TOTAL MAXIMUM DAILY LOAD (TMDL)

For

pH and Iron

In

North and South Suck Creek

Located in the

Lower Tennessee River Watershed (HUC 06020001)

Hamilton, Marion, & Sequatchie Counties, Tennessee

Final

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TDEC

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LIST OF ABBREVIATIONS

AMD	Acid Mine Drainage
CFR	Code of Federal regulations
CFS	Cubic Feet per Second
DEM	Digital Elevation Model
DWPC	Division of Water Pollution Control
EPA	Environmental Protection Agency
GIS	Geographic Information System
HUC	Hydrologic Unit Code
LA	Load Allocation
LDC	Load Duration Curve
LSPC	Loading Simulation Program in C^{++}
MGD	Million Gallons per Day
MOS	Margin of Safety
MRLC	Multi-Resolution Land Characteristic
NHD	National Hydrography Dataset
NPDES	National Pollutant Discharge Elimination System
NPS	Nonpoint Source
RM	River Mile
TDEC	Tennessee Department of Environment & Conservation
TMDL	Total Maximum Daily Load
USGS	United States Geological Survey
WCS	Watershed Characterization SYstem
WLA	Waste Load Allocation

SUMMARY SHEET
Proposed Total Maximum Daily Load (TMDL)
Suck Creek Subwatershed

1) 303(d) Listed Waterbody Information

State: Tennessee
County: Hamilton, Marion, & Sequatchie

Major River Basin: Tennessee River Basin
Watershed: Lower Tennessee River (HUC 06020001)

Waterbody Name: North and South Suck Creek
Waterbody ID: TN06020001421
Location: South Suck Creek from Suck Creek to the headwaters (segment 0100) and North Suck Creek from Suck Creek to the headwaters (segment 0200)
Impacted Stream Length: 25.4 miles Not Supporting
Watershed Area: 22.67 mi^2 (Suck Creek subwatershed)
Tributary to: Tennessee River

Constituent(s) of Concern: pH and iron (South Suck Creek only)

Designated Uses: Fish and Aquatic Life, Recreation, Livestock Watering & Wildlife, and Irrigation

Applicable Water Quality Standard:

Most stringent water quality standard is a range of 6.0 to 9.0 for the Fish & Aquatic Life use classification

National Recommended Water Quality Criteria for iron of 1000 μg/L. Tennessee does not have a numeric water quality criterion for iron. However, TDEC believes that meeting the above criteria will satisfy the requirement that "waters shall not contain toxic substances that will render the waters unsafe or unsuitable" for their designated use classifications.

2. TMDL Development

Analysis Methodology: Based on 2004 303(d) List
Load Duration Curve methodology
Net Alkalinity used as surrogate for pH

Critical Conditions: Methodology addresses all flow conditions

Seasonal Variation: Methodology addresses all seasons

3. TMDL/Allocation

Margin of Safety (MOS): Implicit (conservative modeling assumptions)

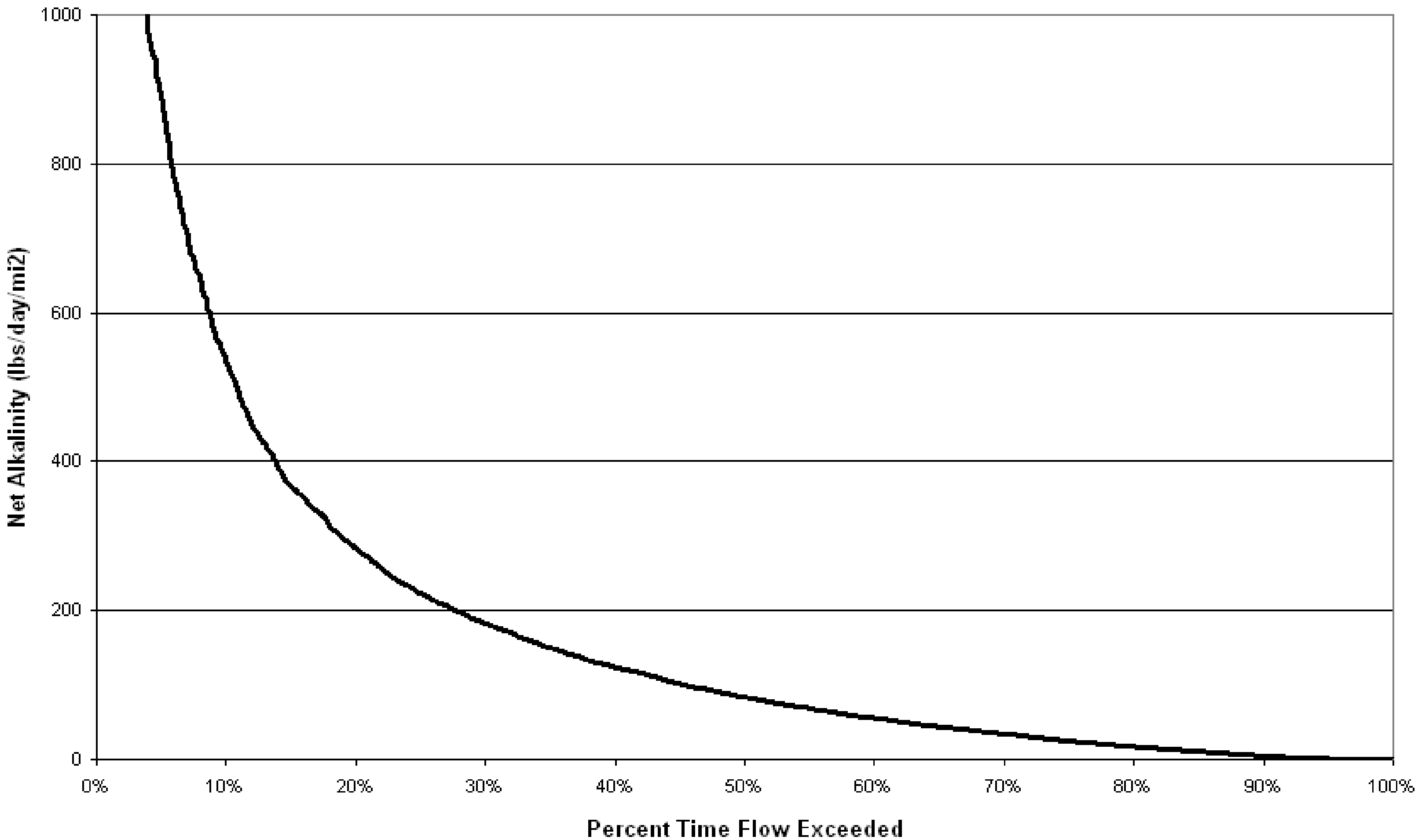
Load Allocation: Consists of two components:

1) The pH of waters originating from nonpoint sources shall be 6.0 to 9.0 standard units.

2) Equal to Net Alkalinity load duration curve created using Target Net Alkalinity (10.8 mg/L) (see Figure on next page and Appendix C), which will provide a pH within the criteria range of 6.0 – 9.0

Waste Load Allocation: **The pH of the effluent from point sources shall be 6.0 to 9.0 standard units. There are no current point sources that discharge to these waters. This requirement applies to any future point sources.**

Analysis of data for South Suck Creek suggests that it is no longer impaired by iron. At this time, de-listing is suggested.



