis Program (WASP) 6.0 eutrophication model with the CE-QUAL-RIV1 hydrodynamic model. A copy of this modeling report is currently available on EPA's internet website at: www.epa.gov/region4/water/tmdl/tennessee.

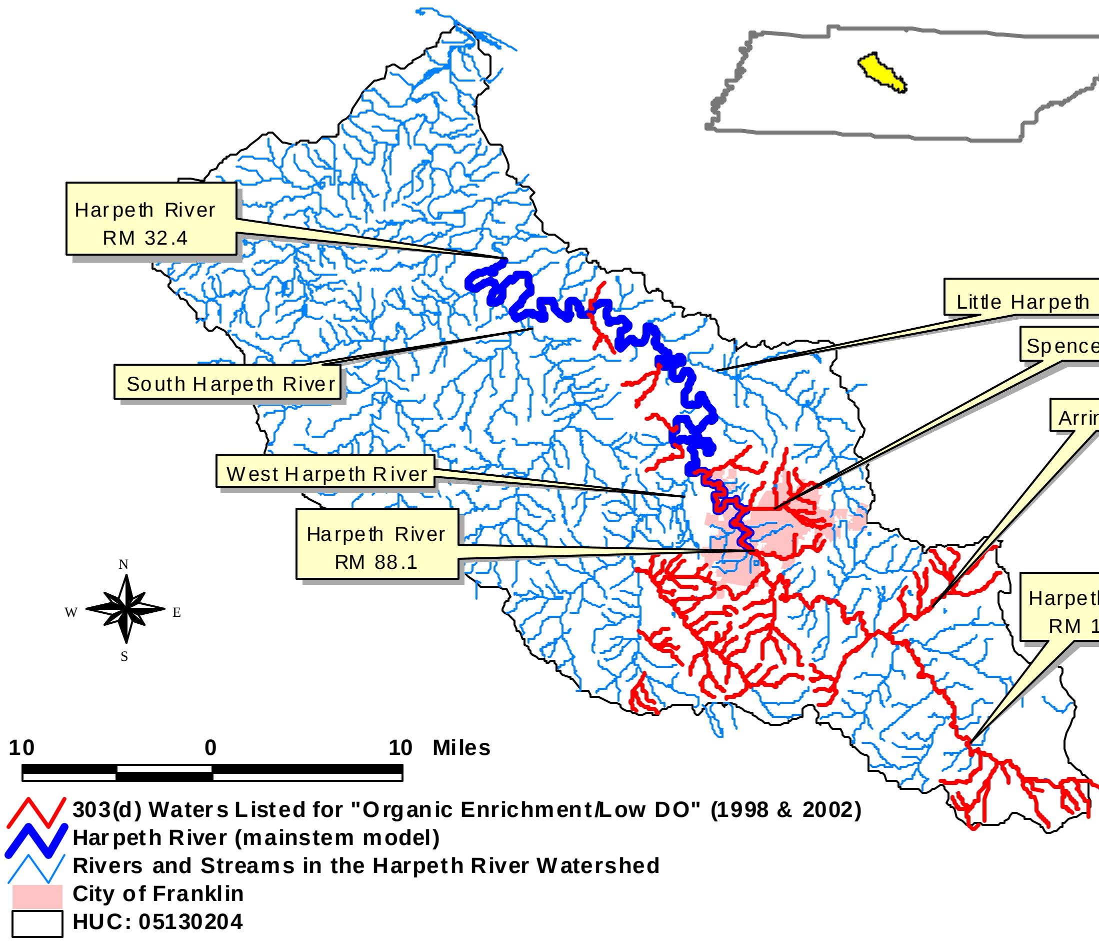

Figure 1 Harpeth River Watershed

General Watershed Overview

The Harpeth River watershed (HUC 05130204) is located in Middle Tennessee (Figure 1) and includes parts of Cheatham, Davidson, Dickson, Hickman, Rutherford, and Williamson Counties. The watershed lies within the Level III Interior Plateau (71) ecoregion and contains three Level IV ecoregions as shown in Figure 3 (USEPA, 1997):

- Western Highland Rim (71f) is characterized by dissected, rolling terrain of open hills, with elevations of 400 to 1000 feet. The geologic base of Mississippian-age limestone, chert, and shale is covered by soils that tend to be cherty, acidic and low to moderate in fertility. Streams are characterized by coarse chert gravel and sand substrates with areas of bedrock, moderate gradients, and relatively clear water. The oak-hickory natural vegetation was mostly deforested in the mid to late 1800's, in conjunction with the iron ore related mining and smelting of the mineral limonite, but now the region is again heavily forested. Some agriculture occurs on the flatter areas between streams and in the stream and river valleys: mostly hay, pasture, and cattle, with some cultivation of corn and tobacco.

- Outer Nashville Basin (71h) is a more heterogeneous region than the Inner Nashville Basin, with more rolling and hilly topography and slightly higher elevations. The region encompasses most all of the outer areas of the generally non-cherty Ordovician limestone bedrock. The higher hills and knobs are capped by the more cherty Mississippian-age formations, and some Devonian-age Chattanooga shale, remnants of the Highland Rim. The region's limestone rocks and soils are high in phosphorus, and commercial phosphate is mined. Deciduous forests with pasture and cropland are the dominant land covers. Streams are low to moderate gradient, with productive nutrient-rich waters, resulting in algae, rooted vegetation, and occasionally high densities of fish. The Nashville Basin as a whole has a distinctive fish fauna, notable for fish that avoid the region, as well as those that are present.

- Inner Nashville Basin (71i) is less hilly and lower than the Outer Nashville Basin. Outcrops of the Ordovician-age limestone are common, and the generally shallow soils are redder and lower in phosphorus than those of the Outer Basin. Streams are lower gradient than surrounding regions, often flowing over large expanses of limestone bedrock. The most characteristic hardwoods within the Inner Basin are a maple-oak-hickory-ash association. The limestone cedar glades of Tennessee, a unique mixed grassland/forest/cedar glades vegetation type with many endemic species, are located primarily on the limestone of the Inner Nashville Basin. The more xeric, open characteristics and shallow soils of the cedar glades also result in a distinct distribution of amphibian and reptile species.

The Harpeth River watershed has approximately 1,364 miles of streams (based on Reach File version 3.0 coverage) and drains a total area of 867 square miles. The Harpeth River is approximately 125 miles in length and flows generally in a northwesterly direction before draining to River Mile (RM) 152.9 of the Cumberland River. Watershed land use distribution is based on the Multi-Resolution Land Characteristic (MRLC) databases derived from Landsat Thematic Mapper digital images from the period 1990-1993. Although changes in the land use of the Harpeth River watershed have occurred since 1993 as a result of rapid development, this is the most current land use data available. Land use for the Harpeth River watershed is summarized in Table 3 and shown in Figure 3.

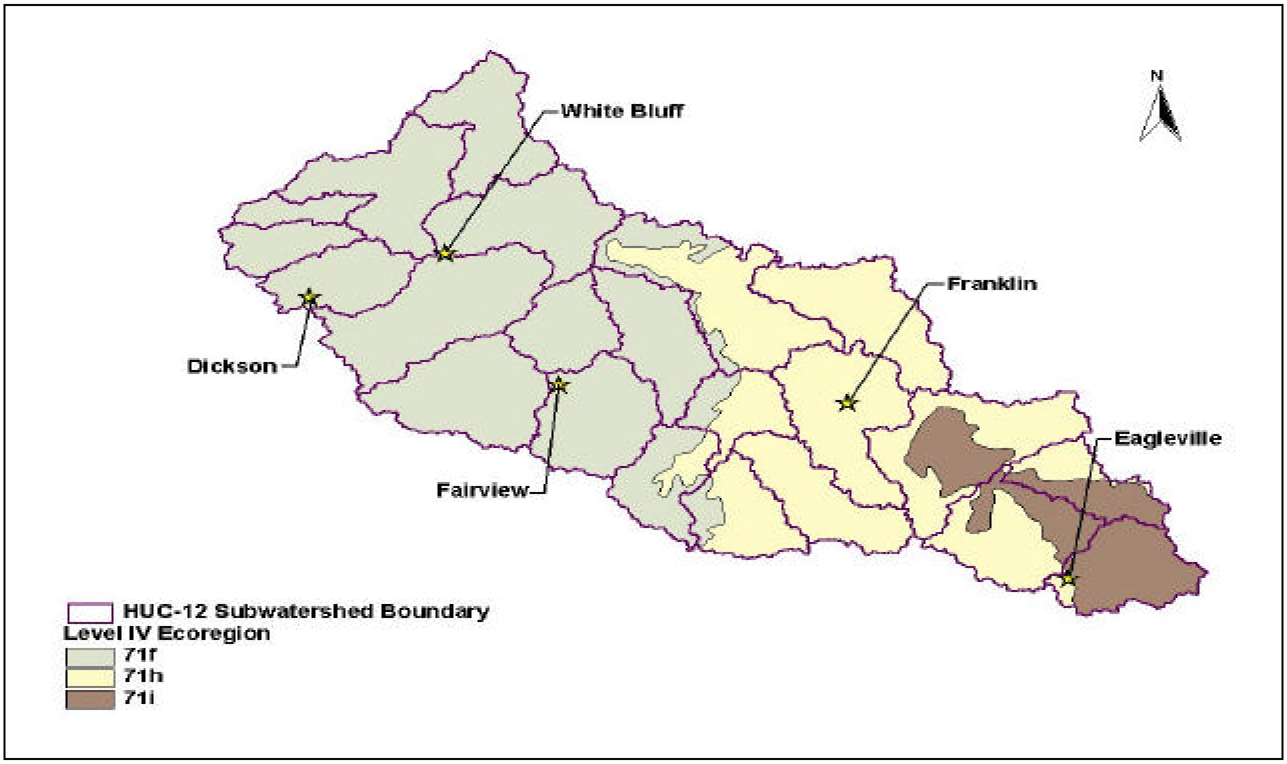

Figure 2 Level IV Ecoregions in the Harpeth River Watershed

Note: TMDL analysis will performed on a HUC-12 subwatershed basis. HUC-12 subwatershed boundaries are shown in figures for reference.

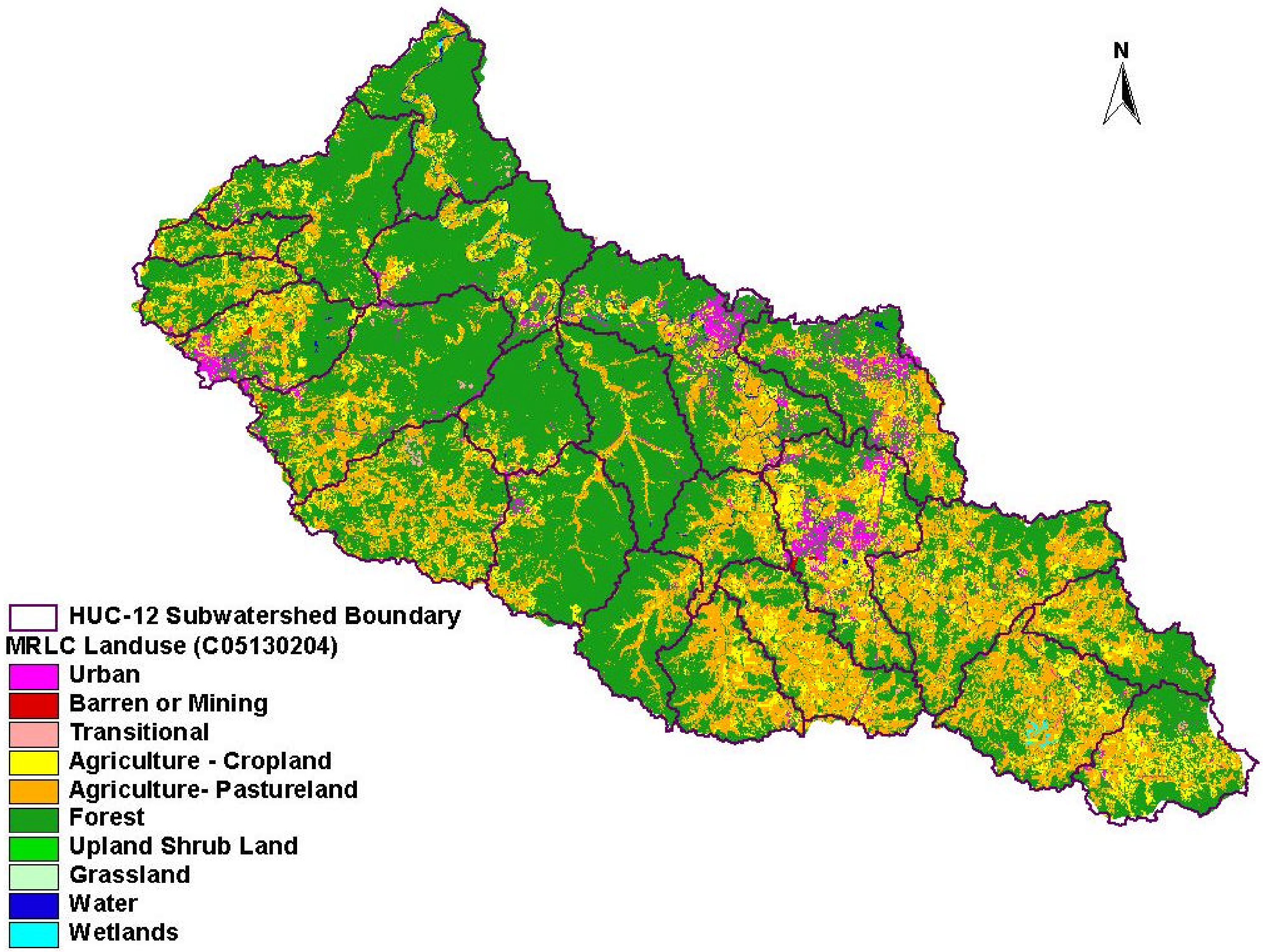

Figure 3 MRLC Land Use Distribution in the Harpeth River Watershed

Table 3 MRLC Land Use Distribution – Harpeth River Watershed

Land Use	Area	
	[acres]	[%]
Bare Rock/Sand/Clay	0	0
Deciduous Forest	278,592	50.1
Emergent Herbaceous Wetlands	13	0.0
Evergreen Forest	13,984	2.5
High Intensity Commercial/Industrial/ Transportation	5,035	0.9
High Intensity Residential	1,214	0.2
Low Intensity Residential	10,373	1.9
Mixed Forest	54,820	9.9
Open Water	2,189	0.4
Other Grasses (Urban/recreational)	8,192	1.5
Pasture/Hay	130,294	23.4
Quarries/Strip Mines/ Gravel Pits	325	0.1
Row Crops	49,041	8.8
Transitional	1,074	0.2
Woody Wetlands	758	0.1
Total	**555,904**	**100.0**

Problem Definition

The State of Tennessee’s final 2002 303(d) list (TDEC, 2003) was approved by the U.S. Environmental Protection Agency (EPA), Region IV on January 15, 2004. The list identified a number of waterbodies in the Harpeth River watershed as not fully supporting designated use classifications due to organic enrichment/Low DO and Low DO (see Table 2). The designated use classifications for the Harpeth River and its tributaries include fish and aquatic life, irrigation, livestock watering & wildlife, and recreation. Some waterbodies in the watershed are also classified for industrial water supply and/or domestic water supply.

When used in the context of waterbody assessments, the term organic enrichment can be used to describe a condition of pollution resulting from several possible factors:

- Organic enrichment can mean the accumulation of organic (carbon containing) materials in a stream. Organic materials naturally accumulate in streams in the form of detritus or debris from the surrounding area. It can also refer to bio-solid materials that have escaped from wastewater treatment processes. In either case, the organic materials will decompose over time through bacterial respiration. Respiration is an oxygen consuming process. Therefore, if large amounts of organic material decompose with little flow or oxygen exchange, a condition of low dissolved oxygen could occur resulting in impairment to stream biology.

- Organic enrichment has also been used to describe the eutrophication effects of high nutrient discharges from point or nonpoint sources. This phenomenon is more appropriately classified as nutrient enrichment. Nutrient rich waters entering streams can cause abundant algae growth. The right combination of nutrients, algae, and sunlight may result in extreme dissolved oxygen fluctuations in the stream. Oxygen is produced during photosynthesis and consumed during respiration and decomposition. Because it requires light, photosynthesis occurs only during daylight hours. At night, photosynthesis may not counterbalance the loss of oxygen through respiration and decomposition resulting in the decline of dissolved oxygen concentrations (TDEC, 2003).

- The algae growth that occurs with organic enrichment can also adversely affect the instream habitat. When the algae becomes choking to fish and aquatic life, it blocks available sunlight to organisms in the substrate. It also covers up and blocks organisms from potential usable habitat.

Concerning the 2002 §303(d) listing of waters identified in Table 2, TDEC used the term “Organic enrichment/Low DO” to describe impairment from: 1) low dissolved oxygen (DO) levels; 2) excessive enrichment from one or more of the three factors described above; or 3) a combination of low dissolved oxygen levels and excessive enrichment. As part of its §303(d) listing process, TDEC conducts assessments of its waters using water quality data, biological data, and field observation data concerning the presence or absence of excessive algae. For the listed segments representing the mainstem of the Harpeth River, the §303(d) listings were based on low dissolved oxygen levels as well as biological assessment data that indicated stressed biota. Concerning all of the other waters in the Harpeth River watershed, the §303(d) listings were based on observations of stressed biota during biological surveys as well as the observation of excessive algae. For all of the §303(d)-listed waters identified as impaired from organic enrichment/Low DO in Table 2, with the exception of the segments representing the mainstem of the Harpeth River, there were no observations of low dissolved oxygen levels in the data that was used for the basis of the §303(d) listings.

The interrelationship of major kinetic processes associated with instream dissolved oxygen is shown schematically in Figure 4. A more detailed discussion of the relationship between nutrients and water quality is presented in Appendix A.

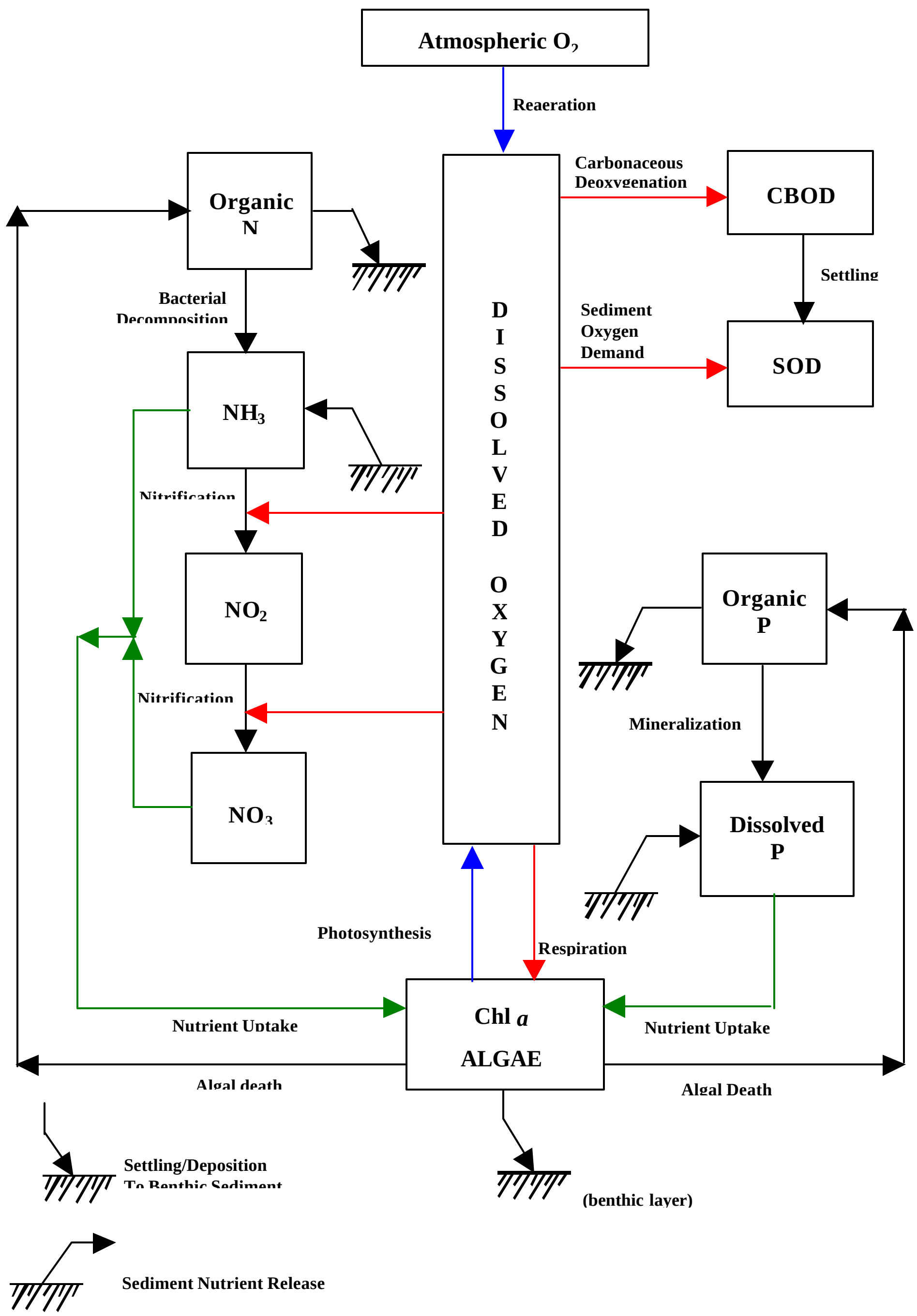

Figure 4 **Interrelationship of Major Kinetic Processes Associated with Instream Dissolved Oxygen (USEPA, 1997a)**

Water Quality Studies Conducted Prior to 2000

Prior to intensive field survey work conducted on the Harpeth River by EPA and TDEC from 2000 to 2002, the available water quality data in the Harpeth River watershed was mostly limited, and much of it was limited to the Harpeth River in the vicinity of the City of Franklin Sewage Treatment Plant (STP). Most of the data consisted of grab samples taken from the mainstem of the Harpeth River over a period of several years where parameters such as temperature, dissolved oxygen (DO), conductivity, pH, 5-day biochemical oxygen demand (BOD5), and ammonia nitrogen (NH3-N) were measured.

Water quality studies had been conducted on the Harpeth River, but many of these studies had been conducted more than 15 years ago. The State of Tennessee had conducted some of these studies, and the focus of their studies was the segment of the Harpeth River immediately downstream from discharge from the City of Franklin STP. The State's studies generally included the collection of water quality samples such as DO, dissolved oxygen (DO), BOD_5, and NH_3-N. The Environmental and Water Resources Engineering program at Vanderbilt University conducted some water quality studies on the Harpeth River in 1977 (Davis et al, 1977) and 1986 (Sulkin, 1987). In 1977, water quality sampling was conducted including diurnal DO measurements, and hydraulic measurements were made in the Harpeth River from RM85.3 to RM82.0 and RM58.3 to RM54.2. In 1986, hydraulic data was collected and water quality sampling was conducted, including diurnal DO measurements, in the Harpeth River from RM85.3 to RM81.6.

Between 1995 and 1999, TDEC conducted additional water quality studies on the Harpeth River during low-flow periods. In 1995, TDEC collected water quality data concurrent with a time-of-travel study on a 2.5-mile segment of the Harpeth River in the vicinity of a wastewater discharge from the City of Franklin. In 1998 and 1999, TDEC collected diurnal DO data downstream of a 0.2 MGD discharge from the Lynnwood STP (at RM 77.9 of the Harpeth River).

Data collected prior to 2000 provided a limited understanding concerning the "organic enrichment/DO" impairment of the Harpeth River watershed. Although the available data provided some level of understanding of the DO processes in the Harpeth River immediately downstream from the Franklin STP, a very small amount of data was available in the portion of the watershed located upstream from the City of Franklin's STP. Based on the available data, it was apparent that low dissolved oxygen levels in the Harpeth River occurred during low-flow conditions. However, the extent and significance of the impairment was not well understood.

Water Quality Studies Conducted in 2000 - 2002

EPA undertook a study of the Harpeth River watershed from RM 62.4 of the Harpeth River to the headwaters. The purpose of conducting the study was to: 1) characterize water quality conditions and assess pollutant sources contributing to the impairment of the Harpeth River; and 2) analyze contributions of nutrients and oxygen-consuming loads to the Harpeth River watershed as part of the TMDL process.

EPA Region 4 designed and conducted 6 field studies of the Harpeth River, with significant assistance from TDEC, between July 2000 and April 2001. The data and information collected during these studies can be found in EPA's draft report, "Harpeth River Modeling Data Report: December 2001." The activities conducted during these studies were as follows:

1. <u>July 28-31, 2000 : reconnaissance (recon) study</u> The purpose of the recon was to gain an understanding of the system sufficient to design an effective low-flow water quality study. An additional objective was added to the scope of the recon when EPA learned of a raw wastewater overflow at the Spencer Creek lift station, near the mouth of Spencer Creek that occurred on July

23, 2000. It became important to obtain water quality data on the River before the sewage spill had an impact. Grab samples were collected at stations between RM114.6 and RM62.4 and included the analysis the nitrogen series, total phosphorus, and total organic carbon.

2. <u>August 21-26, 2000 : low-flow study</u> The study focused on the oxygen producing and consuming processes in the Harpeth River and its primary tributaries (Little Harpeth River, West Harpeth River, and Spencer Creek). Measurements were made of stream reaeration rate coefficients downstream from the Franklin STP and the Lynnwood STP. Sediment Oxygen Demand (SOD) measurements were made at stations amenable to in-situ chamber measurements. Water column production and respiration measurements were made along the length of the stream using light and dark bottle technology. Diurnal water quality measurements were made simultaneously at thirteen stations using multi-probe "sonde" instrumentation at half hour intervals over a span of more than thirty consecutive hours. Water quality samples were taken from the Franklin STP, the Lynnwood STP, the mainstem of the River, and the primary tributaries to the River. Meteorological measurements were made during the study including rainfall, wind speed, and wind direction. In addition, cross-section surveys were made at 22 stations along the mainstem of the Harpeth River.

3. <u>August 27-28, 2000 : rainfall runoff study</u> A two-day loading survey was conducted at three USGS gage stations located on the Harpeth River and one USGS gage station located on Spencer Creek. Three water quality samples were collected from each of these stations during the rising and falling limbs of the individual hydrographs.

4. <u>September 20-24, 2000 : follow-up low-flow survey</u> During a follow-up survey, additional time-of travel data was collected in areas upstream and downstream of the segment where the reaeration study had been conducted in August. A source assessment was also conducted in the Spencer Creek watershed. In addition, a longitudinal float survey was conducted from RM88.1 to RM62.4 and withdrawal lines connected to pumps along the river were documented.

5. <u>September 25-28, 2000 : rainfall runoff study</u> A two-day loading survey was conducted at three USGS gage stations located on the Harpeth River and one USGS gage station located on Spencer Creek. Three water quality samples were collected from each of these stations during the rising and falling limbs of the individual hydrographs.

6. <u>April 16-20, 2001 : medium-flow study</u> The study focused on the oxygen producing and consuming processes in the Harpeth River and its primary tributaries (Little Harpeth River, West Harpeth River, and Spencer Creek) during approximately average environmental conditions (i.e., the flows and temperatures during the springtime were anticipated to be close to the annual average values). It was assumed that these conditions would also reflect the combined impact of point sources and nonpoint sources. Measurements were made of diffusion, which could be correlated to reaeration rate coefficients. Water column production and respiration measurements were made along the length of the stream using light and dark bottle technology. Diurnal water quality measurements were made simultaneously at sixteen stations using multi-probe "sonde" instrumentation at half hour intervals over a span of more than thirty consecutive hours. Water

quality samples were taken from the Franklin STP, the Lynnwood STP, the Cartwright Creek Utility District STP (discharges to RM68.8), the mainstem of the River, and 12 tributaries to the Harpeth River. In addition, meteorological measurements were made during the study including rainfall, wind speed, and wind direction.

During 2002, TDEC measured diurnal dissolved oxygen fluctuations during summer low flow conditions at several locations on the Harpeth River between the confluence of the Little Harpeth River and the South Harpeth River. Measurements were obtained at 30-minute intervals during the periods from 8/2/02 through 8/9/02 and 9/11/02 through 9/25/02 at RMs 45.0, 63.3, 79.8, 84.4, and near RM 88.0. This data (see Appendix B) show a significant diurnal fluctuation with periodic deviations from the minimum concentration of 5 mg/l specified by State water quality standards.

Assessment of Water Quality and Pollution Sources

A significant amount of information was learned from the Harpeth River dataset collected in between 2000 and 2002. Observations in the field as well as assessments of the data collected contributed to the decisions relating to the development of the models used for the TMDL development effot. The important field observations and aspects of the water quality and pollution source assessments are described as follows:

- The Harpeth River appears to be a gaining-losing stream (i.e., there is significant interflow between the river and groundwater), at least in one area of the watershed during low flow conditions. During the July 2000 reconnaissance, a 150-meter segment of the Harpeth River channel, located immediately downstream from the low-head dam at RM89.2, was observed to be completely dry. However, there were no other observed hydraulic discontinuities in the system.

- At least 21 pumps potentially withdraw water from the Harpeth River between RM88.1 and RM62.4. Considering the apparent sizes of the pumps, they would probably not have any significant impact on the flow in the river unless the majority of them were operating simultaneously during low-flow conditions. It is believed that the vast majority of these pumps were not operating during the periods when the low-flow studies were conducted and therefore did not have any significant impact on flow, travel time, or water quality.

- The algae that exists in the Harpeth River appears to be dominated by periphyton. There is no significant presence of macrophytes in the Harpeth River, and the chlorophyll a and nutrient levels measured in the water column were very low (**Table 4**). However, the magnitudes of the diurnal swings in DO were indicative of significant algal productivity and respiration (**Figure 5** and **Figure 6**).

- As indicated by algal growth potential tests conducted during the August 2000 study, the Harpeth River appears to be predominantly a nitrogen-limited system during low flows. As indicated by the April 2000 study, however, the limiting nutrient varies from station to station during higher flow conditions.

- The City of Franklin STP discharges a significant amount of nutrient loads and BOD loads to the Harpeth River. In terms of effluent concentration, however, the nitrogen and BOD levels in the treated wastewater are very low (**Table 4** and **Table 5**).

- During the August 2000 study in the vicinity of RM114.6, a dead calf was observed in the river. (The sampling at this station was conducted upstream from any influence that the dead calf may have had on water quality.) Although this is certainly not something that EPA or TDEC would attempt to simulate in a model, it is recognized that this may be an indicator that the agricultural best management practices in the headwaters of the Harpeth River watershed need improvement.

- During the August 2000 study, the lowest levels of DO in the watershed were observed in the headwaters (i.e., RM114.6) as demonstrated in **Figure 5**. The average DO values generally increased in the downstream direction. In addition, the highest BOD concentrations in the system during the August 2000 study (**Table 4**) as well as the April 2001 study (**Table 5**) were also observed at RM114.6.

- The DO levels in the mainstem of the Harpeth River during the April 2001 study were all above 8.0 mg/l. It is expected that the DO levels in the system are only problematic during low-flow and high temperature conditions.

- Some of the measured DO levels in the Harpeth River at RM62.4 (downstream from the §303(d)-listed segment) were below TDEC's water quality standard for dissolved oxygen of 5.0 mg/l. Therefore, EPA and TDEC decided to extend the model down to RM32.4 (the location of a downstream USGS gage station).

- Based on the available data, the primary sources of BOD in the watershed appear to be: 1) the City of Franklin STP; and 2) agricultural areas in the headwaters. Based on the available data, the sources of nutrient loads appear to be fairly well distributed throughout the watershed.

- Use of a hydrodynamic model upstream from RM88.1 is not practical. The observed low flows in the upper Harpeth River watershed (frequently below 1.0 cubic feet per second) combined with the observed slow travel times result in a significant stability issue with regard to hydrodynamic modeling.

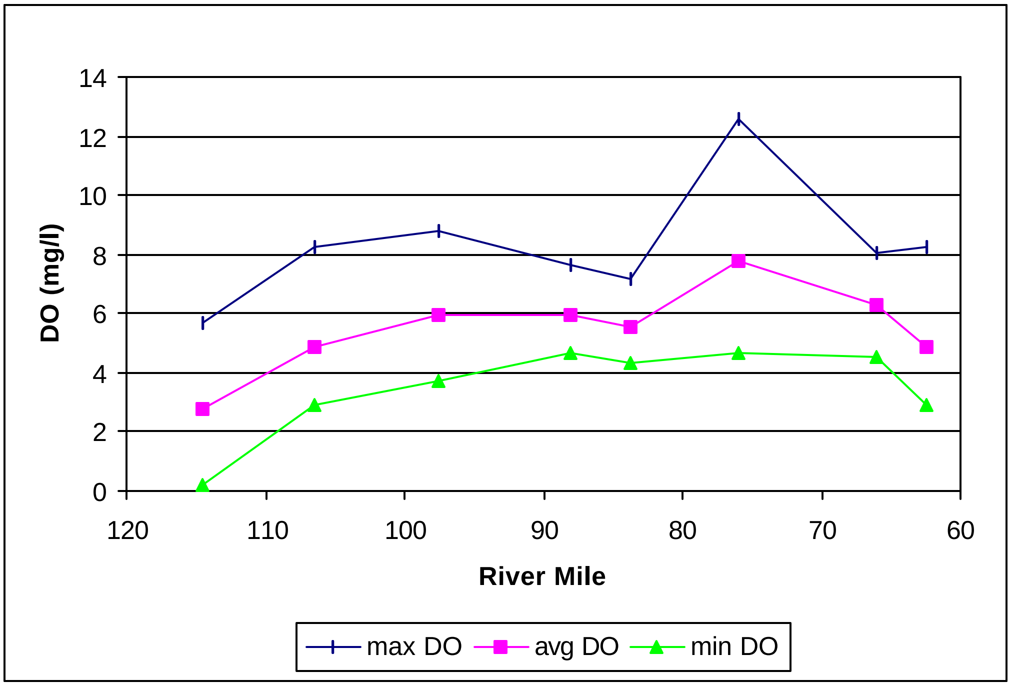

Figure 5 Longitudinal DO profile during the August 2000 study

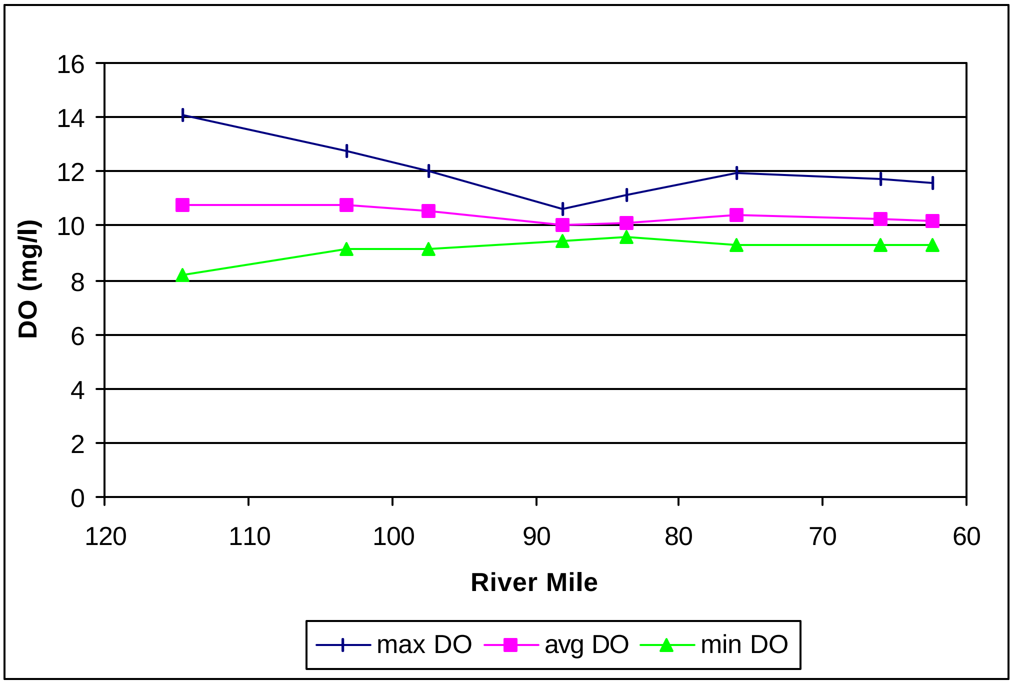

Figure 6 Longitudinal DO profile during the April 2001 study

Table 4 Water quality data collected in August 2000

Station	Flow(cfs)	UltimateC BOD (mg/l)	NH_3-N(mg/l)	NO_2/NO_3 (mg/l)	TKN (mg/l)	Total N (mg/l)	Total P (mg/l)	Chl a (ug/l)
RM114.6	0.02	7.13	0.06	0.05	0.84	0.89	0.09	5
RM106.5	0.03	5.61	0.08	0.19	0.64	0.83	0.25	-
RM97.5	0.03	3.56	0.03	0.05	0.54	0.59	0.26	-
RM88.1	2.6	0.98	0.09	0.29	0.42	0.71	0.28	0.64
Spencer C	1.9	2.72	0.05	0.29	0.47	0.76	0.36	2.75
RM84.4	9.0	3.78	0.09	1.20	0.70	0.77	1.30	1.28
W. Harp R	0.5	2.36	0.07	0.05	0.24	0.29	0.24	2
RM76.0	12.8	3.5	0.04	0.57	0.37	0.94	0.67	2.6
RM66.0	10.9	3.62	0.06	0.36	0.48	0.84	0.43	-
L. Harp R	0.03	1.73	0.05	0.13	0.50	0.63	0.31	6.4
RM62.4	12.0	1.78	0.07	0.31	0.39	0.70	0.46	3.8
Franklin STP	4.96	5.53	0.06	1.90	1.0	2.90	1.8	-
Lynnwood STP	0.24	16.96	0.11	10.0	1.4	11.4	4.0	-

Table 5 Water quality data collected in April 2001

Station	Flow (cfs)	UltimateC BOD (mg/l)	NH_3-N (mg/l)	NO_2/NO_3 (mg/l)	TKN (mg/l)	Total N (mg/l)	Total P (mg/l)	Chl a (ug/l)
RM114.6	24.4	5.25	< 0.05	0.71	0.25	0.96	0.06	0.47
Arrington C	17.5	2.15	< 0.05	0.65	0.15	0.80	0.30	1.43
RM103.1	109	2.64	< 0.05	0.64	0.21	0.85	0.19	0.96
Starnes Cr	5.7	4.46	< 0.05	0.76	0.21	0.97	0.28	0.90
RM97.5	139	4.92	< 0.05	0.70	0.18	0.88	0.20	0.7
5mile Cr	10.4	2.75	< 0.05	1.30	0.2	1.50	0.40	1.73
Watson Br	4.9	3.81	< 0.05	0.79	0.225	1.01	0.34	2.06
RM88.1	178	4.08	< 0.05	0.83	0.23	1.06	0.25	1.48
Spencer C	7.2	3.93	< 0.05	1.10	0.20	1.30	0.27	2.37
RM84.4	213	3.43	< 0.05	1.00	0.24	1.24	0.29	1.28
W. Harp R	130	2.26	< 0.05	0.88	0.15	1.03	0.18	1.26
RM76.0	369	3.04	< 0.05	0.99	0.25	1.24	0.25	0.89
L. Harp R	39.3	3.31	< 0.05	1.20	0.16	1.36	0.22	0.78
RM62.4	503	2.84	< 0.05	0.95	0.27	1.22	0.26	1.24
Franklin STP	6.18	11.94	< 0.05	2.70	0.94	3.64	0.70	-
Lynnwood STP	0.21	13.07	0.051	4.50	0.83	5.33	1.1	-
Cartwright Cr STP	0.52	8.2	< 0.05	9.20	0.67	9.87	1.5	-

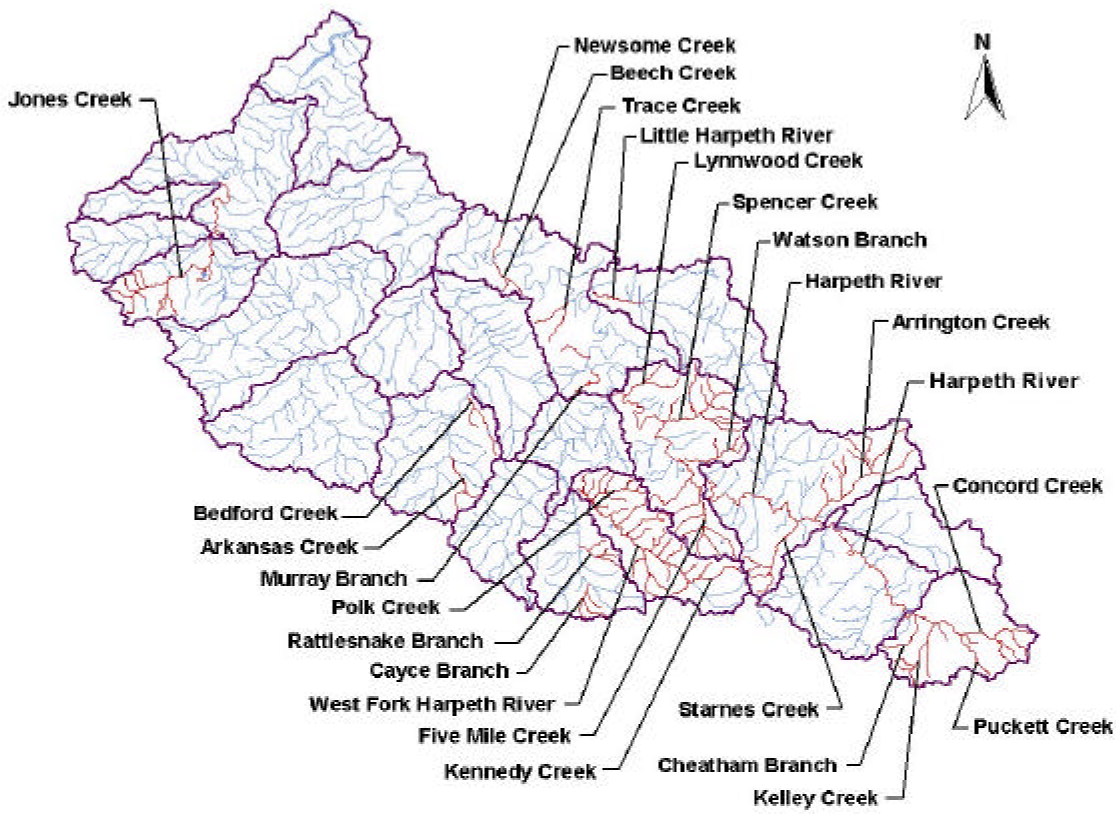

Figure 7 Waterbodies identified on the State's 303(d) List for Organic Enrichment/DO

Target Identification

Water Quality Criteria

Several narrative criteria, applicable to organic enrichment/nutrients, are established in *State of Tennessee Water Quality Standards, Chapter 1200-4-3 General Water Quality Criteria, October 1999 (TDEC, 1999)*:

Applicable to all use classifications (recreation shown):

> Solids, Floating Materials, and Deposits – There shall be no distinctly visible solids, scum, foam, oily slick, or the formation of slimes, bottom deposits or sludge banks of such size and character that may be detrimental to fish and aquatic life.
>
> Other Pollutants – The waters shall not contain other pollutants that will be detrimental to fish or aquatic life.
>
> Dissolved Oxygen (except for fish & aquatic life)– There shall be sufficient dissolved oxygen

> present to prevent odors of decomposition and other offensive conditions.

Applicable to the fish & aquatic life use classification:

> Biological Integrity - The waters shall not be modified through the addition of pollutants or through physical alteration to the extent that the diversity and/or productivity of aquatic biota within the receiving waters are substantially decreased or adversely affected, except as allowed under 1200-4-3-.06. The condition of biological communities will be measured by use of metrices suggested in guidance such as Rapid Bioassessment Protocols for Use in Streams and Rivers (EPA/444/4-89-001) or other scientifically defensible methods. Effects to biological populations will be measured by comparisons to upstream conditions or to appropriately selected reference sites in the same ecoregion (See definition).

In addition, numerical dissolved oxygen criteria are specified for the protection of fish & aquatic life:

> Dissolved Oxygen - The dissolved oxygen shall be a minimum of 5 mg/l except in limited sections of streams where it can be clearly demonstrated that (i) the existing quality of the water due to irretrievable man-induced conditions cannot be restored to the desired minimum of 5 mg/l dissolved oxygen; or (ii) the natural background quality of the water is less than the desired minimum of 5 mg/l. Such exceptions shall be determined on an individual basis, but in no instance shall the dissolved oxygen concentration be less than 3 mg/l. The dissolved oxygen concentrations shall be measured at mid-depth in waters having a total depth of ten (10) feet or less, and at a depth of five (5) feet in waters having a total depth of greater than ten (10) feet. The dissolved oxygen concentration of recognized trout waters shall not be less than 6.0 mg/l. The above criteria are applicable to tailwaters. The dissolved oxygen concentration of trout waters which have been designated as supporting a naturally reproducing population shall not be less than 8.0 mg/l.

These TMDLs are being established at levels necessary to attain the fish and aquatic life designated use, as well as all other designated uses associated with the waters included in Table 2.

TMDL Target

Water Quality Endpoint: Dissolved Oxygen

For all waters in the Harpeth River watershed, the minimum dissolved oxygen concentration of 5 mg/l specified for the protection of fish and aquatic life will be used as the target for the mainstem of the Harpeth River. Specifically, this target is applied to that 303(d)-listed segments where DO levels have been observed.

Table 6 303(d) listed segments targeted with a water quality endpoint of dissolved oxygen

Waterbody ID	Impacted Waterbody	Length of Impairment
TN05130204009-2000	HARPETH RIVER From South Harpeth River to the Little Harpeth River	18.8 miles
TN05130204009-2000	HARPETH RIVER From Little Harpeth River to the West Harpeth River	16.8 miles
TN05130204021-1000	LITTLE HARPETH RIVER From Harpeth River to Otter Cr	4.1 miles
TN05130204 016-1000	HARPETH RIVER West Harpeth River to Spencer Cr	6.8 miles
TN05130204 016-2000	HARPETH RIVER Spencer Creek to Watson Creek	3.9 miles
TN05130204 016-3000	HARPETH RIVER Watson Creek to Mayes Creek	9.0 miles
TN05130204 016-4000	HARPETH RIVER Mayes Creek to Wilson Branch	7.5 miles
TN05130204 018-3000	HARPETH RIVER unnamed trib. To headwaters	7.4 miles

Water Quality Endpoint: Nutrients

In order for a TMDL to be established at protective levels for waters where organic enrichment is preventing attainment of designated uses, a numeric “target” protective of the uses of the waterbody must be identified to serve as the basis for the TMDL. Where State regulation provides a numeric water quality criterion for the pollutant, such as dissolved oxygen, the criteria is the basis for the TMDL. Where state regulation does not provide a numeric water quality criterion at present, as in the case of organic enrichment, a numeric interpretation of the narrative water quality standard must be determined.

One of the three methods mentioned in *Nutrient Criteria Technical Guidance Manual, Rivers and Streams* (USEPA, 2000) that can be used in developing nutrient criteria is the reference stream reach approach. Reference reaches are relatively undisturbed stream segments that can serve as examples of the natural biological integrity of a region. One of the ways to establish a target for TMDL development is the selection of a percentile from the distribution of primary variables of known reference systems. Primary variables include total nitrogen (TN), total phosphorus (TP), chlorophyll *a*, and turbidity or total suspended solids (TSS). EPA recommends the use of the 75th percentile value as the reference condition.

Tennessee has adopted and submitted a narrative water quality criterion for nutrients for the Fish and Aquatic Life use as a part of its triennial review of state water quality standards. The newly adopted criterion is written as follows:

> *The waters shall not contain nutrients in concentrations that stimulate aquatic plant and/or algae growth to the extent that aquatic habitat is substantially reduced and/or the biological integrity fails to meet regional goals. Additionally, the quality of dowstream waters shall not*

be detrimentally affected.

Interpretation of this provision may be made using the document Development of Regionally-based Interpretations of Tennessee's Narrative Nutrient Criterion and/or other scientifically defensible methods.

That criterion is the same as one that was previously adopted and submitted as an emergency rule. Although EPA approved the emergency criterion, EPA has not yet approved the permanent revision to Tennessee's standards. While the newly adopted criterion references a document which includes the selection of a 90th percentile value as an appropriate reference condition for nutrients, the State's standard also provides for use of other scientifically defensible values, in appropriate circumstances.

For the purposes of this TMDL, the 75th percentile values of total nitrogen (TN) and total phosphorus (TP) data collected at Tennessee's Level IV ecoregion reference sites were determined to be an appropriate numeric interpretation of the State's narrative criteria for biological integrity ensuring a sufficient level of protection. Based on EPA's best professional judgement, this numeric translation for the tributaries in the Harpeth River watershed is a scientifically defensible method of determining concentrations of nutrients that are not expected to stimulate aquatic plant and algal growth to the extent that aquatic habitat is substantially reduced and/or biology is not protected.

The watersheds corresponding to Tennessee's Level IV ecoregion reference sites are considered the "least impacted" in the ecoregion and, as such, nutrient loading from these subwatersheds may serve as the appropriate basis for the TMDL target. Detailed information regarding Tennessee ecoregion reference sites can be found in *Tennessee Ecoregion Project, 1994-1999* (TDEC, 2000). The nutrient concentration goals, corresponding to the 75th percentile data for Level IV ecoregions 71f, 71h, & 71i are:

Level IV Ecoregion	Total Nitrogen (mg/l)	Total Phosphorus (mg/l)
71f	0.310	0.018
71h	0.728	0.060
71i	0.755	0.160

Table 7 303(d) listed segments targeted with a water quality endpoint of nutrient concentrations

Waterbody ID	Impacted Waterbody	Length of Impairment
TN05130204021-1000	LITTLE HARPETH RIVER From Harpeth River to Otter Creek	4.1 miles
TN05130204 016	HARPETH RIVER TRIBUTARIES Arrington Cr, Spencer Cr, Watson Br, 5-mile Cr, Lynnwood Cr, and Starnes Cr	79.0 miles
TN05130204 018 – 0200	CONCORD CREEK	15.1 miles
TN05130204 018 – 0300	KELLEY CREEK	9.3 miles
TN05130204 009	HARPETH RIVER TRIBUTARIES Newsome Cr, Trace Cr, and Murray Branch are partially supporting	10.4 miles
TN05130204 009 – 1100	BEECH CREEK	3.6 miles
TN05130204 013	WEST FORK HARPETH RIVER A portion of West Harpeth, plus Cayce Branch, Polk, and Kennedy Creek are partially supporting	62.1 miles
TN05130204 013 – 0610	RATTLESNAKE BRANCH	6.5 miles

Source Assessment

An important part of TMDL analysis is the identification of individual sources, or source categories of pollutants in the watershed that that cause or contribute to the organic enrichment and low dissolved oxygen impairment in the watershed. Under the Clean Water Act, sources are classified as either point or nonpoint sources. Under 40 CFR §122.2, a point source is defined as a discernable, confined, and discrete conveyance from which pollutants are or may be discharged to surface waters. The National Pollutant Discharge Elimination System (NPDES) program regulates point source discharges. Point sources can be described by two broad categories: 1) NPDES regulated municipal and industrial wastewater treatment facilities (WWTFs); and 2) NPDES regulated industrial and municipal storm water discharges. A TMDL must provide Waste Load Allocations (WLAs) for all NPDES regulated point sources. Nonpoint sources are diffuse sources that cannot be identified as entering a waterbody through a discrete conveyance at a single location. For the purposes of these TMDLs, all sources of pollutant loading not regulated by NPDES permits are considered nonpoint sources. The TMDLs must provide Load Allocations (LAs) for these sources.

Point Sources

NPDES Regulated Municipal and Industrial Wastewater Treatment Facilities

Both treated and untreated sanitary wastewater contains the primary nutrients nitrogen (organic nitrogen, ammonia, nitrate, & nitrite) and phosphorus (organic & inorganic) as well as substances that exert a biochemical oxygen demand (BOD) on the receiving waters of the effluent discharges. The BOD discharged from these WWTFs is composed of carbonaceous BOD (CBOD) and nitrogenous BOD, respectively reflecting the oxygen demanding substances associated with carbon and nitrogen.

There are 19 NPDES permitted WWTFs in the Harpeth River watershed that discharge wastewater containing BOD and nutrients. The location of these facilities is shown in Figure 8. Eleven of these facilities discharge upstream of the waters identified in Table 2. These WWTFs discharge varying levels of BOD, nitrogen, and phosphorus. Permit limits and monitoring requirements for selected effluent characteristics are summarized in Tables 8 & 9 for those facilities that are located in HUC-12 subwatersheds containing waterbodies impaired for organic enrichment/low dissolved oxygen. A summary of effluent monitoring data, submitted on Discharge Monitoring Reports (DMRs), from the larger facilities (design flow ≥ 0.25 MGD) is presented in Table 9.

As part of the TMDL development effort, many of the 19 NPDES permitted WWTFs in the Harpeth River watershed were determined not to cause or contribute to violations of water quality standards for the segments addressed by this TMDL. For each discharge, this determination was made based on factors including: 1) the WWTF discharges to a water that is not impaired and is not expected to cause or contribute to a downstream impairment; 2) the WWTF was determined through a modeling or technical analysis not to cause or contribute to an impairment. However, all eleven of the point sources that are located upstream from an impaired segment identified in Table 2 are receiving a wasteload allocation. The NPDES facilities that are receiving a wasteload allocation in this TMDL are identified in Table 10.

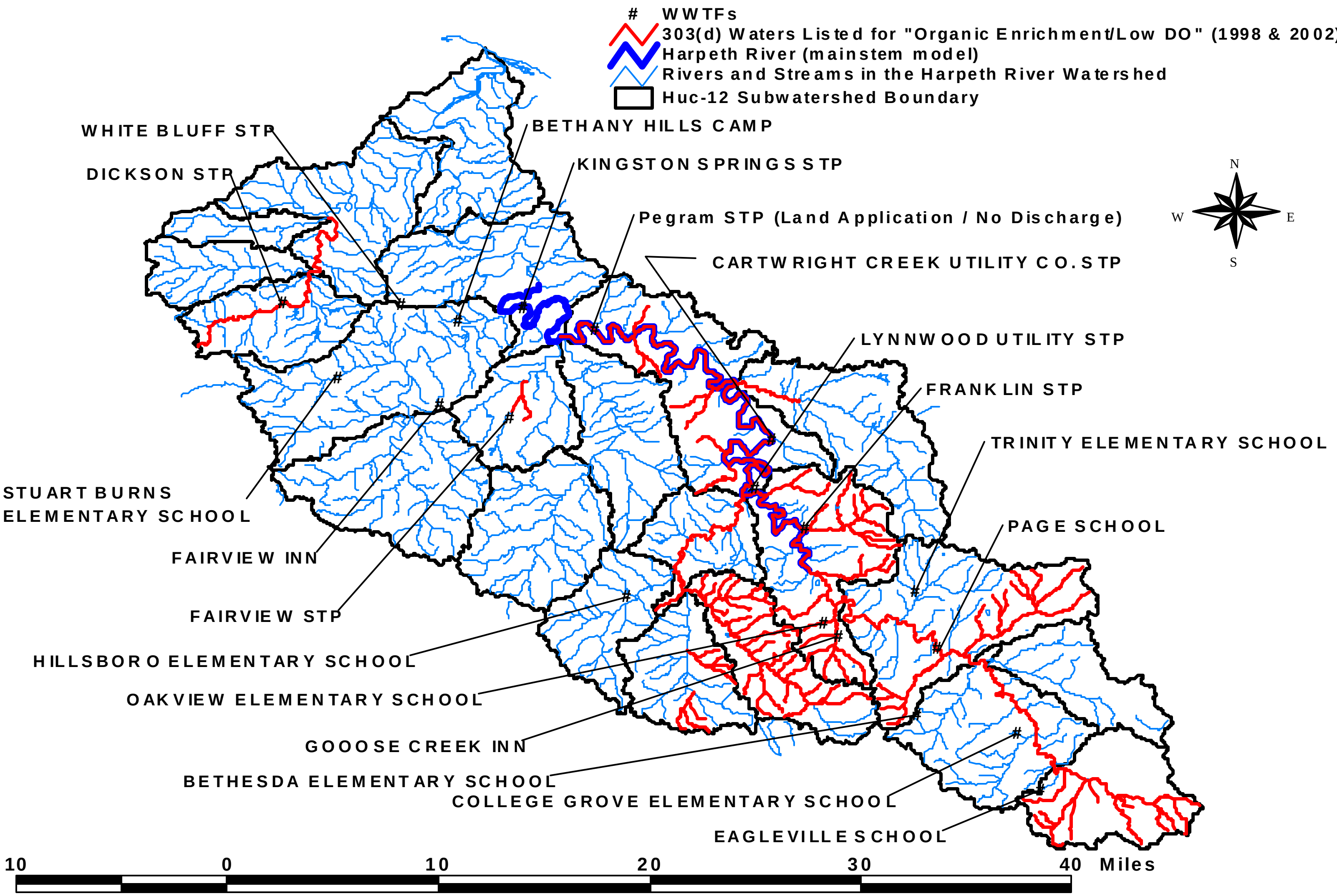

Figure 8 NPDES Permitted Wastewater Treatment Facilities with Discharges Containing BOD or Nutrients

Table 8 NPDES Permit Limits for WWTFs Discharging BOD or Nutrients Upstream of Waterbodies Impaired for OE/Low DO

NPDES Permit No.	Facility	Design Flow [MGD]	Effluent Characteristic	Season [a]	NPDES Permit Limits: Monthly Average [mg/l]	Monthly Average [lbs/day]	Weekly Average [mg/l]	Weekly Average [lbs/day]	Daily Max [mg/l]
TN0027278	Cartwright Creek Utility Co. STP	0.250	$CBOD_5$	S	5	10	7.5	16	10
				W	10	21	15	31	20
			NH_3-N	S	2	4	3	6	4
				W	5	10	7.5	16	10
			DO	Y	6.0 mg/l minimum instantaneous				
TN0029718	Lynwood Utility STP	0.400	$CBOD_5$	S	5	17	7.5	25	10
				W	10	33	15	50	Report
			NH_3-N	S	2	7	3	10	4
				W	5	17	7.5	25	10
			DO	Y	6.0 mg/l minimum instantaneous				
			T. Nitrogen [b]	S	3	10	4.5	15	6
			T. Phosphorus	S	Report	—	—	—	—
TN0067873	Oakview Elementary School	0.010	$CBOD_5$	Y	10	—	—	—	15
			NH_3-N	S	2	—	—	—	3
				W	5	—	—	—	7.5
			DO	Y	6.0 mg/l minimum instantaneous				
TN0057789	Eagleville School	0.018	$CBOD_5$	Y	10	—	—	—	20
			NH_3-N	S	2	—	—	—	4
				W	5	—	—	—	10
			DO	Y	6.0 mg/l minimum instantaneous				
TN0057827	Hillsboro Elementary School	0.030	$CBOD_5$	Y	10	—	—	—	20
			NH_3-N	S	2	—	—	—	4
				W	5	—	—	—	10
			DO	Y	6.0 mg/l minimum instantaneous				

NPDES Permit Limits for WWTFs Discharging BOD or Nutrients to Subwatersheds with Waterbodies Impaired for Organic Enrichment/Low Dissolved Oxygen (continued)

NPDES Permit No.	Facility	Design Flow [MGD]	Effluent Characteristic	Season [a]	NPDES Permit Limits: Monthly Average [mg/l]	Monthly Average [lbs/day]	Weekly Average [mg/l]	Weekly Average [lbs/day]	Daily Maximum [mg/l]
TN0057835	Page School	0.020	$CBOD_5$	S	4	—	—	—	8
				W	25	—	—	—	40
			NH_3-N	S	1	—	—	—	3
				W	5	—	—	—	10
			DO	Y	6.0 mg/l minimum instantaneous				
TN0060216	Goose Creek Inn	0.030	$CBOD_5$	Y	10	—	—	—	20
			NH_3-N	S	2	—	—	—	4
				W	5	—	—	—	10
			DO	Y	6.0 mg/l minimum instantaneous				
TN0064297	Trinity Elementary School	0.013	$CBOD_5$	Y	10	—	—	—	20
			NH_3-N	S	2	—	—	—	4
				W	3	—	—	—	5
			DO	Y	6.0 mg/l minimum instantaneous				
TN0064475	Bethesda Elementary School	0.017	$CBOD_5$	S	15	—	—	—	30
				W	20	—	—	—	35
			NH_3-N	S	1.5	—	—	—	3
				W	3	—	—	—	5
			DO	Y	3.0 mg/l minimum instantaneous				
TN0067164	College Grove Elementary School	0.012	$CBOD_5$	Y	10	—	—	—	15
					25	—	—	—	35
			NH_3-N	S	1	—	—	—	1.5
				W	5	—	—	—	7.5
			DO	Y	5.0 mg/l minimum instantaneous				

Notes: a. Seasonal abbreviations: S = Summer (5/1 through 10/31); W = Winter (11/1 through 4/30); Y = Entire Year.

b. Total nitrogen limits are under appeal as of 11/5/02.

Table 9 NPDES Permit Limits - Franklin STP (TN0028827)

Period Applicable	Design Flow [MGD]	Effluent Characteristic	Season [a]	NPDES Permit Limits: Monthly Average [mg/l]	Monthly Average [lbs/day]	Weekly Average [mg/l]	Weekly Average [lbs/day]	Daily Maximum [mg/l]
Normal Flow Discharge Mode [b] through 5/31/04	5.5	$CBOD_5$	S	6	275	9	413	12
			W	10	459	15	688	20
		NH_3-N	S	0.4	18	0.6	28	0.8
			W	1.5	69	2.3	106	3.0
		DO	Y	8.0 mg/l minimum instantaneous				
		T. Nitrogen [c]	Y	Report	—	—	—	—
		T. Phosphorus	Y	Report	—	—	—	—
High Flow Discharge Mode [d] through 5/31/04	5.5	$CBOD_5$	Y	25	Report	30	Report	35
		NH_3-N	Y	5	Report	7.5	Report	10
		DO	Y	6.0 mg/l minimum instantaneous				
		T. Nitrogen [c]	Y	Report	—	—	—	—
		T. Phosphorus	Y	Report	—	—	—	—
All discharges from 6/1/04 through 11/30/06	12.0	$CBOD_5$	S	6	601	9	901	12
			W	10	1001	15	1500	20
		NH_3-N	S	0.4	40	0.6	60	0.8
			W	1.5	150	2.3	230	3.0
		DO	Y	8.0 mg/l minimum instantaneous				
		T. Nitrogen [c]	S	5.0	—	—	—	—
			W	Report	—	—	—	—
		T. Phosphorus	Y	Report	—	—	—	—

Notes: a. Seasonal abbreviations: S = Summer (5/1 through 10/31); W = Winter (11/1 through 4/30); Y = Entire Year.

b. Normal Discharge Mode: Monthly average effluent flow ≤ 5.5 MGD; or
Monthly average stream flow < 42 MGD (65 cfs), summer; or
Summer dilution ratio < 8:1; or
Monthly average stream flow < 23 MGD (36 cfs), winter; or
Winter dilution ratio < 4.5:1

c. Permittee must comply with a seasonal average of 377 lbs/day for the period 5/1 through 10/31.

d. High Flow Discharge Mode: Monthly average effluent flow > 5.5 MGD; and
Monthly average stream flow ≥ 42 MGD (65 cfs), summer; and
Summer dilution ratio ≥ 8:1; or
Monthly average stream flow ≥ 23 MGD (36 cfs), winter; and
Winter dilution ratio ≥ 4.5:1

Table 9 Summary of Discharge Monitoring Reports

Facility	Effluent Characteristic	Season	Description	DMR Category				
				Monthly Average Concen.	Monthly Average Amount	Weekly Average Concen.	Weekly Average Amount	Daily Maximum Concen
				[mg/l]	[lbs/day]	[mg/l]	[lbs/day]	[mg/l]
Lynwood Utility STP (TN0029718)	CBOD5 (8/00 – 5/03)	S	Minimum	2.3	4.0	3.0	2.5	3.0
			Average	3.1	5.0	3.4	6.5	4.5
			Maximum	4	7.4	5	20.7	9
			POC [a]	0	0	0	0	0
		W	Minimum	2.8	4.2	3.0	5.2	3.0
			Average	4.2	7.8	5.7	12.5	10.1
			Maximum	8.4	15.8	12	31.8	22
			POC [a]	0	0	0	1	1
	NH3 (1/98 – 5/03)	S	Minimum	0.1	0.1	0.1	0.1	0.1
			Average	2.7	4.6	7.0	3.2	6.0
			Maximum	20.6	27.7	32.8	23.1	31.9
			POC [a]	10	4	9	8	12
		W	Minimum	0.1	0.1	0.1	0.1	0.1
			Average	2.7	4.1	4.6	6.6	6.1
			Maximum	19	31	25.8	40.7	30
			POC [a]	5	3	6	3	6
	Total Nitrogen (6/00 – 5/03)	S	Minimum	0.1	0.1	0.1	0.1	0.1
			Average	6.6	7.6	13.3	11.6	16.1
			Maximum	20.4	24.1	44.6	38	56
			POC [a]	c	C	c	c	c
	Total Phosphorus	S	Minimum	¾	¾	¾	¾	¾
			Average	¾	¾	¾	¾	¾
			Maximum	¾	¾	¾	¾	¾
			POC [a]	NA	¾	¾	¾	¾
	DO [b] (1/98 – 5/03)	Y	Minimum	3.5	¾	¾	¾	¾
			Average	7.8	¾	¾	¾	¾
			Maximum	9.9	¾	¾	¾	¾
			POC [a]	1	¾	¾	¾	¾

Summary of Discharge Monitoring Reports (Continued)

Facility	Effluent Characteristic	Season	Description	DMR Category				
				Monthly Average Concen.	Monthly Average Amount	Weekly Average Concen.	Weekly Average Amount	Daily Maximum Concen
				[mg/l]	[lbs/day]	[mg/l]	[lbs/day]	[mg/l]
Franklin STP (TN0028827)	CBOD5 (2/99-4/03)	S	Minimum	1.1	41.5	0.9	13.0	2.0
			Average	2.5	83.9	3.2	119.1	5.9
			Maximum	5.1	190.2	6.5	256.2	10.6
			POC [a]	0	0	0	0	0
		W	Minimum	0.8	48.3	1.2	59.3	2.0
			Average	2.1	112.2	2.9	194.1	4.7
			Maximum	5.8	231.6	8.6	523.8	13
			POC [a]	0	0	0	0	0
	NH3-N (2/99-4/03)	S	Minimum	0.005	0.2	0.006	0.3	0.01
			Average	0.07	2.1	0.11	3.6	0.25
			Maximum	0.44	8.6	0.78	24.9	2.1
			POC [a]	1	0	1	0	1
		W	Minimum	0.015	0.6	0.02	0.6	0.035
			Average	0.22	9.1	0.36	16.9	0.86
			Maximum	3.3	102.9	6.1	174.8	12.4
			POC [a]	1	1	1	1	1
	Total Nitrogen (2/99-4/03)	S	Minimum	0.8	¾	¾	¾	¾
			Average	2.9	¾	¾	¾	¾
			Maximum	9.1	¾	¾	¾	¾
			POC [a]	NA	¾	¾	¾	¾
	Total Phosphorus (2/99-4/03)	S	Minimum	0.01	¾	¾	¾	¾
			Average	0.69	¾	¾	¾	¾
			Maximum	3.4	¾	¾	¾	¾
			POC [a]	NA	¾	¾	¾	¾
	DO [b] (2/99-4/03)	Y	Minimum	7.7	¾	¾	¾	¾
			Average	8.3	¾	¾	¾	¾
			Maximum	9.6	¾	¾	¾	¾
			POC [a]	1	¾	¾	¾	¾

Summary of Discharge Monitoring Reports (Continued)

Facility	Effluent Characteristic	Season	Description	DMR Category				
				Monthly Average Concen.	Monthly Average Amount	Weekly Average Concen.	Weekly Average Amount	Daily Maximum Concen
				[mg/l]	[lbs/day]	[mg/l]	[lbs/day]	[mg/l]
Cartwright Creek Utility Co. STP (TN0027278)	CBOD5 (3/98 – 5/03)	S	Minimum	1	3	1	1	2
			Average	2.0	5.1	3.0	7.6	4.3
			Maximum	5	13	8	25	13
			POC [a]	0	3	1	2	1
		W	Minimum	1	4	2	2	2
			Average	2.4	7.8	3.8	11.5	5.6
			Maximum	8	35	17	64	31
			POC [a]	0	2	1	2	2
	NH3-N (1/98 – 5/03)	S	Minimum	0.2	0	0.2	1.0	0.3
			Average	0.43	1.2	0.87	2.8	1.4
			Maximum	1.5	6	7.6	30	15
			POC [a]	0	1	1	2	1
		W	Minimum	0.1	0	0.2	1.0	0.3
			Average	0.48	1.4	0.65	2.2	1.1
			Maximum	1.2	4	1.5	4	2.7
			POC [a]	0	0	0	0	0
	DO [b] (1/98 – 5/03)	Y	Minimum	6.0				
			Average	7.0				
			Maximum	9.1				
			POC [a]	0				

Notes: a. Number of months with at least one effluent measurement out of compliance with permit limit.

b. Dissolved oxygen is reported as the minimum concentration during the month.

c. Total nitrogen limits are under appeal as of 11/5/02.

Table 10 Wastewater Treatment Facilities receiving a wastleoad allocation in this TMDL

NPDES Permit #	Facility Name	WLA Documentation	Receiving Waterbody
TN0057789	Eagleville School	Table 23	Cheatham Branch
TN0067873	Oakview Elementary School	Table 23	Unnamed tributary to Fivemile Creek
TN0060216	Goose Creek Inn	Table 23	Fivemile Creek
TN0028827	Franklin STP	Table 25	Harpeth River
TN0029718	Lynnwood STP	Table 25	Harpeth River
TN0027278	Cartwright Creek Utility Company STP	Table 25	Harpeth River
TN0057835	Page School	Table 23	Harpeth River
TN0057827	Hillsboro Elementary School	Table 23	Pinewood Branch
TN0064297	Trinity Elementary School	Table 23	Unnamed tributary to Mayes Creek
TN0064475	Bethesda Elementary School	Table 23	Unnamed tributary to Rutherford Creek
TN0067164	College Grove Elementary School	Table 23	Unnamed tributary to Overall Creek

NPDES Regulated Municipal Separate Storm Sewer Systems (MS4s)

Municipal Separate Storm Sewer Systems (MS4s) are recognized as point sources of nutrients that potentially cause or contribute to the impairment of organic enrichment/dissolved oxygen. These discharges occur in response to storm events through road drainage systems, curb and gutter systems, ditches, and storm drains. Large and medium MS4s serving populations greater than 100,000 people are required to obtain an NPDES storm water permit. At present, Metro Nashville/Davidson County is the only MS4 of this size in the Harpeth River watershed that is regulated by the NPDES program (TNS068047). As of March 2003, small MS4s serving urbanized areas, or having the potential to exceed instream water quality standards, were required to obtain a permit under the Phase II storm water regulations. An urbanized area is defined as an entity with a residential population of at least 50,000 people and an overall population density of at 1,000 people per square mile. Franklin, Brentwood, Dickson, Williamson County, and Rutherford County are covered under Phase II of the NPDES Storm Water Program. The Tennessee Department of Transportation (TDOT) is also being issued MS4 permits for State roads in urban areas. Information regarding storm water permitting in Tennessee may be obtained from the TDEC website at http://www.state.tn.us/environment/wpc/stormh2o/

NPDES Concentrated Animal Feeding Operations (CAFOs)

Animal feeding operations (AFOs) are agricultural enterprises where animals are kept and raised in confined situations. AFOs congregate animals, feed, manure and urine, dead animals, and production operations on a small land area. Feed is brought to the animals rather than the animals grazing or otherwise seeking feed in pastures, fields, or on rangeland (USEPA, 2002a). Concentrated Animal Feeding Operations (CAFOs) are AFOs that meet certain criteria with respect to animal type, number of animals, and type of manure management system. CAFOs are considered to be potential point sources of nutrient loading and are required to obtain an NPDES permit. Most CAFOs in Tennessee obtain coverage under TNA000000, *Class II Concentrated Animal Feeding Operation General Permit* (included as Appendix E), while larger, Class I CAFOs are required to obtain an individual NPDES permit. Requirements of both the general and individual CAFO permits include:

- Development of a Nutrient Management Plan (NMP), and approval of the NMP by the Tennessee Department of Agriculture (TDA).

- Liquid waste handling systems, if utilized, be designed, constructed, and operated to contain all process generated waste waters plus the runoff from a 25-year, 24-hour rainfall event. A discharge from a liquid waste handling facility to waters of the state during a chronic or catastrophic rainfall event, or as a result of an unpermitted discharge, upset, or bypass of the system, shall not cause or contribute to an exceedance of Tennessee water quality standards (see Appendix E, II. for definitions of chronic and catastrophic rainfall events).

- Other Best Management Practices (BMPs).

There is currently only one Class II CAFO in the Harpeth River watershed with coverage under the general NPDES permit. The location of this facility is shown in Figure 9. There are no CAFOs with individual permits located in the watershed. It should be noted that the facility is located in a subwatershed containing impaired waterbodies.

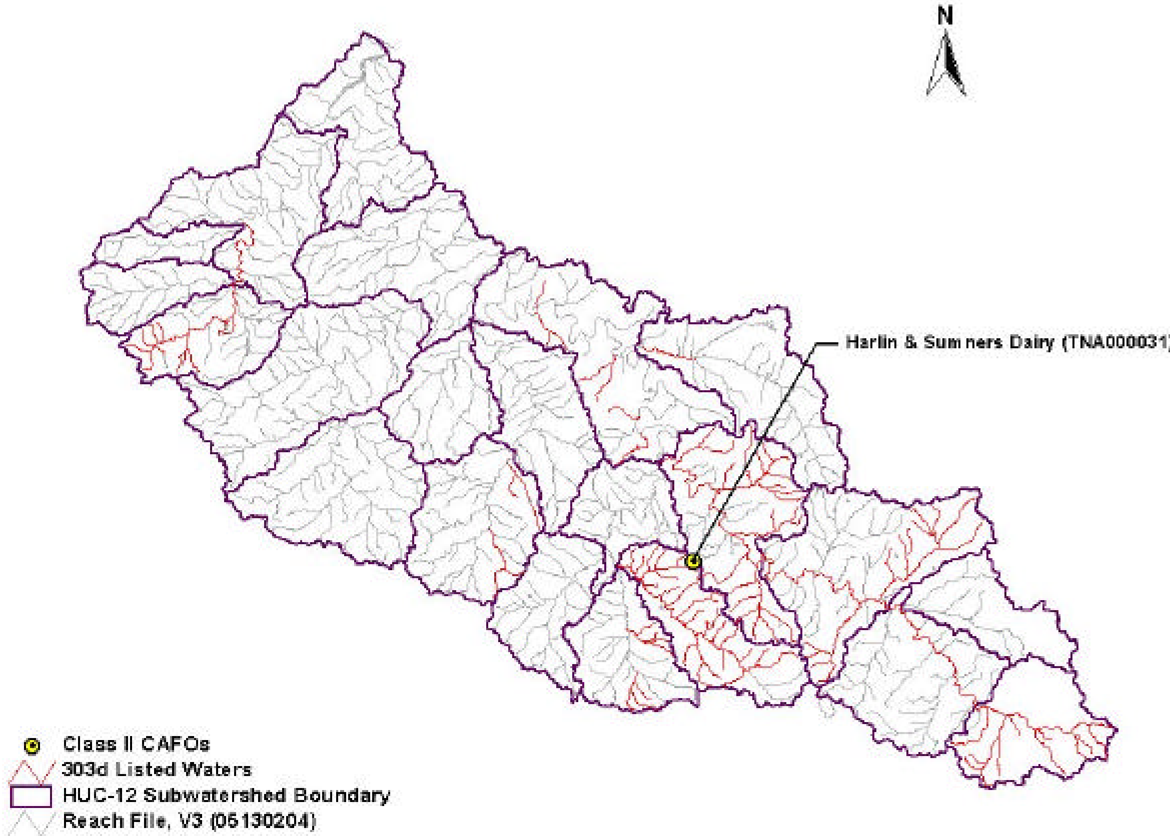

Figure 9 Location of CAFOs in the Harpeth River Watershed

Nonpoint Sources

For many of the waterbodies identified as impaired due to organic enrichment/low dissolved oxygen or nutrients in the Harpeth River watershed, the Tennessee 305(b) report identified nonpoint sources as the principal source of pollution. Possible nonpoint sources of nutrients and organic materials include urban runoff (from areas not covered under an MS4 permit), atmospheric deposition, geology, failing septic systems, and agricultural runoff on land associated with fertilizer application and livestock waste. Typical nutrient loading ranges for various land uses are shown in Table 11. The geology of some watershed areas is dominated by highly phosphatic limestone that creates a significant background source component. Phosphorus can be adsorbed to sediment particles, transported to waterbodies, and released to the water column under certain circumstances. This can result in high concentrations of total phosphorus during runoff events, as well as during low flow conditions.

Table 11 Typical Nutrient Loading Ranges for Various Land Uses

Land Use	Total Phosphorus [kg/ha-y]			Total Nitrogen [kg/ha-y]		
	Minimum	Maximum	Median	Minimum	Maximum	Median
Roadway	0.59	1.50	1.10	1.3	3.5	2.4
Commercial	0.69	0.91	0.80	1.6	8.8	5.2
Single Family – Low Density	0.46	0.64	0.55	3.3	4.7	4.0
Single Family – High Density	0.54	0.76	0.65	4.0	5.6	5.8
Multifamily Residential	0.59	0.81	0.70	4.7	6.6	5.6
Forest	0.10	0.13	0.11	1.1	2.8	2.0
Grass	0.01	0.25	0.13	1.2	7.1	4.2
Pasture	0.01	0.25	0.13	1.2	7.1	4.2

Source: Horner et al., 1994 in *Protocol for Developing Nutrient TMDLs* (USEPA 1999).

Table 12 Livestock Distribution in the Harpeth River Watershed

HUC-12 Subwatershed (05130204__)	Livestock Population (1997 Census of Agriculture)						
	Beef Cow	Cattle	Milk Cow	Chickens		Hogs	Sheep
				Layers	Broilers Sold		
0101	2,515	5,264	325	9	95,085	133	53
0102	3,161	6,238	302	7	0	298	83
0104	3,544	6,843	297	7	0	390	99
0105	1,903	3,675	160	4	0	210	53
0201	2,489	4,806	209	5	0	274	70
0202	1,769	3,415	148	4	0	195	50
0301	1,108	3,021	93	4	0	146	31
0302	1,219	2,599	102	3	0	136	34
0401	784	1,513	66	2	0	86	22
0601	0	2,394	0	5	28	172	3
0604	0	1,846	0	4	21	133	2

Table 13 Population on Septic Systems in the Harpeth River Watershed

HUC-12 Subwatershed (05130204__)	Population On Septic Systems
0101	6,844
0102	3,030
0104	2,727
0105	2,209
0201	1,640
0202	1,365
0301	5,292
0302	8,545
0401	2,465
0601	1,917
0604	2,947

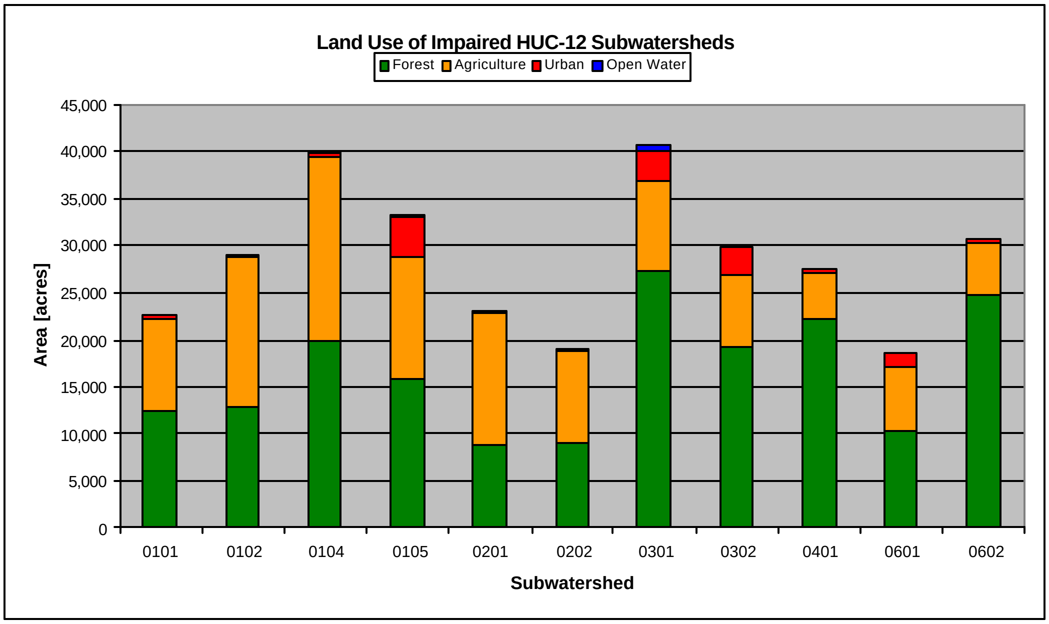

Figure 10 Land Use Area of Impaired HUC-12 Subwatersheds

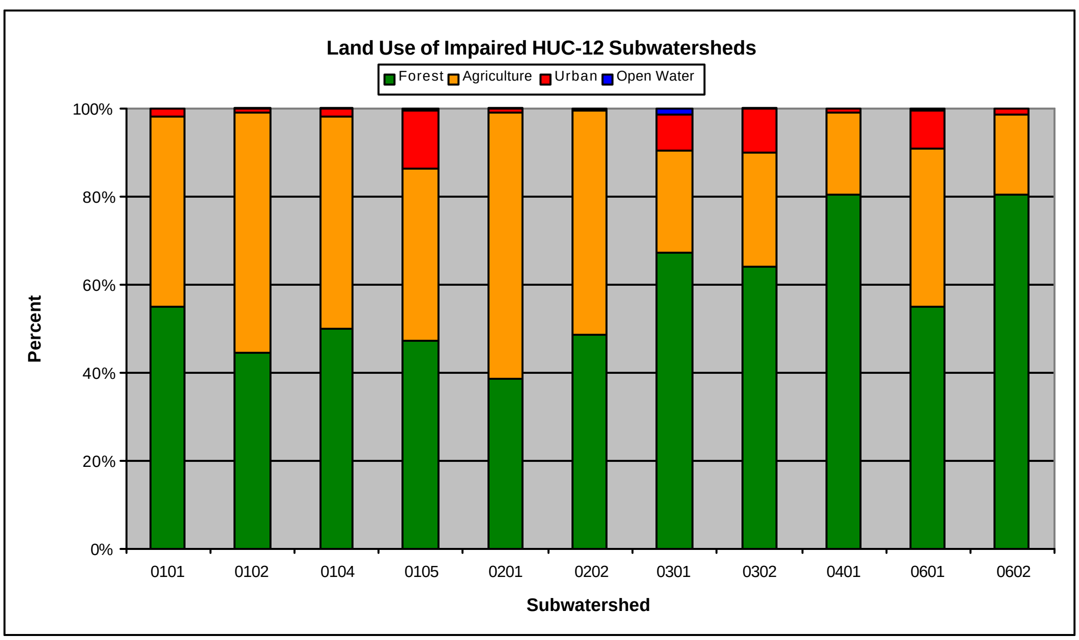

Figure 11 Land Use Percentage of Impaired HUC-12 Subwatersheds

From consideration of the data presented in Tables 12, 13, 14, & F-1 and Figures 3, 10, and 11, several observations can be made:

- Subwatersheds 0101, 0102, 0104, 0105, 0201, and 0202 have significant livestock populations and relatively high percentages of agricultural land. Agricultural sources are a significant source of nutrient loading.

- Subwatersheds 0105, 0301, and 0302 have relatively high percentages of urban land uses. Urban land has the highest loading rates for both phosphorus and nitrogen. Urban land use is concentrated in Franklin (0105), Brentwood (0302), and Metro Nashville-Davidson County (0301 & 0302) which are MS4 Phase I or Phase II urbanized areas.

- Subwatersheds 0101, 0301, and 0302 have the highest populations on septic systems. Failing septic systems can be a significant source of nutrients.

Development of Total Maximum Daily Load

The TMDL process quantifies the amount of a pollutant that can be assimilated in a waterbody, identifies the sources of the pollutant, and recommends regulatory or other actions to be taken to achieve compliance with applicable water quality standards based on the relationship between pollution sources and in-stream water quality conditions. Conceptually, a TMDL can be expressed as the sum of all point source loads (Waste Load Allocations), non-point source loads (Load Allocations), and an appropriate margin of safety (MOS) which takes into account any uncertainty concerning the relationship between effluent limitations and water quality. The objective of a TMDL is to allocate loads among all of the known pollutant sources throughout a watershed so that appropriate control measures can be implemented and water quality standards achieved. 40 CFR §130.2 (i) states that TMDLs can be expressed in terms of mass per time, toxicity, or other appropriate measure.

Development of Nutrient TMDLs

Scope of Nutrient TMDLs

Nutrient TMDLs were developed for all waters identified in Table 7. These TMDLs were developed using a subwatershed approach that involved an analysis of 12-digit hydrologic unit area watersheds. Specifically, nutrient reductions in these subwatersheds are necessary in order for water quality standards to be attained for the waters included in Table 7. The relationship between these impaired segments and the 12-digit subwatersheds that drain to these segments are described in Table 14.

Table 14 Relationship between Impaired segments and 12-digit subwatersheds

Waterbody ID	Impaired Segments	Corresponding 12-digit subwatersheds
TN05130204021-1000	LITTLE HARPETH RIVER From Harpeth River to Otter Creek	0302
TN05130204009 - 1100	Beech Creek	0301
TN05130204 016	HARPETH RIVER TRIBUTARIES Arrington Cr, Spencer Cr, Watson Br, 5-mile Cr, Lynnwood Cr, and Starnes Cr	0104, 0105
TN05130204018-0200, TN05130204018-0300	Concord Creek, Kelley Creek	0101
TN05130204 009	HARPETH RIVER TRIBUTARIES Newsome Cr, Trace Cr, and Murray Branch are partially supporting	0301
TN05130204 013	WEST FORK HARPETH RIVER A portion of West Harpeth, plus Cayce Branch, Polk, and Kennedy Creek are partially supporting	0201
TN05130204013-0610	Rattlesnake Branch	0202

In addition, based on the available data and information, the low dissolved oxygen levels observed in the Little Harpeth River have been determined to be attributed to nutrient enrichment as opposed to impacts from oxygen demanding substances. Therefore, the TMDL for this water will be expressed in terms of nutrients and will not include allocations for BOD.