Target Load Duration Curve

PROPOSED
pH and IRON TOTAL MAXIMUM DAILY LOAD (TMDL)
LOWER TENNESSEE RIVER WATERSHED (HUC 06020001)

North and South Suck Creek – Suck Creek to Headwaters (TN06020001421)

1.0 INTRODUCTION

Section 303(d) of the Clean Water Act 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 meeting designated uses. The TMDL process establishes the allowable loadings of pollutants or other quantifiable parameters for a waterbody based on the relationship between pollution sources and in-stream water quality conditions, so that states can establish water quality based controls to reduce pollution from both point and non-point sources and restore and maintain the quality of their water resources (USEPA, 1991).

2.0 WATERSHED DESCRIPTION

The Lower Tennessee River Watershed (HUC 06020001) is located in eastern Tennessee (Figure 1) and falls within two Level III ecoregions (Southwestern Appalachians and Ridge and Valley). The Suck Creek subwatershed contains two Level IV subecoregions (USEPA, 1997) as shown in Figure 2:

- **Cumberland Plateau (68a)** tablelands and open low mountains are about 1000 feet higher than the Eastern Highland Rim (71g) to the west, and receive slightly more precipitation with cooler annual temperatures than the surrounding lower-elevation ecoregions. The plateau surface is less dissected with lower relief compared to the Cumberland Mountains (69d) or the Plateau Escarpment (68c). Elevations are generally 1200-2000 feet, with the Crab Orchard Mountains reaching over 3000 feet. Pennsylvanian-age conglomerate, sandstone, siltstone, and shale is covered by well-drained, acid soils of low fertility. Bituminous coal that has been extensively surface and underground mined underlies the region. Acidification of first and second order streams is common. Stream siltation and mine spoil bedload deposits continue as long-term problems in these headwater systems. Pockets of severe acid mine drainage persist.

- **Plateau Escarpment (68c)** is characterized by steep, forested slopes and high velocity, high gradient streams. Local relief is often 1000 feet or more. The geologic strata include Mississippian-age limestone, sandstone, shale, and siltstone, and Pennsylvanian-age shale, siltstone, sandstone, and conglomerate. Streams have cut down into the limestone, but the gorge talus slopes are composed of colluvium with huge angular, slabby blocks of sandstone. Vegetation community types in the ravines and gorges include mixed oak and chestnut oak on the upper slopes, mesic forests on the middle and lower slopes (beech-tulip poplar, sugar maple-basswood-ash-buckeye), with hemlock along rocky streamsides and river birch along floodplain terraces.

The Lower Tennessee River Watershed, located in Bledsoe, Bradley, Hamilton, Loudon, Marion, McMinn, Meigs, Rhea, Roane, and Sequatchie Counties, Tennessee, has a drainage area of approximately 1200 square miles (mi^2) in Tennessee. The entire watershed, including portions of Tennessee, Alabama, and Georgia, drains approximately 1,870 square miles. 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 Lower Tennessee River Watershed have occurred since 1993 as a result of development, this is the most current land use data available. Land use for the Lower Tennessee River Watershed is summarized in Table 1. The Suck Creek subwatershed, located in Hamilton, Marion, and Sequatchie Counties, has a drainage area of approximately 23 square miles. Land use for the Suck Creek subwatershed is also summarized in Table 1 and shown in Figure 3.