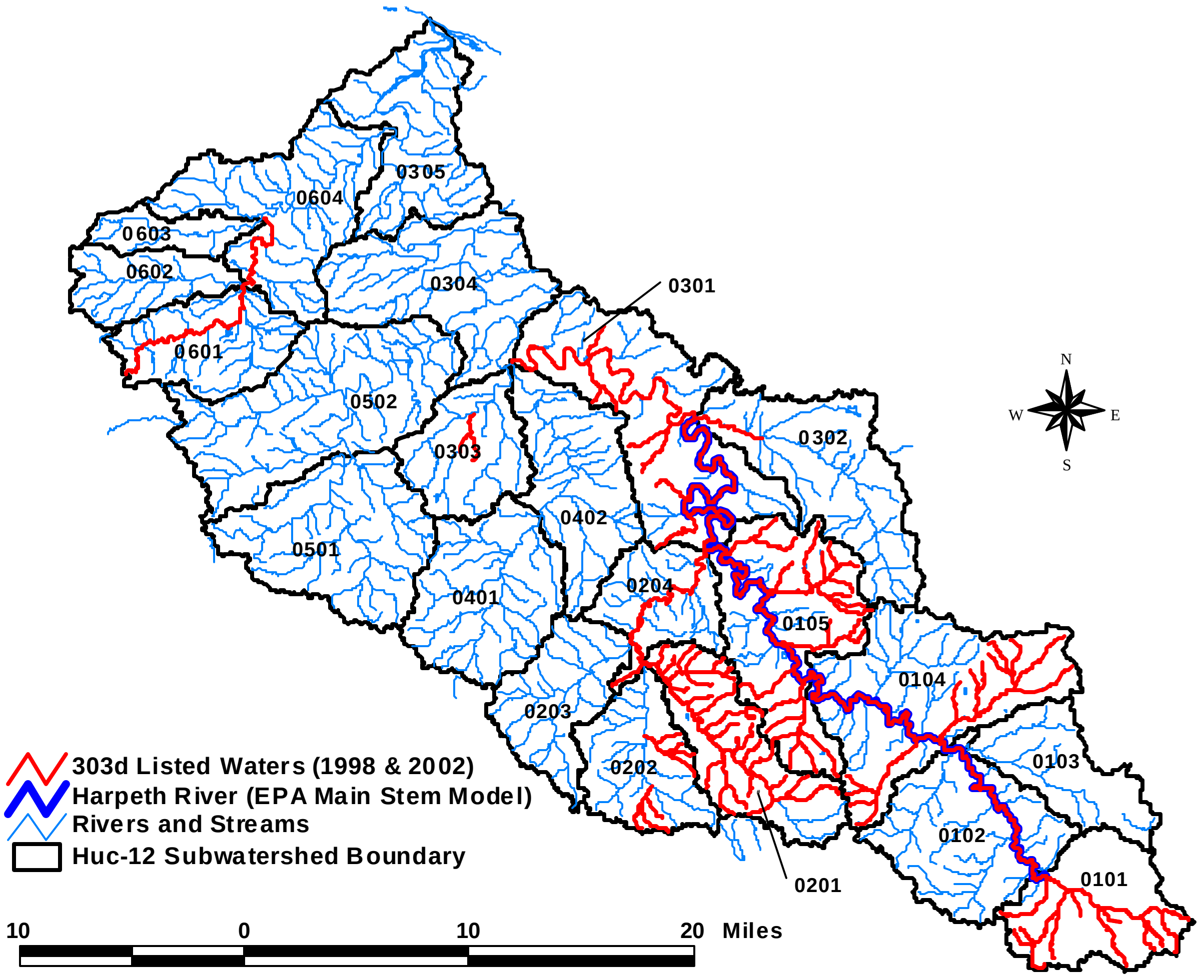

Figure 12 HUC-12 Subwatershed Boundaries in the Harpeth River Watershed

TMDL Approach for Addressing Nutrients

Nutrient TMDLs were developed for the selected subwatersheds identified in the Problem Definition section of the report and are based on the ecoregion-based nutrient concentrations specified in Water Quality Endpoint: Nutrients according to the procedure described in Appendix G. In order to apply the targets over the range of flow conditions encountered in the Harpeth River watershed throughout the year, TMDLs for total nitrogen and total phosphorus are expressed as monthly average loads during a summer period (May 1 – October 31) and monthly average loads during a winter period (November 1 – April 30). Monthly average loads were considered to be more appropriate than daily loads for representing the development of seasonal algal blooms in streams due to excessive nutrient loading and the associated effects on aquatic life. The nutrient TMDLs necessary to protect against organic enrichment for the waters identified in Table 7 are summarized in Table 15.

Table 15 Nutrient TMDLs for Selected Impaired Subwatersheds

HUC-12 Subwatershed (0513020)	Total Nitrogen		Total Phosphorus	
	Summer * [lbs/month]	Winter * [lbs/month]	Summer * [lbs/month]	Winter * [lbs/month]
0101	4480	12478	916	2541
0104	7335	21966	929	2709
0105	5864	18260	483	1505
0201	4062	12649	335	1042
0202	3026	9119	241	732
0301	6253	18537	489	1468
0302	5275	16425	435	1354

* Summer: 5/1 – 10/31; Winter: 11/1 – 4/30.

Estimates of reductions in existing nutrient loading required to attain water quality standards in selected impaired HUC-12 subwatersheds were calculated using a load duration curve methodology according to the procedure described in Appendix H. These estimated reductions are summarized in Table 16.

Table 16 Estimates of Required Load Reductions for Selected Impaired Subwatersheds

HUC-12 Subwatershed (05130204)	Total Nitrogen (%)	Total Phosphorus (%)
0101	20.0	42.4
0104	20.0	42.4
0105	49.4	83.8
0201	53.1	81.3
0202	53.1	81.3
0301	44.8	82.4
0302	34.3	78.1

Units Used to Express Nutrient Wasteload Allocations (WLAs) and Load Allocations (LAs)

For analysis purposes, WWTFs are considered to discharge continuously at their design flow. Since the discharges from these facilities are considered to be independent of subwatershed drainage area and the occurrence of storm events, WLAs are expressed as monthly average loads during a summer period (May 1 – October 31) and monthly average loads during a winter period (November 1 – April 30). Discharges from MS4s and nonpoint sources, however, are dependent on both drainage area size and precipitation. Therefore, for precipitation induced loading, it is more appropriate to express WLAs for MS4s and LAs for nonpoint sources as average semiannual loads per unit area. Summer and winter semiannual periods were selected to conform to historical permitting practices in Tennessee (i.e., Summer: May 1 – October 31;

Winter: November 1 – April 30).

Nutrient Waste Load Allocations

NPDES Regulated Municipal and Industrial Wastewater Treatment Facilities

There are 19 WWTFs in the Harpeth River watershed with individual NPDES permits that require monitoring of nutrients or have the reasonable potential to contribute nutrients to surface waters. Three of these facilities are located in the subwatersheds where they have the potential of impacting waters where a nutrient TMDL target is necessary (i.e., the waters identified in Table 17). Monthly total nitrogen and total phosphorus WLAs for the WWTFs in the selected subwatersheds were developed according to the procedure in Appendix I and are summarized in Table 17:

Table 17 Nutrient WLAs for WWTFs

NPDES Permit No.	Facility	HUC-12 SubWS	WLA			
			Total Nitrogen		Total Phosphorus	
			Summer * [lbs/month]	Winter * [lbs/month]	Summer * [lbs/month]	Winter * [lbs/month]
TN0057789	Eagleville School	0101	45.0	67.6	22.5	33.8
TN0067873	Oakview Elementary School	0105	25.0	37.5	12.5	18.8
TN0060216	Goose Creek Inn	0105	75.1	112.6	37.5	56.3

* Summer: 5/1 – 10/31; Winter: 11/1 – 4/30.

NPDES Regulated Municipal Separate Storm Sewer Systems (MS4s)

NPDES regulated Municipal Separate Storm Sewer Systems (MS4s) are considered point sources of nutrients. WLAs for Phase I & II urban areas are calculated according to the procedure in Appendix I. Since loading from these entities occurs only in response to storm events, WLAs are expressed as average semiannual loads on a unit area basis and applied according to the subwatershed(s) in which the urban area is located. WLAs for existing and future MS4s located in selected impaired HUC-12 subwatersheds are tabulated in Table 18.

Table 18 Nutrient Waste Load Allocations for MS4s

Subwatershed (05130204)	WLAs for MS4s			
	Total Nitrogen		Total Phosphorus	
	Summer *	Winter *	Summer *	Winter *
	[lbs/ac/month]	[lbs/ac/month]	[lbs/ac/month]	[lbs/ac/month]
0101	0.186	0.521	0.037	0.105
0104	0.173	0.520	0.021	0.063
0105	0.164	0.516	0.012	0.041
0201	0.167	0.521	0.014	0.043
0202	0.152	0.459	0.012	0.037
0301	0.148	0.438	0.012	0.035
0302	0.167	0.521	0.014	0.043

* Summer: 5/1 – 10/31; Winter: 11/1 – 4/30.

NPDES Regulated Concentrated Animal Feeding Operations (CAFOs)

CAFOs are not authorized to discharge process wastewater from a liquid waste handling system except during a catastrophic or chronic rainfall event. Any discharges made under these circumstances, or as a result of a system upset or bypass, are not to cause an exceedance of Tennessee water quality standards. Therefore, a WLA of zero has been assigned to this class of facilities.

Nutrient Load Allocations for Nonpoint Sources

Load allocations for nonpoint sources in selected impaired HUC-12 subwatersheds were calculated according to the procedure in Appendix I and are shown in Table 19. These LAs are expressed as average semiannual loads on a unit area basis and are numerically equal to the WLAs for MS4s.

Table 19 Nutrient Load Allocations for Nonpoint Sources

Subwatershed (05130204)	LAs for Nonpoint Sources			
	Total Nitrogen		Total Phosphorus	
	Summer *	Winter *	Summer *	Winter *
	[lbs/ac/month]	[lbs/ac/month]	[lbs/ac/month]	[lbs/ac/month]
0101	0.186	0.521	0.037	0.105
0104	0.173	0.520	0.021	0.063
0105	0.164	0.516	0.012	0.041
0201	0.167	0.521	0.014	0.043
0202	0.152	0.459	0.012	0.037
0301	0.148	0.438	0.012	0.035
0302	0.167	0.521	0.014	0.043

* Summer: 5/1 – 10/31; Winter: 11/1 – 4/30.

Development of TMDLs to Address Low DO Levels in the Harpeth River Headwaters

The water quality characteristics of the Harpeth River, from its headwaters to RM 89.2, are represented by the Enhanced Stream Water Quality Model (QUAL2E) for the purpose of determining the reductions necessary to achieve DO levels that are consistent with the State's water quality standards. As described in EPA's report, "Harpeth River Watershed Modeling Effort: A Tool for TMDL Development", the mainsteam of the Harpeth River was represented by two separate models because of the hydraulic characteristics of this system. This report can currently be accessed on EPA's website at www.epa.gov/region4/water/tmdl/tennessee.

The QUAL2E is a comprehensive and versatile one-dimensional, steady-state stream water quality model. It can simulate up to 15 water quality constituents in any combination desired by the user. The model is applicable to dendritic streams that are well mixed. It assumes that the major transport mechanisms, advection and dispersion, are significant only along the main direction of flow (longitudinal access of the stream). It allows for multiple waste discharges, withdrawals, tributary flows, and incremental inflow and outflow (Brown and Barnwell, 1987).

The QUAL2E model was applied to the upper Harpeth River watershed from the headwaters to RM89.2 (Figure 13). The intention of the model application was to make best efforts to simulate the processes that impact dissolved oxygen concentrations in the segments of the upper Harpeth River system during low-flow conditions. An attempt to calibrate the model was conducted based on the datasets that were collected by EPA and TDEC during 2000 and 2001. The model was parameterized using this data and information in terms of hydraulic characteristics, CBOD and NBOD decay rates, SOD, and reaeration rates. Details concerning this modeling effort are described in the EPA report entiltled, "Harpeth River Watershed

Modeling Effort: A Tool for TMDL Development."

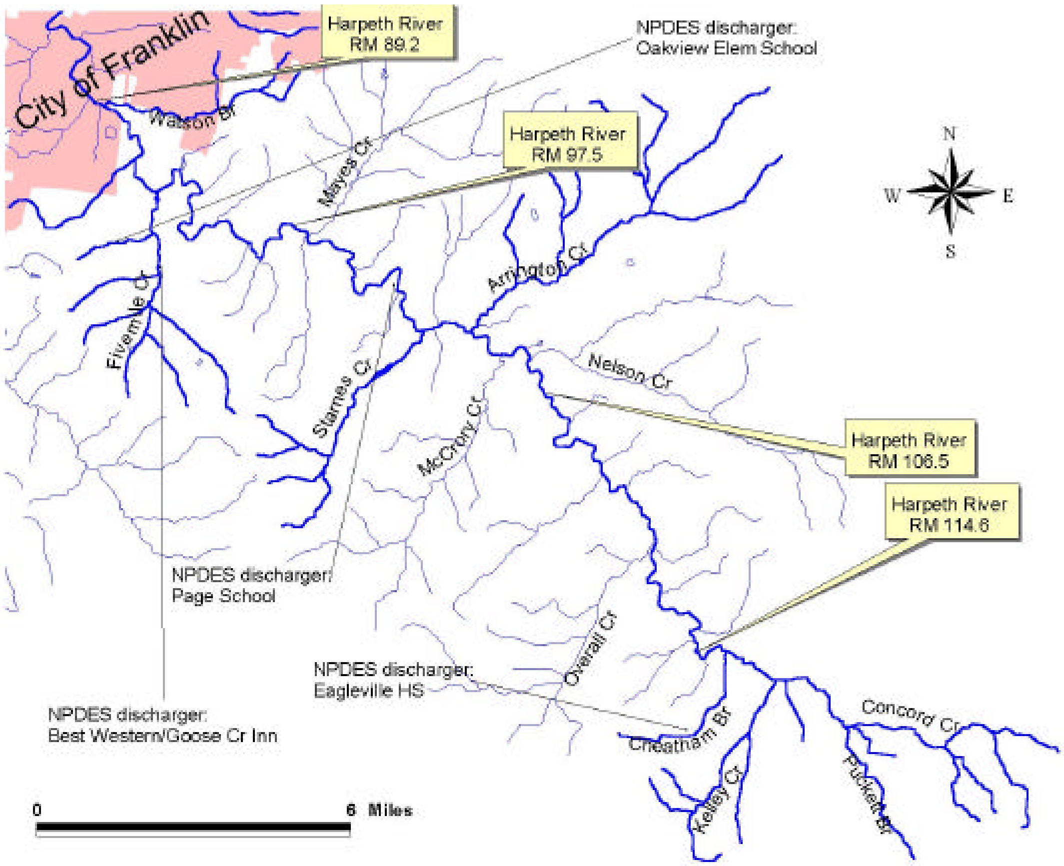

Figure 13 Upper Harpeth River Watershed

Representation of the Harpeth River Headwaters with a QUAL2E Model

The headwaters of the Harpeth River originate from Concord Creek, Puckett Branch, and Kelley Creek. These headwater streams do not receive wastewater discharges from any point sources and they are all located in an area dominated by an agriculture landuse. Therefore these streams are represented, or characterized, as a single headwater reach in QUAL2E. Cheatham Branch is also a headwater stream in an area dominated by an agricultural landuse. However, this stream receives a minor discharge of treated wastewater from Eagleville School and it is included in the model as an individual reach.

The upper Harpeth River receives flows from several other tributaries (Figure 13). It was decided that the tributaries that were impaired from "Organic enrichment/DO" on TDEC's §303(d) list would be included as individual reaches in the QUAL2E model (i.e., Arrington Creek, Starnes Creek, Fivemile Creek, and Watson Branch). Although there is no evidence that any of these tributaries are impaired from low levels of dissolved oxygen, EPA included them in the model as part of the TMDL analysis. In addition, Fivemile Creek and an unnamed tributary to Fivemile Creek receive minor discharges of treated wastewater respectively from the Best Western/Goosecreek Inn and Oakview Elementary School. These waters were included as individual reaches in the model. The other significant tributaries to the upper Harpeth River (i.e., Overall Creek, Nelson Creek, McCrory Creek, and Mayes Creek) are included in the QUAL2E model as point sources. In addition, Page Middle School discharges treated wastewater to the Harpeth River at RM 101.9 and is included in the model.

A low-head dam and a drinking water intake from the City of Franklin are located in the proximity of RM89.2. During EPA's August 2000 water quality study, a 150-meter segment of the Harpeth River channel located immediately downstream from the low-head dam was observed to be dry. EPA did not attempt to describe or represent any of these characteristics as part of the QUAL2E model. However, considering that observed DO levels increase and observed BOD levels decrease in the downstream direction in the upper portion of the Harpeth River, it is evident that water quality standards in the vicinity of RM89.2 will be met as long as water quality standards are met upstream from this point.

The upper Harpeth River watershed is represented as 15 reaches in the QUAL2E model (Table 20). Considering the total length of the system that is modeled as well as the spatial resolution of the available data, the length of each computational element (i.e., Delta X) was selected to be 0.5 miles. Although the QUAL2E model ends at RM88.6, one should be mindful that there are many complex hydraulic processes in the vicinity of RM89.2 that are not simulated (e.g., low-head dam effects on velocity, effects of drinking water intake on flow, the dry portion of the channel).

Table 20 Reaches represented by QUAL2E

Reach number	QUAL2E Reach name	Beginning RM	Ending RM	Headwater reach ( )	Delta X (mile)
1	HR123.1-115.6	123.1	115.6		0.5
2	Cheatham Br	2.5	0		0.5
3	HR115.6-111.1	115.6	111.1		0.5
4	HR111.1-103.6	111.1	103.6		0.5
5	Arrington Cr	8.5	0		0.5
6	HR103.6-102.6	103.6	102.6		0.5
7	Starnes Cr	5.5	0		0.5
8	HR102.6-97.6	102.6	97.6		0.5
9	HR97.6-91.6	97.6	91.6		0.5
10	Fivemile Cr 1	5.0	1.0		0.5
11	UT to Fivemile	1.5	0		0.5
12	Fivemile Cr 2	1.0	0		0.5
13	HR91.6-89.6	91.6	89.6		0.5
14	Watson Br	5.0	0		0.5
15	HR89.6-88.6	89.6	88.6		0.5

Development of TMDL for the Harpeth River Headwaters

The TMDL for the headwaters of the Harpeth River was developed using conservative low flow and high temperatures in the model application. Specifically, a water temperature value of 27 degrees Centigrade and flows equal to the 7-day average, 10-year recurrence interval (7Q10) were applied to the model. The 7Q10 flow for this system was determined based on an area-weighted calculation of a 7Q10 flow published in a U.S. Geological Survey Report for the 7Q10 of the Harpeth River at RM88.1 (USGS, 1995). Specifically, the 7Q10 flow at RM88.1 is 0.5 cubic feet per second (cfs) and the drainage area of the watershed at this station is 191 square miles (mi2). Based on an area-weighted calculation, the 7Q10 flow per square mile is 0.00262 cfs/mi2. Using the drainage areas for each of the flow inputs to the QUAL2E model, the 7Q10 for each subwatershed is described in Table 21 and Table 22. It is important to note that these 7Q10 flows are greater than the flows measured and estimated during the August 2000 study, from which the model was parameterized.

In addition, the point sources in the watershed were included in the model as discharging at design capacity at permitted effluent limits for CBOD5 and NH3-N (see Table 8 and Table 22).

Table 21 Headwater 7Q10 flows used for QUAL2E model

Reach number	Reach name	Flow (cfs)
1	HR123.1-115.6	0.082465
2	Cheatham Br	0.005916
5	Arrington Cr	0.049685
7	Starnes Cr	0.052463
10	Fivemile Cr 1	0.021584
11	UT to Fivemile	0.002539
12	Fivemile Cr 2	0.002170
14	Watson Br	0.022497

Table 22 7Q10 flows for point tributaries and NPDES discharges

Point Source/ Tributary	Flow (cfs)
Eagleville School	0.027846
Overall Creek	0.032336
Nelson Creek	0.067917
McCrory Creek	0.030520
Page Middle School	0.031400
Mayes Creek	0.039881
Best Western-Goosecreek Inn	0.046410
Oakview Elementary	0.015470

When running the model during critical conditions, the predicted DO levels in the headwater reaches are as low as 2.65 mg/l (see Figure 14). Based on how the model was parameterized, the model is extremely sensitive to sediment oxygen demand (SOD), relative to carbonaceous or nitrogenous oxygen demand. In addition, removing the minor point source discharges in the model simulations had no effect on the predicted DO levels in the mainstem of the Harpeth. In order for the DO standard to be attained in the Harpeth River headwaters, it is necessary to reduce the SOD in the segment represented by Reach #1 in the model (i.e., the Harpeth River segment upstream from RM 115.6) by 65% (see Figure 15).

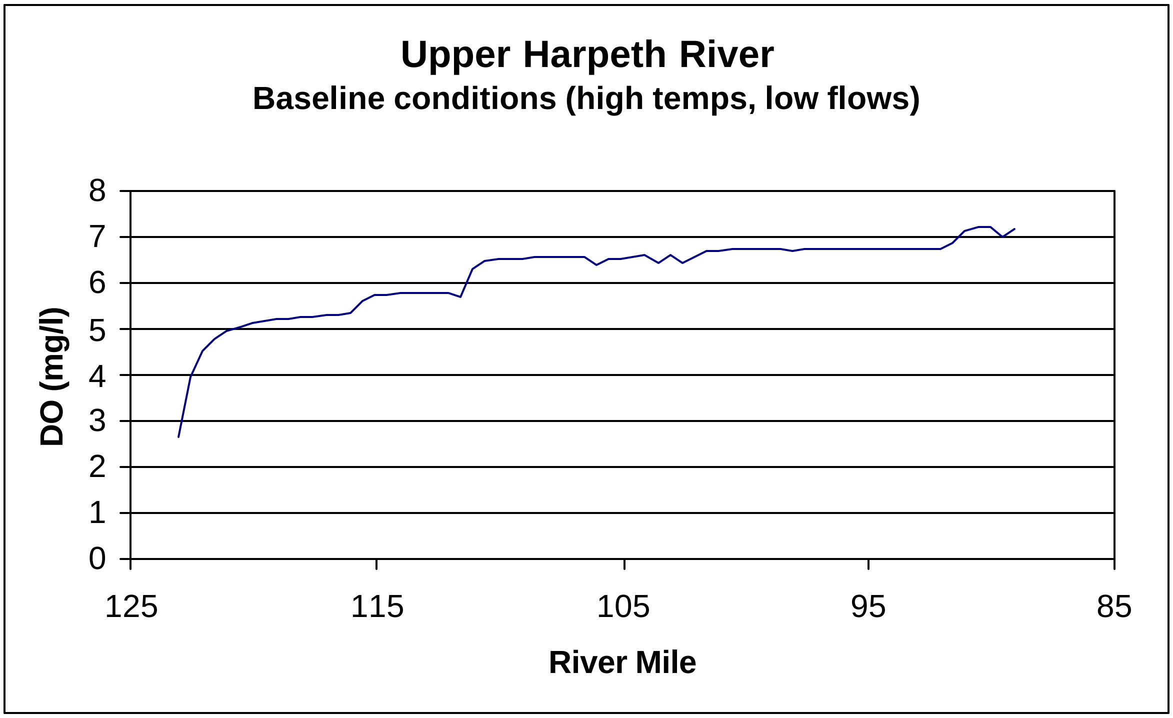

Figure 14 Predicted DO levels for QUAL2E baseline conditions

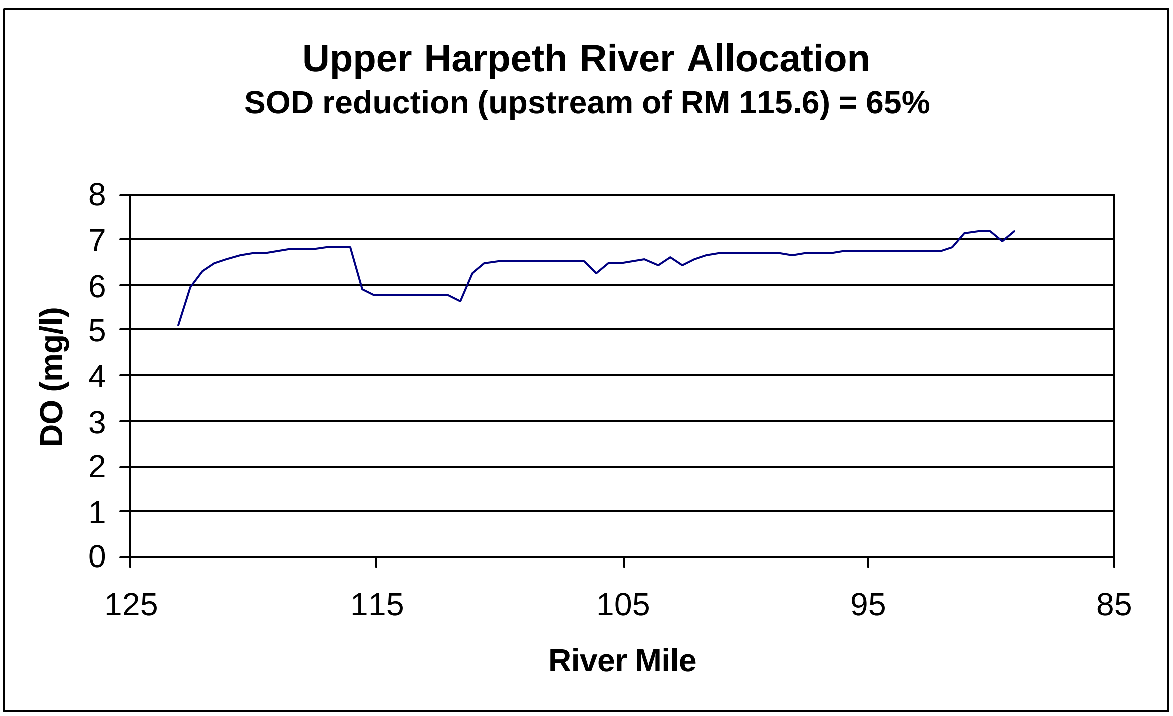

Figure 15 Predicted DO levels for QUAL2E Allocation Run

Allocations for the Upper Harpeth River TMDL

Considering that reductions in NBOD and CBOD in the Harpeth River headwaters are predicted to have an insignificant impact on instream DO level, the allocations are established to achieve an SOD reduction of 65% in the waters upstream from RM 115.6 of the Harpeth River. In order to achieve an SOD reduction of 65%, it is conservatively assumed that external load reductions on the order of 65% will be necessary. It is also conservatively assumed that reductions on the order of 65%, on a long-term average basis, will need to be achieved from nutrient loads (i.e., total phosphorus and total nitrogen) as well as loads from carbon sources (i.e., CBOD). Both the watershed load allocations to control nutrients on a monthly basis to protect the tributaries in the Upper Harpeth River, summarized in Table 19, and the load allocations on an annual average basis to control CBOD and nutrients to attain the dissolved oxygen criterion in the Upper Harpeth River, summarized in Table 24, apply to the subwatershed 051302040101. This will ensure that the summer monthly averages will protect the tributaries as well as attain a greater annual average load reduction than the nutrient TMDL would require alone.

The watershed upstream from RM 115.6 of the Harpeth River can be represented by the 12-digit subwatershed, 05130204 0101 (see Figure 1 and Figure 12). Based on the information that was used to establish the nutrient allocations for this subwatershed, the existing annual nutrient loads are approximated to be 102,000 lbs/year for total nitrogen and 21,000 lbs/year for total phosphorus. If a 65% reduction is applied to these estimated existing loads, the resulting allocation will be 35,700 lbs/year for total nitrogen and 7,350 lbs/year from total phosphorus.

The existing CBOD loads entering the Harpeth River from the 12-digit subwatershed, 05130204 0101, are not well characterized. Therefore, the CBOD allocation will be in terms of a percent reduction and will be consistent with the percent reduction of SOD that is necessary for water quality standards to be attained.

There are eight NPDES-permitted point sources that discharge upstream of the upper Harpeth River segment and therefore require a Wasteload allocation as referenced in Table 10. They are: 1) Eagleville School; 2) Page School; 3) Goose Creek Inn; 4) Oakview Elementary School; 5) Hillsboro Elementary School; 6) College Grove Elementary School; 7) Bethesda Elementary School; and 8) Trinity Elementary School. Based on QUAL2E predictions and best professional judgement, these facilities are not expected to have any impact on instream DO levels at their permitted limits. In addition, loads from these facilities enter the Harpeth River downstream of RM 115.6. Table 23 and Table 24 include the allocations to ensure attainment of the dissolved oxygen water quality standard in the headwaters of the Harpeth River.

Table 23 Wasteload Allocation to protect DO levels in the headwaters of the Harpeth River

NPDES facility	* Summer Total Nitrogen Load [a] (lbs/month)	* Winter Total Nitrogen Load [a] (lbs/month)	* Summer Total Phosphorus Load [a] (lbs/month)	* Winter Total Phosphorus Load (lbs/month)	* Summer Total $CBOD_5$ Load [b] (lbs/month)	* Winter Total $CBOD_5$ Load [b] (lbs/month)
Eagleville School (TN0057789)	45.0	67.6	22.5	33.8	45.0	45.0
Page School (TN0057835)	50.0	75.1	25.0	37.5	20.0	125.1
Goose Creek Inn (TN0060216)	75.1	112.6	37.5	56.3	75.1	75.1
Oakview Elementary (TN0067873)	25.0	37.5	12.5	18.8	25.0	25.0
Trinity Elementary School (TN0064297)	32.5	48.8	16.3	24.4	32.5	32.5
Bethesda Elementary School (TN0064475)	42.5	63.8	21.3	31.9	63.8	85.1
College Grove Elementary School (TN0067164)	30.0	45.0	15.0	22.5	30.0	75.1
Hillsboro Elementary School	75.1	112.6	37.5	56.3	75.1	75.1
CAFOs	0	0	0	0	0	0
MS4s	NA	NA	NA	NA	NA	NA

Notes: a -The allowable nutrient load is consistent with the nutrient allocation provided in Table 18

b – The allowable CBOD5 load is based on the facilities permitted limits

* Summer: May 1 – October 31; Winter: November 1 – April 30

Table 24 Load Allocation to protect DO levels in the headwaters of the Harpeth River

12-digit subwatershed	Total Nitrogen Load (lbs/year)	Total Phosphorus Load (lbs/year)	Total Reduction in CBOD (percent)
05130204 0101	35,700	7,350	65%

Development of TMDLs to address the low dissolved oxygen levels in the Harpeth River from river mile 88.1 to river mile 32.4.

This section of the TMDL report addresses the impacts of pollutant sources on dissolved oxygen concentrations in the main-stem of the Harpeth River. This section of the Harpeth River is subject to a range of flows (less than 1 cfs to more than 20,000 cfs) that have a significant impact on the ability of the River to maintain the 5.0 mg/l dissolved oxygen concentration necessary to achieve the State's water quality standards. Because of the wide range of flow regimes present in the watershed throughout a given year, EPA developed and calibrated a dynamic water quality model for the Harpeth River.

Dynamic Model Development by EPA

This model development effort was based upon six field studies of the Harpeth River conducted by EPA Region 4 staff, with significant assistance from TDEC personnel, between July 2000 and April 2002. The resulting system of linked dynamic models consists of three functional parts:

Loading Simulation Program in C++ (LSPC)

CE-QUAL-RIV1

Water Quality Analysis Simulation Program, version 6 (WASP6)

Details of the field studies and development of the linked dynamic models are documented in the "Harpeth River Watershed Modeling Effort: A Tool for TMDL Development, USEPA2002", (TMDL Modeling Report) which is currently available on EPA's website at www.epa.gov/region4/water/tmdl/tennessee. A summary of the three components is presented below.

LSPC Model

The Loading Simulation Program in C++ (LSPC) is a comprehensive data management and modeling system that is capable of representing loading, both flow and water quality, from nonpoint and point sources and simulating in-stream processes. LSPC includes the Hydrological Simulation Program – Fortran (HSPF) algorithms for hydrology, sediment, general water quality, and stream transport.

In order to simulate stream flows, watershed loadings, and resulting concentrations of nutrients and BOD in streams, the Harpeth River watershed was divided into subwatersheds as described in the TMDL Modeling Report.

CE-QUAL-RIV1 Model

CE-QUAL-RIV1 is a one dimensional (cross-sectionally averaged) hydrodynamic and water quality model, meaning that the model resolves longitudinal variations in hydraulic and water quality characteristics and is applicable where lateral and vertical variations are small. Only the hydraulic component of the model was used in this application. The hydrodynamic model is typically used to predict one-dimensional hydraulic variations in streams with highly unsteady flows that occur in the Harpeth River.

Geomorphic data for modeled sections of the Harpeth River were derived from existing stream cross-sections and interpolated data. The final geometric configuration for the model consisted of 135 cross-sections representing segment lengths of 1848-3000 feet. Upstream boundary flows were obtained from 15-minute flow data at USGS Station 03432500 located at river mile 88.1 near Franklin. In order to maintain model stability, a minimum flow of one cfs was imposed for all upstream boundary flows. Flow data at USGS Station 03434500 (near Kingston Springs at river mile 32.4) was used for the downstream model boundary conditions. LSPC model output data provided the tributary flows for inputs into the CE-QUAL-RIV1 model. Flow from the Franklin STP was considered to be significant and included as a point source. Additional data to support the model development included instantaneous measurements of stream flow and stage at selected locations for the monitoring periods of 8/22/2000-8/24/2000 and for 4/18/2001 and time-of-travel studies conducted by TDEC in 1995 and EPA in 2000 and 2001.

The CE-QUAL-RIV1 model was calibrated for flow for the water years 2000 and 2001 using the data described above. A detailed description of the model calibration process and results are presented in the TMDL Modeling Report.

WASP6 Model

The WASP6 model is a dynamic compartment-modeling program for aquatic systems, including both the water column and the under-lying benthos. The time-varying processes of advection, dispersion, point and diffuse mass loading, and boundary exchange are represented in the basic program. WASP6 was run using the EUTRO subroutine for conventional water quality analyses to assess the Harpeth River.

The calibrated CE-QUAL-RIV1 model was linked to the WASP6 model so that the water quality evaluation capabilities of WASP6 could be applied to the simulated real-time stream flows generated by the hydrodynamic model. This linkage allows the assessment of water quality on a real-time basis as well.

The WASP6 model was calibrated initially to data collected in water year 2000. This calibration adequately matched the observed data and was verified with other data sets in 2001. In addition, the model predicted the dissolved oxygen sag minimum around river mile 45, the critical low dissolved oxygen condition, which was later verified by TDEC monitoring. A detailed description of the water quality model and calibration are presented in the TMDL Modeling Report.

Development of the TMDL for the Harpeth River from River Mile 88.1 to River Mile 32.4

The objective of this TMDL is to determine where in the River and under what flow and loading conditions the dissolved oxygen concentrations are most depressed and predict what pollutant load reductions are necessary to achieve the water quality criterion of 5.0 mg/l. Using the calibrated WASP6 model, a continuous simulation was run for the dissolved oxygen profile in the River for the years 2000 and 2001. This extensive data output file was evaluated to determine the current critical conditions for the Harpeth River. The time period August 24, 2000, at 4 pm was chosen as an appropriate critical condition because of the severe dissolved oxygen depletion to near 1.0 mg/l at river mile 44, and the stability and duration of this dissolved oxygen sag event. The intent is to identify a critical condition that is not biased by unstable perturbations, which can occur in a dynamic model. This severe dissolved oxygen depletion occurred about 40 miles downstream of the Franklin Sewage Treatment Plant (STP) discharge indicating that additional sources of pollution are likely contributing to the depletion of the dissolved oxygen in the River.

The principal sources of pollution impacting this section of the Harpeth River are the major NPDES facility, Franklin STP described in Table 9, two minor facilities, Lynnwood STP and Cartwright STP which are described in Table 8, and the watershed runoff of nutrients depicted in Figure 13 and requiring nutrient load reductions documented in Table 19. A variety of pollutant load scenarios were investigated and the scenarios used to develop the TMDL are presented below in Figures 16 and 17.

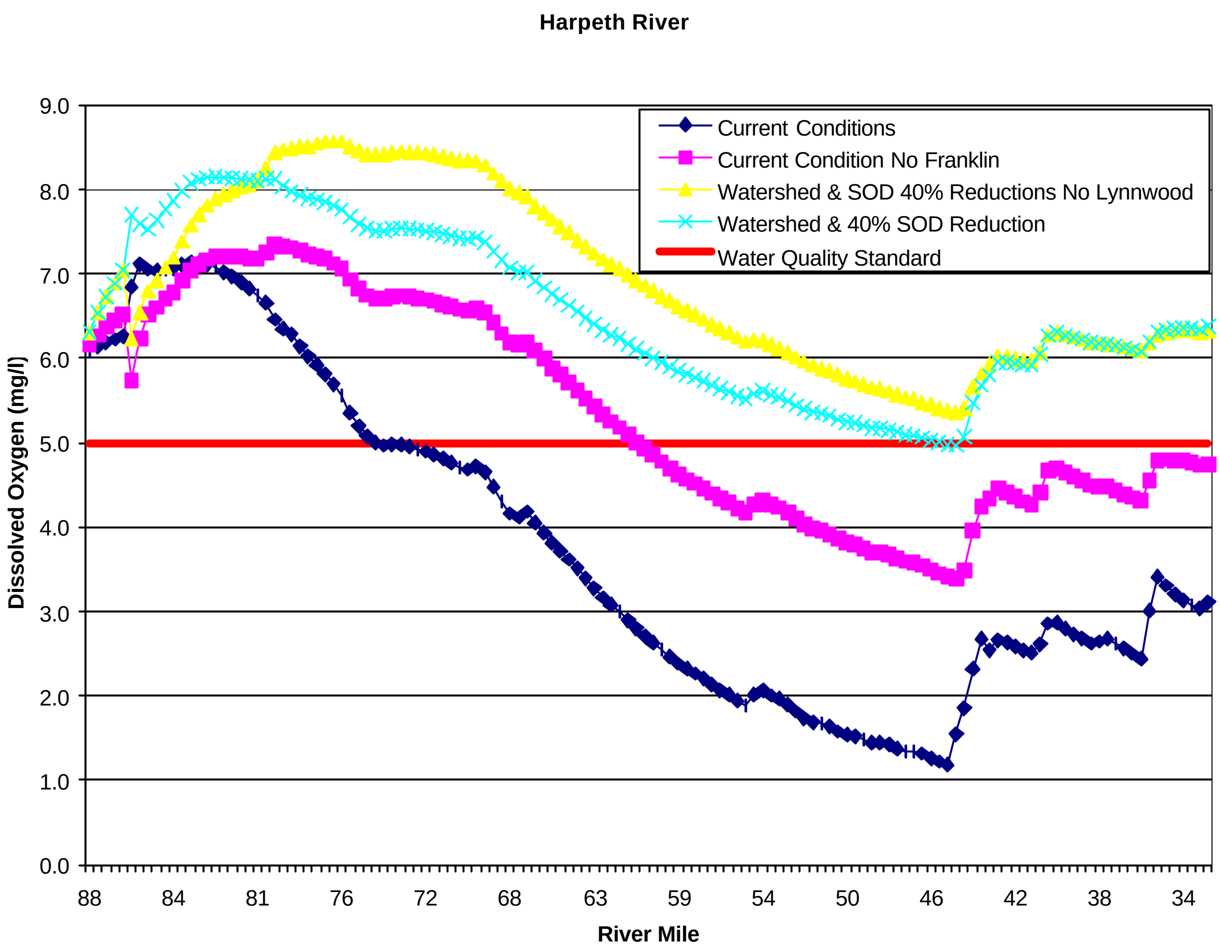

Figure 16 Predicted DO levels versus Pollutant Reduction Scenarios at Critical Conditions

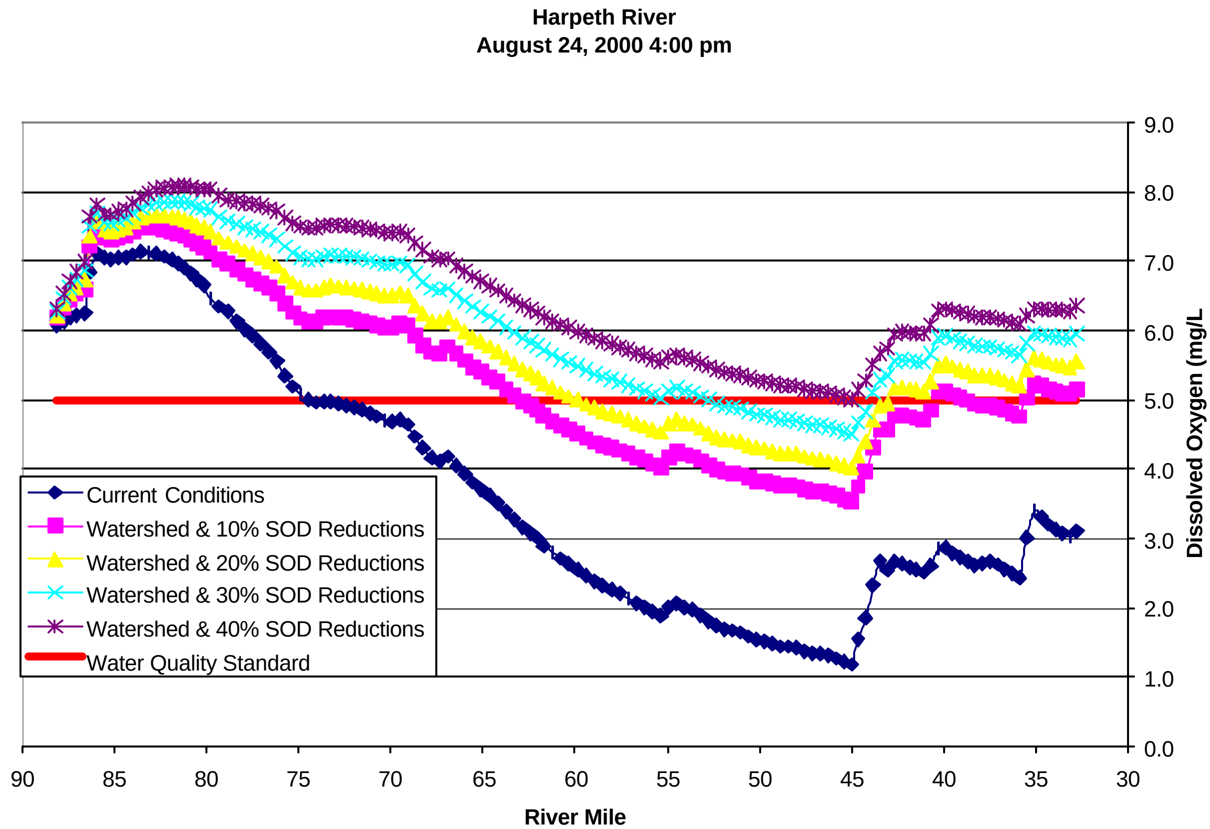

Figure 17 Predicted DO levels versus SOD Reductions at Critical Conditions

As can be seen in Figure 16, removal of the Franklin STP discharge improves water quality but does not provide sufficient pollutant load reduction to achieve the water quality criterion of 5.0 mg/l. An SOD reduction of 40 percent will achieve the water quality criterion. An additional scenario, removing the largest minor discharger, Lynnwood STP, along with a 40 percent SOD reduction illustrates that the relative impact of this facility and by analogy, Cartwright Creek STP, are not sources requiring additional controls to achieve water quality standards.

The sensitivity of the Harpeth River to SOD reductions is illustrated in Figure 17. A 10 percent reduction achieves the greatest incremental improvement in water quality but it does take the 40 percent reduction to fully achieve water quality standards under these critical conditions. It is interesting to note that the removal of the Franklin STP discharge is roughly equilavent to a 10 percent reduction in SOD. As discussed in the headwaters of the Harpeth River section, there is a relationship between the control of polluted runoff from a watershed and the expected relative reduction in the SOD in the receiving stream. EPA believes that there is a reasonable expectation that the nutrient reduction targets for the subwatersheds will require the implementation of best management practice controls sufficient to also achieve a 40 percent reduction in SOD.