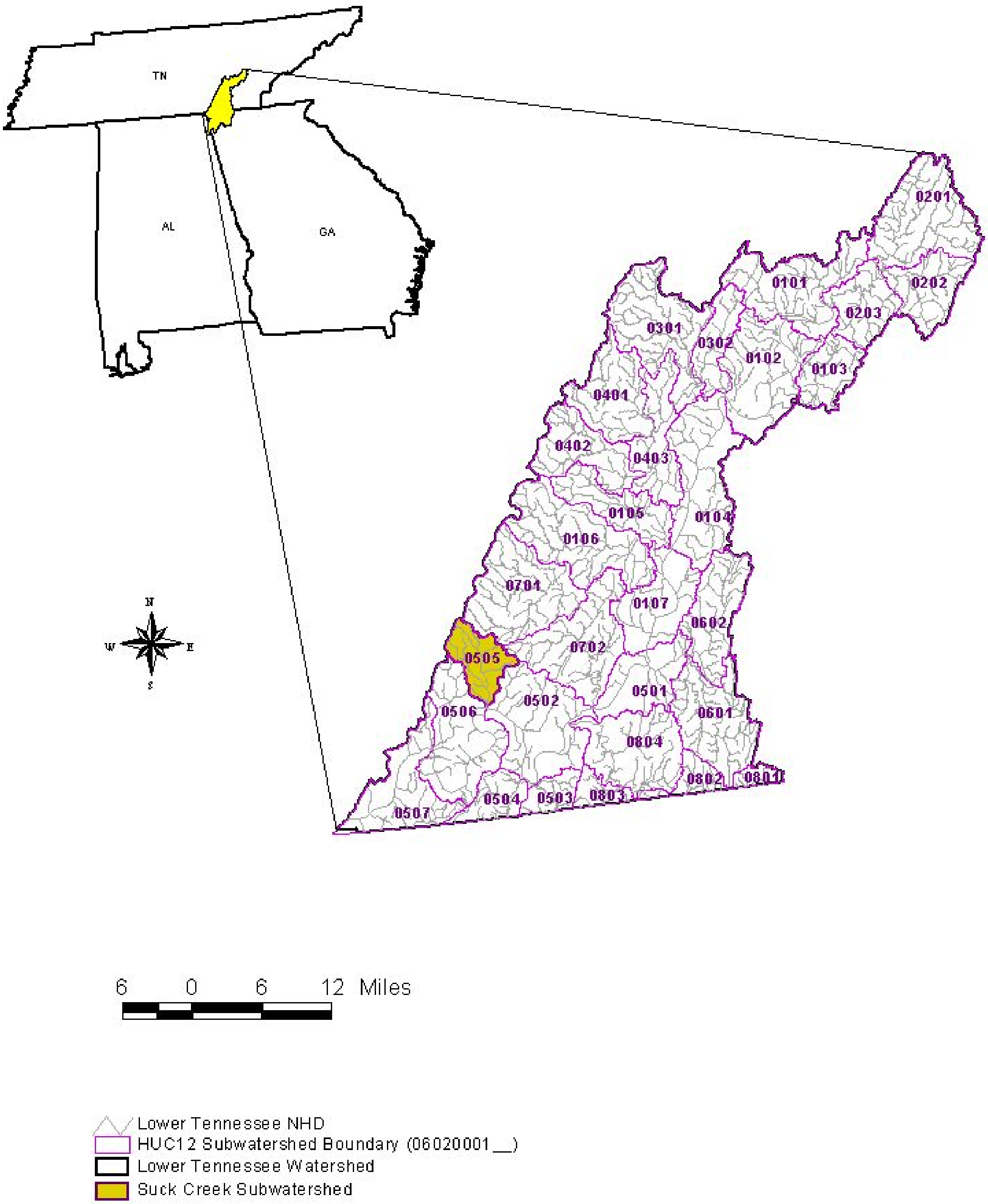


Figure 1 Location of Lower Tennessee River Watershed

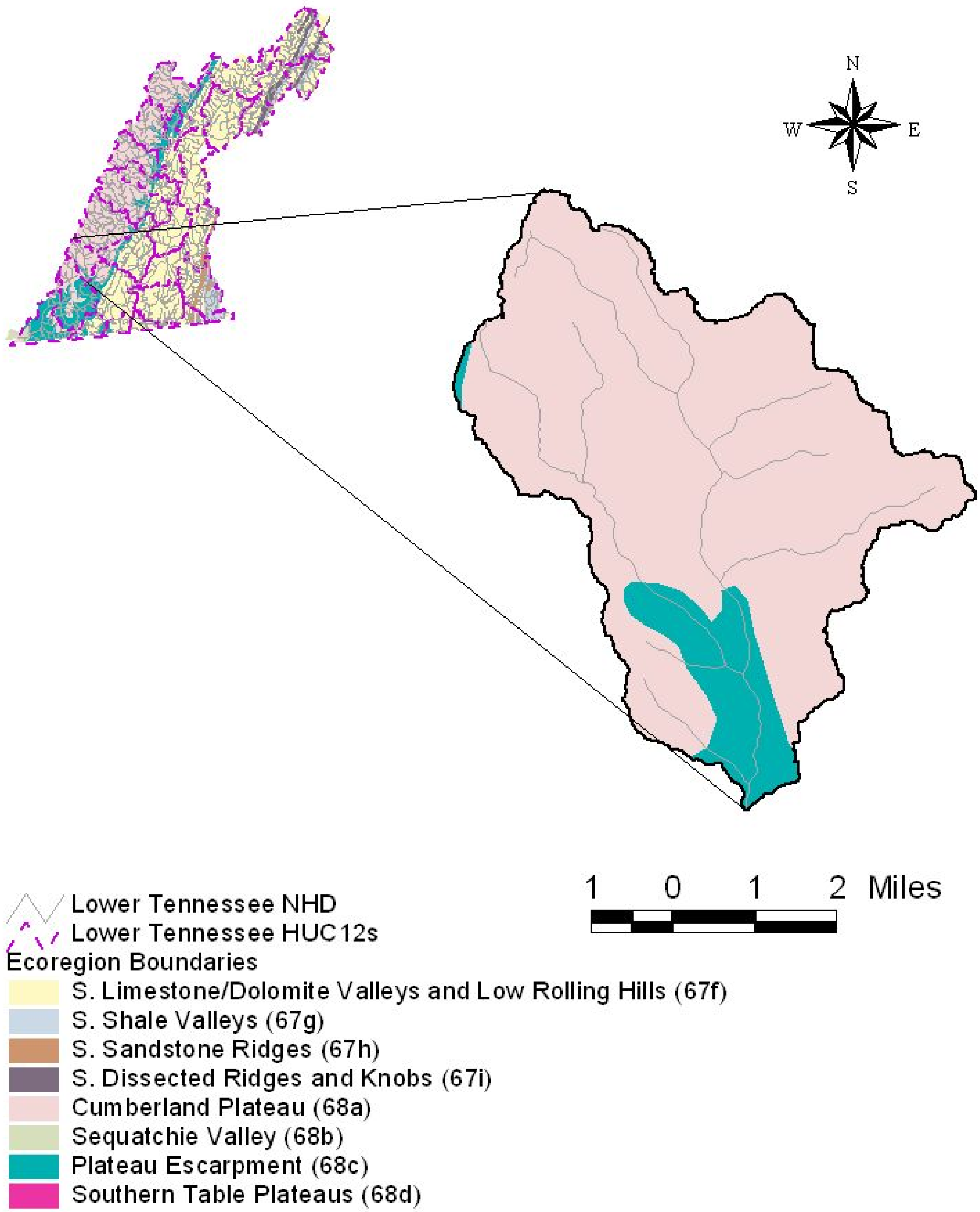


Figure 2 Suck Subwatershed Ecoregion Designation

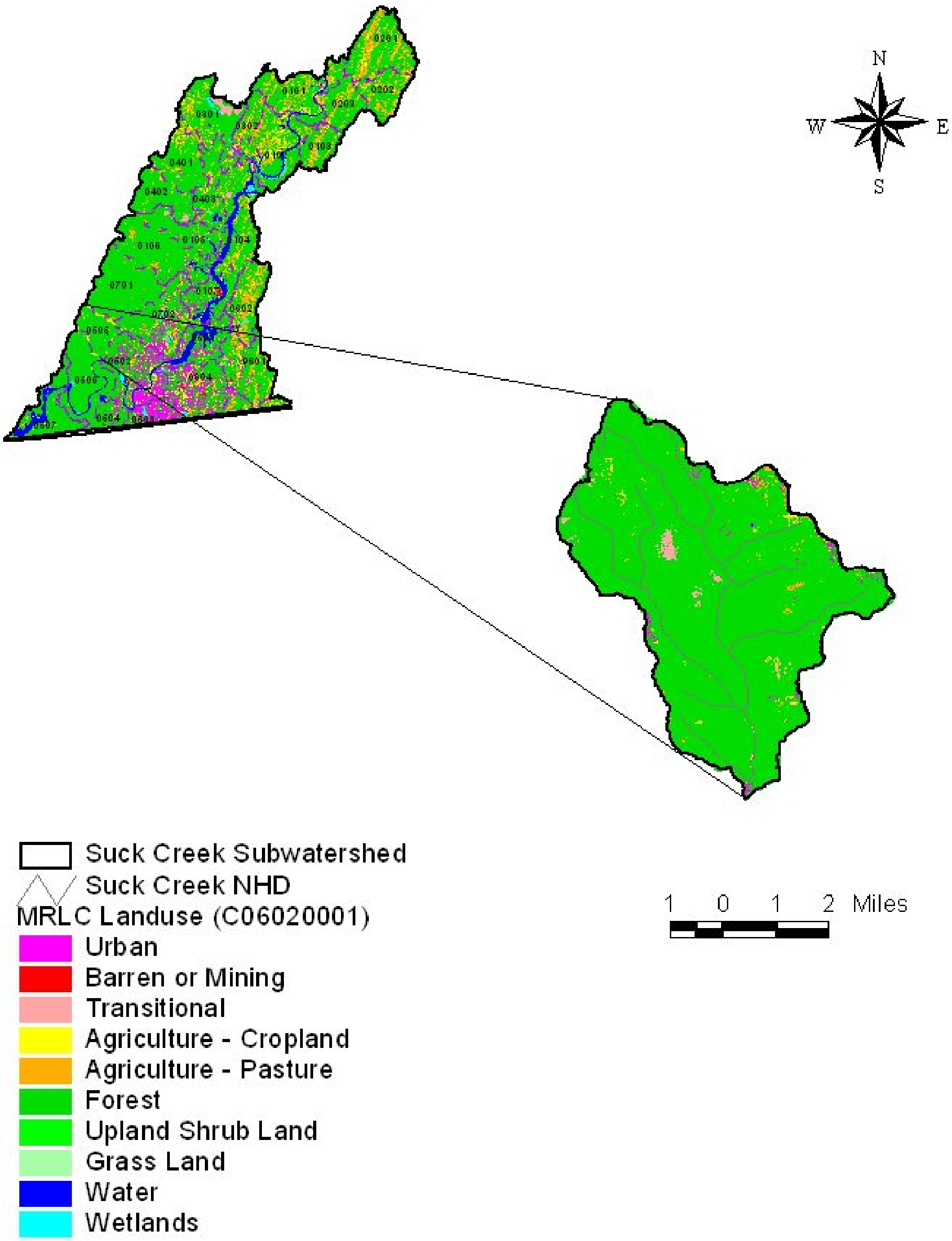


Figure 3 Lower Tennessee River Watershed & Suck Subwatershed Land Use Distribution