To fully assess the potential impacts of the Franklin STP, the WASP6 model was run with Franklin STP operating at its design flow of 12 MGD and CBOD5 permitted concentration of 6 mg/l for the summer monthly average. The WASP6 model used ultimate CBOD to calculate impacts on dissolved oxygen. Two samples of Franklin STP discharge were evaluated to determine the ratio of ultimate CBOD to CBOD5. EPA used the most conservative ratio of 5.3, which is significantly greater than the typical range 3-3.5 for advanced secondary STPs. The model was run under the critical condition, assuming the 40 percent reduction of SOD is achieved and the Franklin STP operating at the design conditions. In addition, the model was run with incremental STP load reductions to determine the allowable load under design flow conditions. The results of these model runs are presented in Figure 18.

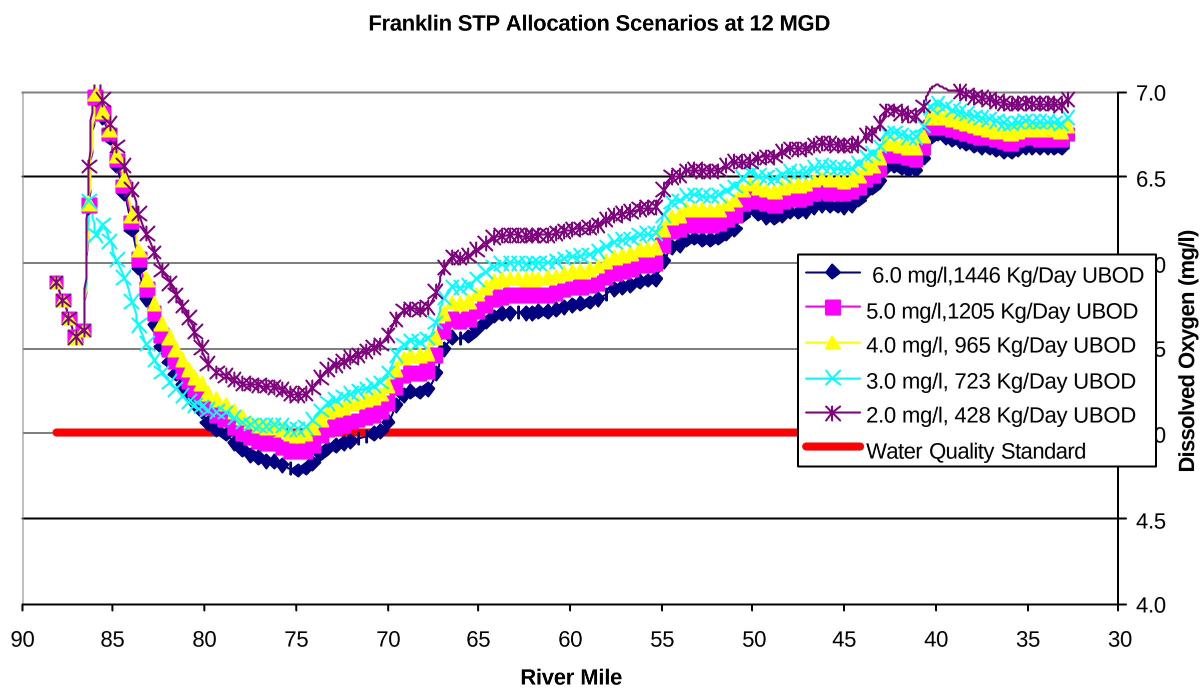

Figure 18 Predicted DO levels versus Franklin STP Treatment Levels at Critical Conditions

It is clear that the Franklin STP is projected to create a dissolved oxygen deficit about 10 miles downstream of the discharge. The incremental load reduction analysis indicates that the allowable CBOD5 concentration should be 4.0 mg/l calculated using the ultimate CBOD to CBOD5 ratio of 5.3:1. It is interesting to note that even with the existing permit limit of 6 mg/l CBOD5 at the 12 MGD design flow; the dissolved oxygen concentrations actually improve downstream from the projected improvements the 40 % SOD reductions achieve with Franklin STP operating at current conditions. This effect can be attributed to the increased flow of about 6 MGD, which is saturated with oxygen to 8.0 mg/l as required under the permit. Under existing conditions, the STP was discharging at less than one half of the design flow. The introduction of this significant increased load of oxygen to the stream, over 400 pounds of oxygen per day, plus the improvements in the stream re-aeration characteristics at very low flow conditions account for the significant improvements in the far downstream dissolved oxygen concentrations.

TMDL Allocations for the Harpeth River from River Mile 88.1 to River Mile 32.4

The TMDL for this portion of the Harpeth River is developed to ensure year-round protection of water quality standards. Reductions of pollutant loads during the summer season (May through October), when low-flow, high temperature conditions are expected to occur, are necessary to attain water quality standards for this period. In order to ensure protection during the winter season (November through April), the period during which the dissolved oxygen criterion is currently being maintained, pollutant loads must not increase above existing levels.

The allocations are developed to attain water quality standards in consideration of the existing effluent flow conditions as well as the effluent flows at the STP design conditions. Under existing effluent flows, an extensive dissolved oxygen deficit occurs during summer low flow conditions in the river from RM 75 to approximately RM 45, which is the primary reach of concern.

As discussed in the previous Section, the only effective means of achieving the dissolved oxygen criterion of 5.0 mg/l during the summer season is to significantly reduce the SOD in the River. As discussed earlier in this report, year-round nutrient reductions are required for the HUC-12 subwatersheds in order to ensure protection of biological integrity of the impaired waters within those subwatersheds (see Table 16). The nutrient allocations for the subwatersheds affecting the primary reach of concern of the lower Harpeth River already require reductions in total nitrogen and phosphorous (median reductions of 44% and 81.3% respectively) which are greater than the 40 percent reduction in SOD necessary to achieve water quality standards. Using the conservative assumption that a percent reduction in watershed pollutant load will achieve a comparable reduction in stream SOD, the implementation of best management practices to address the nutrient controls to protect the tributary streams to the Harpeth River should produce sufficient SOD reduction in the Harpeth River.

As a point of comparison, the allocations for nitrogen, the limiting nutrient in the Harpeth River, for the six subwatersheds discharging to the lower Harpeth River is 1060 pounds per day (calculated using data in Table 16). The three STPs that discharge to the lower Harpeth River are projected to discharge 327 pounds of nitrogen per day at design flow conditions (calculated from data in Table 8 and Table 10). Since Franklin STP contributes 290 pounds of the 327 pounds per day and is 40 miles upstream from the most severe dissolved oxygen deficit, it is reasonable to assume that watershed discharges closer to the impacted zone have a more pronounced impact on SOD. In addition, the three STPs are currently operating close to advanced wastewater treatment performance levels of less than 4 mg/l CBOD5, 1 mg/l ammonia, and 5 mg/l total nitrogen. These STPs are performing at treatment levels, which are technically and economically difficult to surpass. Therefore, EPA considers it appropriate to allocate the allowable total nitrogen load to the lower Harpeth River as a 76% contribution from the watersheds (1060 lbs/day as an annual load) and a

24% contribution from the STPs, (327 lbs/day as an annual load). In consideration of seasonal variability of effluent nitrogen levels, the three STPs are expected to discharge nitrogen loads during the winter months that are greater than the loads discharged during the summer months. This will be consistent with the TMDL as long as the annual average nitrogen wasteload allocations are achieved.

The future condition where Franklin STP operates at design flow and pollutant loads and creates a dissolved oxygen deficit ten miles downstream was used to allocate pollutant reductions to the STP to ensure water quality standards will be achieved under the current 12 MGD design flow conditions. The load reduction analysis indicates that the allowable CBOD5 concentration should be lowered to 4 mg/l from the current allowable 6 mg/l, based upon the use of the ultimate CBOD to CBOD5 ratio of 5.3:1. A summary of the TMDL load allocations is presented in the Tables below.

Table 25 Wasteload Allocation to STPs to protect DO levels in the lower Harpeth River

Facility	* Summer CBOD5 Lbs/day	* Summer Ammonia lbs/day	* Winter CBOD5 lbs/day	* Winter Ammonia lbs/day	Annual Total N lbs/day
Franklin STP	400 (4.0mg/l)	40 (0.4 mg/l)	1001 (10.0 mg/l)	150 (1.5 mg/l)	290 (2.9 mg/l)
Lynnwood STP	17 (5.0 mg/l)	7 (2.0mg/l)	33 (10.0 mg/l)	17 (5.0mg/l)	22 (6.6 mg/l)
Cartwright Creek STP	10 (5.0 mg/l)	4 (2.0 mg/l)	21 (10.0 mg/l)	10 (5.0 mg/l)	15 (7.0 mg/l)

* Summer: May 1 – October 31; Winter: November 1 – April 30

Table 26 Wasteload and Load Allocations to Watershed Runoff protect DO levels in the lower Harpeth River

HUC-12 Subwatershed (05130204)	Total Nitrogen * Summer lbs/month	Total Nitrogen * Winter lbs/month	WLA Percent Reduction in MS4 Area	LA Percent Reduction in rural area
0104	7335	21966	20.0	20.0
0105	5864	18260	49.4	49.4
0201	4062	12649	53.1	53.1
0202	3026	9119	53.1	53.1
0301	6253	18537	44.8	44.8
0302	5275	16425	34.3	34.3

* Summer: May 1 – October 31; Winter: November 1 – April 30

Margin of Safety (MOS)

There are two methods for incorporating a MOS in the analysis: a) implicitly incorporate the MOS using conservative model assumptions to develop allocations; or b) explicitly specify a portion of the TMDL as the MOS and use the remainder for allocations. In these TMDLs, an implicit MOS was incorporated through the use of conservative modeling assumptions.

MOS for nutrient TMDLs

The primary conservative assumption was the selection of target concentrations based on the 75th percentile of nutrient data collected from Level IV ecoregion reference sites. These sites represent the least impacted streams in the ecoregion. In addition, the use of a monthly time-averaging period is assumed. An explicit MOS of 5% of the TMDL was also utilized prior to calculation of WLAs & LAs (see Appendix I).

MOS for TMDL for Harpeth River Headwaters

The primary conservative assumption was the use of critical low-flow and temperature conditions in the model runs to determine the allocations.

MOS for TMDL for Harpeth River Mile 88.1 to River Mile 32.4

The use of calibrated dynamic models allowed EPA to identify critical flow and pollutant loading conditions that had the most severe impacts on the dissolved oxygen concentration in the River both in terms of magnitude and duration. In addition, there are two controlling conditions: 1) SOD impacts under current loads from the Franklin STP and 2) the impacts of the Franklin STP at design flow with SOD reduced by 40 percent. When both these conditions are mitigated by pollutant load reductions, the projected dissolved oxygen concentrations exceed 6.0 mg/l where the River now experiences low flow dissolved oxygen levels near 1.0 mg/l.

Seasonal Variation

These TMDLs were developed and designed to provide for year-round protection of water quality and therefore sufficiently address seasonal variations in environmental conditions.

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APPENDIX A

Nutrients & Water Quality

Nutrients and Water Quality

The following information was excerpted from *Protocol for Developing Nutrient TMDLs, First Edition* (USEPA, 1999). Minor formatting changes and the identification of the table have been made for inclusion in this TMDL document. References cited have been included on the last page of this Appendix.

Impact of Nutrients on Designated Uses

Excess nutrients in a waterbody can have many detrimental effects on designated or existing uses, including drinking water supply, recreational use, aquatic life use, and fishery use. For example, drinking water supplies can be impaired by nitrogen when nitrate concentrations exceed 10 mg/L and can cause methemoglobinemia (Blue Baby Syndrome) in infants. Water supplies containing more than 100 mg/L of nitrate can also taste bitter and can cause physiological distress (Straub, 1989).

Although these are examples of the direct impacts that can be associated with excessive nutrient loadings, waters more often are listed as impaired by nutrients because of their role in accelerating eutrophication. Eutrophication, or the nutrient enrichment of aquatic systems, is a natural aging process of a waterbody that transforms a lake into a swamp and ultimately into a field or forest. (The term *eutrophication* as used in this document refers to the nutrient enrichment of both lakes and rivers, although it is recognized that rivers do not have the same natural aging process.) This aging process can accelerate with excessive nutrient inputs because of the impact they have without other limiting factors, such as light.

A eutrophic system typically contains an undesirable abundance of plant growth, particularly phytoplankton, periphyton, and macrophytes. Phytoplankton, photosynthetic microscopic organisms (algae), exist as individual cells or grouped together as clumps or filamentous mats. Periphyton is the assemblage of organisms that grow on underwater surfaces. It is commonly dominated by algae but also can include bacteria, yeasts, molds, protozoa, and other colony forming organisms. The term macrophyte refers to any larger than microscopic plant life in aquatic systems. Macrophytes may be vascular plants rooted in the sediment, such as pond weeds or cattails, or free-floating plant life, such as duckweed or coontail.

The eutrophication process can impair the designated uses of waterbodies as follows:

- *Aquatic life and fisheries.* A variety of impairments can result from the excessive plant growth associated with nutrient loadings. These impairments result primarily when dead plant matter settles to the bottom of a waterbody, stimulating microbial breakdown processes that require oxygen. Eventually, oxygen in the hypolimnion of lakes and reservoirs can be depleted, which can change the benthic community structure from aerobic to anaerobic organisms. Oxygen depletion also might occur nightly throughout the waterbody because of plant respiration. Extreme oxygen depletion can stress or eliminate desirable aquatic life and nutrients, and toxins also might be released from sediments when dissolved oxygen and pH are lowered (Brick and Moore, 1996).

Breakdown of dead organic matter in water also can produce un-ionized ammonia, which can adversely affect aquatic life. The fraction of ammonia present as un-ionized ammonia depends on temperature and pH. Fish may suffer a reduction in hatching success, reductions in growth rate and morphological development, and injury to gill tissue, liver, and kidneys. At certain ammonia levels fish also might suffer a loss of equilibrium, hyperexcitability, increased respiratory activity and oxygen uptake, and increased heart rate. At extreme ammonia levels, fish may experience convulsions, coma, and death (USEPA, 1986a; revised 1998b).

- *Drinking water supply.* Diatoms and filamentous algae can clog water treatment plant filters and reduce the time between backwashings (the process of reversing water flow through the water filter to remove debris). Disinfection of water supplies impaired by algal growth also might result in water that contains potentially carcinogenic disinfection byproducts, such as trihalomethanes. An increased rate of production and breakdown of plant matter also can adversely affect the taste and odor of the drinking water.

- *Recreational use.* The excessive plant growth in a eutrophic waterbody can affect recreational water use. Extensive growth of rooted macrophytes, periphyton, and mats of living and dead plant material can interfere with swimming, boating, and fishing activities, while the appearance of and odors emitted by decaying plant matter impair aesthetic uses of the waterbody.

Nutrient Sources and Transport

Both nitrogen and phosphorus reach surface waters at an elevated rate as a result of human activities. Phosphorus, because of its tendency to sorb to soil particles and organic matter, is primarily transported in surface runoff with eroded sediments. Inorganic nitrogen, on the other hand, does not sorb as strongly and can be transported in both particulate and dissolved phases in surface runoff. Dissolved inorganic nitrogen also can be transported through the unsaturated zone (interflow) and ground water. Because nitrogen has a gaseous phase, it can be transported to surface water via atmospheric deposition. Phosphorus associated with fine-grained particulate matter also exists in the atmosphere. This sorbed phosphorus can enter natural waters by both dry fallout and rainfall. Finally, nutrients can be directly discharged to a waterbody via outfalls for wastewater treatment plants and combined sewer overflows. Table A-1 presents common point and nonpoint sources of nitrogen and phosphorus and the approximate associated concentrations.

Table A-1. Sources And Concentrations Of Nutrients from Common Point and Nonpoint Sources

Source	Nitrogen (mg/l)	Phosphorus (mg/l)

Urban Runoff	3-10	0.2 – 1.7
Livestock operations	6 – 800 [a]	4 – 5
Atmosphere (wet deposition)	0.9	0.015 [b]
Untreated wastewater	35	10
Treated wastewater (secondary treatment)	30	10

a As organic nitrogen; b Sorbed to airborne particulate

Source: Novotny and Olem, 1994

Once in the waterbody, nitrogen and phosphorus act differently. Because inorganic forms of nitrogen do not sorb strongly to particulate matter, they are more easily returned to the water. Phosphorus, on the other hand, can sorb to sediments in the water column and on the substrate and become unavailable. In lakes and reservoirs, continuous accumulation of sediment can leave some phosphorus too deep within the substrate to be reintroduced to the water column, if left undisturbed; however, a portion of the phosphorus in the substrate might be reintroduced to the water column. The activities of benthic invertebrates and changes in water chemistry (such as the reducing conditions of bottom waters and sediments often experienced during the summer months in a lake) also can cause phosphorus to desorb from sediment. A large, slow-moving river also might experience similar phosphorus releases. The sudden availability of phosphorus in the water column can stimulate algal growth. Because of this phenomenon, a reduction in phosphorus loading might not effectively reduce algal blooms for many years (Maki et al., 1983).

Nutrient Cycling

The transport of nutrients from their sources to the waterbody of concern is governed by several chemical, physical, and biological processes, which together compose the nitrogen or phosphorus cycle. Nutrient cycles are important to understand for developing a TMDL because of the information they provide about nutrient availability and the associated impact on plant growth.

Nitrogen

Nitrogen is plentiful in the environment. Almost 80 percent of the atmosphere by volume consists of nitrogen gas (N2). Although largely available in the atmosphere, N2 must be converted to other forms, such as nitrate ($NO3^-$), before most plants and animals can use it. Conversion into usable forms, both in the terrestrial and aquatic environments, occurs through the four processes of the nitrogen cycle. Three of the processes—nitrogen fixation, ammonification, and nitrification—convert gaseous nitrogen into usable chemical forms. The fourth process, denitrification, converts fixed nitrogen back to the gaseous N2 state.

- *Nitrogen fixation.* The conversion of gaseous nitrogen into ammonia ions ($NH3$ and $NH4^+$). Nitrogen-fixing organisms, such as blue-green algae (cyanobacteria) and the bacteria *Rhizobium* and *Azobacter*, split molecular nitrogen (N2) into two free nitrogen molecules. The nitrogen molecules combine with hydrogen molecules to yield ammonia ions.

- *Ammonification.* A one-way reaction in which decomposer organisms break down wastes and nonliving organic tissues to amino acids, which are then oxidized to carbon dioxide, water, and ammonia ions. Ammonia is then available for absorption by plant matter.

- *Nitrification.* A two-step process by which ammonia ions are oxidized to nitrite and nitrate, yielding energy for decomposer organisms. Two groups of microorganisms are involved in the nitrification process. First, *Nitrosomonas* oxidizes ammonia ions to nitrite and water. Second, *Nitrobacter* oxidizes the nitrite ions to nitrate, which is then available for absorption by plant matter.

- *Denitrification.* The process by which nitrates are reduced to gaseous nitrogen by facultative anaerobes. Facultative anaerobes, such as fungi, can flourish in anoxic conditions because they break down oxygen containing compounds (e.g., $NO3^-$) to obtain oxygen.

Once introduced into the aquatic environment, nitrogen can exist in several forms—dissolved nitrogen gas (N2), ammonia ($NH4^+$ and NH3), nitrite ($NO2^-$), nitrate ($NO3^-$), and organic nitrogen as proteinaceous matter or in dissolved or particulate phases. The most important forms of nitrogen in terms of their immediate impact on water quality are the readily available ammonia ions, nitrites, and nitrates (dissolved nitrogen). (Note that plants cannot directly use nitrate but must first convert it to ammonium using the enzyme nitrate reductase. Because the ability to do this is ubiquitous, nitrate is considered to be bioavailable.) Particulate and organic nitrogen, because they must be converted to a usable form, are less important in the short term. Total nitrogen (TN) is a measurement of all forms of nitrogen.

Nitrogen continuously cycles in the aquatic environment, although the rate is temperature-controlled and thus very seasonal. Aquatic organisms incorporate available dissolved inorganic nitrogen into proteinaceous matter. Dead organisms decompose, and nitrogen is released as ammonia ions and then converted to nitrite and nitrate, where the process begins again. If a surface water lacks adequate nitrogen, nitrogen-fixing organisms can convert nitrogen from its gaseous phase to ammonia ions.

Phosphorus

Under normal conditions, phosphorus is scarce in the aquatic environment. Unlike nitrogen, phosphorus does not exist as a gas and therefore does not have gas-phase atmospheric inputs to aquatic systems. Rocks and natural phosphate deposits are the main reservoirs of natural phosphorus. Release of these deposits occurs through weathering, leaching, erosion, and mining. Terrestrial phosphorus cycling includes immobilizing inorganic phosphorus into calcium or iron phosphates, incorporating inorganic phosphorus into plants and microorganisms, and breaking down organic phosphorus to inorganic forms by bacteria. Some phosphorus is inevitably transported to aquatic systems by water or wind.

Nutrients and Water Quality

Phosphorus in freshwater and marine systems exists in either an organic or inorganic form.

- *Organic phosphorus*. Organic particulate phosphorus includes living and dead particulate matter, such as plankton and detritus. Organic nonparticulate phosphorus includes dissolved organic phosphorus excreted by organisms and colloidalphosphorus compounds.

- *Inorganic phosphorus*. The soluble inorganic phosphate forms $H2PO4^-$, $HPO4^{2-}$, and $PO4^3$, known as soluble reactive phosphorus (SRP), are readily available to plants. Some condensed phosphate forms, such as those found in detergents, are inorganic but are not available for plant uptake. Inorganic particulate phosphorus includes phosphorus precipitates, phosphorus adsorbed to particulate, and amorphous phosphorus.

The measurement of all phosphorus forms in a water sample, including all the inorganic and organic particulate and soluble forms mentioned above, is known as total phosphorus (TP). TP does not distinguish between phosphorus currently unavailable to plants (organic and particulate) and that which is available (SRP). SRP is the most important form of phosphorus for supporting algal growth because it can be used directly. However, other fractions are transformed to more bioavailable forms at various rates dependent on microbial action or environmental conditions. In streams with relatively short residence times, it is less likely that the transformation from unavailable to available forms will have time to occur and SRP is the most accurate estimate of biologically available nutrients. In lakes, however, where residence times are longer, TP generally is considered an adequate estimation of bioavailable phosphorus.

Phosphorus undergoes continuous transformations in a freshwater environment. Some phosphorus will sorb to sediments in the water column or substrate and be removed from circulation. Phytoplankton, periphyton, and bacteria assimilate the SRP (usually as orthophosphate) and change it into organic phosphorus. These organisms then may be ingested by detritivores or grazers, which in turn excrete some of the organic phosphorus as SRP. Some previously unavailable forms of phosphorus also convert to SRP. Continuing the cycle, the SRP is rapidly assimilated by plants and microbes.

Human activities have resulted in excessive loading of phosphorus into many freshwater systems. Overloads result in an imbalance of the natural cycling processes. Excess available phosphorus in freshwater systems can result in accelerated plant growth if other nutrients and other potentially limiting factors are available.

<u>Other Limiting Factors</u>

Many natural factors combine to determine rates of plant growth in a waterbody. First of these is whether sufficient phosphorus and nitrogen exist to support plant growth. The absence of one of these nutrients generally will restrict plant growth. In inland waters, typically phosphorus is the limiting nutrient of the two, because blue-green algae can "fix" elemental nitrogen from the water as a nutrient source. In marine waters, either phosphorus or nitrogen can be limiting. Although carbon and trace elements are usually abundant, occasionally they can serve as limiting nutrients. However, even if all necessary nutrients are available, plant production will not necessarily continue unchecked. Many natural factors, including light availability, temperature, flow levels, substrate, grazing, bedrock type and elevation, control the levels of macrophytes, periphyton, and phytoplankton in waters. Effective management of eutrophication in a waterbody may require a simultaneous evaluation of several limiting factors.

- *Light availability.* Shading of the water column inhibits plant growth. Numerous factors can shade waterbodies, including: (1) as plant production increases in the upper water layer, the organisms block the light and prevent it from traveling deeper into the water column; (2) riparian growth along waterbodies provides shade; and (3) particulates in the water column scatter light, decreasing the amount penetrating the water column and available for photosynthesis.

  With seasonally high particulate matter or shading (e.g., in deciduous forests), the high nutrients may cause excessive growth only during certain times of the year: for example, streams where snowmelt is common in the spring. Snowmelt could lead to high levels of suspended particulate matter and low algal biomass. During stable summer flows, however, there will be lower levels of suspended matter and hence higher algal biomass.

- *Temperature.* Temperature affects the rates of photosynthesis and algal growth, and composition of algal species. Depending on the plant, photosynthetic activity increases with temperature until a maximum photosynthetic output is reached, when photosynthesis declines (Smith, 1990). Moreover, algal community species composition in a waterbody often changes with temperature. For example, diatoms most often are the dominant algal species at water temperatures of 20 ° to 25 °C, green algae at 30 ° to 35 °C, and blue-green algae (cyanobacteria) above 35 °C (Dunne and Leopold, 1978; USEPA, 1986b).

- *Water Velocity.* Water movement in large lakes, rivers, and streams influences plant production. Stream velocity has a two-fold effect on periphyton productivity: increasing velocity to a certain level enhances biomass accrual but further increases can result in substantial scouring (Horner et al., 1990). Large lakes and estuaries can experience the scouring action of waves during strong storms (Quinn, 1991). In rivers and streams, frequent disturbance from floods (monthly or more frequently) and associated movement of bed materials can scour algae from the surface rapidly and often enough to prevent attainment of high biomass (Horner et al., 1990). Rapid flows can sweep planktonic algae from a river reach, while low flows may provide an opportunity for proliferation.

- *Substrate.* Macrophytes and periphyton are influenced by the type of substrate available. Macrophytes prefer areas of fine sediment in which to root (Wright and McDonnell, 1986, in Quinn, 1991). Thus, the addition and removal of sediment from a system can influence macrophyte growth. Periphyton, because of its need to attach to objects, grows best on large, rough substrates. A covering of sediment over a rocky substrate decreases periphyton biomass (Welch et al., 1992).

- *Grazing.* Dense populations of algae-consuming grazers can lead to negligible algal biomass, in spite of high levels of nutrients (Steinman, 1996). The existence of a "trophic cascade" (control of algal biomass by community composition of grazers and their predators) has been demonstrated for some streams (e.g., Power, 1990). Managers should realize the potential control of algal biomass by grazers, but they also should be aware that populations of grazers can fluctuate seasonally or unpredictably and fail to control biomass at times. Consideration of grazer populations might explain why some streams with high nutrients have low algal biomass.

- *Bedrock*. The natural effects of bedrock type also might help explain trophic state. Streams draining watersheds with phosphorus-rich rocks (such as rocks of sedimentary or volcanic origin) can be enriched naturally and, therefore, control of algal biomass by nutrient reduction in such systems might be difficult. Review of geologic maps and consultation with a local soil scientist might reveal such problems. Bedrock composition has been related to algal biomass in some systems (Biggs, 1995).

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APPENDIX B

Results of Greenspan CS304 Combination Sensor

Deployment in the Harpeth River

Figure B-1 Diurnal Dissolved Oxygen in the Harpeth River (8/2/02 to 8/11/02)

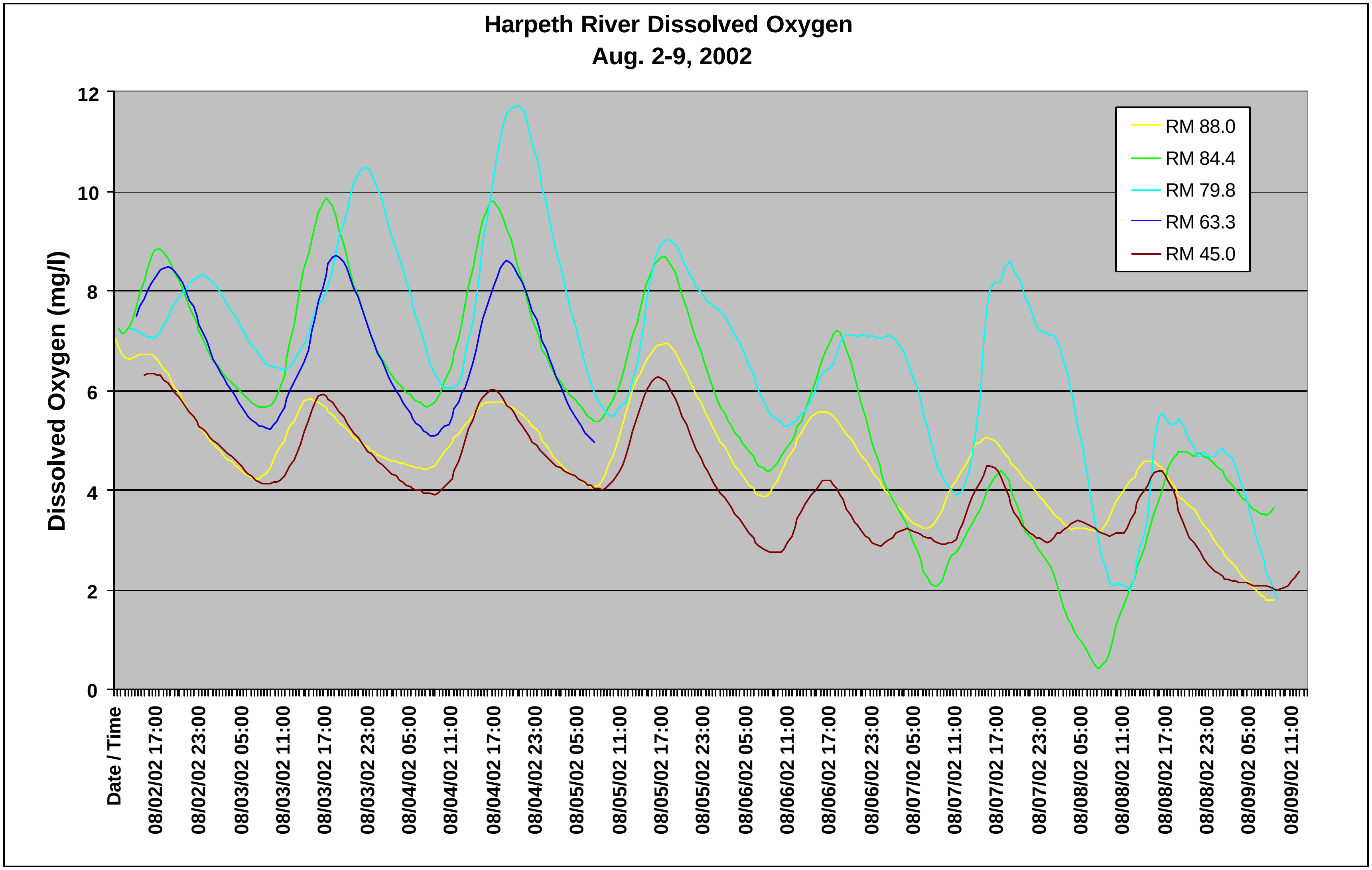


Figure B-2 Harpeth River Temperature (8/2/02 to 8/11/02)

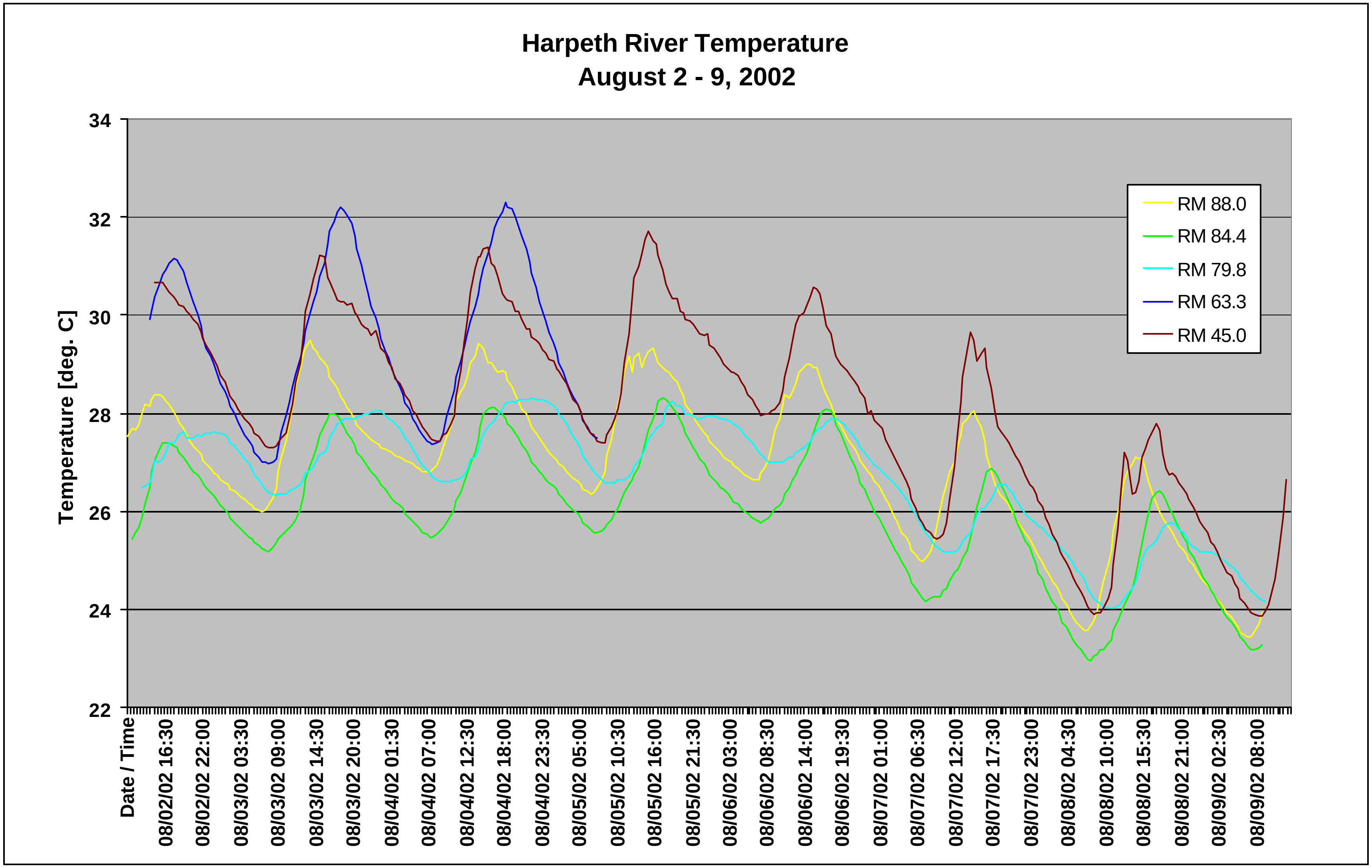


Figure B-3 Harpeth River Conductivity (8/2/02 to 8/11/02)

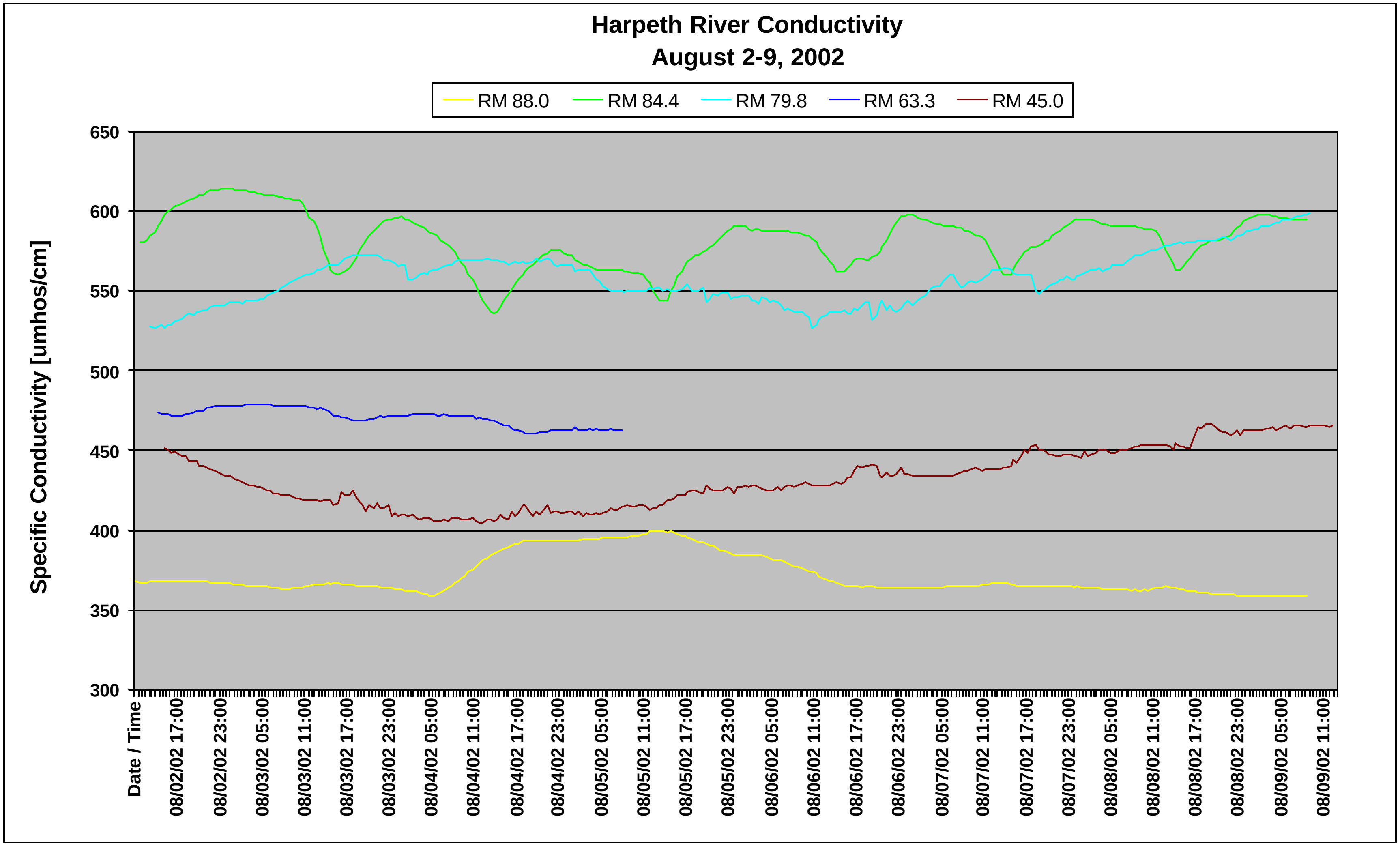


Figure B-4 Diurnal Dissolved Oxygen in the Harpeth River (9/11/02 to 9/25/02)

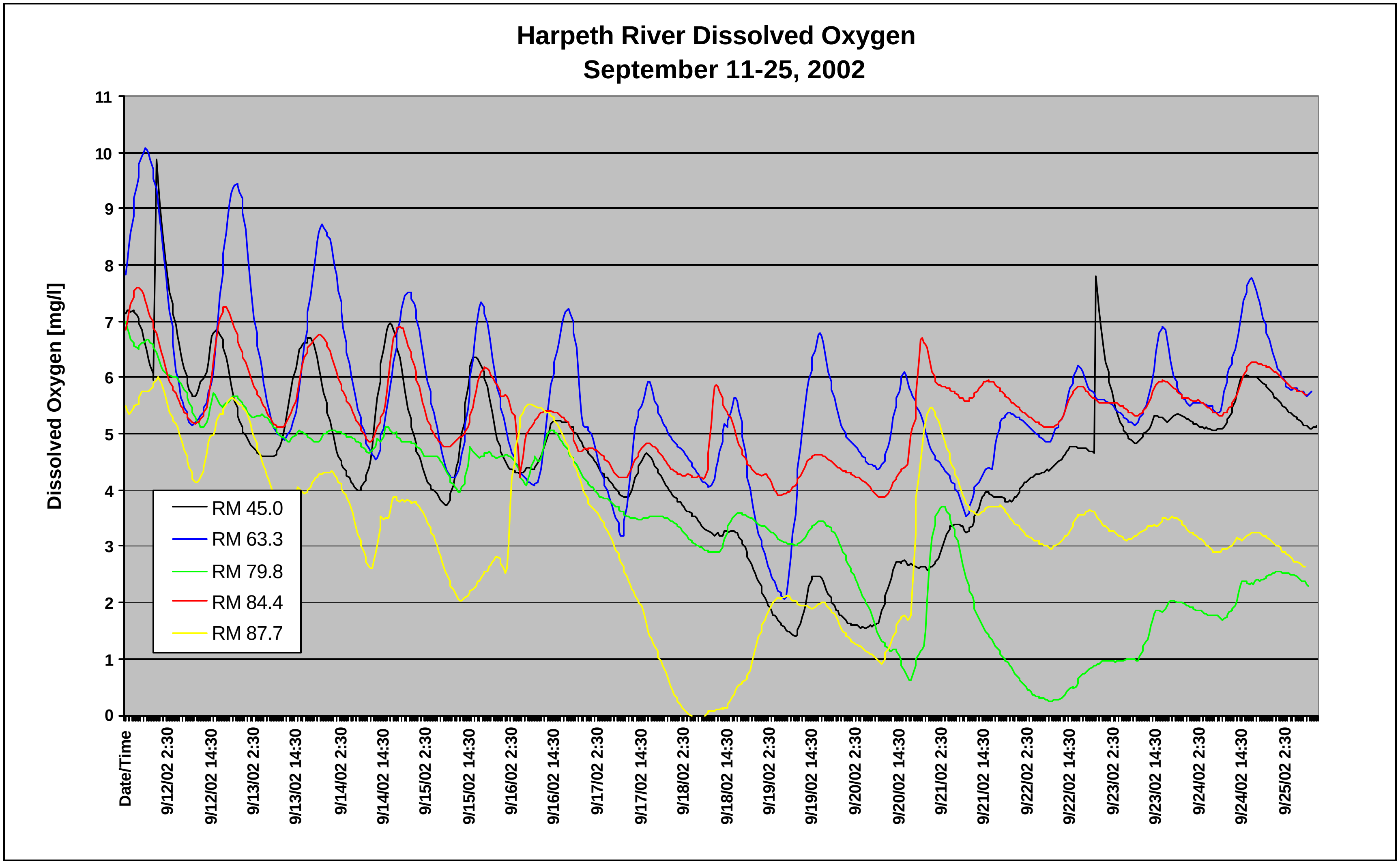
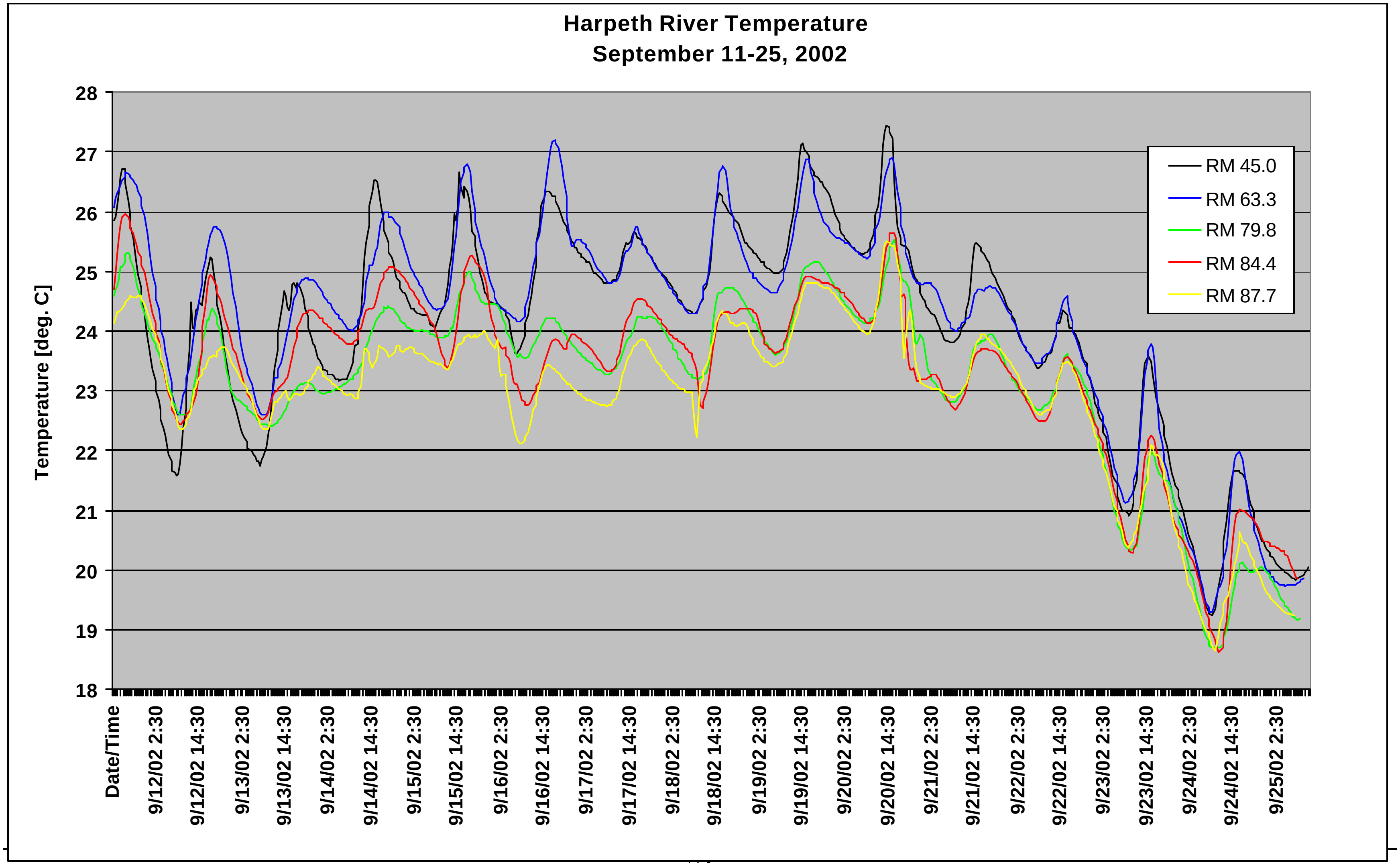