Table 1 Land Use Distribution – Lower Tennessee River Watershed & Suck Creek Subwatershed

Land use	Suck Creek Subwatershed (060200010505)		Lower Tennessee Watershed (TN only) (06020001)		Lower Tennessee Watershed (06020001)	
	[acres]	[%]	[acres]	[%]	[acres]	[%]
Bare Rock/Sand/Clay	0	0	41	0	41	0
Deciduous Forest	9,695	66.8	318,445	41.0	475,555	39.7
Emergent Herbaceous Wetlands	0	0	1,574	0.2	1,329	0.1
Evergreen Forest	883	6.1	97,287	12.5	151,404	12.6
High Intensity Commercial/Industrial/ Transportation	29	0.2	12,797	1.6	15,710	1.3
High Intensity Residential	4	0	5,446	0.7	6,407	0.5
Low Intensity Residential	102	0.7	30,909	4.0	37,949	3.2
Mixed Forest	3,405	23.5	145,860	18.8	254,057	21.2
Open Water	2	0	34,640	4.5	34,967	2.9
Other Grasses (Urban/recreational)	16	0.1	9,403	1.2	12,242	1.0
Pasture/Hay	131	0.9	79,958	10.3	147,402	12.3
Quarries/Strip Mines/Gravel Pits	0	0	1,172	0.2	1,321	0.1
Transitional	143	1.0	26,435	3.4	11,326	0.9
Row Crops	98	0.7	7,464	1.0	41,952	3.5
Woody Wetlands	0	0	5,068	0.7	5,303	0.4
Total	14,507	100.0	776,499	100.0	1,196,966	100.0

3.0 PROBLEM DEFINITION

The State of Tennessee's final 2004 303(d) list (TDEC, 2004a) was approved by the U.S. Environmental Protection Agency (EPA), Region IV in August of 2005. The list identified 25.4 miles of Suck Creek (North and South Suck Creek from Suck Creek to the headwaters) as not supporting designated use classifications due, in part, to pH associated with abandoned mines. Historical records indicate that the Durham Coal & Iron Company and the Suck Creek Coal Company were active in the 1920s. Information regarding formation of acid mine drainage (AMD) is contained in Appendix A. The designated use classifications for Suck Creek and its tributaries include fish and aquatic life, irrigation, livestock watering & wildlife, and recreation. The results of the 2004 303(d) list are summarized in Table 2.

Table 2 2004 303(d) List – Suck Creek Subwatershed

Waterbody ID	Impacted Waterbody	County	Miles/Acres Impaired	CAUSE	Pollutant Source
TN06020001 421 – 0100	South Suck Creek	Marion	9.2	pH Iron Siltation	Abandoned Mining
TN06020001 421 – 0200	North Suck Creek	Marion Sequatchie	16.2	pH	Abandoned Mining

There are no active mines in the Suck Creek subwatershed. The impaired segments in the Suck Creek subwatershed are shown in Figure 4.

4.0 TARGET IDENTIFICATION

The allowable instream range of pH for the Suck Creek subwatershed, is established in *State of Tennessee Water Quality Standards, Chapter 1200-4-3 General Water Quality Criteria, January, 2004 (Revised)* (TDEC, 2004b) for applicable use classifications. The Fish & Aquatic Life criteria pH range for "all other wadeable streams" of 6.0 to 9.0 is the most stringent for the waterbodies covered by this TMDL. The criteria were approved by the Environmental Protection Agency (EPA) in September 2004.

According to the Pennsylvania Department of Environmental Protection (PDEP, 1998), the "acidity or net alkalinity of a solution, not the pH, is probably the best single indicator of the severity of AMD." In order to facilitate analysis of existing pollutant loads and load reductions required to restore the Suck Creek subwatershed to fully supporting all of its designated use classifications, net alkalinity will be used as a surrogate parameter for TMDL development. For the purposes of this TMDL, the following terms are defined:

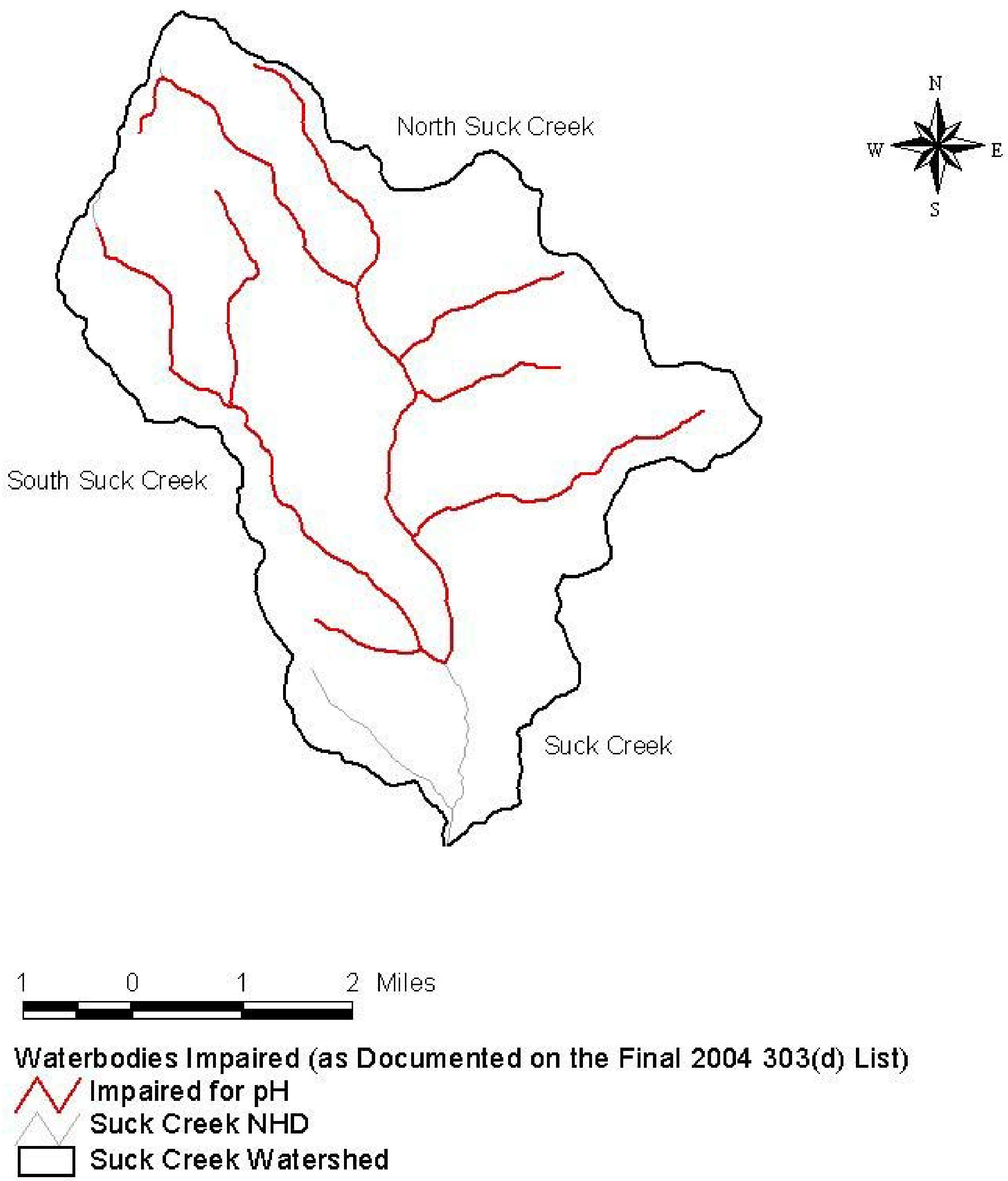


Figure 4 Suck Creek Subwatershed Impaired Segments

Acidity	The quantitative capacity of a water to react with a strong base to a designated pH. Expressed as milligrams per liter calcium carbonate.
Total Alkalinity	A measure of the ability of water to neutralize acids. Expressed as milligrams per liter calcium carbonate.
Net Alkalinity	The total alkalinity minus the acidity. Expressed as milligrams per liter calcium carbonate.

Water quality monitoring of the Suck Creek subwatershed was conducted by Division of Water Pollution Control (DWPC) personnel from the Chattanooga Environmental Field Office (EFO) during the period from 7/28/04 through 5/31/05 (See Appendix B & Table 3). Monitoring stations were located at several points in North and South Creek (see Figure 5). Since there is no specified numerical criterion for net alkalinity, a net alkalinity of 10.8 mg/l $CaCO_3$, was selected as the numerical target for this TMDL based on analysis of all available monitoring data for Tennessee (see Appendix C).

The linkage between pH and net alkalinity and the appropriateness of the net alkalinity numerical target can be demonstrated through inspection of monitoring data presented in Table 4 and Figure 6. Three of the four samples with net alkalinity concentrations greater than 10.8 mg/L, and for which a pH value was available, have a pH that is not in compliance with water quality standards. These three samples are also the only three points out of 152 points statewide with net alkalinity concentrations greater than 10.8 mg/L and pH that is not in compliance with water quality standards. (See Appendix C.) These three points will be considered as anomalies because they represent only 2.0% of the available data statewide.

In order to characterize net alkalinity (as $CaCO_3$) over the range of flow conditions encountered in the subwatershed, the target net alkalinity (as $CaCO_3$) is expressed by means of a target load duration curve. The target load duration curve, developed in Appendix D and shown in Figure 7, is typical of the load duration curves derived for North and South Suck Creek. In order to meet Tennessee Water Quality Standards for pH, this TMDL requires that net alkalinity (as $CaCO_3$) loads of streams in the Suck Creek subwatershed meet, or exceed, the loads per unit area specified in the target load duration curve (Figure 7).

There is currently no numerical criterion for iron established in *State of Tennessee Water Quality Standards, Chapter 1200-4-3 General Water Quality Criteria, January 2004 (Revised)* (TDEC, 2004b). U.S.EPA has published National Recommended Water Quality Criteria (USEPA, 2006). The recommended criterion continuous concentration (CCC) for iron is 1000 μg/L and has been selected as the appropriate numeric target for South Suck Creek. TDEC believes that meeting this criteria will satisfy the requirement that “waters shall not contain toxic substances that will render the waters unsafe or unsuitable” for their designated use classifications.

Table 3 Suck Creek Subwatershed Monitoring Data

Monitoring Site	Parameter	Units	Sample Date											
			3/7/00	7/28/04	8/11/04	9/9/04	10/11/04	11/4,9/04	12/16/04	2/1/05	3/22/05	4/6/05	5/3/05	5/31/05
North Suck Creek	Flow	cfs	10.67	11.01	6.51	12.32	1.74	20.36	18.35	15.23	6.85	27.59	17.17	0.98
	Total Alkalinity	mg/L[a]	9.00	U[b]	U[b]	U[b]	U[b]	U[b]	U[b]	U[b]	18.00	U[b]	U[b]	15.00
(Mile 0.1)	Acidity	mg/L[a]		1.20	U[b]	U[b]	3.56	U[b]	1.15	1.40	U[b]	U[b]	1.10	1.20
South Suck Creek	Flow	cfs		5.60	3.30	6.28	0.88	33.77	9.35	7.78	3.45	14.06	8.75	0.50
	Total Alkalinity	mg/L[a]		U[b]	U[b]	32.40	U[b]	U[b]	U[b]	U[b]	U[b]	U[b]	U[b]	20.00
(Mile 0.1)	Acidity	mg/L[a]		1.63	U[b]	2.44	1.08	3.70	5.99	5.50	3.00	2.40	4.40	3.10

[a] mg/L $CaCO_3$

[b] U denotes analyte requested but not detected. Detection limit is 10 mg/L for total alkalinity and 1 mg/L for acidity

Table 4 Comparison of Suck Creek Subwatershed pH & Net Alkalinity

Monitoring Site	Parameter	Units	Sample Date											
			3/7/00	7/28/04	8/11/04	9/9/04	10/11/04	11/4,9/04	12/16/04	2/1/05	3/22/05	4/6/05	5/3/05	5/31/05
North Suck Creek	pH	--	5.53	6.39	6.42	6.24	5.81	5.55	5.27	5.80	5.80	6.50	6.50	6.44
Mile 0.1	Net Alkalinity	mg/L[a]	8.50	3.80	4.50	4.50	1.44	4.50	3.85	3.60	18.50	4.50	3.90	13.80
South Suck Creek	pH	--		5.50	6.59	5.20	4.97	5.13	4.37	4.90	4.90	5.20	5.10	5.14
Mile 0.1	Net Alkalinity	mg/L[a]		3.37	4.50	29.96	3.92	1.30	-0.99	-0.50	2.00	2.60	0.60	16.90