Figure B-5 Harpeth River Temperature (9/11/02 to 9/25/02)



APPENDIX C

Example of Stream Assessment

(Upper Harpeth River)

Example of Stream Assessment – Upper Harpeth River (6 pages)

STREAM; Upper Harpeth River (TN) (WBA Full) STATION #: 5130204 18 6.97=RF3

WBID #: TN05130204016

COUNTY: Rutherford WBID NAME: Upper Harpeth R

NOTE: TCW QA/QC & TRAI (see TCW separate sheets)

TYPE OF ASSESSMENT: WBA, WWC, RBA, ACAP, General, Observation, Other: WS WBA / RBPI

DRAINAGE BASIN: Lower Cumberland ECOREGION: 71H

POINT (S) OF ASSESSMENT (include RM): RM=116.2 @ SHOEMAKER / RIVER ROAD (used to be Swamp Road) (~1000' ASSESSED) (1:45-3:00)

LAT/LONG FOR EACH POINT: 35° 45' 39" / 86° 37' 39" = GPS

DATE OF ASSESSMENT: 08/06/97 DATE OF REPORT: 08/06 + ASSESSOR: AMG

DRAINS TO: Cumberland R @RM 152.9 @RM -> @RM ->

STREAM ORDER: 4th ELEVATION: 720 FT. USGS STA 034320

WATERSHED SIZE: 64.6 mi² 3Q20: 0.0 AT WHAT RM AND/OR LAT/LONG AND SOURCE: RM 102.2 [35° 49' 14" / 86° 41' 16"]

QUADRANGLE # AND NAME: 70SW College Grove, TN MAP ATTACHED? YES NO

GEOLOGIC FORMATION:

TOTAL LENGTH OF STREAM ASSESSED: 1000' assessed

WHAT % OF THE STREAM'S WATERSHED DID YOU OBSERVE, DESCRIBE IT: ~90% of US WS about 0.5 mi: 80% pasture cows / 20% roads, residents / riparian loss = extensive

PREVIOUS 7-DAY PRECIP: flash flooding, heavy downpour, mod. rainfall, light rainfall, none, don't know

CHANNEL FLOW STATUS: water fills 98-100% of the available channel / 0-2 % of channel substrate exposed

PRESENT AIR TEMP: ~ 89°F WEATHER: sunny, clear

REASON YOU'RE THERE: WATER SHED Screening

LIFE ASSESSED? YES, NO BUGS AND/OR FISH (circle) COLLECTED? YES, NO BUGS AND/OR FISH

LIST TYPE AND LOG NUMBER OF SAMPLES WS Screening

METHOD OF SAMPLING? No riffle in this area, pooled backed up, slow moving water, = rock turn & grass roots

LIST WHAT WAS SEEN AND INDICATE RELATIVE ABUNDANCE OR CIRCLE IF: ~~LIST IS ATTACHED~~

DOMINANT (> AND = 50):

VERY ABUNDANT (30-49):

ABUNDANT (10-29): Beetles - Haliplidae

COMMON (3-9): Baetidae, Damselfly

RARE (<3): Snails

grass beds (~3 sweeps)

CHEMICAL SAMPLES TAKEN? YES NO RESULTS ATTACHED? YES NO

pH (s.u.)	/ 6.89	DISS OXYGEN (ppm)	5.6 / 5.55
CONDUCTIVITY (µmhos)	/ 410	TIME	
TEMPERATURE	25°C / 24.2 °C OR °F		

= YSI #3 (meter)

YSI #3 DO meter

METERS USE Hydrolab Surveyor II, Hydrolab Datasonde III, Other: YSI 600/610 = BATT out = Reads not reliable @ this time

SIZE OF STREAM (circle one): very sm.=<5'wide small 5'-10' med.= 10'-30'wide lg.=30'-80' very large=>80'

STREAM SUBSTRATE TYPE (%): flatrock 50, boulder 5, cobble 5, gravel 5, fines (silt 35) (sand)

% CANOPY COVER (circle one): 80-100% 50-75% <50%

FILAMENTOUS ALGAE PRESENT? excessive, moderate, some, none

SEDIMENT PRESENT? excessive, moderate, some, none

WATER APPEARANCE (circle those that apply): clear, slightly turbid, mod. turbid, turbid, opaque, oil sheen

PHOTOS TAKEN?: YES NO NUMBER OF PHOTOS: 2 (#5 4/5, #6 4/5)

CAUSE	Source
1600 (H)	1410 (H)
1100 (M)	7600 (H)
0900 (M)	7000 (?)

IMPACTS: (circle and rate, with 5 most severe, those that apply):

PERMITTED DISCHARGE	1 2 3 4 5	INDUSTRIAL STORMWATER	1 2 3 4 5	BYPASS	1 2 3 4 5
SPILL/ILLEGAL DISCHARGE	1 2 3 4 5	WATER INTAKE	1 2 3 4 5	URBAN STORMWATER	1 2 3 4 5
SOIL FROM CONSTRUCTION	1 2 3 4 5	SOIL EROSION - AGRICULTURE	1 2 3 4 5	LIVESTOCK	1 2 3 4/5
PEST/HERB RUNOFF	1 2 3 4 5	DAM	1 2 3 4 5	STREAM ALTERATION	1 2 3 4 5
SEVERE BANK EROSION	1 2 3 4 5	RESIDENTIAL IMPACTS	1 2 3 4 5	RIPARIAN LOSS	1 2 3 4 5
LANDFILL 1 2 3 4 5	MINING	1 2 3 4 5	LOGGING	1 2 3 4 5	UNKNOWN 1 2 3 4 5
OTHER:			OTHER:		

RATE THE FOLLOWING USE CLASSIFICATIONS (S),(T), (PS), (NS):

NS FISH & AQUATIC LIFE IRRIGATION RECREATION LW AND W

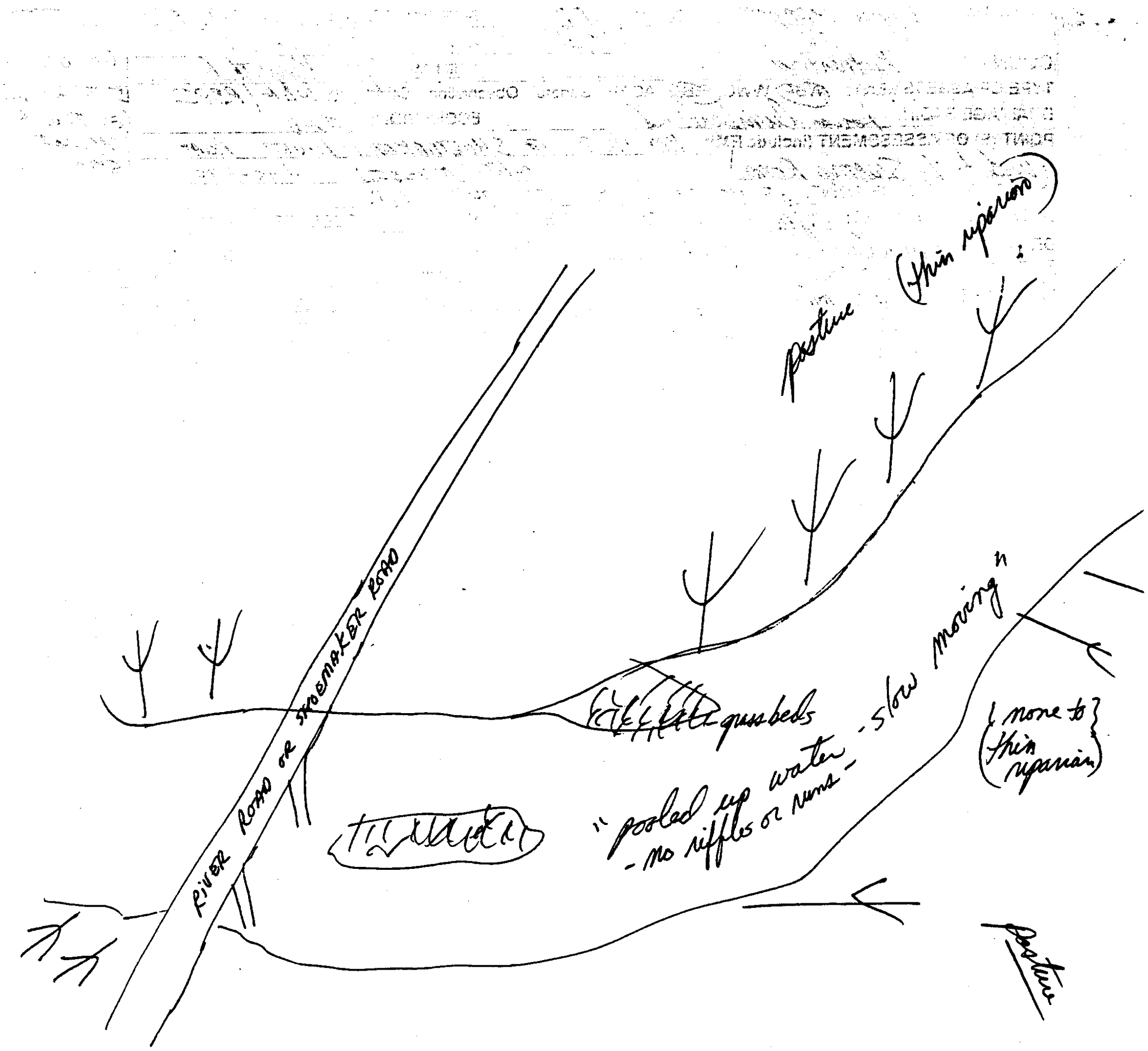
BASED ON WHAT YOU OBSERVED OR MEASURED WOULD YOU CONSIDER THIS STREAM OVERALL (circle one): SUPPORTING (S), THREATENED (T)*, PARTIALLY SUPPORTING (PS), NONSUPPORTING (NS)

*A"T"status designates an immediate threat to the stream, indicating within a two year period or less the stream status may degrade to "PS".

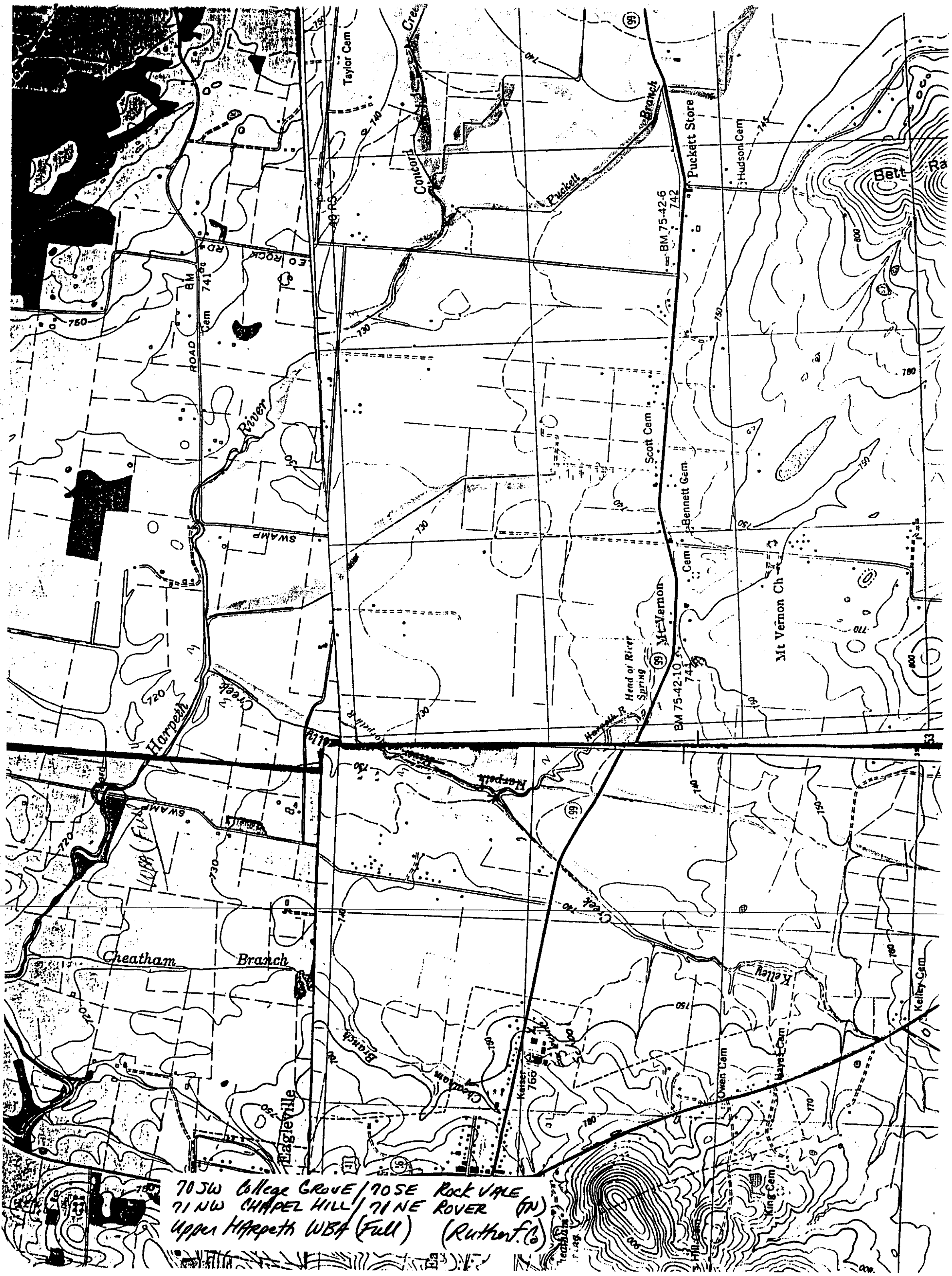
EXPLAIN THE REASONS FOR YOUR ASSESSMENT, IF AN IMPACT FULLY EXPLAIN THE CAUSE AND TYPE OF IMPACT

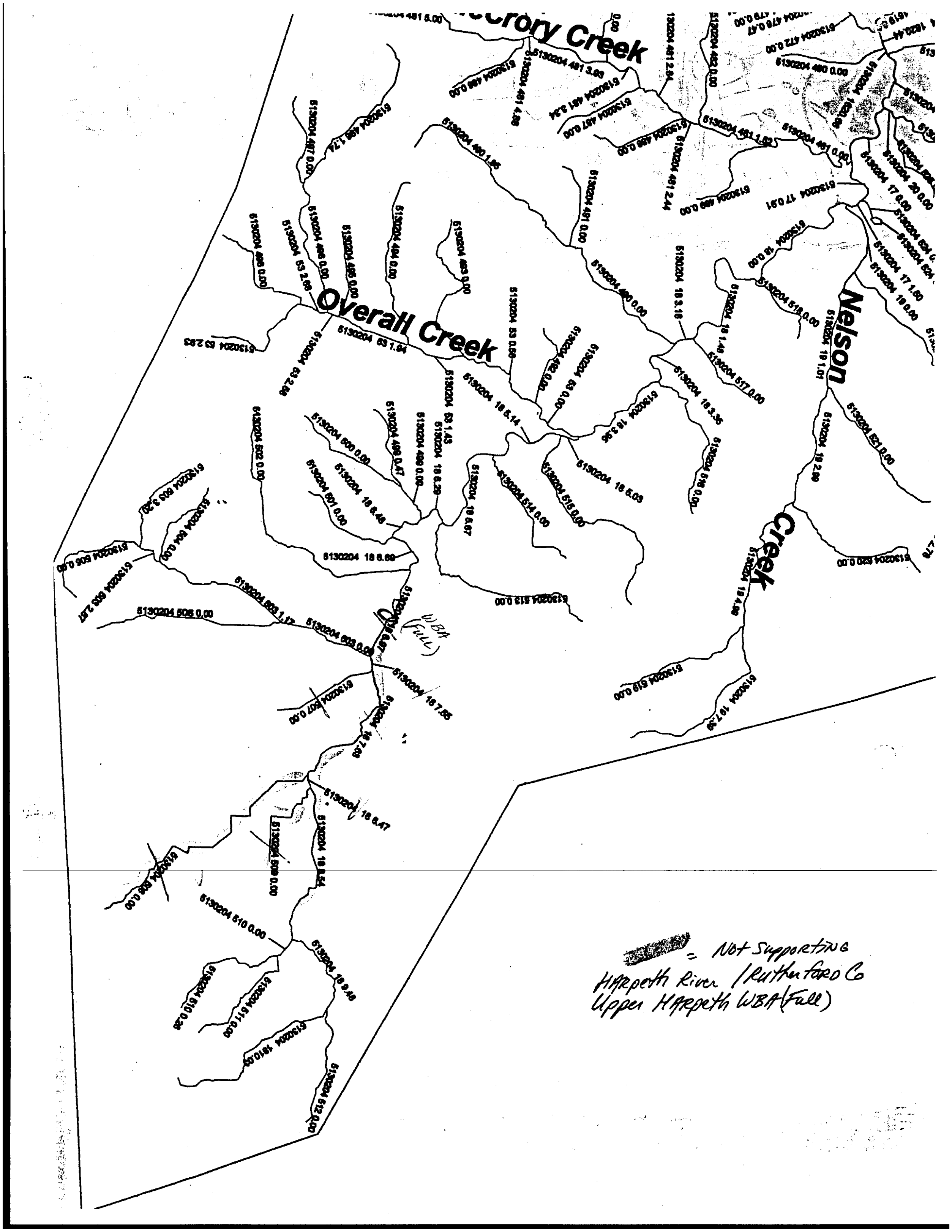
Macroinvertebrates were scarce on rocks - a grass roots net sweep (~3 sweeps) revealed few Macroinvertebrates - @ this time this appears to represent an overall "NS" status - fish were noted - quite numerous - extensive riparian loss - pasture cows

Habitat Score= 92



	Riffle	Run	Pool
L =	—	—	—
W =	—	—	—
D =	—	—	—


70 SW College GROVE / 70 SE Rock VALE
71 NW CHAPEL HILL / 71 NE ROVER (TN)
Upper HArpeth WBA (Full) (Rutherf.Co)
Taylor Cem
Concord
Puckett
Branch
Puckett Store
Hudson Cem
BM 75-42-6
742
River
Harpeth
Scott Cem
Bennett Cem
Mt Vernon
Mt Vernon Ch
Head of River Spring
BM 75-42-10
Cheatham
Branch
Eagleville
Kelley
Kelley Cem
Owen Cem
Hayes Cem
King Cem


Crory Creek
Overall Creek
Nelson
Creek
5130204 63 1.94
5130204 18 6.69
5130204 506 0.00
WBA (Full)
= Not Supporting
Harpeth River / Rutherford Co
Upper Harpeth WBA (Full)

HABITAT ASSESSMENT FIELD DATA SHEET TN 05130204016 Upper Harpeth WBA (Full) ***RIFFLE/RUN PREVALENT STREAMS***

STREAM Upper Harpeth River DATE Wed 08/06/97

SITE @ Shoemaker / River Rd INVESTIGATOR AMC = (92)

(~100 ft - feet assessed)

Riffle/Run Prevalent Streams **are those in moderate to high gradient landscapes that sustain water velocities of approximately 1 ft/sec or greater. Natural streams have substrates primarily composed of coarse sediment particles (i.e., gravel or larger) or frequent coarse particulate aggregations along stream reaches.**

Habitat Parameter	Category: Optimal	Suboptimal	Marginal	Poor
1. Instream Cover (Fish)	Greater than 50% mix of snags, submerged logs, undercut banks, or other stable habitat.	30-50% mix of stable habitat; adequate habitat for maintenance of populations.	10-30% mix of stable habitat; habitat availability less than desirable.	Less than 10% mix of stable habitat; lack of habitat is obvious.
SCORE 15.5	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Epifaunal Substrate no riffles in this area, still pooled, standing water	Well-developed riffle and run; riffle is as wide as stream and length extends two times the width of stream; abundance of cobble.	Riffle is as wide as stream but length is less than two times width; abundance of cobble; boulders and gravel common.	Run area may be lacking; riffle not as wide as stream and its length is less than 2 times the stream width; gravel or large boulders and bedrock prevalent; some cobble present.	Riffles or runs virtually nonexistent; large boulders and bedrock prevalent; cobble lacking.
SCORE 5	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Embeddedness	Gravel, cobble, and boulder particles are 0-25% surrounded by fine sediment.	Gravel, cobble, and boulder particles are 25-50% surrounded by fine sediment.	Gravel, cobble, and boulder particles are 50-75% surrounded by fine sediment.	Gravel, cobble, and boulder particles are more than 75% surrounded by fine sediment.
SCORE 6.5	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	New embankments present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted.
SCORE 13	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Sediment Deposition	Little or no enlargement of islands or point bars and less than 5% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from coarse gravel; 5-30% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, coarse sand on old and new bars; 30-50% of the bottom affected; sediment deposits at obstruction, constriction, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 50% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE 8	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

(92) = Even near headwaters of Upper Harpeth River = cattle, no riparian, silted water

Barbour and Stribling, Visual-Based Habitat Assessment, Figure 10

RIFFLE/RUN PREVALENT STREAMS

Habitat Parameter	Category: Optimal	Suboptimal	Marginal	Poor
6. Frequency of Riffles not sure on this parameter	Occurrence of riffles relatively frequent; distance between riffles divided by the width of the stream equals 5 to 7; variety of habitat is key. In the highest gradient streams (e.g., headwaters), riffles are continuous, and placement of boulders or other large, natural obstruction is evaluated as providing habitat diversity.	Occurrence of riffles infrequent; distance between riffles divided by the width of the stream equals 7 to 15.	Occasional riffle or bend; bottom contours provide some habitat; distance between riffles divided by the width of the stream is between 15 to 25.	Generally all flat water or shallow riffles; poor habitat; distance between riffles divided by the width of the stream is between ratio >25.
SCORE 5(?)	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Channel Flow Status	Water reaches base of both lower banks and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE 19	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank Vegetative Protection (score each bank) Note: determine left or right side by facing downstream.	More than 90% of the streambank surfaces covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption, through grazing or mowing, minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 2 inches or less in average stubble height.
SCORE 3 (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE 3 (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
9. Bank Stability (score each bank)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. < 5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE 6 (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE 6 (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
SCORE 1 (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE 1 (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0

Total Score ____ 92

Barbour and Stribling, Visual-Based Habitat Assessment, Figure 10, p. 2

APPENDIX D

Water Quality Monitoring Data

There are a number of water quality monitoring stations that provide data for waterbodies identified as impaired for organic enrichment/low dissolved oxygen or nutrients in the Harpeth River watershed. The location of these monitoring stations is shown in Figure 5. Monitoring data recorded at these stations for organic enrichment/low dissolved oxygen or nutrient parameters since 1/1/93 are tabulated in Table D-1.

Table D-1 Water Quality Monitoring Data – Harpeth River Watershed

Monitoring Station	Date	NH_3 (as N)	TKN	DO	NO_3+NO_2	Total Phosphorus	Temp	Flow
		[mg/l]	[mg/l]	[mg/l]	[mg/l]	[mg/l]	[°C]	[cfs]
ARKAN000.1WI	10/10/01	<0.02	<0.10	10.1	0.03	0.068	14.4	1.82
	11/29/01	0.02	0.38	9.7	0.17	0.604	14.0	
	12/15/01	<0.02	0.11	12.0	0.20	0.28	10.4	
	12/18/01	<0.02	0.18	12.0	0.10	0.050	10.4	6.95
	1/22/02	<0.02	<0.10	15.3	0.11	0.033	3.7	
	2/26/02	<0.02	<0.10	14.0	0.10	0.01	5.8	8.19
	3/26/02	<0.02	0.12	11.4	0.64	0.05	11.6	
	4/5/02	<0.02	<0.10	11.1	0.04	<0.004	12.6	7.47
	4/8/02	<0.02	<0.10		0.04	<0.004		
	5/6/02	<0.02	<0.10		0.03	<0.004	16.1	9.14
	6/25/02	0.04	0.12	11.5	0.26	0.247	20.4	
CHEAT000.1RU	10/9/01	<0.02	<0.10	9.4	0.64	<0.004	15.5	0.08
	11/8/01	0.06	0.14	12.7	0.19	0.071	14.1	0.01
	2/21/02	<0.02	<0.10	12.8	0.38	0.15	10.1	1.74
	5/23/02	<0.02	<0.10	9.8	2.32	0.087	14.1	0.16
CONCO001.1RU	10/9/01	<0.02	<0.10	5.7	0.29	<0.004	12.0	0.27
	11/8/01	0.09	<0.10	8.4	0.12	0.057	7.6	0.02
	12/11/01	<0.02	0.11	6.8	0.48	0.023	12.7	
	12/12/01	<0.02	<0.10	7.1	0.47	0.058	12.6	
	1/29/02	<0.02	<0.10	6.9	0.22	0.56	12.7	
	2/21/02	<0.02	<0.10	9.6	0.11	0.01	8.5	0.22

	3/18/02		0.35 [c]	9.4	0.16	0.21 [c]	13.1	
	4/10/02	<0.02	<0.10	9.7	0.04	<0.004	11.8	0.29
	5/23/02	<0.02	<0.10	8.9	0.04	0.011	14.0	0.06
	6/11/02	0.03	0.34	**3.1**	0.20	0.05	20.6	0.01
	7/29/02				0.05	0.167		

Table D-1 Water Quality Monitoring Data – Harpeth River Watershed (Continued)

Monitoring Station	Date	NH_3 (as N)	TKN	DO	NO_3+NO_2	Total Phosphorus	Temp	Flow
		[mg/l]	[mg/l]	[mg/l]	[mg/l]	[mg/l]	[°C]	[cfs]
ECO71I15	1/24/00	<0.02	<0.10	11.9	1.05	0.17	3.1	49. 9
	5/3/00	<0.02	0.15	10.8	0.55	0.11	19.4	43.7
	7/13/00	0.13	0.22	6.2	0.50	0.16	26.9	0.70
	10/31/00	0.02	1.12	10.1	0.09	0.92	17.7	0.09
	5/9/01	0.03	0.26	9.8	0.42	0.25	20.0	
	10/9/01	<0.02	<0.10	10.4	0.93	0.211	14.7	11.34
	11/8/01	0.08	<0.10	11.5	0.21	0.153	11.3	5.03
	12/12/01	0.09	0.13	10.1	1.11	0.142	12.7	187.5
	1/29/02	0.02	0.13	10.4	0.96	0.190	13.0	
	2/21/02	<0.02	<0.10	12.9	0.26	0.12	11.0	77.3
	3/18/02	<0.02	<0.10 [c]	9.5	0.37	0.39 [c]	13.1	
	4/10/02	<0.02	<0.10	11.2	0.35	0.07	15.7	104.1
	5/23/02	<0.02	<0.10	12.9	0.83	0.131	16.0	
	6/11/02	0.03	0.36	6.6	0.72	0.22	19.4	3.03
FIVEM001.4WI	10/10/01	<0.02	<0.10	10.1	0.97	0.501	17.8	0.84
	11/29/01	0.09	0.47	8.9	0.66	11.8	15.5	
	12/18/01	<0.02	<0.10	10.8	1.98	0.414	13.8	19.1
	1/22/02	<0.02	<0.10	13.6	1.87	0.309	9.4	17.0
	2/28/02	<0.02	<0.10	14.8	1.33	0.33	3.1	7.09
	3/27/02	<0.02	0.18	12.3	1.5	0.33	9.4	21.2
	4/11/02	<0.02	<0.10	15.5	0.97	0.30	13.1	34.2

	5/15/02	<0.02	<0.10	9.2	1.47	0.40	14.7	34.2
	6/4/02	0.11	0.45	12.6	2.18	0.49	21.8	2.09
HARPE079.8WI	10/10/01	<0.02	0.16	7.8	0.74	0.402	17.0	31.54
	11/29/01	0.03	2.20	9.9	0.05	5.69	15.3	
	12/18/01	<0.02	0.10	9.8	1.57	0.271	13.6	310
	1/22/02	<0.02	0.15	12.1	1.35	0.202	8.5	400
	2/28/02	<0.02	<0.10	14.7	0.90	0.20	4.6	295.8
	3/27/02	<0.02	0.41	10.6	1.31	0.28	11.2	970
	4/11/02	<0.02	<0.10	13.3	1.05	0.22	15.9	
	5/15/02	<0.02	<0.10	7.7	1.21	0.39	16.0	
	6/4/02	<0.02	0.19		1.08	0.42	24.3	39.04
	3/19/03		0.41		1.23	0.85		
	4/3/03		<0.10		0.59+	0.2		
HARPE084.4WI	3/19/03		0.29		1.01	1.1		
	4/3/03		<0.10		0.73	0.27		

Table D-1 Water Quality Monitoring Data – Harpeth River Watershed (Continued)

Monitoring Station	Date	NH_3 (as N)	TKN	DO	NO_3+NO_2	BOD_5	Total Phosphorus	Temp	Flow
		[mg/l]	[mg/l]	[mg/l]	[mg/l]	[mg/l]	[mg/l]	[°C]	[cfs]
HARPETH085.2	6/8/94	<0.02		8.9		<2		21.5	
	5/23/95	<0.02		10.4		<2		18.5	
	6/18/96	<0.02		**9.3**		<2		23.8	
	7/9/97	0.02		7.5		2		19.9	
HARPE087.7DA	3/19/03		0.4		0.76		0.76		
	4/3/03		<0.10		0.38		0.12		
HARPE092.4WI	10/10/01	<0.02	0.11	8.3	0.65		0.404	15.6	16.22
	11/29/01	0.05	0.40	8.7	0.72		3.22	15.3	
	12/18/01	<0.02	0.22	**10.1**	1.36		0.227	12.7	360
	1/22/02	<0.02	0.10	12.1	1.13		0.142	7.5	460
	2/28/02	<0.02	<0.10	14.4	0.49		0.18	2.4	160
	3/27/02	<0.02	0.31	11.2	0.84		0.21	10.3	500
	4/11/02	<0.02	<0.10	11.9	0.43		0.15	15.5	193
	5/15/02	<0.02	<0.10	8.4	1.03		0.34	15.2	
	6/4/02	<0.02	0.12	15.2	0.72		0.28	24.5	24.56
JONES014.4DI	9/10/02				0.19		0.15		
	9/17/02				0.28		0.15		
JONES019.6DI	11/13/01	<0.02	<0.10	16.1	0.62		0.118	12.3	10.3
	12/5/01	<0.02	<0.10	10.6	1.75		0.027	14.7	48.47
	2/19/02	<0.02	0.17 [c]	18.6	0.40 [c]		0.22 [c]	10.1	13.47
	3/27/02	<0.02	<0.10	11.8	0.96		0.34	13.0	

	4/25/02	0.16	0.26	12.9	1.32		0.16	16.7	23.49
	5/14/02	<0.02	<0.10	10.8	0.93		0.10	17.0	56.17
	6/12/02	<0.02	<0.10	11.3	1.24		0.54	25.2	8.08
JONES021.7	6/8/94	<0.02		8.9		<2		21.5	
	5/23/95	<0.02		10.4		<2		18.5	
	6/18/96	<0.02		9.3		<2		23.8	
	7/9/97	0.02		7.5		2		19.9	
RATTL000.2WI	10/2/02				4.80		0.18		
	10/9/02				3.90		0.17		

Table D-1 Water Quality Monitoring Data – Harpeth River Watershed (Continued)

Monitoring Station	Date	NH_3 (as N)	TKN	DO	NO_3+NO_2	Total Phosphorus	Temp	Flow
		[mg/l]	[mg/l]	[mg/l]	[mg/l]	[mg/l]	[°C]	[cfs]
KELLE000.4RU	10/9/01	<0.02	<0.10		0.03	<0.004	15.2	2.57
	11/8/01	0.07	<0.10	12.1	0.44	0.187	11.9	0.54
	12/12/01	0.04	0.13	8.6	0.61	0.030	13.2	36.07
	1/29/02	0.02	0.21	8.0	0.15	0.116	11.8	91.57
	2/21/02	<0.02	<0.10	10.7	0.35	0.04	10.6	18.06
	3/18/02	<0.02	<0.10 [c]	9.5	0.17	0.18 [c]	13.0	
	4/10/02	<0.02	<0.10	9.2	0.10	<0.004	16.4	64.52
	5/23/02	<0.02	<0.10	13.3	0.51	0.024	17.2	3.71
	6/11/02	0.03	0.34	6.6	0.61	0.03	23.4	0.54
	7/29/02				0.36	0.056		
	8/6/02				0.23	0.085		
LHARP001.0WI	10/18/01	<0.02	0.11	11.0	1.65	0.367	11.8	14.85
	11/20/01	<0.02	0.18	9.0	0.09	0.250	10.8	1.33
	12/13/01	0.18	0.18	9.6	0.36	0.353	14.9	218.9
	1/23/02	0.06	0.31	10.7	0.95	0.848	10.9	160
	2/28/02	<0.02	<0.10	15.9	1.05	0.18	4.2	29.3
	4/11/02	<0.02	<0.10	18.0	0.77	0.18	16.1	41.28
	5/15/02	<0.02	<0.10	8.34	1.28	0.26	16.4	94.36
	6/4/02	<0.02	0.28		0.85	0.32	24.6	5.5
LHARP001.8WI	10/2/02				1.53	0.15		
	10/9/02				1.27	0.13		

PUCKE000.9RU	10/9/01	<0.02	<0.10	7.0	0.28	<0.004	13.5	0.45
	11/8/01	0.08	<0.10	9.7	0.09	<0.004	9.5	0.01
	12/12/01	0.02	0.17	10.0	0.21	0.12	11.1	2.57
	1/29/02	0.02	0.12	8.7	0.18	0.019	12.4	1.87
	2/21/02	<0.02	<0.10	8.7	0.10	0.02	10.0	1.33
	4/10/02	0.04	<0.10	10.8	0.12	<0.004	15.1	0.42
	5/26/02	<0.02	0.10	8.7	0.19	<0.004	13.7	0.06
WHARP017.7WI	10/10/01	<0.02	<0.10	8.4	0.91	0.394	14.5	1.82
	11/29/01	0.19	0.54	8.1	0.60	3.80	15.3	
	12/18/01	<0.02	0.26	10.4	2.43	0.349	12.9	66.93
	1/22/02	<0.02	<0.10	13.1	2.22	0.244	8.2	23.37
	2/26/02	0.02	0.20	13.6	1.52	0.21	8.1	23.37
	3/26/02	0.04	0.41	10.4	1.8	0.47	13.0	
	4/8/02	<0.02	<0.10	10.8	1.72	0.28	13.7	36.92
	5/6/02	<0.02	0.11	9.3	1.41	0.34	16.2	47.83
	6/25/02	0.03	<0.10	8.5	1.33	0.579	22.1	2.10

Table D-2 Water Quality Monitoring Data – TN/TP Ratio

Monitoring Station	Sample Date	Flow [cfs]	Total Nitrogen [a] [mg/l]	Total Phosphorus [mg/l]	TN/TP
ARKAN000.1WI	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	11/29/01		0.55	0.604	0.9
	12/15/01		0.31	0.28	1.1
	12/18/01	6.95	0.28	0.050	5.6
	1/22/02		0.16	0.033	4.8
	2/26/02	8.19	0.15	0.01	15.0
	3/26/02		0.76	0.05	15.2
	4/5/02	7.47	0.09	0.002 [c]	45.0
	4/8/02		0.09	0.002 [c]	45.0
	5/6/02	9.14	0.08	0.002 [c]	40.0
	6/25/02		0.38	0.247	1.5
				Average	15.9
CHEAT000.1RU	[illegible]	[illegible]	[illegible]	[illegible] [c]	[illegible]
	11/8/01	0.01	0.33	0.071	4.6
	2/21/02	1.74	0.43	0.15	2.9
	5/23/02	0.16	2.37	0.087	27.2
				Geometric Mean	18.8
CONCO001.1RU	[illegible]	[illegible]	[illegible]	[illegible] [c]	[illegible]
	11/8/01	0.02	0.17	0.057	3.0
	12/11/01		0.59	0.023	25.7
	12/12/01		0.52	0.058	9.0
	1/29/02		0.27	0.56	0.5
	2/21/02	0.22	0.16	0.01	16.0
	3/18/02		0.51	0.21	2.4
	4/10/02	0.29	0.09	0.002 [c]	45.0
	5/23/02	0.06	0.09	0.011	8.2
	6/11/02	0.01	0.54	0.05	10.8
				Average	29.0
FIVEM001.4WI	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	11/29/01		1.13	11.8	0.1
	12/18/01	19.1	2.03	0.414	4.9
	1/22/02	17.0	1.92	0.309	6.2
	2/28/02	7.09	1.38	0.33	4.2
	3/27/02	21.2	1.68	0.33	5.1
	4/11/02	34.2	1.02	0.30	3.4
	5/15/02	34.2	1.52	0.40	3.8
	6/4/02	2.09	2.63	0.49	5.4

	Geometric Mean	2.7

Table D-2 Water Quality Monitoring Data – TN/TP Ratio (Continued)

Monitoring Station	Sample Date	Flow [cfs]	Total Nitrogen [a] [mg/l]	Total Phosphorus [mg/l]	TN/TP
ECO71I15	1/24/00	49. 9	1.1	0.17	6.5
	5/3/00	43.7	0.7	0.11	6.4
	7/13/00	0.70	0.72	0.16	4.5
	10/31/00	0.09	1.21	0.92	1.3
	5/9/01		0.68	0.25	2.7
	10/9/01	11.34	0.98	0.211	4.6
	11/8/01	5.03	0.26	0.153	1.7
	12/12/01	187.5	1.24	0.142	8.7
	1/29/02		1.09	0.190	5.7
	2/21/02	77.3	0.31	0.12	2.6
	3/18/02		0.42	0.39	1.1
	4/10/02	104.1	0.4	0.07	5.7
	5/23/02		0.88	0.131	6.7
	6/11/02	3.03	1.08	0.22	4.9
				Average	4.5
HARPE079.8WI	10/10/01	31.54	0.9	0.402	2.2
	11/29/01		2.7	5.69	0.5
	12/18/01	310	1.67	0.271	6.2
	1/22/02	400	1.5	0.202	7.4
	2/28/02	295.8	0.95	0.20	4.8
	3/27/02	970	1.72	0.28	6.1

	4/11/02		1.1	0.22	5.0
	5/15/02		1.26	0.39	3.2
	6/4/02	39.04	1.27	0.42	3.0
	3/19/03		1.42	0.85	1.7
	4/3/03		0.64	0.2	3.2
				Average	3.9
HARPE084.4WI	3/19/03		1.3	1.1	1.2
	4/3/03		0.78	0.27	2.9
				Geometric Mean	1.8
HARPE087.7DA	3/19/03		1.16	0.76	1.5
	4/3/03		0.43	0.12	3.6
				Geometric Mean	2.3

Table D-2 Water Quality Monitoring Data – TN/TP Ratio (Continued)

Monitoring Station	Sample Date	Flow [cfs]	Total Nitrogen [a] [mg/l]	Total Phosphorus [mg/l]	TN/TP
HARPE092.4WI	10/10/01	16.22	0.76	0.404	1.9
	11/29/01		1.12	3.22	0.3
	12/18/01	360	1.58	0.227	7.0
	1/22/02	460	1.23	0.142	8.7
	2/28/02	160	0.54	0.18	3.0
	3/27/02	500	1.15	0.21	5.5
	4/11/02	193	0.48	0.15	3.2
	5/15/02		1.08	0.34	3.2
	6/4/02	24.56	0.84	0.28	3.0
				Geometric Mean	3.0
JONES019.6DI	11/13/01	10.3	0.67	0.118	5.7
	12/5/01	48.47	1.8	0.027	66.7
	2/19/02	13.47	0.45	0.22	2.0
	3/27/02		1.01	0.34	3.0
	4/25/02	23.49	1.49	0.16	9.3
	5/14/02	56.17	0.98	0.10	9.8
	6/12/02	8.08	1.5	0.54	2.8
				Geometric Mean	6.7
KELLE000.4RU	10/9/01	2.57	0.08	0.002 [c]	40.0
	11/8/01	0.54	0.49	0.187	2.6
	12/12/01	36.07	0.74	0.030	24.7

	1/29/02	91.57	0.36	0.116	3.1
	2/21/02	18.06	0.4	0.04	10.0
	3/18/02		0.22	0.18	1.2
	4/10/02	64.52	0.15	0.002 [c]	75.0
	5/23/02	3.71	0.56	0.024	23.3
	6/11/02	0.54	0.95	0.03	31.7
				Geometric Mean	12.1
LHARP001.0WI	10/18/01	14.85	1.76	0.367	4.8
	11/20/01	1.33	0.27	0.250	1.1
	12/13/01	218.9	0.54	0.353	1.5
	1/23/02	160	1.26	0.848	1.5
	2/28/02	29.3	1.1	0.18	6.1
	4/11/02	41.28	0.82	0.18	4.6
	5/15/02	94.36	1.33	0.26	5.1
	6/4/02	5.5	1.13	0.32	3.5
				Geometric Mean	3.0

Table D-2 Water Quality Monitoring Data – TN/TP Ratio (Continued)

Monitoring Station	Sample Date	Flow [cfs]	Total Nitrogen [a] [mg/l]	Total Phosphorus [mg/l]	TN/TP
PUCKE000.9RU	10/9/01	0.45	0.33	0.002 [c]	165
	11/8/01	0.01	0.14	0.002 [c]	70.0
	12/12/01	2.57	0.38	0.12	31.7
	1/29/02	1.87	0.3	0.019	15.8
	2/21/02	1.33	0.15	0.02	7.5
	4/10/02	0.42	0.17	0.002 [c]	85.0
	5/26/02	0.06	0.29	0.002 [c]	145
				Geometric Mean	47.4
WHARP017.7WI	10/10/01	1.82	0.96	0.394	2.4
	11/29/01		1.14	3.80	0.3
	12/18/01	66.93	2.69	0.349	7.7
	1/22/02	23.37	2.27	0.244	9.3
	2/26/02	23.37	1.72	0.21	8.2
	3/26/02		2.21	0.47	4.7
	4/8/02	36.92	1.77	0.28	6.3
	5/6/02	47.83	1.52	0.34	4.5
	6/25/02	2.10	1.38	0.579	2.4
				Geometric Mean	3.7

Notes: a. Sum of NO_3+NO_2 and TKN.

b. Multiple samples taken on date indicated. Values shown reflect sample with most parameters analyzed.

c. Sample reported as <0.004, 0.002 (½ of detection level) used for calculation of TN/TP ratio.