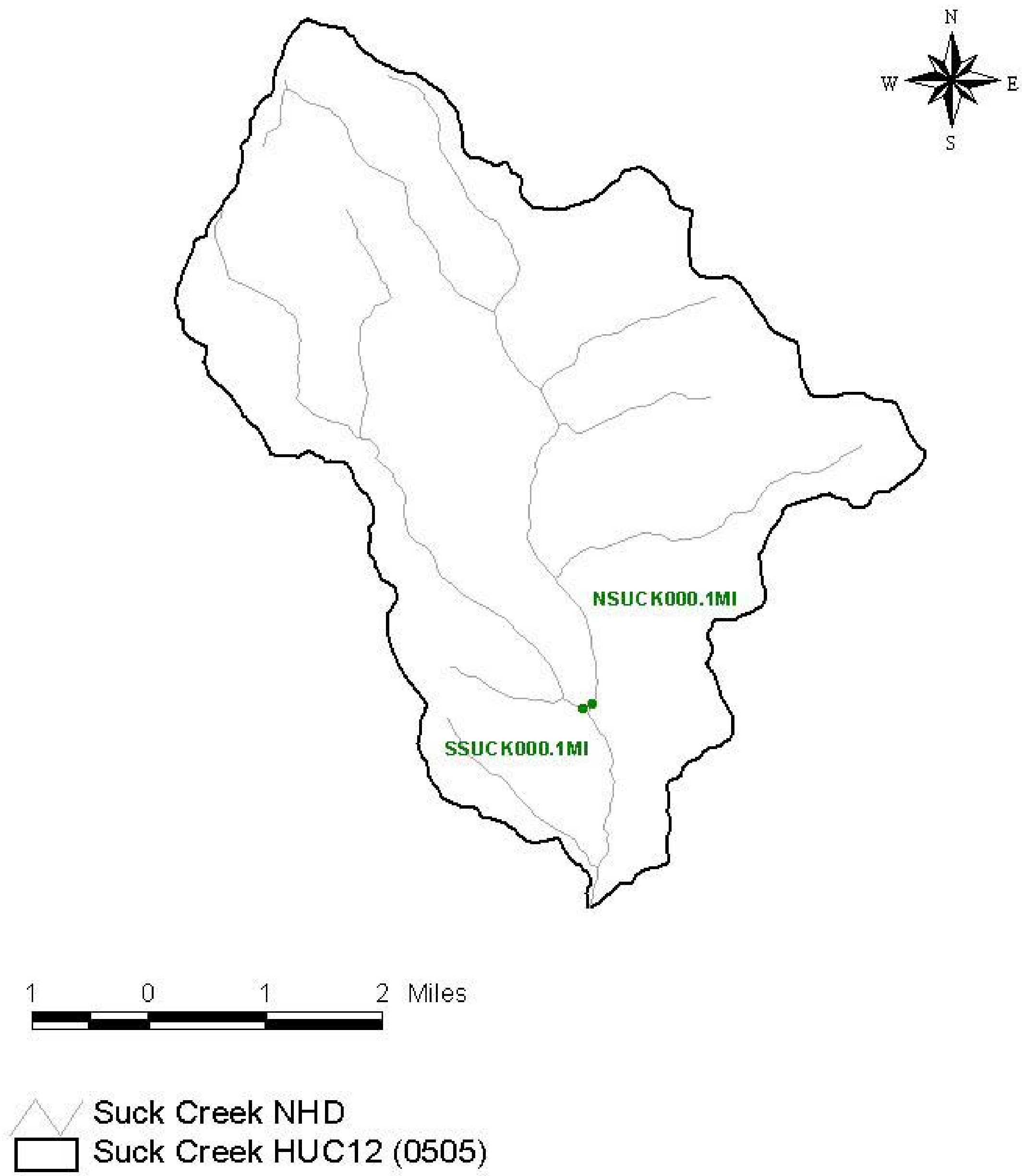


Figure 5   Suck Creek Subwatershed Monitoring Stations

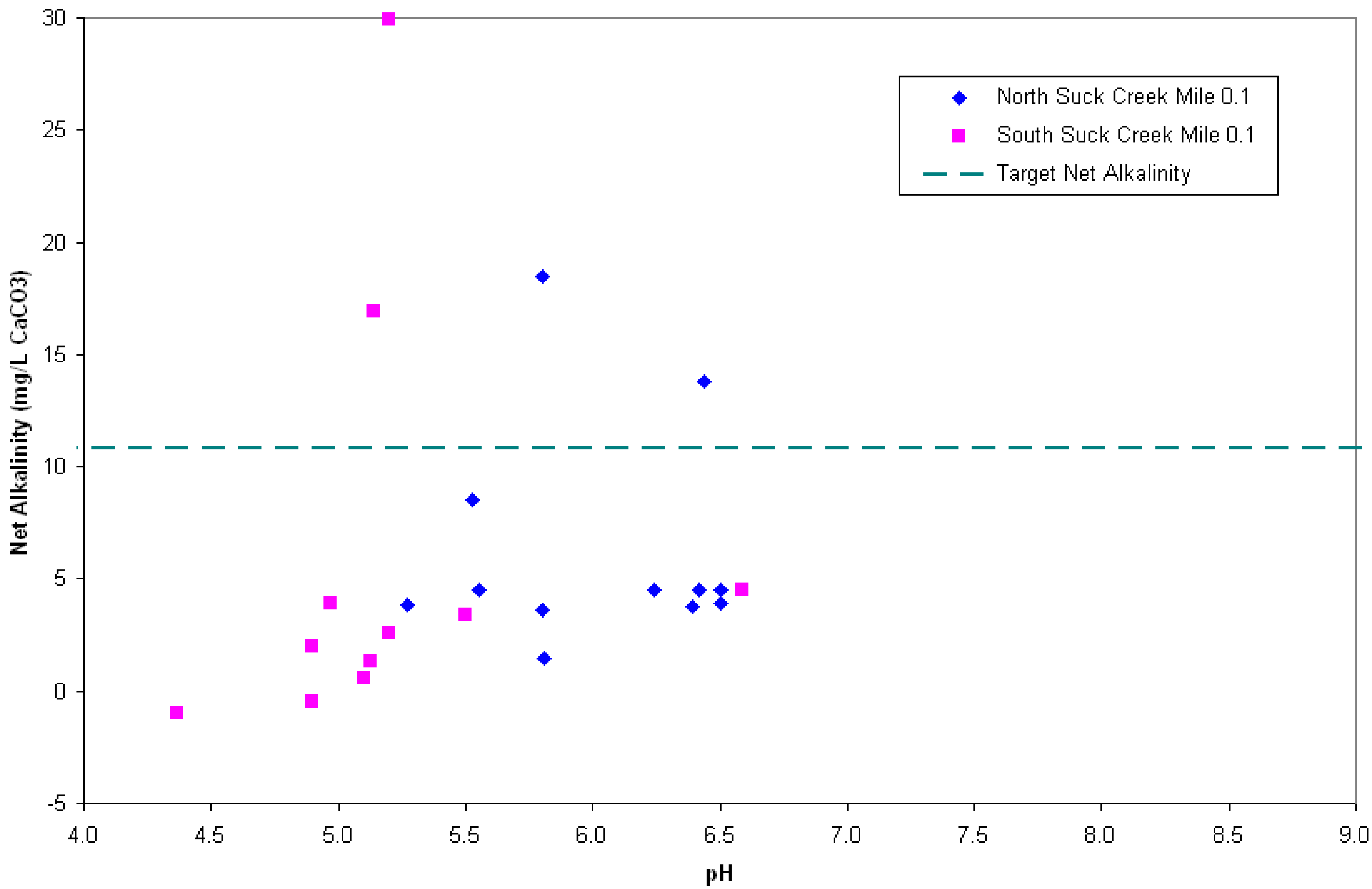


Figure 6 Relationship Between Net Alkalinity and pH in Suck Subwatershed

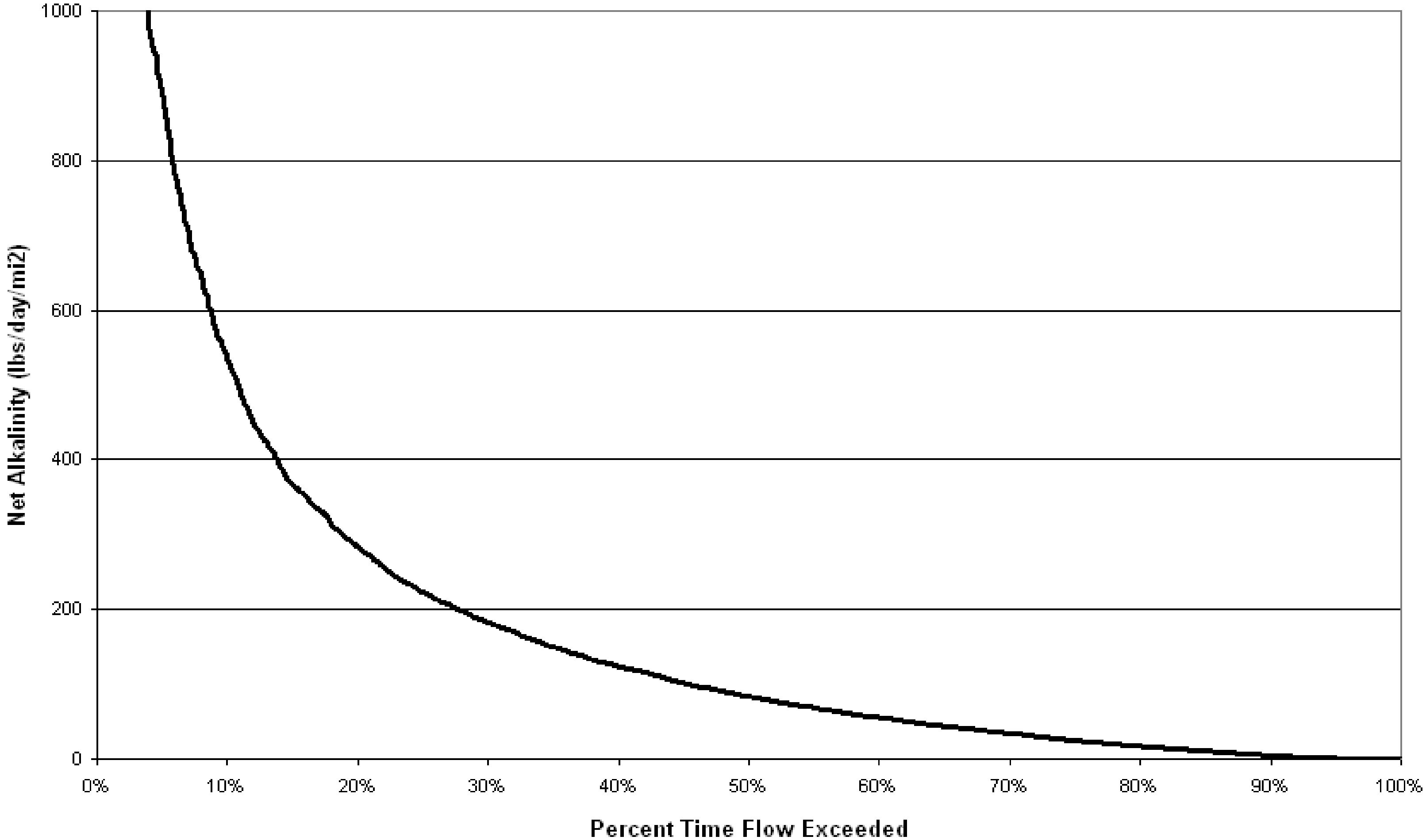


Figure 7 Target Load Duration Curve

5.0 WATER QUALITY ASSESSMENT AND DIFFERENCE FROM TARGET

The flow, acidity, and total alkalinity data collected at each monitoring site (ref: Appendix B) in the Suck Creek subwatershed are tabulated in Table 3. For each site, net alkalinity was calculated using the methodology described in Appendix F. It should be noted that, for a number of samples, the total alkalinity or acidity were reported as "not detected". The detection limits for these samples were 10 mg/l for total alkalinity and 1 mg/l for acidity. For the purpose of calculating net alkalinity, the analyte concentrations were estimated to be one half of the appropriate detection limit. As a point of reference, the instream pH corresponding to net alkalinity concentrations for subwatershed monitoring sites are summarized in Table 4.

For each site, the difference between the target net alkalinity load and the calculated net alkalinity load was determined using the methodology described in Appendix F. The results are summarized in Tables F-3 and F-4. A negative sign indicates that the net alkalinity load must be increased to meet the target. In each case, calculated net alkalinity loads deviated from the target load duration curve as shown in Figures F-3 and F-4. Observed net alkalinity load values plotted below the target net alkalinity load curve indicate points at which the net alkalinity load must be increased, either by increasing the total alkalinity or decreasing the total acidity, to meet the target net alkalinity load. The net alkalinity values for North and South Suck Creek reflect the use support status in the 2004 303(d) List (ref.: Table 2).

The iron data collected for South Suck Creek is tabulated in Appendix B. Analysis of the data suggests that South Suck Creek is no longer impaired by iron. At this time, de-listing is suggested.

6.0 SOURCE ASSESSMENT

An important part of the TMDL analysis is the identification of individual sources, or source categories, of low pH in the subwatershed and the amount of pollutant loading contributed by each of these sources. Sources are broadly classified as either point or non-point sources. A point source can be defined as a discernable, confined, and discrete conveyance from which pollutants are or may be discharged to surface waters. Non-point sources include all other sources of pollution.

6.1 Point Sources

There are no known point source discharges of low pH effluent in the Suck Creek subwatershed.

6.2 Non-point Sources

There are a number of abandoned surface mining sites in the Suck Creek subwatershed that are susceptible to the formation of acid mine drainage as discussed in Appendix A. In the 2004 303(d) List (ref.: Table 2), abandoned mining was identified as the source of low pH in impaired waterbodies in the subwatershed.

7.0 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. 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:

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

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 (e.g. pounds per day), toxicity, or other appropriate measure.

7.1 TMDL Representation

In general, waterbodies become impaired due to excessive loading of particular pollutants that result in concentrations that violate instream water quality standards. A TMDL establishes the maximum load that can be assimilated by the waterbody, without violating standards, and allocates portions of this load to point and non-point sources. This normally involves reductions in loading from existing levels, with WLAs & LAs of zero as the ideal.

The use of net alkalinity as a surrogate parameter, however, requires a different approach. Existing levels of net alkalinity in impaired subwatersheds are negative, while target values are positive. The concept of a “maximum net alkalinity load” does not appropriately represent the desired target condition with respect to AMD caused impairment. Net alkalinity targets can be achieved by reducing acidity, increasing total alkalinity, or some combination of both.

The net alkalinity TMDL for the Suck Creek subwatershed is considered to correspond to the target load duration curve as developed in Appendix D.

7.2 Margin of Safety

There are two methods for incorporating an 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 this TMDL, an implicit MOS was incorporated through the use of conservative modeling assumptions. These include: 1) the use of a 10-year continuous simulation that incorporates a wide range of meteorological events, 2) the use of the load duration curve, which addresses pollutant loading over the entire range of flow, and 3) the use of a positive net alkalinity target of 10.8 mg/L based on analysis of all available monitoring data for Tennessee (see Appendix C).

7.3 Determination of Total Maximum Daily Loads

The TMDL for net alkalinity in the Suck Creek subwatershed is defined by the target load duration curve developed in Appendix D (ref: Figure D-4). The target load duration curve was developed on a unit area basis and is applicable for all impaired subwatersheds.