APPENDIX E

Class II Concentrated Animal feeding Operation General Permit

State of Tennessee

Department of Environment and Conservation

Division of Water Pollution Control

Class II Concentrated Animal Feeding Operation General Permit

Permit Number: TNA000000

I. REGULATORY AUTHORITY FOR THIS GENERAL PERMIT

This general permit is implemented under the authority of the Tennessee Water Quality Control Act of 1977, Chapter 1200-4-10 of the Rules of the Tennessee Department of Environment and Conservation (TDEC), and the National Pollutant Discharge Elimination System (NPDES) program delegation from the United States Environmental Protection Agency (USEPA).

II. DEFINITIONS

A. An "Animal Feeding Operation" (AFO) is a facility that stables or confines, and feeds or maintains animals for a total of 45 days or more in any 12-month period and does not sustain crops, vegetation forage growth, or post-harvest residues in the normal growing season over any portion of the facility.

B. A "Concentrated Animal Feeding Operation" (CAFO) is an animal feeding operation which meets the criteria in Section VI.B.1 or 2 of this general permit, or which the Division designates under Section VI.B.3 or 4 of this general permit.

C. A "Catastrophic Event" is a rainfall event equal to or greater than the 24-hour, 25-year storm, or the occurrence of a tornado or other severe event as determined by the Division which would cause an overflow from the waste retention structure.

D. A "Chronic Event" is a series of wet weather conditions that preclude de-watering of waste retention structures that are maintained in accordance with the waste handling system plan.

E. "Division" is the Division of Water Pollution Control.

F. "Existing Operation" means a facility that began feeding animals on or before May 1, 1999.

G. "Expanded Operation" means a facility that will increase the number of animals being fed above the design basis previously approved by TDA.

H. "Mature Dairy Animal" means a dairy cow that has reached the level of maturity to be milked on a daily basis. For CAFO counting purposes, this term applies only to animals that are being actively milked, and are regularly confined in a central area where wastes are concentrated. This definition shall not apply to heifers and dairy cows that are not being milked on a daily basis and are being kept on pasture.

I. "New Operation" means a facility that began feeding animals after May 1, 1999.

J. "NRCS" is the United States Department of Agriculture, Natural Resources Conservation Service.

K. "Sinkhole" means a depression in a karst area, commonly with a circular pattern. Its drainage is subterranean, its size is measured in meters and tens of meters, and is commonly funnel shaped. This definition is contained in the Fourth Edition of the Glossary of Geology.

L. "TDA" is the Tennessee Department of Agriculture.

M. "Wetlands" means those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas.

III. DISCHARGE PROHIBITED

Any discharge of wastewater from a CAFO is prohibited, unless such discharge results from a catastrophic or chronic storm event.

IV. STEPS FOR OBTAINING COVERAGE UNDER THIS GENERAL PERMIT

This general permit for concentrated animal feeding operations (CAFOs) is issued by the Division of Water Pollution Control (Division). Review and approval of all nutrient management plans and waste handling system plans required under this general permit will be performed by the Tennessee Department of Agriculture (TDA).

A. **New Operations.** CAFOs that begin feeding animals after May 1, 1999, which meet the provisions of Section VI.B.1 or VI.B.2 of this general permit, or AFOs that are designated as CAFOs by the Division per VI.B.3 or VI.B.4 of this general permit, must do the following:

1. Complete a Notice of Intent (NOI) form, which can be obtained from any of TDEC's Environmental Assistance Centers (1-888-891-TDEC), Agricultural Extension Service Offices, or from TDA. Attached to this form shall be:

    a. One copy of a nutrient management plan for the CAFO that meets the requirements of Section VIII.B of this general permit;

b. If liquid manure will be managed, the NOI must also have attached one copy of a waste handling system plan for the CAFO that meets the requirements of Section VIII.C of this general permit.

2. Submit the NOI and the required attachments to TDA per Section VII.C of this general permit for review. Upon approval, TDA will forward the completed NOI to the Division. TDA will also return copies of the approved documents to both the preparer and the operator. Upon receipt of the NOI, the Division will send a letter of coverage to the operator of the CAFO.

3. In all cases, new CAFOs shall meet the provisions of this general permit on or before the date they begin feeding animals.

B. Existing Operations. CAFOs that began feeding animals on or before May 1, 1999, which meet the provisions of Section VI.B.1 or VI.B.2 of this general permit, or AFOs that are designated as CAFOs by the Division per VI.B.3 or VI.B.4 of this general permit, must do the following:

1. Complete a NOI form, which can be obtained from any of TDEC's Environmental Assistance Centers (1-888-891-TDEC), Agricultural Extension Service Office, or from TDA.

2. Submit the NOI to TDA. TDA will forward the completed NOI to the Division. The Division will issue a letter of coverage to the existing CAFO, which will include a schedule of compliance. This schedule of compliance will contain the following requirements:

a. On or before May 1, 2001, the operator shall submit to TDA one copy of a nutrient management plan, consistent with Section VIII.B of this general permit; and

b. On or before May 1, 2001, the operator of a liquid waste handling system shall:

i. either submit one set of design drawings for any necessary modifications to the system;

ii. or submit a report to TDA, which documents a history of system performance and demonstrates compliance with the provisions of this general permit. The operator should consult with TDA to obtain a copy of the report format.

c. If construction is necessary to meet the provisions of this general permit, the operator shall complete the work within 1 year of the plans approval date by TDA.

3. In all cases, existing CAFOs shall meet the provisions of this general permit no later than May 1, 2001, except for completion of construction per IV.B.2.c above.

C. Expanding Operations

1. CAFOs that are already covered under this general permit, that intend to increase the numbers of animals to a level above the design basis previously approved by TDA, must have an approved updated system design before the CAFO begins feeding the additional animals.

2. Existing operations that desire to expand prior to receiving approval from TDA for their current operations, shall have an approved system to accommodate the increased number of animals by May 1, 2001. Facilities that choose to expand operations after May 1, 2001, shall be given one year to have an approved system to accommodate the increased number of animals.

V. TERM OF GENERAL PERMIT AND AUTHORIZATION

This general permit shall be effective from May 1, 1999, until April 30, 2004. Any persons who have submitted a Notice of Intent (NOI) and have not been told to apply for an individual permit will be mailed a letter of coverage per Section IV of this general permit and will be authorized to operate a Class II CAFO in accordance with all conditions of this general permit, their nutrient management plan and their waste handling system plan.

VI. COVERAGE UNDER THIS GENERAL PERMIT

A. General Permit Area. For existing facilities, the general permit is issued for all areas of Tennessee which have been identified as being located in watersheds of 303(d) listed streams identified as being impacted due to livestock operations

New facilities that meet the size criteria of Section VI, B,1 or VI, B, 2 and which locate in Tennessee after May 1, 1999, must obtain a Class II CAFO permit, regardless of their location in the state.

B. Applicability.

1. **Single Species Operations.** The provisions of this general permit apply to existing AFOs that confine the following numbers of livestock, and the operations are located in watersheds of stream segments specifically identified as impacted due to livestock operations that are identified in the 303(d) list of impaired waters for the State of Tennessee. The provisions of this general permit also apply to all new AFOs that confine the following numbers of livestock, and that propose to locate in Tennessee after May 1, 1999.

ANIMAL TYPE	LIQUID MANURE MANAGEMENT	DRY MANURE MANAGEMENT
Poultry (broilers and/or laying hens)	9,000 up to 30,000 birds	50,000 or greater(existing operations), 20,000 or greater (new operations)
Swine	751-2500 over 55 pounds each	751 or greater
Dairy (Mature Animals)	201-700	201 or greater`
Slaughter and Feeder Cattle	301-1000	301 or greater
For all other commercial species, the number of animals contained in 40 CFR Part 122, Appendix B, shall apply		

2. **Combined Species Operations.** This general permit also applies to combined operations having 301 to 1,000 animal units based on the following categories; and the operations are located in watersheds of stream segments specifically identified as impacted due to livestock operations that are identified in the 303(d) list of impaired waters for the State of Tennessee.

Dairy Cattle:	1.4 animal units per head
Slaughter and Feeder cattle:	1.0 animal unit per head
Swine:	0.4 animal units per head

3. **Case-by-Case Designation of CAFOs.** The Division may designate any AFO with fewer animals as a Class II CAFO upon determining that it is a contributor of pollution to the waters of the State.

   a. In making this designation the Division shall consider the following factors:

      i. The size of the AFO and the amount of waste reaching waters of the State;

      ii. The location of the AFO relative to waters of the State;

      iii. The means of conveyance of animal wastes and process waste waters into waters of the State;

iv. The slope, vegetation, rainfall, and other factors affecting the likelihood or frequency of discharge of animal waste and process waste waters into waters of the State.

b. No AFO with less than the numbers of animals set forth in Section VI.B.1 of this general permit shall be designated by the Division as a CAFO unless:

i. Pollutants are discharged into waters of the State through a man-made ditch, flushing system, or other similar man-made device; or

ii. Pollutants are discharged directly into waters of the State which originate outside of the facility and pass over, across, or through the facility or otherwise come into direct contact with the animals confined in the operation.

c. Coverage under this general permit shall not be required from an AFO designated under this section until the Division has conducted an on-site inspection of the operation and determined that the operation should and could be regulated under this general permit.

4. **Operator-Requested Designation.** Upon the request of the operator, the Division may designate any AFO with fewer animals than listed in VI.B.1 or VI.B.2 as a Class II CAFO to be covered under this general permit. All terms and provisions of this general permit will be applicable. Such operator may also request to have the designation terminated, and this request will be granted unless the conditions for case-by-case designation are found.

5. **Limitations on Coverage**. The following activities are not authorized by this general permit.

CAFOs for poultry, ducks, turkeys, swine, dairy, slaughter and feeder cattle, sheep or lambs, or horses which confine numbers of animals in excess of those listed in Section VI.B.1 or VI.B.2 of this general permit. These CAFOs are considered Class I and will be covered under individual NPDES permits.

VII. NOTIFICATION REQUIREMENTS

A. Deadlines for Notification

1. **Existing Operations.** Any CAFO that desires coverage under this general permit shall submit an NOI to TDA by August 1, 1999.

2. **New Operations.** Any new CAFO that begins feeding animals after May 1, 1999, shall obtain coverage under this general permit, and shall submit an NOI at least 30 days prior to feeding animals at the facility.

3. **Ownership Change**: Whenever the person, firm, organization, or other entity that operates the CAFO covered under this general permit changes, notification of change of ownership shall be submitted to the Division.

B. Contents of Notice of Intent

1. **Facility Operator**. The name of the person, firm, organization, or other entity which operates the subject facility, the mailing address where correspondence should be sent and the name and phone number of a contact person.

2. **Facility Identification**. The legal and official name of the operation, and the address or location of the operation as well as the name and phone number of a contact person.

3. **Nearby Waters and Site Location Information**. A USGS topographic map, a county tax map or a soil map showing the acreage of the operation, and the name of the water body nearest the operation.

4. **Certification and Signature**. The certification statement shall be signed in accordance with Section VIII.A of this general permit.

C. Where to Submit

NOIs are to be submitted, along with all required attachments, to the Tennessee Department of Agriculture at the following address:

CAFO Notice of Intent

Tennessee Department of Agriculture

Ellington Agricultural Center

Nashville, TN 37204

VIII. GENERAL CONDITIONS

A. Signatory Requirements. All NOIs, requests for termination of general permit coverage, or other information submitted to the Division or to TDA shall be made in writing .

1. Signature. All information required or requested to be submitted by the Division or TDA shall be signed as follows:

a. For a corporation: by a responsible corporate officer. For the purpose of this section, a responsible corporate officer is the president, secretary, treasurer or vice-president of the corporation, or any other person who performs similar policy or decision-making functions for the corporation; or

b. For a partnership or sole proprietorship: by a general partner or the proprietor; or

c. A duly authorized representative. For the purpose of this section, a duly authorized representative is the person identified in writing to the Division or TDA who has been given the authority to sign for the person described in VIII.A.1.(a) or (b) above.

2. Certification. Any person signing documents under this section shall make the following certification:

"I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the site, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations."

B. Nutrient Management Plan (NMP). For any new CAFO, the applicant shall obtain approval from TDA for the nutrient management plan per Section IV.A of this general permit. For an existing CAFO, the applicant shall obtain approval from TDA for the nutrient management plan per Section IV.B of this general permit. The NMP is to be generally consistent with the current NRCS *Field Office Technical Guide* and the NRCS *Agriculture Waste Management Field Handbook* or other NMP approved by TDA. The NMP shall contain the following:

1. Aerial site photographs or maps and soil maps showing the location of animal waste application fields and the location of all nearby streams, lakes, wetlands and known sinkholes;

2. Current and planned plant production sequence and rotation;

3. Identification of non-application buffer strips around the application site(s) that are sufficient to protect water quality;

4. Soil test results for phosphorus and potassium for application sites;

5. Nitrogen budget for application fields which accounts for all applied sources and realistic yield expectations;

6. Proposed application method and schedule; and

7. Dead animal disposal method.

Land application of animal waste shall be in accordance with the approved NMP, the Clean Water Act, and its implementing regulations. An operator desiring to make changes to their NMP shall notify and receive approval from TDA.

C. Liquid Waste Handling System. Liquid animal waste treatment and/or storage systems, or expansions to existing liquid waste handling facilities, shall be designed by a registered Professional Engineer, licensed to practice in Tennessee by the State Board of Architectural and Engineering Examiners, or by a person with engineering approval authority from the NRCS. Dry manure management systems that exceed 5 days' unprotected exposure of waste will be considered liquid waste management systems, and may require an individual NPDES permit. The plans for the treatment system shall bear the seal of the Professional Engineer or shall contain the verification of the NRCS approval authority. Liquid waste handling system plans will include the following:

1. A map indicating the location of streams, lakes, known sinkholes and other potentially sensitive areas or resources (e.g. wetlands);

2. A description of the proposed system and all system components and practices. Design and performance of waste handling systems must provide for no discharge, except as may be associated with catastrophic or chronic storm events;

3. For new operations only, setbacks from existing residential structures, streams, lakes and sinkholes that are adequate to protect water quality, public health, well heads and groundwater, consistent with the guidelines found in the NRCS *Field Office Technical Guide*; and

4. For new operations only, a soil and geological suitability report including site evaluation criteria contained in NRCS *Agricultural Waste Management Field Handbook* (AWMFH);

5. Liquid waste handling facilities shall be designed, constructed and operated to contain all process generated waste waters plus the runoff from a 25-year, 24-hour rainfall event.

6. In the event of a discharge from the liquid waste handling facility to waters of the state, during a chronic or catastrophic rainfall event, or in the event of an unpermitted discharge, upset or bypass of the system, a sample of the discharge shall be collected and analyzed for the following parameters: fecal coliform, 5-day biochemical oxygen demand, total

suspended solids, total nitrogen, total phosphorus, copper and zinc, or pesticide and other pollutants which the owner/operator has reason to believe could be present in the discharge. Results of analyses shall be mailed to the Division of Water Pollution Control at the appropriate EAC Office address provided in Section I,3.

7. Any such discharge to waters of the state shall not cause or contribute to an exceedance of Tennessee's water quality standards.

D. Record Keeping. Records shall be retained by the owner at the facility location for a minimum of two years, and shall contain the following:

1. Soil test results and recommended nutrient application rates;
2. Quantities and sources of all nutrients applied;
3. Dates and methods of applications;
4. Type of crop and dates planted;
5. Harvest dates and yields including residue removed;
6. Manure nutrient analysis;
7. Certificates, licenses and permits, as may be required; and
8. Quantities of manure transported off-site, including the recipient, date and volume transported and the final destination and end use of material.
9. Notification of any discharges or overflows to waters of the State;
10. Records of "freeboard" necessary to contain all process generated waste waters plus the runoff from a 25-year, 24-hour rainfall event.
11. Results of any sampling or analysis of pollutants discharged to waters of the State.

E. Dead Animal Disposal. The CAFO shall provide appropriate disposal of dead animals by composting, rendering, incineration, disposal in a Class I permitted landfill or burial on-site, in accordance with a nutrient management plan as approved by TDA, unless necessitated by emergency.

F. Inspection. Any duly authorized officer, employee or representative of TDEC or EPA may, upon presentation of credentials, enter and inspect any property, premises or place on or related to the collection, treatment, storage and land application of wastes, except for production facilities where bio-security is a concern, at any reasonable time for the purpose of determining compliance with this general permit. Staff may inspect and obtain a copy of any records that must be kept under the terms and conditions of this general permit; and may obtain samples of the wastewater, groundwater or surface water.

G. **Closure of Liquid Manure System**. If a liquid manure handling system is to be taken out of operation at a permitted facility, the permittee shall empty the waste storage pond or structure and shall remove any residual waste.

H. **Termination of General Permit.** An operator of a CAFO covered under this general permit shall notify the Division, at the address listed below, when the CAFO is no longer in operation.

CAFO General Permit Termination

Division of Water Pollution Control

401 Church Street- 6th Floor Annex

Nashville, TN 37243-1534

I. **Emergencies**. Should the facility experience a discharge of animal waste or another emergency that has the potential to impact waters of the state, the permittee should notify the Division as follows:

1. By telephone, immediately upon occurrence, 1-888-891-TDEC, for discharges:

   a. Resulting from non-precipitation events (e.g. structural failure, equipment breakdown, human error); or

   b. That threaten to cause a fish kill; or

   c. That threaten potable water supplies; or

   d. That otherwise threaten public health.

2. In writing, within 5 days of occurrence, with the following information:

   a. Cause of the discharge;

   b. Period of discharge, including exact times and dates;

   c. An estimation of the discharge volume;

   d. Location of discharge to waters of the state; and

   e. Corrective steps taken.

3. The completed report shall be mailed to:

CAFO Discharge Report

Tennessee Division of Water Pollution Control

(to the appropriate Environmental Assistance Center listed below):

EAC counties and addresses are listed from West to East Tennessee.

Fayette, Shelby and Tipton Counties:

TN DEPT OF ENV AND CONSERVATION

DIVISION OF WATER POLLUTION CONTROL

2510 MT MORIAH ROAD SUITE E-645

MEMPHIS TN 38115-1520

Benton, Carroll, Chester, Crockett, Decatur, Dyer, Gibson, Hardeman, Hardin, Haywood, Henderson, Henry, Lake, Lauderdale, McNairy, Madison, Obion, Weakly counties:

TN DEPT OF ENV AND CONSERVATION

DIVISION OF WATER POLLUTION CONTROL

362 CARRIAGE HOUSE DRIVE

JACKSON TN 38305-2222

Cheatham, Davidson, Dickson, Houston, Humphreys, Montgomery, Robertson, Rutherford, Stewart, Sumner, Williamson, Wilson:

TN DEPT OF ENV AND CONSERVATION

DIVISION OF WATER POLLUTION CONTROL

537 BRICK CHURCH PARK DRIVE

NASHVILLE TN 37243-1550

Bedford, Coffee, Franklin, Giles, Hickman, Lawrence, Lewis, Lincoln, Marshall, Maury, Moore, Perry, Wayne

TN DEPT OF ENV AND CONSERVATION

DIVISION OF WATER POLLUTION CONTROL

2484 PARK PLUS DRIVE

COLUMBIA TN 38401

Cannon, Clay, Cumberland, DeKalb, Fentress, Jackson, Macon, Pickett, Putnam, Overton, Smith, Trousdale, Van Buren, Warren, White

TN DEPT OF ENV AND CONSERVATION

DIVISION OF WATER POLLUTION CONTROL

1221 SOUTH WILLOW AVE

COOKEVILLE TN 38506

Bledsoe, Bradley, Grundy, Hamilton, McMinn, Marion, Meigs, Polk, Rhea, Sequatchie

TN DEPT OF ENV AND CONSERVATION

DIVISION OF WATER POLLUTION CONTROL

STATE OFFICE BUILDING SUITE 550

540 MCCALLIE AVE

CHATTANOOGA TN 37402

Anderson, Blount, Campbell, Claiborne, Cocke, Grainger, Hamblen, Jefferson, Knox, Loudon, Monroe, Morgan, Roane, Scott, Sevier, Union

TN DEPT OF ENV AND CONSERVATION

DIVISION OF WATER POLLUTION CONTROL

2700 MIDDLEBROOK PIKE SUITE 220

KNOXVILLE TN 37921

Carter, Greene, Hancock, Hawkins, Johnson, Sullivan, Unicoi, Washington Counties

TN DEPT OF ENV AND CONSERVATION

DIVISION OF WATER POLLUTION CONTROL

2305 SILVERDALE ROAD

JOHNSON CITY TN 37601

J. **Duty to Mitigate**. The permittee shall take all reasonable steps to minimize or prevent any discharge in violation of this general permit.

K. **Liability for Damages**. Nothing in this general permit shall be construed to relieve the permittee from civil or criminal penalties for noncompliance. Additionally, notwithstanding this general permit, it shall be the responsibility of the permittee to conduct its operation in a manner such that public or private nuisances or public health hazards will not be created.

Nothing in this general permit shall be construed to preclude the institution of any legal action or relieve the permittee from any responsibilities, liabilities, or penalties established pursuant to any applicable State law or the Federal Water Pollution Control Act, as amended.

Coverage under this general permit shall not relieve the permittee of the responsibility for damages to surface waters or ground waters resulting from the operation of this facility in a manner not in accordance with any provision of this general permit.

A permittee who has submitted an NOI and received permit coverage has the duty to comply with all provisions of this Class II General Permit.

L. **Submittal of Other Information**. When the permittee becomes aware that he or she failed to submit any relevant facts or submitted incorrect information in the NOI or in any other report to TDA or the Division, he or she shall promptly submit such facts or information.

CAFO_GP7 C:

APPENDIX F

Land Use Distribution in Impaired HUC-12 Subwatersheds

Table F-1 MRLC Land Use Distribution of Impaired HUC-12 Subwatersheds

Land Use	HUC-12 Subwatershed (05130204__)							
	0101		0102		0104		0105	
	[acres]	[%]	[acres]	[%]	[acres]	[%]	[acres]	[%]
Open Water	6	0.03	70	0.24	158	0.40	219	0.66
Low Intensity Residential	182	0.80	85	0.29	337	0.84	2,521	7.57
High Intensity Residential	5	0.02	1	0.00	7	0.02	406	1.22
High Intensity Commercial /Industrial/Transportation	63	0.28	74	0.25	120	0.30	1,342	4.03
Bare Rock/Sand/Clay	0	0.00	0	0.00	0	0.00	0	0.00
Transitional	109	0.48	0	0.00	1	0.00	53	0.16
Deciduous Forest	7,363	32.54	6,866	23.61	11,189	27.97	7,431	22.30
Evergreen Forest	1,452	6.42	1,129	3.88	1,400	3.50	1,047	3.14
Mixed Forest	3,428	15.15	4,551	15.65	6,675	16.69	4,558	13.68
Pasture/Hay	5,790	25.58	12,221	42.03	15,559	38.90	8,355	25.08
Row Crops	4,118	18.20	3,733	12.84	3,951	9.88	4,681	14.05
Other Grasses (Urban/Recreational)	115	0.51	23	0.08	602	1.51	2,542	7.63

Woody Wetlands	0	0.00	310	1.07	0	0.00	24	0.07
Emergent Herbaceous Wetlands	0	0.00	12	0.04	0	0.00	0	0.00
Quarries/Strip Mines/Gravel Pits	0	0.00	0	0.00	0	0.00	141	0.42
Subtotal – Urban	359	1.59	160	0.55	465	1.16	4,322	12.97
Subtotal - Agriculture	9,908	43.78	15,954	54.87	19,510	48.78	13,056	39.12
Subtotal - Forest	12,358	54.61	12,891	44.34	19,866	49.67	15,743	47.25
Total	**22,631**	**100.00**	**29,075**	**100.00**	**39,999**	**100.00**	**33,320**	**100.00**

Table F-1 MRLC Land Use Distribution of Impaired HUC-12 Subwatersheds (Continued)

Land Use	HUC-12 Subwatershed (05130204__)							
	0201		0202		0301		0302	
	[acres]	[%]	[acres]	[%]	[acres]	[%]	[acres]	[%]
Open Water	42	0.18	12	0.06	613	1.51	79	0.26
Low Intensity Residential	86	0.37	92	0.49	2,359	5.79	2,069	6.90
High Intensity Residential	0	0.00	3	0.02	345	0.85	81	0.27
High Intensity Commercial /Industrial/Transportation	107	0.46	19	0.10	517	1.27	755	2.52
Bare Rock/Sand/Clay	0	0.00	0	0.00	0	0.00	0	0.00
Transitional	40	0.17	0	0.00	15	0.04	0	0.00
Deciduous Forest	5,545	24.03	7,080	37.50	19,433	47.73	9,187	30.66
Evergreen Forest	494	2.14	246	1.30	1,199	2.94	1,682	5.61
Mixed Forest	2,713	11.76	1,724	9.13	5,286	12.98	6,317	21.08
Pasture/Hay	10,926	47.35	7,755	41.08	7,369	18.10	6,130	20.46
Row Crops	3,037	13.16	1,869	9.90	2,091	5.14	1,641	5.48
Other Grasses (Urban/Recreational)	83	0.36	80	0.42	1,354	3.33	2,025	6.76

Woody Wetlands	0	0.00	0	0.00	95	0.23	0	0.00
Emergent Herbaceous Wetlands	0	0.00	0	0.00	0	0.00	0	0.00
Quarries/Strip Mines/Gravel Pits	0	0.00	0	0.00	38	0.09	0	0.00
Subtotal – Urban	233	1.01	114	0.60	3,236	7.95	2,905	9.69
Subtotal - Agriculture	13,963	60.52	9,624	50.97	9,460	23.24	7,771	25.93
Subtotal - Forest	8,835	38.29	9,130	48.36	27,405	67.31	19,211	64.11
Total	**23,073**	**100.00**	**18,880**	**100.00**	**40,174**	**100.00**	**29,966**	**100.00**

Table F-1 MRLC Land Use Distribution of Impaired HUC-12 Subwatersheds (Continued)

Land Use	HUC-12 Subwatershed (05130204__)					
	0401		0601		0604	
	[acres]	[%]	[acres]	[%]	[acres]	[%]
Open Water	10	0.04	88	0.47	10	0.03
Low Intensity Residential	224	0.82	830	4.44	197	0.64
High Intensity Residential	39	0.14	213	1.14	10	0.03
High Intensity Commercial /Industrial/Transportation	52	0.19	590	3.15	99	0.32
Bare Rock/Sand/Clay	0	0.00	0	0.00	0	0.00
Transitional	2	0.01	7	0.04	78	0.25
Deciduous Forest	21,058	76.74	7,893	42.18	22,431	73.16
Evergreen Forest	182	0.66	511	2.73	393	1.28
Mixed Forest	753	2.74	1,384	7.40	1,652	5.39
Pasture/Hay	3,440	12.54	4,328	23.13	3,338	10.89
Row Crops	1,543	5.62	2,362	12.62	2,259	7.37
Other Grasses (Urban/Recreational)	136	0.50	411	2.20	159	0.52

Woody Wetlands	0	0.00	0	0.00	34	0.11
Emergent Herbaceous Wetlands	0	0.00	0	0.00	0	0.00
Quarries/Strip Mines/Gravel Pits	0	0.00	97	0.52	0	0.00
Subtotal – Urban	317	1.16	1,640	8.76	384	1.25
Subtotal - Agriculture	4,983	18.16	6,690	35.75	5,597	18.26
Subtotal - Forest	22,129	80.65	10,296	55.02	24,669	80.46
Total	**27,439**	**100.00**	**18,714**	**100.00**	**30,660**	**100.00**

APPENDIX G

Development of Nutrient TMDLs

DEVELOPMENT OF NUTRIENT TMDLS

Target nutrient concentrations for Level IV ecoregions 71f, 71h, & 71i were used to develop nutrient TMDLs for the Upper Duck River watershed using the procedure outlined below. Information regarding ecoregion reference sites in Tennessee can be found in *Tennessee Ecoregion Project, 1994-1999* (TDEC, 2000).

Development of Target Nutrient Loads for Level IV Ecoregions

1. Reference sites for Level IV ecoregions 71f, 71h, & 71i were identified (see Figure G-1) and the watershed, corresponding to USGS 8-digit hydrologic unit codes (HUCs), in which each site was located noted. This information is summarized in Table G-1.

Table G-1 Location of Level IV Ecoregion Reference Sites

Level IV Ecoregion	Reference Site	Stream	Watershed	
			Name	HUC
71f	ECO71F12	South Harpeth Creek	Harpeth	05130204
	ECO71F16	Wolf Creek	Lower Duck	06040003
	ECO71F19	Brush Creek	Buffalo	06040004
	ECO71F27	Swanegan Branch	Pickwick Lake	06030005
	ECO71F28	Little Swan Creek	Lower Duck	06040003
71h	ECO71H03	Flynn Creek	Upper Cumberland (Cordell Hull Lake)	05130106
	ECO71H06	Clear Fork	Caney Fork	05130108
	ECO71H09	Carson Fork	Stones	05130203
71i	ECO71I03	Stewart Creek	Stones	05130203

	ECO71I10	Flat Creek	Upper Duck	06040002
	ECO71I12	Cedar Creek	Cumberland (Old Hickory Lake)	05130201
	ECO71I14	Little Flat Creek	Upper Duck	06040002
	ECO71I15	Harpeth River	Harpeth	05130204

2. Using the Loading Simulation Program in C++ (LSPC), each 8-digit HUC containing a Level IV ecoregion reference site was calibrated for hydrology (LSPC is based on the Hydrological Simulation Program – Fortran [HSPF] and has been utilized extensively for pathogen TMDLs in EPA Region IV). The calibrations were performed over a 10-year period using an appropriate USGS continuous gaging station. Special attention was paid to total volume of water, both on a yearly basis as well as for the entire 10-year period. The hydrologic parameters in the calibrated model were validated where possible using another USGS continuous gaging station.

3. The calibrated watershed models were then utilized to simulate the daily flow at each ecoregion reference site for a 10-year period.

4. The total nitrogen target concentration (ref. Section 4.2.2) was applied to the each daily flow at each ecoregion reference site to generate daily total nitrogen loads.

5. The average monthly total nitrogen loads for January were calculated for each site by summing the daily loads for each January during the 10-year period and dividing by 10. This process was repeated for all other months.

6. Average semiannual total nitrogen loads were calculated for reference sites by summing the average monthly loads for each six month period (May-October & November-April).

7. The average semiannual total nitrogen loads, on a unit area basis, were calculated for each ecoregion reference site by dividing the average semiannual loads (Step 6) by the corresponding reference site drainage areas. Average semiannual total nitrogen loads per unit area are shown in Table G-2 for each ecoregion reference site.

Table G-2 Average Semiannual Nutrient Loads for Ecoregion Reference Sites

Ecoregion Reference Site	Total Nitrogen		Total Phosphorus	
	May-Oct [lbs/ac/6 mo.]	Nov-Apr [lbs/ac/6 mo.]	May-Oct [lbs/ac/6 mo.]	Nov-Apr [lbs/ac/6 mo.]
ECO71F12	0.5455	1.7255	0.0317	0.1002

ECO71F16	0.5161	1.0885	0.0300	0.0632
ECO71F19	0.6309	1.3213	0.0366	0.0767
ECO71F27	0.5484	1.0738	0.0318	0.0624
ECO71F28	0.6295	1.3169	0.0366	0.0765
ECO71H03	1.8732	4.3209	0.1544	0.3561
ECO71H06	0.8439	2.7838	0.0696	0.2294
ECO71H09	0.7452	2.9570	0.0614	0.2437
ECO71I03	0.7812	3.0813	0.1656	0.6530
ECO71I10	1.1073	3.4787	0.2347	0.7372
ECO71I12	1.4027	3.2069	0.2973	0.6796
ECO71I14	1.6895	3.6258	0.3580	0.7684
ECO71I15	1.1970	3.1854	0.2537	0.6751

8. The average semiannual total nitrogen load per unit area for Level IV ecoregion 71f was determined by calculating the geometric mean of semiannual total nitrogen loads per unit area (Step 7) of the five ecoregion 71f reference sites. The target average semiannual total nitrogen loads per unit area for Level IV ecoregions 71h (3 sites) & 71i (5 sites) were determined in a similar manner.

9. Steps 4 through 8 were repeated for total phosphorus. Target nutrient loads, on a unit area basis, for Level IV ecoregions 71f, 71h & 71i are summarized in Table G-3.

Table G-3 Target Semiannual Nutrient Loads for Level IV Ecoregions 71f, 71h, & 71i

Level IV Ecoregion	Total Nitrogen		Total Phosphorus	
	May-Oct	Nov-Apr	May-Oct	Nov-Apr
	[lbs/acre/6 mo.]	[lbs/acre/6 mo.]	[lbs/acre/6 mo.]	[lbs/acre/6 mo.]
71f	0.5721	1.2854	0.0332	0.0746
71h	1.0561	3.2887	0.0870	0.2710

71i	1.1967	3.3095	0.2536	0.7014

Development of Nutrient TMDLs for Subwatersheds in the Harpeth River Watershed

Note: Calculations for Subwatershed 051302040102 (Harpeth River) are shown. The procedure for other subwatersheds is similar.

10. Since the Subwatershed 051302040102 is approximately 63% in ecoregion 71h and 37% in ecoregion 71i, target nutrient loads for the subwatershed as a whole were based on an area-weighted combination of the ecoregion target loads:

$$TMDL_{0102} = (TL_{71h})\ (A_{71h}) + (TL_{71i})\ (A_{71i})$$

where: $TMDL_{0102}$ = TMDL for Subwatershed 051302040102 [lbs/6 mo.]

TL_{71h} = Target load for ecoregion 71h [lbs/acre/6 mo.]

A_{71h} = Area of subwatershed in ecoregion 71h [acres]

TL_{71i} = Target load for ecoregion 71i [lbs/acre/6 mo.]

A_{71i} = Area of subwatershed in ecoregion 71i [acres]

As an example, for total nitrogen during the May-October time period as a 6-month average:

$$TMDL_{0102} = (1.0561 \text{ lbs/ac/6 mo.})\ (18{,}337 \text{ ac}) + (1.1967 \text{ lbs/ac/6 mo.})\ (10{,}741 \text{ ac})$$

$$TMDL_{0102} = 32{,}219 \text{ lbs/6 mo.}$$

Note: Calculations were performed using a spreadsheet program and may differ slightly from example values due to round off.

Semiannual nutrient TMDLs for selected HUC 12 subwatersheds are calculated in terms of a monthly average (i.e., dividing the semiannual load by 6) and are summarized in Table G-4.

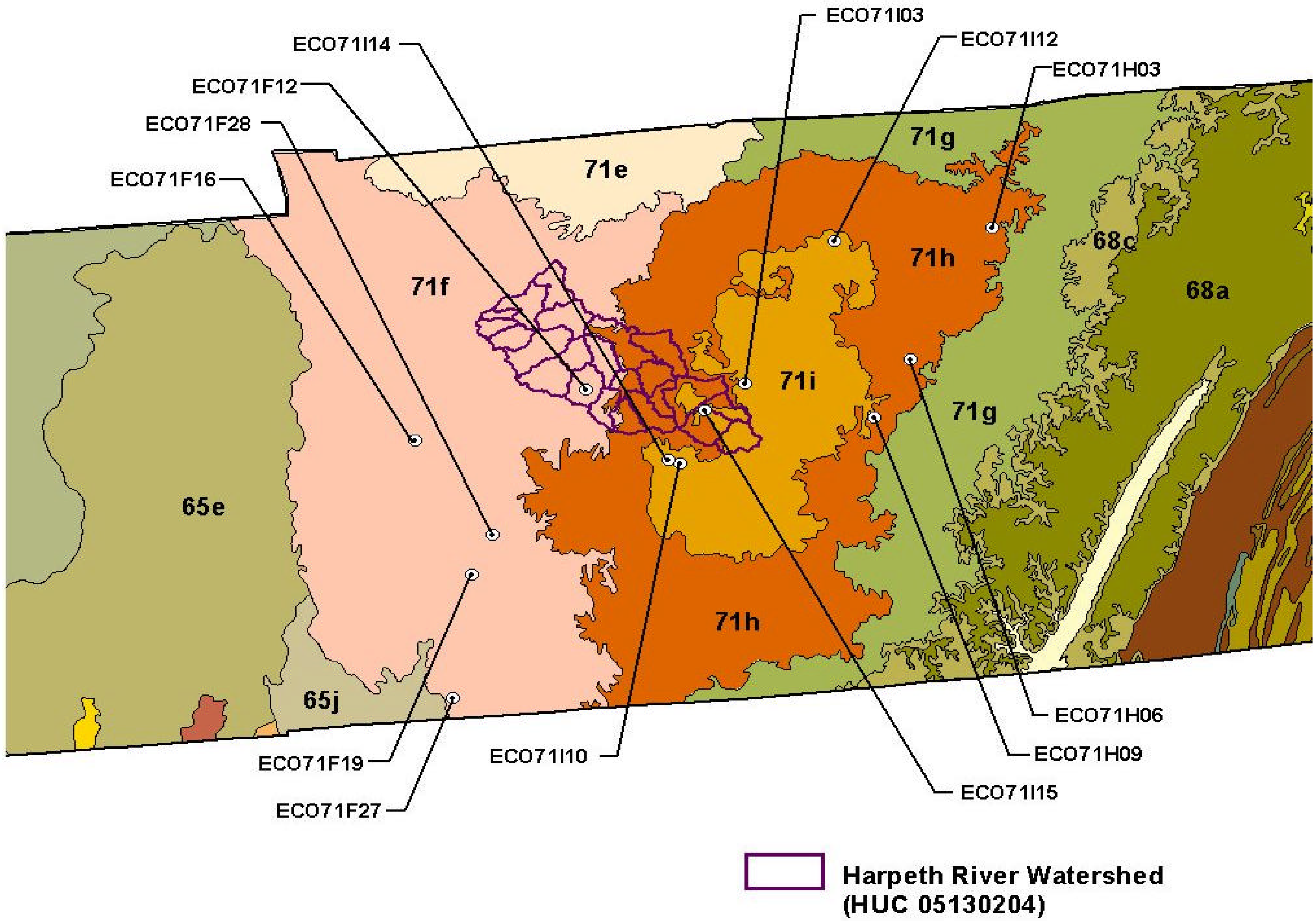
Table G-4 Nutrient TMDLs for Selected Impaired HUC-12 Subwatersheds

HUC-12 Subwatershed (05130204__)	Total Nitrogen		Total Phosphorus	
	Summer * [lbs/month]	Winter * [lbs/month]	Summer * [lbs/month]	Winter * [lbs/month]
0101	4480	12478	916	2541

0104	7335	21966	929	2709
0105	5864	18260	483	1505
0201	4062	12649	335	1042
0202	3026	9119	241	732
0301	6253	18537	489	1468
0302	5275	16425	435	1354

a. Summer: 5/1 – 10/31; Winter: 11/1 – 4/30.

Figure G-1 Reference Sites in Level IV Ecoregions 71f, 71h, & 71i



APPENDIX H

Estimation of Required Reduction in Nutrient Loading

The reductions in existing nutrient loading required to achieve specified TMDLs were estimated using load duration curves and water quality monitoring data.

Development of Load-Duration Curve and Estimation of Required Load Reductions

Nutrient load-duration curves for HUC-12 subwatersheds 0101, 0102, & 0104 were developed from the flow-duration curve of the Harpeth River at USGS continuous record station 03432350 at Franklin (RM 88.1), the appropriate drainage areas, and monitoring data collected in 1999 & 2000 using the following procedure:

1. A flow-duration curve for USGS 03432350 was constructed using daily mean flows for the period from 10/1/96 through 9/2/02. A flow duration curve is a cumulative distribution of daily discharges arranged to show percentage of time specific flows were exceeded during the period of record (the largest daily mean flow during this period is exceeded 0% of the time and the smallest daily mean flow is exceeded ~100% of the time). USGS 03432350 is a continuous record station located at RM 88.1 of the Harpeth River, at the Highway 96 bridge in Franklin.

2. Each ranked daily mean flow was divided by the drainage area upstream of the USGS station to create a flow-duration curve on a unit drainage area basis. (There is, therefore, a "percent of days that the flow per unit area is exceeded" associated with each of the 1,369 measured daily mean flows per unit area).

3. Each ranked daily mean flow on a unit area basis was multiplied by the drainage area upstream of water quality monitoring station HARPE092.4WI to create a flow duration curve for the Harpeth River at the station location.

4. A composite target total nitrogen concentration was determined for the HARPE092.4WI drainage area using the target concentrations for Level IV ecoregions 71h & 71i (ref.: Section 4.2.2) and the fraction of the drainage area in each ecoregion:

$$TN_{Composite} = \frac{[(TN_{71h})(DA_{71h})] + [(TN_{71i})(DA_{71i})]}{(DA_{71h} + DA_{71i})}$$

$$TN_{Composite} = \frac{[(0.728\ mg/l)(53{,}801\ acres)] + [(0.755\ mg/l)(54{,}503\ acres)]}{(53{,}801\ acres + 54{,}503\ acres)}$$

$$TN_{Composite} = 0.742\ mg/l$$

5. A target load-duration curve was generated for the Harpeth River at the HARPE092.4WI station location the by applying the composite target total nitrogen concentration to each of the 2,163 ranked flows:

   $$(\text{Target Load})_{HARPE092.4WI} = (TN_{Composite})_{HARPE092.4WI} \times (Q) \times (UCF)$$

   where: Q = daily mean flow
   UCF = the required unit conversion factor

6. Total Nitrogen loads were calculated for each of the samples collected at the HARPE092.4WI monitoring station (ref.: Table C-1) by multiplying the sample concentration by the measured flow (and the required unit conversion factor).

7. Using the flow duration curve developed in Step 3, the "percent of days the flow was exceeded" (PDFE) was determined for each sampling event. Each sample load was then plotted on the load duration curve developed in Step 5 according to the PDFE. The resulting curve is shown in Figure H-1.

8. The percent load reduction corresponding to each sample load was determined through comparison with the target load corresponding to the PDFE. The overall reduction of existing nutrient load required to meet the TMDL target was estimated to be the geometric mean of the individual sample reductions. Negative reductions were not used in the estimation of the overall reduction.

   Note: The geometric mean was used in cases where the number of individual sample reductions was less than ten. The arithmetic mean (average) was used where the number of individual sample reductions was ten or greater.

9. Steps 1 through 8 were repeated for total phosphorus. The load duration curve for total phosphorus is shown in Figure H-2. Sample loads, target loads, PDFEs, and approximate required reductions in nutrient loading for the Harpeth River upstream of HARPE092.4WI are summarized in Table H-1. The estimated load reductions were applied to impaired subwatersheds 0101, 0102, & 0104.

Load duration curves for selected other HUC-12 subwatersheds containing waterbodies identified as impaired due to organic enrichment/low dissolved oxygen or nutrients are shown in Figures H-3 through H-8. Sample loads, target loads, PDFEs, and approximate required reductions in nutrient loading for these waterbodies are summarized in Tables H-2 through H-4.

Figure H-1 Total Nitrogen Load Duration Curve for the Harpeth River at HARPE092.4WI

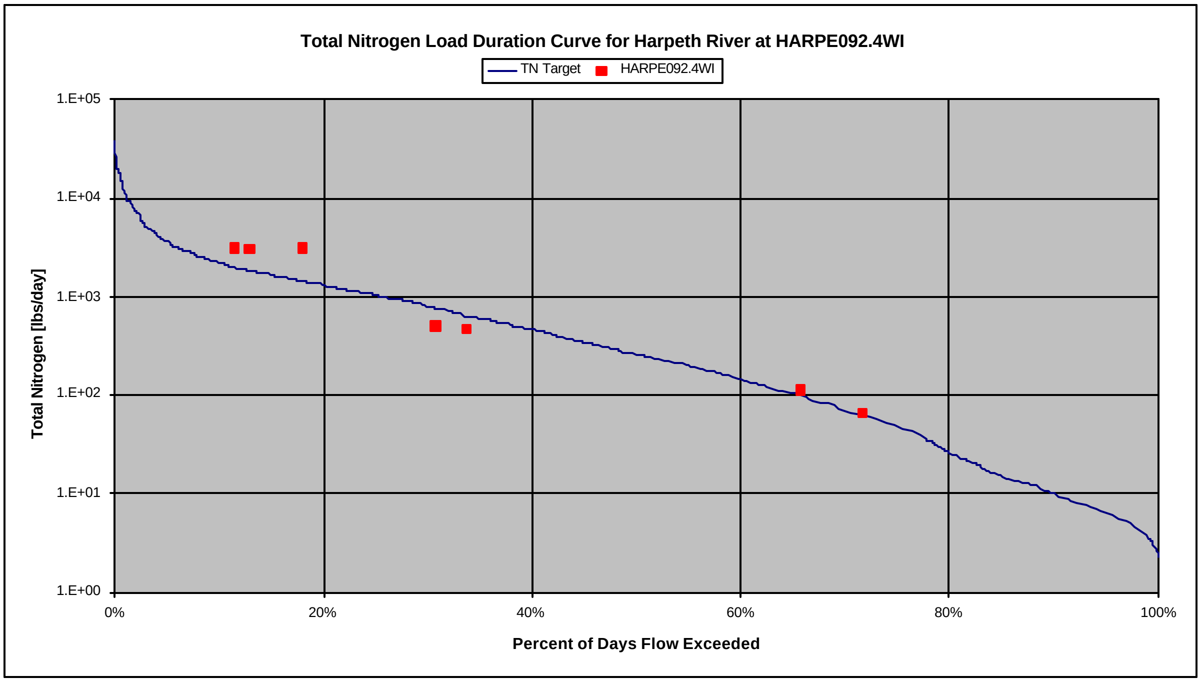


Figure H-2 Total Phosphorus Load Duration Curve for the Harpeth River at HARPE092.4WI

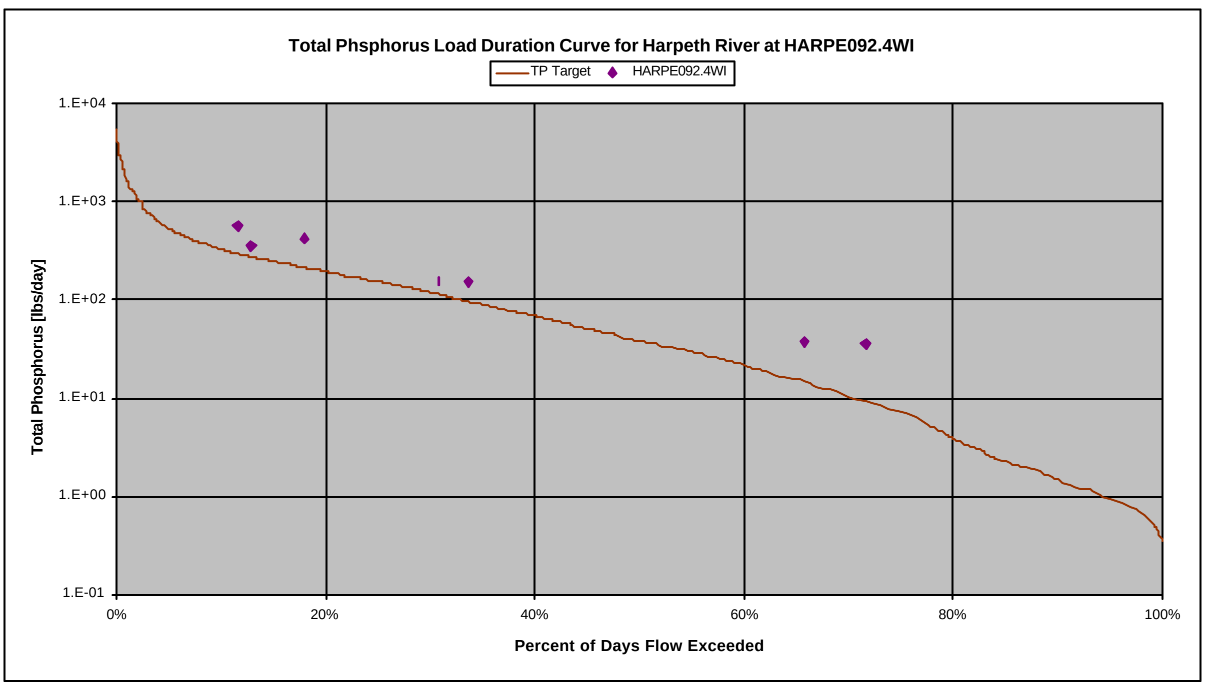


Figure H-3 Total Nitrogen Load Duration Curve for West Harpeth River at WHARP017.7WI

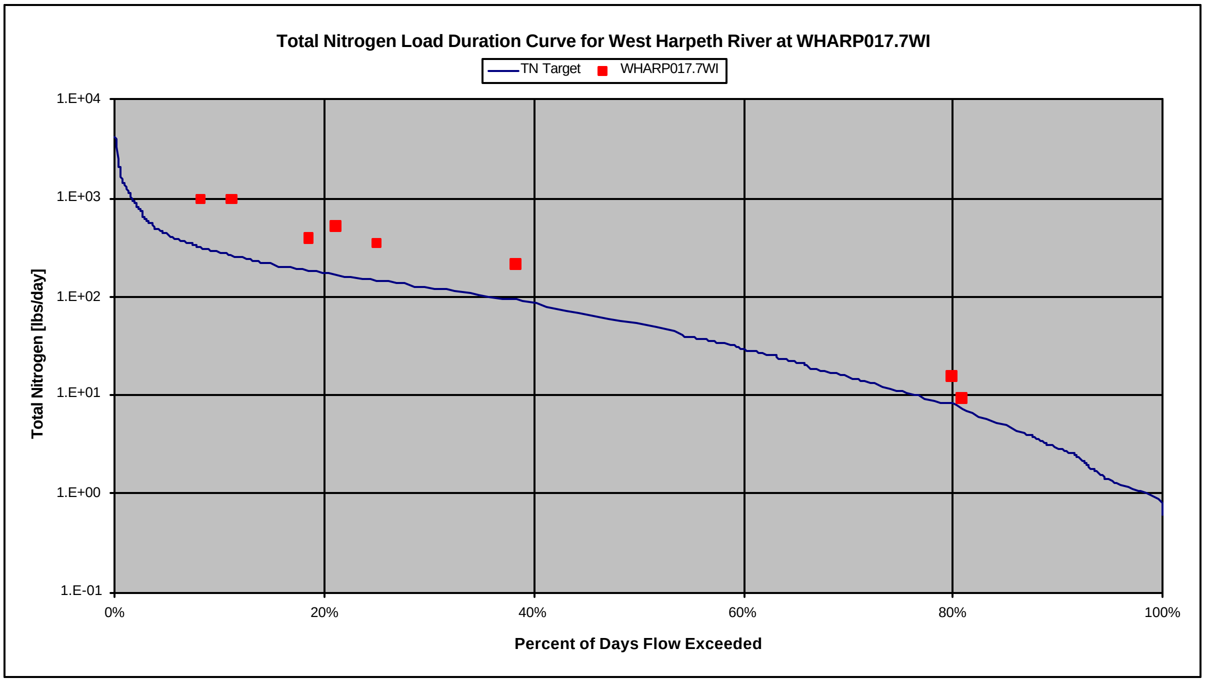


Figure H-4 Total Phosphorus Load Duration Curve for the W. Harpeth River at WHARP017.7WI

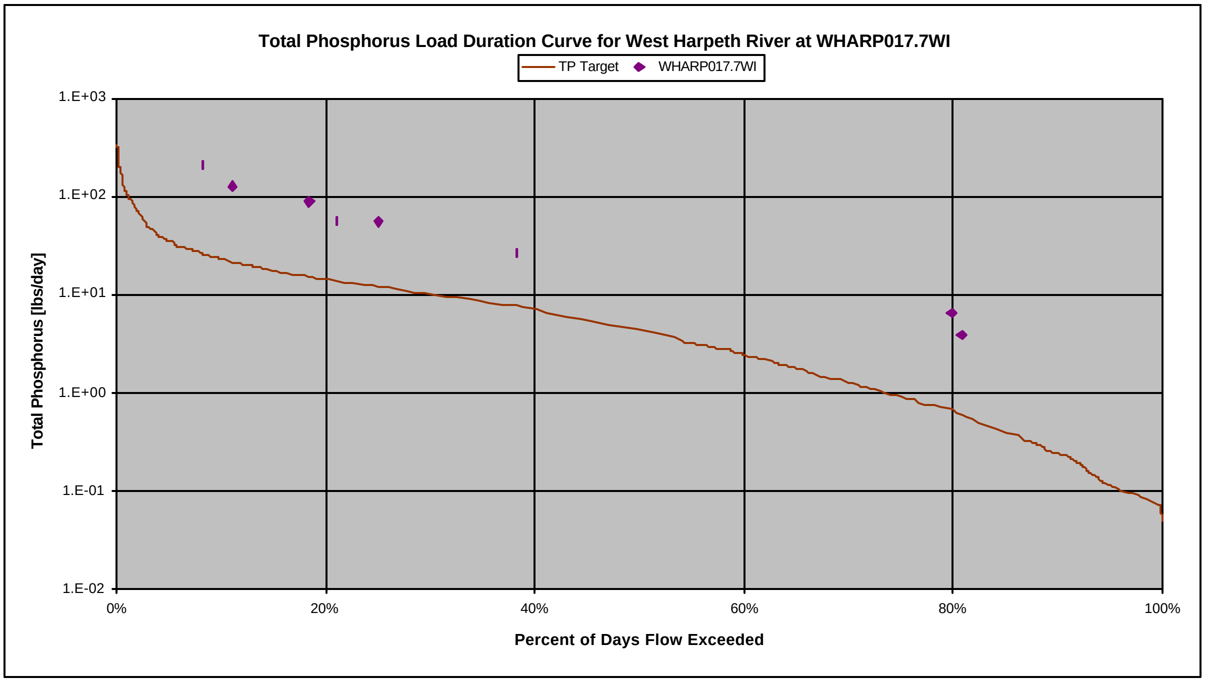


Figure H-5 Total Nitrogen Load Duration Curve for the Little Harpeth River at LHARP001.0WI

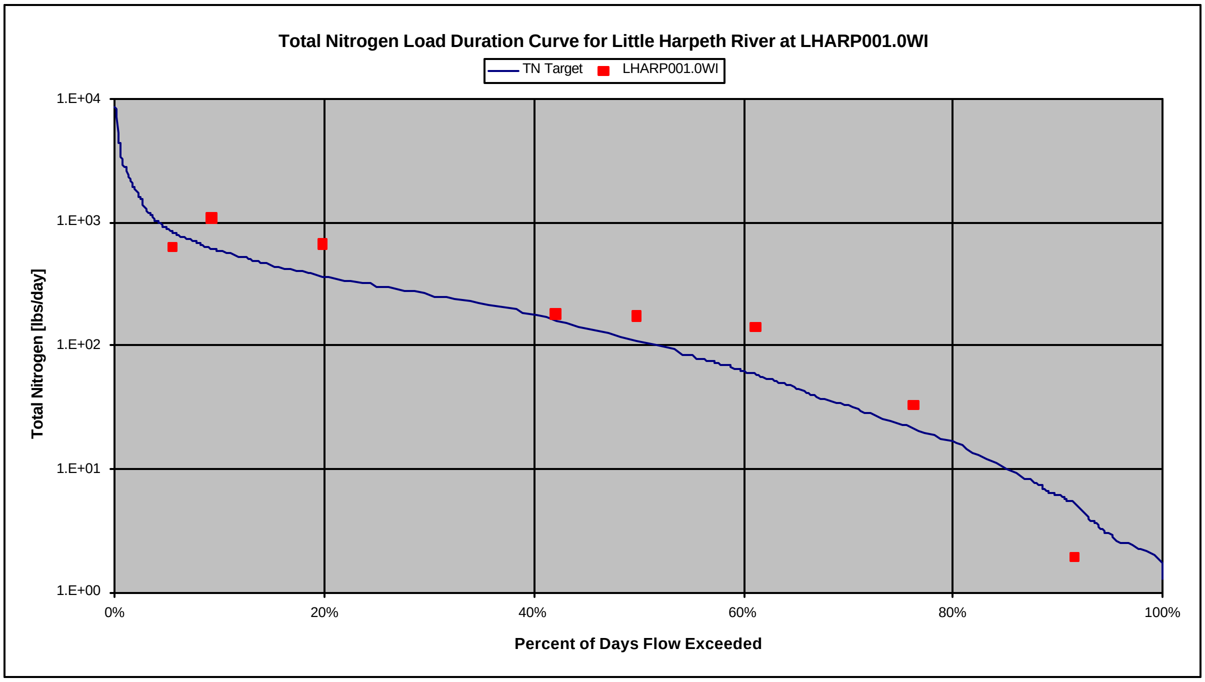


Figure H-6 Total Phosphorus Load Duration Curve for the Little Harpeth River at LHARP001.0WI

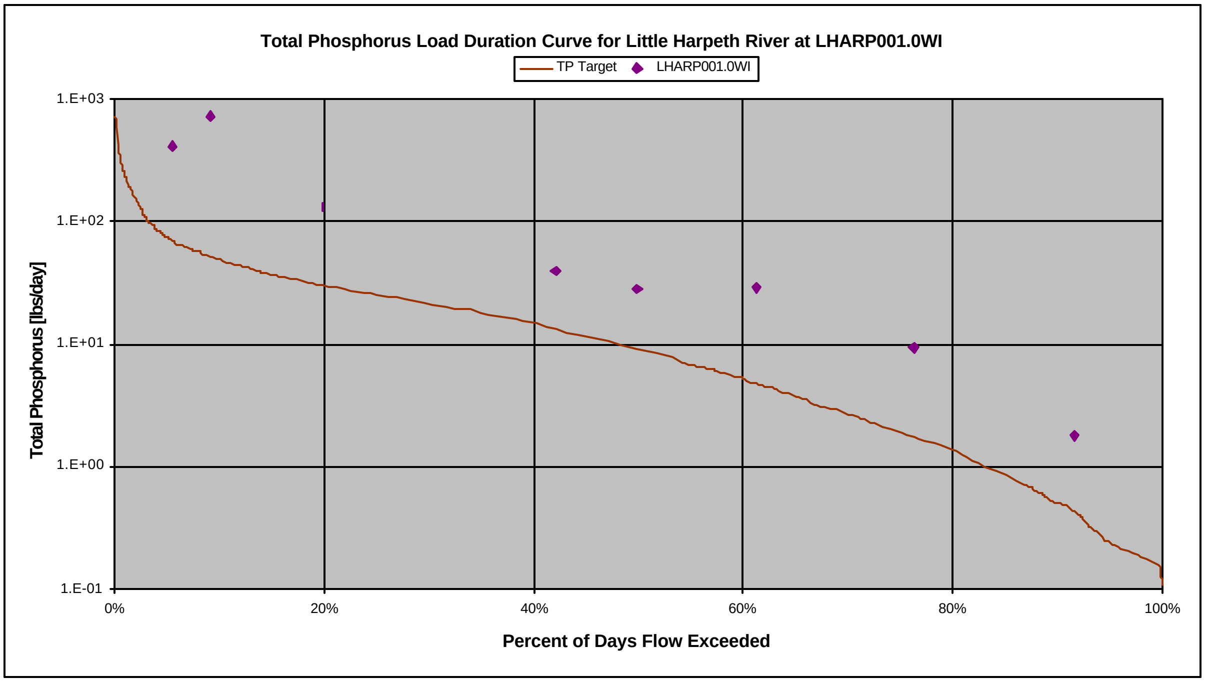


Figure H-7 Total Nitrogen Load Duration Curve for Arkansas Creek at ARKAN000.1WI

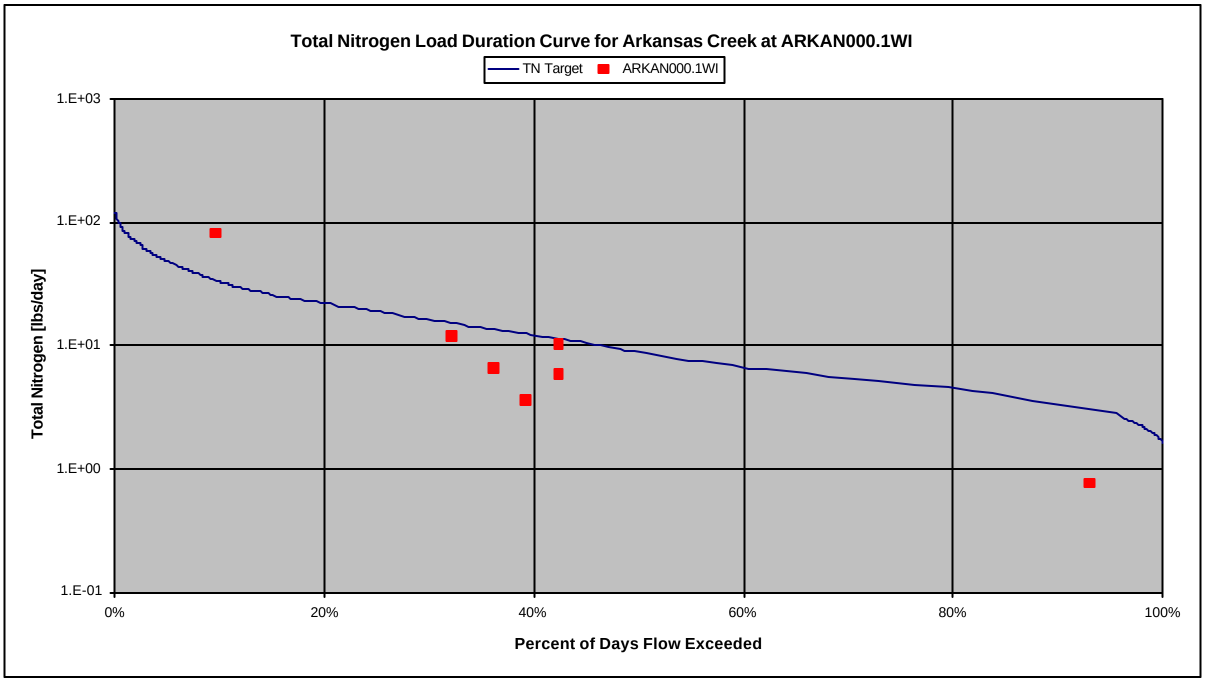


Figure H-8 Total Phosphorus Load Duration Curve for Arkansas Creek at ARKAN000.1WI

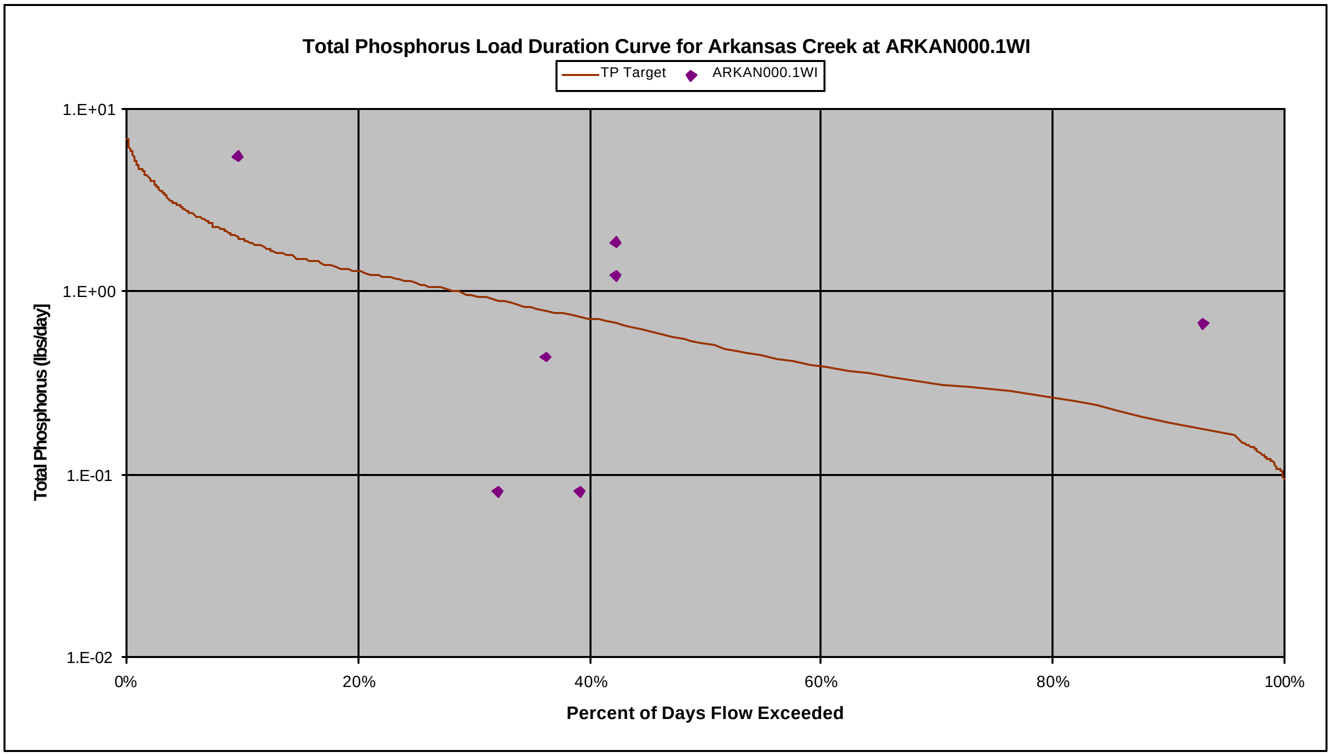


Table H-1 Determination of Estimated Overall Required Nutrient Reduction for Harpeth River at HARPE092.4WI

Sample Date	Flow	PDFE (Approx.)	Total Nitrogen				Total Phosphorus			
			Sample Concen. [a]	Sample Load	Target Load	Reqd. Reduction	Sample Concen.	Sample Load	Target Load	Reqd. Reduction
	[cfs]	[%]	[mg/l]	[lbs/day]	[lbs/day]	[%]	[mg/l]	[lbs/day]	[lbs/day]	[%]
10/10/01	16.22	71.6	0.76	66.46	63.79	4.0	0.404	35.33	9.46	73.2
12/18/01	360	18.0	1.58	3,066	1,439	53.1	0.220	427.0	213.3	50.0
1/22/02	460	12.9	1.23	3,050	1,839	39.7	0.142	352.2	272.7	22.6
2/28/02	160	33.7	0.54	465.8	641.5	NR [b]	0.180	155.3	95.10	38.8
3/27/02	500	11.6	1.15	3,100	1,999	35.5	0.210	566.1	296.3	47.7
4/11/02	193	30.8	0.48	499.4	769.1	NR [b]	0.150	156.1	144.0	27.0
6/4/02	24.56	65.8	0.84	111.2	99.24	10.8	0.280	37.07	14.71	60.3
					Geometric Mean ®	**20.0**			**Geometric Mean ®**	**42.4**

Notes: a. Value shown is the calculated sum of NO_3+NO_2 & TKN sample concentrations.

b. NR = Sample load is lower than target load; no reduction required.

Table H-2 Determination of Estimated Overall Required Nutrient Reduction for West Harpeth River at WHARP017.7WI

Sample Date	Flow	PDFE (Approx.)	Total Nitrogen				Total Phosphorus			
			Sample Concen. [a]	Sample Load	Target Load	Reqd. Reduction	Sample Concen.	Sample Load	Target Load	Reqd. Reduction
	[cfs]	[%]	[mg/l]	[lbs/day]	[lbs/day]	[%]	[mg/l]	[lbs/day]	[lbs/day]	[%]
10/10/01	1.82	80.8	0.96	9.42	7.30	22.6	0.394	3.87	0.60	84.5
12/18/01	66.9	11.1	2.69	970.6	263.5	72.9	0.349	125.9	21.71	82.8
1/22/02	42.8	21.1	2.27	524.1	166.2	68.3	0.244	56.34	13.70	75.7
2/26/02	23.4	38.3	1.72	216.7	93.23	57.0	0.210	26.46	7.68	71.0
3/26/02	81.5	8.2	2.21	971.4	320.2	67.0	0.470	206.6	26.39	87.2
4/8/02	36.9	25.0	1.77	352.3	145.9	58.6	0.280	55.73	12.03	78.4
5/6/02	47.8	18.4	1.52	391.9	186.5	52.4	0.340	87.67	15.37	82.5
6/25/02	2.10	79.8	1.38	15.62	8.11	48.1	0.579	6.56	0.67	89.8
					Geometric Mean ®	**53.1**			**Geometric Mean ®**	**81.3**

Notes: a. Value shown is the calculated sum of NO_3+NO_2 & TKN sample concentrations.

b. NR = Sample load is lower than target load; no reduction required.

Table H-3 Determination of Estimated Overall Required Nutrient Reduction for Little Harpeth River at LHARP001.0WI

Sample Date	Flow	PDFE (Approx.)	Total Nitrogen				Total Phosphorus			
			Sample Concen. [a]	Sample Load	Target Load	Reqd. Reduction	Sample Concen.	Sample Load	Target Load	Reqd. Reduction
	[cfs]	[%]	[mg/l]	[lbs/day]	[lbs/day]	[%]	[mg/l]	[lbs/day]	[lbs/day]	[%]
10/18/01	14.9	61.2	1.76	140.9	58.17	58.7	0.367	29.38	4.79	83.7
11/20/01	1.33	91.6	0.27	1.94	5.22	NR [b]	0.250	1.79	0.43	76.0
12/13/01	218.9	5.5	0.54	637.3	855.4	NR [b]	0.353	416.6	70.50	83.1
1/23/02	160	9.2	1.26	1,087	624.5	42.5	0.848	731.5	51.47	93.0
2/28/02	29.3	49.8	1.10	173.8	111.2	36.0	0.180	28.43	9.17	67.8
4/11/02	41.3	42.1	0.82	182.5	162.5	10.9	0.180	40.06	13.40	66.6
5/15/02	94.4	19.876.2	1.33	676.6	367.8	45.6	0.260	132.3	30.32	77.1
6/4/02	5.50		1.13	33.51	21.39	36.2	0.320	9.49	1.76	81.4
			Geometric Mean ⊗			**34.3**	**Geometric Mean ⊗**			**78.1**

Notes: a. Value shown is the calculated sum of NO_3+NO_2 & TKN sample concentrations.

b. NR = Sample load is lower than target load; no reduction required.

Table H-4 Determination of Estimated Overall Required Nutrient Reduction for Arkansas Creek at ARKAN000.1WI

Sample Date	Flow	PDFE (Approx.)	Total Nitrogen				Total Phosphorus			
			Sample Concen. a	Sample Load	Target Load	Reqd. Reduction	Sample Concen.	Sample Load	Target Load	Reqd. Reduction
	[cfs]	[%]	[mg/l]	[lbs/day]	[lbs/day]	[%]	[mg/l]	[lbs/day]	[lbs/day]	[%]
10/10/01	1.82	93.0	0.08	0.78	3.07	NR [b]	0.068	0.67	0.18	73.4
12/18/01	6.95	42.3	0.28	10.49	11.53	NR [b]	0.050	1.87	0.67	64.2
1/22/02	6.86	42.3	0.16	5.92	11.53	NR [b]	0.033	1.22	0.67	45.1
2/26/02	8.19	36.2	0.15	6.62	13.58	NR [b]	0.010	0.44	0.79	NR [b]
3/26/02	20.3	9.6	0.76	83.34	34.07	59.1	0.05	5.48	1.98	63.9
4/5/02	7.47	39.2	0.09	3.62	12.55	NR [b]	0.002	0.08	0.73	NR [b]
5/6/02	9.14	32.1	0.25	12.17	15.37	NR [b]	0.002	0.10	0.89	NR [b]
			Geometric Mean ®			**59.1**	**Geometric Mean ®**			**60.7**

Notes: a. Value shown is the calculated sum of NO_3+NO_2 & TKN sample concentrations.

b. NR = Sample load is lower than target load; no reduction required.

APPENDIX I

Development of Nutrient WLAs & LAs

Determination of Waste Load Allocations for WWTFs

WWTFs in selected impaired subwatersheds are assigned individual facility WLAs, expressed as semiannual loads, for total nitrogen and total phosphorus. WLAs are based on the design flows (ref.: Table 8) and existing nutrient discharge concentrations from these facilities. In the absence of effluent monitoring data, and in consideration of the information contained in *Technical Guidance Manual For Developing Total Maximum Daily Loads, Book 2: Streams And Rivers, Part 1: Biochemical Oxygen Demand/Dissolved Oxygen And Nutrients/Eutrophication* (USEPA, 1997a), facility nutrient loading was estimated using the following concentrations :

Time Period	T. Nitrogen	T. Phosphorus
5/1 – 10/31	10 mg/l	5 mg/l
11/1 – 4/30	15 mg/l	7.5 mg/l

Semiannual total nitrogen loading for the Eagleville School (TN0057789) can be calculated for the summer months (5/1 – 10/31):

$[TN]_{Summer}$ = (0.018 MGD) (10 mg/l) (8.34) (30 days)

$[TN]_{Summer}$ = 45.0 lbs/month

where: 0.018 MGD = facility design flow

8.34 = unit conversion factor

Semiannual total nitrogen loading for the winter months (11/1 – 4/30):

$[TN]_{Winter}$ = (0.018 MGD) (15 mg/l) (8.34) (30 days)

$[TN]_{Winter}$ = 67.6 lbs/month

Semiannual loading for total phosphorus is calculated in a similar manner:

$[TP]_{Summer}$ = (0.018 MGD) (8.34) (5 mg/l)(30 days) = 22.5 lbs/month

$$[TP]_{Winter} = (0.018 \text{ MGD}) (8.34) (7.5 \text{ mg/l})(30 \text{ days}) = 33.8 \text{ lbs/month}$$

WLAs for other WWTFs located in selected impaired subwatersheds are calculated using the same procedure.

Determination of Waste Load Allocations for CAFOs

CAFOs are not authorized to discharge process wastewater from a liquid waste handling system except during a catastrophic or chronic rainfall event. Any discharges made under these circumstances, or as a result of a system upset or bypass, are not to cause an exceedance of Tennessee water quality standards. Therefore, a WLA of zero has been assigned to this class of facilities.

Determination of Waste Load Allocations for Municipal Separate Storm Sewer Systems & Load Allocations for Nonpoint Sources

A TMDL can be expressed as the sum of all point source loads (Waste Load Allocations), nonpoint source loads (Load Allocations), and an appropriate margin of safety (MOS) which takes into account any uncertainty concerning the relationship between effluent limitations and water quality:

$$TMDL = \Sigma WLAs + \Sigma LAs + MOS$$

where (ΣWLAs) includes the contributions from all WWTFs, CAFOs, and MS4s

Expanding the terms:

$$TMDL = \Sigma(WLA_{WWTF}) + Load_{MS4} + (\Sigma WLA)_{CAFO} + Load_{NPS} + MOS$$

where: TMDL = [lbs/month]

WLA_{WWTF} = Sum of WLAs for all WWTFs [lbs/month]

WLA_{CAFO} = Sum of WLAs for all CAFOs [lbs/month]

$Load_{MS4}$ = Semiannual average nutrient load from all MS4 discharges [lbs/month]

$$= \Sigma\{(WLA_{MS4}) (A_{MS4})\}$$

$Load_{NPS}$ = Semiannual average nutrient load from all nonpoint sources [lbs/month]

$$= \Sigma\{(LA_{NPS}) (A_{NPS})\}$$

MOS = Explicit Margin of Safety [lbs/month]

Solving for ($Load_{MS4}$ + $Load_{NPS}$):

$$(\text{Load}_{MS4} + \text{Load}_{NPS}) = \text{TMDL} - \Sigma(\text{WLA}_{WWTF}) - \Sigma(\text{WLA}_{CAFO}) - \text{MOS}$$

If the $(\text{WLA})_{MS4}$ & $(\text{LA})_{NPS}$ terms are expressed on a unit area basis (lbs/ac/yr):

$$\Sigma\{(\text{WLA}_{MS4})\ (A_{MS4})\} + \Sigma\{(\text{WLA}_{NPS})\ (A_{NPS})\} = \text{TMDL} - \Sigma(\text{WLA}_{WWTF}) - \Sigma(\text{WLA}_{CAFO}) - \text{MOS}$$

where: A_{MS4} = Drainage area of MS4 [acres]

A_{NPS} = Drainage area of nonpoint source [acres]

If $(\text{WLA}_{MS4}) = (\text{LA}_{NPS})$, and noting that $(\Sigma A_{MS4}) + (\Sigma A_{NPS}) \approx (A_{subw})$, then the left side of the above equation can be rewritten as:

$$\begin{aligned}(\text{WLA}_{MS4})\ (\Sigma A_{MS4}) + (\text{LA}_{NPS})\ (\Sigma A_{NPS}) &= (\text{LA}_{NPS})\ \{(\Sigma A_{MS4}) + (\Sigma A_{NPS})\} \\ &= (\text{LA}_{NPS})\ (A_{subw})\end{aligned}$$

therefore:

$$(\text{LA}_{NPS})\ (A_{subw}) = \text{TMDL} - \Sigma(\text{WLA}_{STP}) - \Sigma(\text{WLA}_{CAFO}) - \text{MOS}$$

Solving for (LA_{NPS}):

$$\text{LA}_{NPS} = \frac{\text{TMDL} - (\Sigma\text{WLA}_{STP}) - (\Sigma\text{WLA}_{CAFO}) - \text{MOS}}{(A_{subw})}$$

The calculation for total nitrogen in Subwatershed 051302040105 during the summer months is shown as an example. Calculations for the winter months, total phosphorus, and other subwatersheds are similar.

Total Nitrogen in Subwatershed 051302040104

$$LA_{NPS} = \frac{TMDL - (\Sigma WLA_{STP}) - (\Sigma WLA_{CAFO}) - MOS}{(A_{subw})}$$

Using an explicit MOS of 5% of the TMDL:

$$LA_{NPS} = \frac{TMDL - (\Sigma WLA_{STP}) - (\Sigma WLA_{CAFO}) - \{(0.05)\ (TMDL)\}}{(A_{subw})}$$

$$LA_{NPS} = \frac{\{(0.95)\ (TMDL)\} - (\Sigma WLA_{STP}) - (\Sigma WLA_{CAFO})}{(A_{subw})}$$

Substituting the appropriate values from Tables 15, 17, & F-1 and noting that $\Sigma WLA_{CAFO} = 0$:

$$LA_{NPS} = \frac{\{(0.95)\ (5865\ \text{lbs/month})\} - \{(25.0\ \text{lbs/month}) + (75.1\ \text{lbs/month})\} - (0)}{(33{,}320\ \text{ac})}$$

therefore:

$$LA_{NPS} = WLA_{MS4} = 0.164\ \text{lbs/ac/month}$$

Semiannual nutrient WLAs for WWTFs, MS4s, CAFOs, and LAs for nonpoint sources are summarized in Table I-1 for total nitrogen and Table I-2 for total phosphorus.

TMDL Responsiveness Summary
Harpeth River TMDL - Proposed September 30, 2003

Commenters	
1	Black & Veatch Corporation, 3011 Armory Drive, Suite 220 Nashville, TN 37204-3721, October 28, 2003
2	Lee Barclay, US Fish & Wildlife Service, 446 Neal Street, Cookeville, TN 38501, October 28, 2003
3	Barry Sulkin, November 26, 2003, via e-mail

TN - Harpeth River Comments
August 2004

Commenter #1

Comment

In the draft TMDL report, allowable loadings and allocations are first developed for the nutrients nitrogen and phosphorus. The percent reductions required for each sub-watershed are presented in Table 16 of the report.

The report next discusses the procedure used to develop the TMDL for dissolved oxygen (D0). The primary factor affecting DO is the high sediment oxygen demand. EPA estimated that reductions in sediment oxygen demand (SOD) would be directly proportional to loadings of nutrients. Using the water quality model, EPA determined that for the existing conditions, a 40 percent reduction in nutrient loadings and SOD would be required to achieve the DO criteria of 5 mg/L. EPA also concluded that for the existing condition, the reductions in nutrients that would be required to implement the nutrient TMDL would also result in the DO criteria being met. This would occur because for the two sub-watersheds in the area of problem DO concentrations, the required reductions are 45 to 49 percent total nitrogen and 82 to 84 percent total phosphorus.

The report then examines the future condition and the expansion of the Franklin treatment plant. Using the model, EPA estimated that a 5-day carbonaceous biochemical oxygen demand ($CBOD_5$) concentration limit of 4 mg/L would be required. However, the modeling was conducted using nutrient reductions of 40 percent i.e., the required value for the existing condition, and not the expected higher reductions percentages. If the model were run using the expected values noted above, the estimated limit for $CBOD_5$ would be greater. We request that this issue be examined further and the model run using the expected nutrient reductions.

Response: Although there are some individual tributaries upstream from the mainstem of the Harpeth River for which nutrient reductions greater than 40% are required, there are other tributaries upstream from the mainstem of the Harpeth River for which reductions less than 40% are required. EPA ran the model based on the expected nutrient reductions in consideration of all upstream sources of nutrients. Based on EPA's best professional judgement, the overall reduction of nutrients in the tributaries are expected to result in SOD reductions of 40% in the mainstem of the Harpeth River. In consideration of this expectation, EPA determined that a $CBOD_5$ allocation to the City of Franklin of 400 pounds per day (based on an effluent concentration of 4 mg/l) is necessary to ensure the attainment of water quality standards.

Comment

In the draft TMDL report, the WASP6 model used ultimate CBOD to calculate impacts on dissolved oxygen. As indicated on page 51 of the draft TMDL, EPA analyzed two samples of Franklin WWTP effluent to determine the ultimate CBOD to $CBOD_5$ ratio and selected the more conservative (higher) of the two results (a ratio of 5.3) for use in the water quality modeling. The draft TMDL report acknowledges that the ratio of 5.3 used in the load allocation is conservative and that typical ratios for advanced secondary WWTPs range from 3.0 - 3.5. Since the ultimate CBOD to $CBOD_5$ ratio of 5.3 is significantly higher than typical ratios for highly treated WWTP effluent, and since it represents the highest value obtained, we request that a greater number of sample results be considered for increased statistical validity in selecting the ratio used.

To this end, the City of Franklin took the composite samples for October 1, 2 and 3, 2003 and split each with two independent testing laboratories for ultimate BOD testing. The average C of the samples is shown in the table below. Each lab split its respective samples three times for parallel tests. The ultimate BOD testing is based on Standard Methods for the Examination of Water and Wastewater, 20th Edition. The labs are measuring accumulated dissolved oxygen every five days during the test. Following are the measurements taken at day 20 of the test.

Date of Sample	Ave. $CBOD_5$ (mg/L)	Ultimate BOD: Franklin WWTP Lab (mg/L)(1)	Ultimate BOD: Environmental Science Lab (mg/L)(1)	Ultimate BOD: ELAB of Tennessee (mg/L) (1)
October 1, 2003	1.0	3.6	2.74	2.53
October 2, 2003	1.1	2.3	1.67	2.54
October 3, 2003	0.9	2.2	2.78	2.73(2)

Response: For well-treated effluent, the ultimate demand of oxygen is not expected to be exerted within 20 days. For measuring and calculating ultimate oxygen demand in effluent wastewater, EPA consistently uses 120-day tests to ensure accurate and representative values. The sample data provided for the 20-day Ultimate CBOD analysis may potentially be representative of the $CBOD_{20}$ value, but it is not representative of the ultimate CBOD.

Comment

Upon receipt of the draft TMDL, the City of Franklin immediately initiated the ultimate $CBOD_5$ testing discussed in Comment No. 2, above. Subsequent to the start of these tests, we received a copy of the Georgia Environmental Protection Division protocol for long term BOD tests. This protocol requires analysis of the BOD samples for a duration of 120 days in combination with analyses of nitrate-nitrogen and nitrite-nitrogen at specified intervals. It was confirmed with Mr. Mark Koenig of USEPA Science and Ecosystem Support Division that this methodology was utilized for the Franklin effluent samples analyzed by EPA during the development of the TMDL. This duration of testing is quite extensive and significantly exceeds standard test requirements used in the wastewater treatment industry. We respectfully request that EPA confirm the validity of using ultimate BOD test results obtained at a duration of 120 days relative to the actual hydraulic detention time of the affected section of the Harpeth River. The City of Franklin requests that if this methodology is required, that additional time be provided to complete additional tests. We also request that the EPA provide a summary of the previous test results for informational and comparison purposes.

Response: For measuring and calculating ultimate oxygen demand in effluent wastewater, EPA consistently uses 120-day tests to ensure accurate and representative values. Similar to many eutrophication models supported by EPA, the Water-quality Analysis Simulation Program (WASP) model requires that values for CBOD be input as Ultimate CBOD values, regardless of hydraulic retention time for the river that is represented by the model.

EPA provided the commenter with the opportunity to conduct the 120-day tests to measure ultimate CBOD. By e-mail dated October 14, 2003, Mark Koenig of EPA Region 4's Science and Ecosystem Support Division provided Chris deBarbadillo of Black & Veatch Corporation with the recommended methodology for conducting long-term tests for ultimate CBOD. Mr. Koenig received test results by e-mail dated June 1, 2004, from Ms. deBarbadillo. Based on an analysis of this data and information, EPA determined that the tests were not conducted in a manner consistent with the recommended methodology. Therefore, the data and information provided was not sufficient to justify changes to the TMDL.

As requested, EPA provided the commenter, by letter dated August 19, 2004 from Thomas McGill to Roger D. Lindsey, a copy of the summary of the long-term CBOD test results conducted by the EPA. In addition, EPA provided the City of Franklin, per letter dated July 31, 2002 from Gail Mitchell to Eddy Woodard, with an enclosed report (Harpeth River Modeling Data Report, December 2001) which included a summary of the long-term CBOD test results conducted by the EPA.

Comment

The waste load allocation (WLA) of 290 lbs/day of total nitrogen (TN) for the Franklin WWTP appears in several places in the draft TMDL report and is discussed on page 52. The total allowable load for TN in the lower section of the river was developed using the method discussed in Appendix G. The method used to calculate the required load reduction is presented in Appendix H. The loads and percent reductions are listed in Tables 15 and 16 (page 37). The report states that the three WWTPs are projected to discharge 336 lb/day total and that these numbers are based on data in Table 10. Table 10 refers to Table 25, which is the table at the end of the allocation section stating the WLA for the wastewater treatment plants. It is not readily apparent how the value of 290 lbs/day was developed. We believe the WLA was developed by applying the current annual average concentration for TN measured in the WWTP effluent (2.9 mg/L as indicated in Table 9, Summary of Discharge Monitoring Reports, page 26 to the design flow rate of 12 million gallons per day (mgd). Later in the same paragraph the report states that the plants are "currently operating close to advanced wastewater treatment performance levels of 4 mg/L $CBOD_5$, 1 mg/L ammonia, and 5mg/L total nitrogen."

It is noted that Table 25 has a discrepancy in the calculation of total nitrogen. The report test indicates that the total from the three WWTPs is 336 lbs/day. However, if the total nitrogen allocations for Franklin, Lynnwood and Cartwright WWTPs are added, the total is 326 lbs/day. Second, a total nitrogen of 290 lbs/day is indicated for the Franklin WWTP, but the corresponding concentration is listed at 3.0 mg/L. However, 290 lbs/day at 12 mgd corresponds to 2.9 mg/L. A similar situation is noted for the Cartwright facility.

Response: The commenter is correct that the total nitrogen allocation of 290 lbs/day for the City of Franklin was developed based on a concentration of 2.9 mg/l and a design flow rate of 12 mgd.

The identification of 3.0 mg/l as the effluent concentration corresponding to a load of 290 lbs/day from the City of Franklin in Table 25 is a typographical error. The report has been corrected to reflect a value of 2.9 mg/l, consistent with the information in the rest of the report.

The identification of 14 lbs/day as an allocation for the Cartwright Creek Sewage Treatment Plant is a typographical error. The report has been corrected to reflect a value of 15 lbs/day for this facility.

The identification of 336 lbs/day as the sum of the total nitrogen allocation for the three WWTPs is a typographical error. The report has been corrected to reflect a value of 327 lbs/day.

Comment

The TN limit listed in the Franklin WWTP NPDES permit is a monthly average concentration of 5 mg/L and seasonal (May 1 - October 31) average loading of 377 lbs/day. The TN loading limit is based on the 99^{th} percentile concentration of TN (5.65 mg/L) and the 99^{th} percentile of flow (8.00 mgd) discharged to the Harpeth River. The commonly accepted limit of technology for effluent TN is considered to be 3.5 mg/L by some states, and not less than 3.0 mg/L nationwide. We are not aware of any WWTP in the United States or elsewhere that is required to meet a limit of less than 3mg/L, and those that do not have a limit of 3 mg/L are normally regulated on an annual or 12-month rolling average basis.

It is noted that the 12 mgd permitted flow for the Franklin WWTP represents an annual average. Therefore, some months will see average flows of greater than 12 mgd while others are lower. The TN loading limit in the NPDES permit was incorporated as a seasonal average to accommodate maximum month flows. We have tabulated the month to annual average flow ratios from 1996 through 2002 (see attached Table 1). Many of the months with high ratios occur in the winter and spring. However, there are some occurrences of high ratios in the summer months. As an example, we applied the month flow to annual average flow ratios for 2000 to an annual average flow 12 mgd (within the data set, the year 2000 represents a summer season with moderate flow variation). The total nitrogen discharged in lbs/day was calculated for effluent TN concentrations of both 3.5 and 3.0 mg/L. Table 2 lists the pounds that would be discharged for each month under this condition. It is clear that under flow conditions similar to these, that the nitrogen allocation of 290 lbs/day would be extremely difficult for the Franklin WWTP to meet, even if regulated on a seasonal average basis.

The TN loading limit included in the Franklin WWTP NPDES permit is based on established statistical methods and is reasonable based on available denitrification technologies. We request your consideration of including a TN load of 377 lbs/day for the Franklin WWTP in the TMDL. If a lower nitrogen allocation must be considered, we request that other point and non-point sources be requested to further reduce nitrogen prior to requiring the Franklin WWTPS to meet a limit that is lower than the limit of technology.

Response: In consideration of the anticipated nutrient reductions from nonpoint sources, a maximum total nitrogen load of 290 lbs/day from the City of Franklin is determined to be necessary in order to ensure that the SOD in the mainstem of the Harpeth River is reduced by 40%. Total nitrogen loads from the City of Franklin that exceed 290 lbs/day would potentially result in a SOD reduction which is less than 40%. A SOD reduction of 40% is necessary for the attainment of Tennessee's dissolved oxygen criteria of 5 mg/l in the mainstem of the Harpeth River.

The City's wasteload allocation for total nitrogen is more than ten times greater than the wasteload allocation for any other wastewater treatment facility in the watershed. In addition, the City receives 89% of the allocated wasteload for all continuous point sources discharging to the mainstem of the Harpeth River.

EPA disagrees that 290 lbs/day for a facility with a design flow of 12 mgd is below the limit of technology for nitrogen. Based on an analysis of the City of Franklin's reported data, the City's effluent nitrogen loads have historically not exceeded 290 lbs/day for the vast majority of reported samples.

Based on an analysis of total nitrogen data provided by the City representing effluent samples collected from March 1999 through February 2002, 106 of 160 (i.e., 66%) of the samples indicated total nitrogen concentrations below 2.9 mg/l. In addition, several National Pollutant Discharge Elimination System (NPDES) permits in the southeastern United States have been issued with effluent limitations for total nitrogen equal to or less than 3.0 mg/l. Several NPDES permits issued in Florida require effluent limits for total nitrogen less than 2.9 mg/l including the following municipalities: Titusville-Blue Heron Plant (2.0 mg/l); Broward County - South Central (2.0 mg/l); Seminole County (1.8 mg/l); Indian River County - W. Regional (1.25 mg/l); Orange County - E. Service Area (2.8 mg/l); and Orlando - Iron Bridge (2.3 mg/l).

Commenter #2

Comment

Historic endangered species collection records in the Harpeth River watershed exists for the Federally endangered dromedary pearly mussel (*Dromas dromas*), yellow blossom (*Epioblasma florentina florentina), tan riffleshell (Epioblasma florentina walkeri), and catspaw (Epioblasma obliquata*). Although we have no historic records, the Federally endangered Cumberlandian combshell (*Epioblasma brevidens*) may have also occurred in the watershed. The Harpeth River watershed has experienced significant degradation due to agricultural and urban development. There have been numerous extensive fish kills in the watershed as a result of the release of ineffectively treated wastewater.

Current endangered species collection records available to the Service do not indicate that Federally listed or proposed endangered *or threatened species occur within the Harpeth River watershed. A Federal candidate species, the fluted kidneyshell (Ptychobranchus subtentum), and a species of concern, sheepnose (Plethobasus cyphus*), are known to presently exist in the Harpeth River watershed. The Service recently prepared a candidate elevation package for the sheepnose. We note, however, that collection records available to the Service may not be all-inclusive. Our database is a compilation of collection records made available by various individuals and resource agencies. This information is seldom based on comprehensive surveys of all potential habitat and thus does not necessarily provide conclusive evidence that protected species are present or absent at a specific locality. We encourage EPA to assimilate the most recent biological data collected in the Harpeth River watershed and determine whether survey efforts for Federally listed species have been adequate to establish their presence or absence in the impaired waterbodies. Additional survey efforts may be warranted.

Response: Concerning the establishment of TMDLs, EPA exercises judgment and makes decisions based on the best available data and information. In general, EPA relies on information provided by the U.S. Fish and Wildlife Service (Service) to determine whether federally listed or proposed species or critical habitat are present in waters or watersheds addressed by a TMDL. The current endangered species collection records available to the Service do not indicate that Federally listed or proposed endangered or threatened species occur within the Harpeth River watershed. In addition, in consideration of all data and information (including biological data) collected and compiled as part of the Harpeth River TMDL effort, EPA has no data or information to suggest the presence of endangered or threatened species in the Harpeth River watershed.

EPA is generally supportive of any data collection efforts that will enable the Service to better understand whether species are present in any waterbody or watershed, including the Harpeth River. However, EPA believes the current available data and information is sufficient to establish a TMDL for the Harpeth River without additional survey efforts to determine the presence of endangered or threatened species.

Comment

The modeling associated with the calculation of load allocations for TN and TP utilizes average annual flows in the Harpeth River tributaries. During critical low flow periods, the actual loading of nutrients associated with organic enrichment is likely substantially higher, especially during storm events. Since TSS and chlorophyll a values are not utilized in the modeling procedures, we believe a more conservative approach is needed to obtain the required load allocations for TN and TP in the watershed. Additional modeling for TSS would also appear to be technically feasible and warranted. We would encourage EPA to re-model the load allocations based on measured monthly or seasonal critical minimum flows in the impaired tributaries.

Response: If the nutrient allocations for the tributaries were established based on an annual-averaging period (as opposed to a monthly-averaging period as required by the TMDL), EPA expects that biological integrity would likely be attained because of the conservative numeric translation of the State's narrative biological integrity criteria. The allocations in the TMDL require that the tributaries must meet nutrient loading levels that are statistically expected to be lower than levels associated with 25% of the reference streams within the same sub-ecoregion. As part of the margin of safety, the allocations for the tributaries are based on a monthly-averaging period, instead of an annual averaging period.

There is not sufficient data and information to establish reasonably accurate estimates of the current loads or the loads necessary to attain standards (i.e., the allocated loads) for an averaging period of less than year. Therefore, annual average flows were used to estimate the current loads as well as the loads necessary to attain standards. However, EPA chose an averaging period of one month for the allocations in the TMDL as a conservative approach. The use of the one month averaging period is sufficiently conservative to provide protection of water quality standards during all times of the year, including during storm events and low flow conditions.

Regarding consideration of TSS in the TMDL, a TMDL for sediment in the Harpeth River watershed was developed and submitted by the State on May 10, 2002, and approved by EPA on October 31, 2002.

Regarding the use of chlorophyll a, the State has not adopted numeric criteria for this parameter. However, EPA believes that by establishing allocations that ensure nutrient levels do not exceed reference conditions, the biological integrity is expected to be protected.

Comment

Pursuant to Chapter 1200-4-3-.05(4) of Tennessee's General Water Quality Criteria, all other criteria, including nutrient criteria under the fish and aquatic life use, shall be applied on the basis of stream flows equal to or exceeding the 30-day minimum 5-year recurrence interval. Although an evaluation of 7Q10 flows in the watershed is referenced in the appendices for this TMDL, critical low flows measured at the U.S. Geological Survey gauging station at the Highway 46 bridge have, on many occasions, been below 0.5 cubic feet per second (CFS). We would expect tributary flows to be substantially lower. The methods for calculating the load allocations in this TMDL may not be consistent with guidance contained in 40 CFR § 130.32(7).

Response: The applicable water quality standards for this TMDL require that the State's biological integrity criteria must be attained for stream flows greater to or exceeding the 7-day minimum, 10-year recurrence interval (7Q10 flow). The 7Q10 statistically represents a lower value for flow than the 30-day minimum 5-year recurrence interval (30Q5). Providing protection of the biological integrity for flows equal to or exceeding of 7Q10 inherently ensures protection of biological integrity for flows that are less than 30Q5 but are equal to or exceed 7Q10. Therefore, using 7Q10 as the basis for protecting biological integrity provides a greater level of protection than would be provided if 30Q5 were used as the basis.

EPA acknowledges that on rare occasions the flows in the Harpeth River may be less than the 7Q10. However, the State's water quality criteria for the Fish and Aquatic Life use are not applicable during those conditions.

EPA agrees that on occasion, flows substantially less than 0.5 CFS are expected in the tributaries, particularly in the headwaters. In fact, based on EPA's technical analysis, the 7Q10 flows for the Harpeth River tributaries are as low as 0.0003 CFS. The

TMDL established for the Harpeth River watershed provides protection to the tributaries for flows equal to or greater than 7Q10, including flows which are substantially less than 0.5 CFS.

Section 130.32(7) of Chapter 40 of the Code of Federal Regulations is a citation in a rule that was promulgated by EPA on July 13, 2000 and was subsequently withdrawn on March 13, 2003, and is currently not in effect. The TMDL, and the methods used in its development, are consistent with Section 303(d) of the Clean Water Act and its implementing regulations.

Comment

The same modeling deficiencies are apparent for waste load allocations for sediment oxygen demanding (SOD) materials. Based on the contributions to flow within the Harpeth River watershed that the effluents of many of the wastewater treatment facilities have during critical low flow periods of record, we are concerned with the definitive statement that these facilities were determined not to cause or contribute to violations of water quality standards for the segments addressed by this TMDL. That is contrary to a later statement that the City of Franklin WWTF contributes approximately 10% of the SOD in the reach below their effluent outfall. It is estimated that the City of Franklin WWTF effluent may comprise approximately 80% of the base flow of the Harpeth River below the effluent outfall. When the City of Franklin WWTF reaches its approved expansion limit of 12 million gallons per day (MGD), the effluent could compromise over 90% of the base flow in the Harpeth River during critical low flow periods of record. Definitive data regarding water withdrawals above the effluent point sources may not have been included in the model as well. We do not concur that these facilities are independent of sub-watershed drainage area and occurrence of storm events. If these calculations are indeed indicative of current critical low flow conditions in the watershed, then there exists no unallocated assimilative capacity in the mainstem which precludes an adequate margin of safety (MOS) from being implemented pursuant to 40 CFR §130.32(8) and (9).

Response: The effect of SOD on dissolved oxygen occurs continuously and has its most significant impact during low flow conditions. However, the effect that the TMDL reductions for nutrients and other organic materials will have on SOD is expected to occur over a long period (i.e., potentially more than a year). Therefore, the loads that contribute to the SOD and the reductions necessary to result in the attainment of water quality standards are evaluated with respect to a long-term averaging period, as opposed to a short-term period represented by critical conditions. The facilities in the watershed that did not receive allocations in the proposed TMDL were determined not to have the potential to cause or contribute to excursions of water quality standards or to affect SOD. For each point source, this determination was made from one or both of the following considerations: 1) the point source discharges to a water that is not impaired and is not expected to cause or contribute to a downstream impairment; 2) the WWTF was determined through a modeling or technical analysis not to cause or contribute to an impairment.

Based on EPA's reevaluation of all point sources in the watershed, wasteload allocations have been provided to all point sources that discharge organic loads upstream of the impaired waters addressed by the TMDL. Although these facilities were determined to not cause or contribute to excursions of water quality standards, these point sources are receiving allocations equal to their existing permitted loads to ensure that they continue to discharge at levels which do not cause or contribute to excursions of water quality standards. There are 4 additional point sources which are receiving a wasteload allocation that were not identified as receiving a wasteload allocation in the proposed TMDL report. The additional point sources include: 1) Bethesda Elementary School; 2) College Grove Elementary School; 3) Trinity Elementary School; and 4) Hillsboro Elementary School.

EPA concurs that the discharge from the City of Franklin potentially causes or contributes to excursions of water quality standards and affects SOD in the mainstem of the Harpeth River. As a result, the City of Franklin received a wasteload allocation which requires a reduction of $CBOD_5$ and total nitrogen loads respectively to levels of 290 lbs/day and 400 lbs/day (from 377 lbs/day and 601 lbs/day). These reductions from the City of Franklin as well as the reductions required from the nonpoint sources are expected to result in SOD reductions sufficient to ensure protection of the water quality standards.

The effects of water withdrawals on the Harpeth River are not expected to be significant. During the water quality surveys that EPA conducted on the Harpeth River in 2000 and 2001, 21 pumps and pump lines were observed that could potentially withdraw water from the watershed. Most of the pumps did not appear to be significant in size, and most of them were not operating at the time they were observed. In addition, in consideration that the entire record of daily flows on the Harpeth River between 1991 and 2001 were used in the modeling analysis of the mainstem, any effects from withdrawals would inherently be reflected in the daily flow measurements.

Sections 130.32(8) and (9) of Chapter 40 of the Code of Federal Regulations are citations in a rule that was promulgated by EPA on July 13, 2000 and was subsequently withdrawn on March 13, 2003, and is currently not in effect. The TMDL, and the methods used in its development, are consistent with Section 303(d) of the Clean Water Act and its implementing regulations.

Comment

The monthly average five-day Carbonaceous Biological Oxygen Demand ($CBOD_5$) NPDES permit limits at the various NPDES permitted facilities identified in this TMDL are utilized. We believe a more conservative approach would be to utilize the daily maximum $CBOD_5$ NPDES permit limitation for the individual WWTFs modeled at critical low flow conditions. At least for the tributary systems, it appears that the 7Q10 flows utilized in the model were higher than the measured flows during an August 2000 study. Modeling conducted in the mainstem may not have adequately reflected critical low flow conditions.

Response: EPA recognizes that requiring allocations on a daily time-averaging period would be a more conservative approach than requiring allocations on a monthly time-averaging period. However, this additional level of conservatism for a technical approach to develop the TMDL is unnecessary to ensure the protection of water quality standards during critical conditions (i.e., high temperatures and low flows). The use of high temperatures and critical low flows as part of a dissolved oxygen modeling analysis to generate allocations, based on a monthly averaging-period, has historically been recognized by the Agency as an appropriate conservative technical approach.

The commenter is correct that some of the flows measured in the August 2000 study were below the estimated 7Q10 flows. The model representing the tributaries in the upper watershed was developed and calibrated using the August 2000 data. The allocations were established based on the use of this calibrated model to ensure protection of water quality standards for flows equal to or exceeding 7Q10.

The mainstem analysis was conducted using a dynamic model and a 10-year record of flow, which included the August 2000 period. The TMDL approach was conducted to ensure that the DO criteria would be protective during the 10-year period, thereby ensuring that critical low flow conditions are represented in the analysis.

Comment

In a July 31, 2000, correspondence from EPA to TDEC, EPA recommended that the State adopt ambient water quality criteria for ammonia based upon EPA's updated 1999 guidance. This was a priority in the last triennial review of the State's water quality standards. Since the state did not adopt that criteria and NH_3-N criterion exists in EPA's recommended water quality criteria, we believe that additional modeling for NH_3-N is also technically feasible and warranted. The EPA-recommended criteria were recently utilized in an ammonia/organic enrichment/low DO TMDL developed by TDEC for Eagle Creek. We believe that the concentrations of NH_3-N present in the effluents of the WWTFs in the watershed also have direct applicability to the nitrogen loading issues discussed above in the watershed.

The Service has been actively involved in researching the toxicity of ammonia to Unionid mussels and sensitive fish species. It should be noted that the NH_3-N criteria established in the 1999 Update of Ambient Water Quality Criteria for Ammonia (USEPA 1999) is not as protective as alternative criteria recently developed by the Service. At a pH of 7.51 SU and temperature of 25.28°C, EPA's recommended criterion continuous concentration (CCC) is 2.16 mg/l and the criterion maximum concentration (CMC) is 19.6 mg/l. Our research has resulted in alternative recommended chronic ammonia guidelines of approximately 0.3 to 0/7 mg/l total ammonia as nitrogen at a pH pf 8 SU. This range is similar to ammonia values derived in other independent research. In North Carolina, the Service utilized an approach where the upper 90th percentile of pH values in a target waterbody was used in calculating an alternative criterion for that specific pH value. Due to the apparent potential minimal densities and diversity of sensitive Unionid mussel and fish species in the Harpeth River watershed, we believe that additional evaluation of ammonia toxicity issues in the watershed is warranted.

Response: The effluent wasteload allocations provided for ammonia in the TMDL ensure that instream levels are below the CCC of 2.16 mg/l and CMC of 19.6 mg/l recommended in EPA's most recent guidance. Therefore, the wasteload allocations provided for ammonia (to protect the DO levels), are expected to provide protection against ammonia toxicity in the receiving waters.

EPA encourages the U.S. Fish and Wildlife Service to share any data and information associated with ammonia toxicity in the Harpeth River watershed with the State and EPA.

Comment

We are also concerned that this TMDL does not identify all of the potential sources of organic enrichment and sediment oxygen demanding materials associated with permitted facilities which receive coverage under the State's NPDES general permit programs. For example, sites in the watershed with coverage under the State's NPDES stormwater permit program are not identified. We must assume that these facilities would receive a waste load allocation of zero, but there is no data to suggest that this is the case. There is one Class II concentrated animal feeding operations (CAFOs) NPDES general permit facility (i.e. Harlin and Sumners Dairy) located in an impaired waterbody and this facility was assigned a waste load allocation of zero. This facility is authorized, however, to discharge during chronic rainfall events. No discharge monitoring data for this facility was provided in the TMDL. We are not aware that specific effluent limitations for these facilities have ever been implemented in the respective State's general NPDES permits. The deficiencies associated with the Source Assessment (page 19) for this TMDL should be corrected.

Response: Organic enrichment and nutrient loading is not a problem associated with general construction activities. Construction activities disturb soil and earth, which may potentially result in pollutant discharges to streams associated with total suspended solids, turbidity, siltation, and sediment. However, construction activities covered by EPA's general permit do not involve or result in the processing, generation, or discharge of pollutants associated with organic enrichment and nutrients. EPA determined that there are two categories of wet-weather discharges that required a wasteload allocation: (1) CAFOs; and (2) Municipal Separate Storm Sewer Systems (MS4s). CAFOs and MS4s received allocations to ensure they will not cause or contribute to excursions of water quality standards. EPA has no data or information to suggest that any other category of wet-weather discharges potentially impact nutrients and dissolved oxygen.

CAFOs in the Harpeth River watershed are categorically provided a wasteload allocation of zero which requires that all CAFOs in the watershed, including Harlin and Sumners Dairy, must not discharge any levels of nutrients or oxygen demanding substances.

Comment

Since many of the sub-watersheds in the Harpeth River basin are also impaired due to siltation/habitat alteration and facilities covered under the State's NPDES general permit program are not routinely required to utilize sediment detention or treatment structures, this oversight substantially reduces the stated conservative assumptions associated with the estimation of waste load allocations for sediment oxygen demanding materials. It also likely reduces the stated conservative assumptions regarding load allocations for TN and TP due to the potential input water soluble nutrients from unidentified agricultural and silvicultural operations, as well as water soluble nutrients applied to unidentified disturbed construction areas to enhance revegetation efforts. Since the modeling procedures are based on an estimated geometric mean of annual nutrient loading, any MOS should also reflect storm event inputs for the sources should be modeled at critical low flow periods of record, instead of average flows.

Response: A TMDL for sediment in the Harpeth River watershed was developed and submitted by the State on May 10, 2002, and approved by EPA on October 31, 2002 to address impairment associated with siltation/habitat alteration. The sediment TMDL addressed impacts from general construction activities and identified pollutant reductions necessary for water quality standards to be attained.

EPA disagrees with the commenter that the siltation/habitat alteration impairment that was addressed by TMDLs in 2002 "reduces the stated conservative assumptions used in the [organic enrichment/low dissolved oxygen] TMDL." The conservative assumptions used in this TMDL are specific to pollutants associated with organic enrichment/low dissolved oxygen (e.g., use of low flows, high temperatures, the use of the 75th percentile of nutrient datasets to derive appropriate instream targets), and are not related to the impairment associated with siltation/habitat alteration.

The use of a geometric mean was not used in the development of the model, nor was it used or generated from any calculations in the TMDL.

Comment

For those operations that do utilize such structures, we question the ultimate effectiveness of stormwater detention or treatment structures designed to handle 2-year, 24-hour precipitation events in the current NPDES stormwater general permit program. Stormwater detention basins designed to handle a 10-year, 24-hour event, or greater, would provide a more appropriate level of protection. We are also not aware of any requirements for the use of treatment chemicals or sediment flocculate being imposed on these facilities.

Under EPA's revised new source performance standards (40 CFR Chapter 1, §434.63), Effluent Limitations for Precipitation Events, existing best available control technologies recommended by EPA for coal mining operations indicate that a criteria of 0.5 ml/l (maximum, not to be exceeded) for total settleable solids is achievable. Additionally, TDEC personnel involved in the coal mining regulatory program have indicated that a level of 0.1ml/l may be more protective for sensitive species. A total settleable solids effluent limit of 0.08 ml/l was recently included in a NPDES permit for a coal mining operation in the State. Any effluent limitation for total settleable solids should be based on a peak discharge, not an arithmetic average or geometric mean.

Although the specific numeric NPDES permit limits for TSS for the identified facilities covered under an individual NPDES permit discussed in this TMDL were not provided, other NPDES permits in the State authorize discharges of TSS levels in the range of 40 mg/l to 50 mg/l (weekly average or daily maximum). Lower limits are specified in the State's regulations for discharges to water quality limited/effluent limited stream segments. A correlation between TSS levels and total settleable solids (when measured by the gravimetric method) may exist. We believe that a substantial reduction in pollutants, whether originating from a defined point source or from nonpoint sources, can only be accomplished through implementation of a site-specific control program that utilizes best available control technologies for the capture and treatment of stormwater and sediment.

Response: The TMDL identified the pollutant reductions and loads necessary to attain the applicable water quality standards. However, the TMDL is not the appropriate mechanism to prescribe specific permit requirements. Concerning the issuance of NPDES permits for point sources addressed by this TMDL, in accordance with 40 CFR Section 122.44(d)(1)(vii)(B), the State should ensure that permit requirements are consistent with the assumptions and requirements of the wasteload allocation.

Comment

There were no specific data regarding the number or nature of aquatic resource alteration permits

(ARAPS) or construction projects (e.g., unauthorized gravel dredging) that are not permitted included in this proposed TMDL. The TMDL also failed to include a narrative regarding compliance evaluations performed by TDEC for discharge monitoring reports required under currently authorized NPDES permits, or a discussion of current monitoring and enforcement activities in the Harpeth River watershed.

Response: EPA did not conduct an analysis of ARAPs as part of the TMDL development. However, the allocations in the TMDL are specific to all activities in the subwatershed addressed by the TMDL. Therefore, loadings from ARAP activities and other potential nonpoint sources should not exceed the load allocation in order to ensure the attainment of water quality standards.

Compliance and enforcement information is relevant to the TMDL development as it relates to characterizing current conditions and identifying sources of impairment. EPA's used all available data and information, including discharge monitoring reports, in its development of the TMDL. An extensive discussion of EPA's source characterization and the conditions which caused impairment is included in the *Source Assessment* section of the TMDL report.

EPA recognizes that a TMDL improves water quality when there is a plan for implementing the TMDL. However, CWA section 303(d) does not establish any new implementation authorities beyond those that exist elsewhere in State, local, Tribal or Federal law. Thus, the wasteload allocations within TMDLs are implemented through enforceable water quality-based effluent limitations in NPDES permits authorized under section 402 of the CWA. Load allocations within TMDLs are implemented through a wide variety of State, local, Tribal and Federal nonpoint source programs (which may be regulatory, non-regulatory, or incentive-based, depending on the program), as well as voluntary action by committed citizens. See New Policies for Establishing and Implementing Total Maximum Daily Loads (TMDLs), dated August 8, 1997.

Comment

Many of the referenced individual NPDES permits, the Nashville/Davidson County Municipal Separate Storm Sewer System (MS4), the proposed Phase II MS4s, and the Tennessee Department of Transportation MS4 contribute significant stormwater discharges to the Harpeth River watershed. According to EPA's 1991 national guidance for TMDL development, if a point source NPDES permit limit is based on a waste load allocation that relies on non-point source load reduction, then the NPDES permit record is to include: (1) reasonable assurances that needed nonpoint source controls will be implemented and maintained, or (2) a monitoring program to demonstrate the nonpoint source load reductions. Assurances may include local ordinances, grant conditions or other enforceable conditions. We would appreciate additional information on how EPA or the State will implement these requirements.

Response: There is reasonable assurance that significant nonpoint source reductions will be implemented based on several activities funded by EPA. The Harpeth River basin is one of three watersheds which are being addressed by the Cumberland River Compact through a $600,000 grant targeting watershed restoration and protection activities. In addition, the Harpeth River Watershed Association has been selected to receive a $200,000 grant from Region 4 to undertake watershed restoration projects and facilitate a stakeholder process to effectively implement TMDL load reductions. In addition, the Harpeth River Watershed Association has received CWA Section 319 grants focusing on agricultural and suburban stormwater pollution controls for sediment and nutrients. To date, five demonstration BMP projects have been installed to assess treatment performance. The results of these studies will provide valuable BMP design information to effectively implement the load allocation targets established in the Harpeth River Watershed TMDLs for siltation/habitat alteration and organic enrichment/low dissolved oxygen.

In addition, the wasteload allocations established in the Harpeth River TMDL for the most significant point sources were developed with an expectation that they are sufficient to ensure the point sources do not cause or contribute to excursions of water quality standards violations, regardless of the levels of nonpoint source reductions that are achieved.

For example, the model representing the mainstem of the Harpeth River was run under scenarios with and without the City of Franklin's discharge present. For the scenario where the discharge is present, the loads are set equal to that provided in the wasteload allocation. Based on the significant reaeration provided by the effluent to the river when the City's discharge is present, the DO levels in the Harpeth River are predicted to be significantly higher under the scenario that includes the presence of the point sources.

Concerning discharges from areas covered by an MS4 NPDES permit, the established wasteload allocations are set to a level to ensure that the allowable loads do not exceed levels associated with loadings from reference areas, where the biological integrity criteria are fully supported.

For the point sources that discharge to the upper part of the Harpeth River watershed, the model was run with and without the discharges present. There is no difference in the predicted water quality, whether or not the discharges are present.

Comment

We are concerned that the 19 identified NPDES discharges in the impaired waterbodies may not be in compliance with 40 CFR §122.4(I) and 40 CFR §131.10. We believe that in some cases, for discharges into 303(d) listed waters, sites currently permitted under the State's NPDES general permit program may need to obtain coverage under an individual NPDES permit in order to meet the pollutant reduction goals outlined in this TMDL. Our interpretation of existing Federal regulations indicates that a new discharge(s) which contributes additional pollutant loading into 303(d) listed waters should be precluded.

We are not aware of a routine monitoring program (i.e., sample collection and analysis) in place to evaluate the effectiveness of various best management practices (BMPs) associated with existing NPDES individual and stormwater general permits and ARAP permits issued by TDEC. NPDES permits may need to provide for more stringent limits on the point source if expected nonpoint source load reductions are not demonstrated. We are not certain that the sensitivities of all aquatic organisms, including listed species, were considered in the development of this TMDL. Due to the known distribution of Federally listed species in other major Cumberland River tributaries, we believe that additional evaluations of the water quality and habitats in the Harpeth River watershed are necessary.

Response: EPA expects that the TMDL will be implemented consistent with the Clean Water Act and its implementing regulations, including those associated with NPDES permit requirements.

Concerning NPDES permit coverage under an individual permit as opposed to a general permit, the commenter may consider providing the State with comments, data, or other information during the public comment period for the proposed issuance of the general NPDES permit.

The TMDL was developed based on protection of the State's applicable water quality standards. That is, the TMDL is established at a level to maintain the biological integrity of the impaired waters in the Harpeth River watershed. Specifically, the allocations for nutrients were established based on levels associated with reference streams, where the biological integrity criteria is fully supported.

Comment

Until such time that a comprehensive review of the NPDES and other regulatory programs in the Harpeth River watershed is completed, we recommend that a moratorium on the issuance of Aquatic Resource Alteration Permits, Section 401 Water Quality Certifications, NPDES individual permits, and stormwater construction general permits in the impaired waterbodies be implemented. Since BMPs for controlling erosion associated with agricultural and silvicultural activities in the watershed are strictly voluntary and no regulatory mechanisms currently exist to control these discharges, we believe that this TMDL, as proposed, will fail to achieve its desired numeric target levels within two years.

Although it may be preferable to rely on voluntary, incentive-based mechanisms to achieve the desired improvements to water quality in the impaired waterbodies, we believe that the State of Tennessee and EPA should consider an administrative review of the effectiveness of existing voluntary programs designed to control erosion in the impaired waterbodies, and consider additional regulatory mechanisms to achieve the desired TMDL targets. We encourage EPA to develop a specific monitoring plan and implementation schedule for this proposed TMDL. Specific monitoring and implementation methodologies have not been included in the previous TMDLs we have reviewed in Tennessee.

Response: TMDL implementation, including monitoring plans and implementation schedules, is not a required component of TMDLs, in accordance with Section 303(d) of the Clean Water Act. However, after TMDLs are established, EPA expects that TMDLs will be implemented consistent with the Clean Water Act and its implementing regulations, including those associated with NPDES permit requirements.

We encourage the commenter to participate in the State of Tennessee's Watershed Approach (see http://www.state.tn.us/environment/wpc/watershed for more information). Four main features of the State's Watershed Approach are: 1) Identifying and prioritizing water quality problems in the watershed, 2) Developing increased public involvement, 3) Coordinating activities with other agencies, and 4) Measuring success through increased and more efficient monitoring and other data gathering.

Comment

Within the framework of our Memorandum of Agreement (MOA) Regional Review Team, we would like to discuss the applicability of utilizing alternative existing criteria developed for activities outside the scope of those NPDES discharges discussed in this TMDL. We strongly encourage EPA to re-evaluate existing NPDES individual permits, stormwater general permits, and aquatic resource alteration permits in place within the Harpeth River watershed to ensure compliance with existing Federal regulations.

We would like to work cooperatively with the State of Tennessee and EPA in prioritizing critical treatment areas in these impaired watersheds, while leveraging available funding from our agencies to correct the identified problems. We believe that this TMDL could be enhanced with a thorough evaluation of existing land uses and management practices in the impaired watersheds and ecoregional reference sites, as well as implementation of the technical recommendations outlined above.

Response: EPA is willing to participate in discussions relating to water quality standards and TMDL implementation issues relevant to the Harpeth River watershed.

EPA expects that TMDLs will be implemented consistent with the Clean Water Act and its implementing regulations, including those associated with NPDES permit requirements.

<u>Commenter #3</u>

Comment

In the interest of brevity, at this time our comments will only be given in the form of what we find lacking in this TMDL, and will not cover all issues or details.

1. Lack of Daily Maximum Loads and permit limits for DO-related pollutants - monthly and annual averages are not acceptable, consistent with criteria, or supported. This includes nutrients that are only evaluated as annual loads - while this may be partly justified in some cases for lakes, this is a flowing river for which an annual load alone makes little sense.

Response: In accordance with 40 CFR Section 130.2(i), TMDLs may be expressed in terms of mass per time, toxicity, or other appropriate measure to ensure the attainment of water quality standards. The nutrient allocations are established based on a monthly average duration, not an annual average duration. The duration of exposure to nutrients that would cause algal growth sufficient to result in adverse effects to the biological integrity is a relatively long-term process (up to 6 or 7 months). However, allocations on a monthly average basis were established as a conservative approach to ensure year-round attainment of water quality standards.

The TMDL for the dissolved oxygen impairment was based upon an analysis of the calibrated dynamic water quality model, WASP. A single day critical hourly dissolved oxygen deficit was used to represent the critical condition. Such an approach is more conservative than taking the seven day average dissolved oxygen concentration which a steady state water quality model would provide in assessing the 7Q10 critical condition flow period. The dissolved oxygen impacts will be best mitigated by effectively reducing seasonal loads to minimize the accumulation of SOD causing material.

Comment

2. Lack of correlation to sediment TMDL of last year - which we also commented on and found to be unacceptable and, in fact not actually a TMDL as per the regulations.

Response: This TMDL is independent of the sediment TMDL, submitted by the State on May 10, 2002, and approved by EPA on October 31, 2002. The previous sediment TMDL, which addressed all statutory and regulatory requirements, focused on controlling the "clean sediment" (i.e., sediment composed of inorganic material) which has an adverse impact on the aquatic community habitat. The TMDL to address organic enrichment/low dissolved oxygen focuses on nutrient and BOD pollutant load reductions necessary to maintain the dissolved oxygen stream criterion of 5 mg/l and protect the biological integrity.

Comment

3. Lack of any proposed permit limits for most of the point sources - i.e. municipal and industrial/construction storm water permits.

Response: Consistent with Section 303(d) of the Clean Water Act and its implementing regulations, the Harpeth River TMDL identifies the wasteload and load reductions necessary to attain water quality standards. EPA expects the State will implement the wasteload allocations through establishment of appropriate NPDES permit requirements, including permit limits, consistent with the applicable federal statutory and regulatory requirements.

Based on EPA's reevaluation of all point sources in the watershed, wasteload allocations have been provided to all point sources that discharge organic loads upstream of the impaired waters addressed by the TMDL. As a result, there are 5 additional point sources which are receiving a wasteload allocation that were not identified as receiving a wasteload allocation in the proposed TMDL report. The additional point sources include: 1) Bethesda Elementary School; 2) College Grove Elementary School; 3) Trinity Elementary School; and 4) Hillsboro Elementary School. As stated in the proposed TMDL report, these facilities were determined to not cause or contribute to excursions of water quality standards. Therefore, these point sources are receiving allocations equal to their existing permitted loads to ensure that they continue to discharge at levels which do not cause or contribute to excursions of water quality standards.

Comment

4. Allowing continuation of existing permit limits for most of the permits that currently have limits, with the presumption that in-stream capacity will be made available through significant reduction of SOD and sediment inputs from currently non-limited sources (see item 3 above).

Response: The decision for allocating pollutant load reductions necessary to achieve the water quality criterion for dissolved oxygen was based upon the relative impacts made by both point and nonpoint sources of pollution. The TMDL analysis demonstrated that the smaller point sources have a minimal impact on the severe dissolved oxygen sag.

Even if these facilities were removed from the watershed, there would be no significant improvements in water quality. Only by attaining significant nonpoint source load reductions will the impairment be sufficiently mitigated. This conclusion is substantiated by model results as well as the relative loads contributions currently entering the system from point sources and nonpoint sources.

Significant nonpoint source reductions, which in turn will reduce SOD levels will be implemented based on several activities funded by EPA. The Harpeth River basin is one of three watersheds which are being addressed by the Cumberland River Compact through a $600,000 grant targeting watershed restoration and protection activities. In addition, the Harpeth River Watershed Association has been selected to receive a $200,000 grant from Region 4 to undertake watershed restoration projects and facilitate a stakeholder process to effectively implement TMDL load reductions. In addition, the Harpeth River Watershed Association has received CWA Section 319 grants focusing on agricultural and suburban stormwater pollution controls for sediment and nutrients. To date, five demonstration BMP projects have been installed to assess treatment performance. The results of these studies will provide valuable BMP design information to effectively implement the load allocation targets established in the Harpeth River Watershed TMDLs for siltation/habitat alteration and organic enrichment/low dissolved oxygen.

5. Minimal reduction to Franklin's permit limits based only on monthly average, not daily maximum assessment, and presumption of available in-stream capacity from SOD/sediment input reductions with no assurance of implementation; and no reconsideration given to last year's significant expansion of Franklin's permit prior to TMDL completion.

Response: This characterization of the Franklin WWTP impacts is not accurate. First, the total maximum daily load is based on an hourly minimum worst case scenario occurring during a 10-year period. Using such a conservative assessment value in developing a monthly average permit limit is expected to result in the attainment of water quality standards. In addition, the SOD reductions are necessary to mitigate a dissolved oxygen sag occurring 30 miles downstream of the dissolved oxygen sag caused by the projected City of Franklin WWTP discharge (12 MGD) under design flow conditions.

There is reasonable assurance that significant nonpoint source reductions will be implemented based on several activities funded by EPA. The Harpeth River basin is one of three watersheds which are being addressed by the Cumberland River Compact through a $600,000 grant targeting watershed restoration and protection activities. In addition, the Harpeth River Watershed Association has been selected to receive a $200,000 grant from Region 4 to undertake watershed restoration projects and facilitate a stakeholder process to effectively implement TMDL load reductions. In addition, the Harpeth River Watershed Association has received CWA Section 319 grants focusing on agricultural and suburban stormwater pollution controls for sediment and nutrients. To date, five demonstration BMP projects have been installed to assess treatment performance. The results of these studies will provide valuable BMP design information to effectively implement the load allocation targets established in the Harpeth River Watershed TMDLs for siltation/habitat alteration and organic enrichment/low dissolved oxygen.

EPA recognizes that a TMDL improves water quality when there is a plan for implementing the TMDL. However, CWA section 303(d) does not establish any new implementation authorities beyond those that exist elsewhere in State, local, Tribal or Federal law. Thus, the wasteload allocations within TMDLs are implemented through enforceable water quality-based effluent limitations in NPDES permits authorized under section 402 of the CWA. Load allocations within TMDLs are implemented through a wide variety of State, local, Tribal and Federal nonpoint source programs (which may be regulatory, non-regulatory, or incentive-based, depending on the program), as well as voluntary action by committed citizens. See New Policies for Establishing and Implementing Total Maximum Daily Loads (TMDLs), dated August 8, 1997.

6. No reduction, and even an increase in load from Lynwood STP, ignoring previous studies in 1998 showing impacts from before expansion; again apparently based on a presumed but unsupported future reduction in SOD/sediment input.

Response: EPA reviewed all available data and information, including data and information from 1998, with respect to the Lynnwood Sewage Treatment Plant (STP) and its impact on the Harpeth River. Based on a modeling sensitivity analysis, the Lynnwood STP has an insignificant impact on dissolved oxygen levels in the Harpeth River. Therefore, an allocation was provided to Lynnwood STP based on the facility's design effluent flow rate and concentrations equal to those required in the current NPDES permit for the facility. This allocation as well as the allocations provided to the other point sources and the nonpoint sources, ensure the attainment of water quality standards.

7. No correlation clearly given for the relationship between the DO-consuming parameters of SOD, BOD, ammonia, N&P to show how it all balances to determine the safe carrying capacity of the river, allowable loads, and permit limits.

Response: The water quality model, WASP, uses accepted reaction kinetic based relationships to assess the relative impacts of BOD, SOD and ammonia on a stream's dissolved oxygen profile under varying flow regimes. EPA acknowledges that the relationship between nutrient loads from the 12-digit subwatersheds and the SOD in the Harpeth River is not well understood. Therefore, as explained in the TMDL report, EPA used a conservative assumption that nutrient load reductions from the tributaries are expected to be proportional to the expected SOD reductions.

8. Lack of documentation to support claim of verified model or level of uncertainty upon which to base accuracy and margin of safety.

Response: The models used in the TMDL development were calibrated, to the extent possible, based on consideration of all available data and information. EPA completed a modeling report on July 31, 2002, to thoroughly document the development of the model and identify the conservative assumptions used in the modeling effort. EPA did not have data and information sufficient to numerically quantify the level of uncertainty with respect to the TMDL development. However, where uncertainty occurred in the analysis, EPA used appropriate conservative assumptions to ensure that the allocations are sufficient to result in the attainment of water quality standards.

9. Apparent lack of correlation with Franklin water withdrawal and proposal to increase withdrawal in near future - before standards are met in the river, thus potentially causing further impacts.

Response: Based on information provided by TDEC, the State is considering a proposal by the City of Franklin to withdraw up to 16 cubic feet per second (cfs) from the Harpeth River at the location of its current intake (i.e., River Mile 89.2). As part of the proposal, the City would not withdraw water during conditions when the flow in the Harpeth River (at the location of the intake) is less than 5 cfs. The 7Q10 of the Harpeth River at the location of the intake is less than 0.5 cfs. Therefore, EPA expects that the allocations established by the TMDL will be protective of the applicable water quality standards, regardless of how the State acts on the City of Franklin's proposal for water withdrawal.

10. Lack of clarity on SOD/sediment reductions - are these to be reductions of existing in-stream loads, existing/future inputs, both?

Response: The reductions of the SOD require reductions of nutrients and other organic material entering the Harpeth River. The reductions of sediment (composed of inorganic material) to the Harpeth River watershed were identified in the TMDL for siltation/habitat alteration submitted by the State on May 10, 2002, and approved by EPA on October 31, 2002. Considering that the causes and sources of SOD and sediment are not necessarily the same, the allocations were identified using different methods of analysis.

The SOD in the mainstem of the Harpeth River should be reduced to levels 40% below the current SOD exerted by the Harpeth River in order for water quality standards to be attained. EPA expects that the achievement of nutrient load reductions identified for the 12-digit subwatersheds will result in the achievement of SOD by at least 40%.