7.4 Determination of WLAs, & LAs

As previously stated, the TMDL can be expressed as the sum of all Waste Load Allocations (WLAs), Load Allocations (LAs), and an appropriate margin of safety (MOS). The pH of the effluent from point sources shall be 6.0 to 9.0 standard units. There are no current point sources that discharge to these waters. This requirement applies to any future point sources.

The LA for each subwatershed, then, is equal to: 1) the target load duration curve (ref: Figure D-4); and 2) the requirement that the pH of waters originating from nonpoint sources shall be 6.0 to 9.0 standard units. (See Section 5.0 for further details.)

7.5 Seasonal Variation

The target load duration curve, and therefore the TMDL and LAs, is applicable over the entire range of flow for all waterbodies in the Suck Creek subwatershed in all seasons.

8.0 IMPLEMENTATION PLAN

Monitoring conducted in 2004 and 2005 has identified North and South Suck Creek in the Suck Creek subwatershed as impaired due to low pH. This condition is a result of AMD from land disturbance caused by past coal mining activities. It should be noted that the stream water quality documented during sampling conducted for this TMDL is not typical of the more severe acid mine drainage situations. Acid mine drainage has one or more of four major components: high acidity (low pH < 6 or alkalinity < 20 mg/L), high metal concentrations (> 500 μg/L), elevated sulfate levels (> 74 mg/L), and excessive suspended solids and/or siltation. While monitoring data for North and South Suck Creek indicates high acidity and low pH, metals and sulfate concentrations remain low.

Required LAs will be implemented in several steps to reduce acidity and/or increase total alkalinity so as to result in an increase of instream net alkalinity. In order to meet Tennessee Water Quality Standards for pH, this TMDL requires that net alkalinity (as $CaCO_3$) loads of streams in the Suck Creek subwatershed meet, or exceed, the loads per unit area specified in the target load duration curve (ref.: Figure 7).

Step 1: Conduct additional water and minespoil testing to identify specific AMD sites and delineate actual areas of acid production at each site.

Step 2: Once sites have been identified, remediation plans will be developed utilizing primarily passive treatment schemes (versus treatment by chemical addition) to provide a long-term solution to stream impairment.

Remediation measures that have proved successful include, but are not limited to:

- Regrading of spoil
- Isolation of acid producing material from water contact
- Anoxic limestone drains
- Constructed wetlands.

The Abandoned Mine Lands Section of the DWPC has expertise in the development of AMD remediation plans and has completed a number of reclamation projects on abandoned mines in the Tennessee coalfield. A number of these projects have included measures designed to remediate acid production caused by land disturbance due to past mining. One reclamation project was completed at the Three Sisters site in the North Chickamauga Creek subwatershed in 2000 at a cost of $95,000. Additional information related to this project is available at: http://www.epa.gov/region4/water/nps/projects/tn96-1.htm

The Mining Section issues NPDES permits for discharges of wastewater from coal and non-coal mines and, where applicable, Mining Law permits to non-coal facilities in Tennessee. This section of the DWPC has worked with a number of permitted mine sites, offering considerable technical advice in the remediation of problems similar to those found in the Suck Creek subwatershed.

Step 3: Conduct follow-on water quality testing of North and South Suck Creek to verify the effectiveness of remediation measures. Parameters should include flow, pH, acidity, and total alkalinity.

9.0 PUBLIC PARTICIPATION

In accordance with 40 CFR §130.7, the proposed pH TMDL for Suck Creek will be placed on Public Notice for a 35-day period and comments solicited. Steps that will be taken in this regard include:

1) Notice of the proposed TMDL was posted on the Tennessee Department of Environment and Conservation website. The announcement invited public and stakeholder comment and provided a link to a downloadable version of the TMDL document.

2) Notice of the availability of the proposed TMDL (similar to the website announcement) was included in one of the NPDES permit Public Notice mailings which is sent to approximately 90 interested persons or groups who have requested this information.

10.0 FURTHER INFORMATION

Further information concerning Tennessee's TMDL program can be found on the Internet at the Tennessee Department of Environment and Conservation website:

www.state.tn.us/environment/wpc/tmdl.htm

Technical questions regarding this TMDL should be directed to the following members of the Division of Water Pollution Control staff:

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APPENDIX A

Acid Mine Drainage

Acid Mine Drainage Formation

The following information regarding acid mine drainage formation was taken from the U.S. Department of Interior (DOI), Office of Surface Mining (OSM) website at www.osmre.gov/amdform.htm. The first section on the Chemistry of Pyrite Weathering is reproduced below. Discussion of subsequent sections can be found on the OSM website.

The formation of acid drainage is a complex geochemical and microbially mediated process. The acid load ultimately generated from a minesite is primarily a function of the following factors:

- Chemistry
- Microbiological Controls
- Depositional environment
- Acid/base balance of the overburden
- Lithology
- Mineralogy
- Minesite hydrologic conditions

Chemistry of Pyrite Weathering

A complex series of chemical weathering reactions are spontaneously initiated when surface mining activities expose spoil materials to an oxidizing environment. The mineral assemblages contained in the spoil are not in equilibrium with the oxidizing environment and almost immediately begin weathering and mineral transformations. The reactions are analogous to “geologic weathering” which takes place over extended periods of time (i.e., hundreds to thousands of years) but the rates of reaction are orders of magnitude greater than in “natural” weathering systems. The accelerated reaction rates can release damaging quantities of acidity, metals, and other soluble components into the environment. The pyrite oxidation process has been extensively studied and has been reviewed by Nordstrom (1979). For purposes of this description, the term “pyrite” is used to collectively refer to all iron disulfide minerals.

The following equations show the generally accepted sequence of pyrite reactions:

$2\ FeS_2 + 7\ 0_2 + 2\ H_2O \rightarrow\rightarrow 2\ Fe^{2+} + 4\ SO_4^{2-} + 4\ H^+$ (Equation 1)

$4\ Fe^{2+} + O_2 + 4\ H^+ \rightarrow 4\ Fe^{3+} + 2\ H_2O$ (Equation 2)

$4\ Fe^{3+} + 12\ H_2O \rightarrow 4\ Fe(OH)_3 + 12\ H^+$ (Equation 3)

$FeS_2 + 14\ Fe^{3+} + 8\ H_2O \rightarrow 15\ Fe^{2+} + 2\ SO_4^{2-} + 16\ H^+$ (Equation 4)

In the initial step, pyrite reacts with oxygen and water to produce ferrous iron, sulfate and acidity. The second step involves the conversion of ferrous iron to ferric iron. This second reaction has been termed the “rate determining” step for the overall sequence.

The third step involves the hydrolysis of ferric iron with water to form the solid ferric hydroxide (ferrihydrite) and the release of additional acidity. This third reaction is pH dependent. Under very acid conditions of less than about pH 3.5, the solid mineral does not form and ferric iron remains in solution. At higher pH values, a precipitate forms, commonly referred to as "yellowboy."

The fourth step involves the oxidation of additional pyrite by ferric iron. The ferric iron is generated by the initial oxidation reactions in steps one and two. This cyclic propagation of acid generation by iron takes place very rapidly and continues until the supply of ferric iron or pyrite is exhausted. Oxygen is not required for the fourth reaction to occur.

The overall pyrite reaction series is among the most acid-producing of all weathering processes in nature.

APPENDIX B

Suck Creek Monitoring Data

Table B-1 North Suck Creek Monitoring Data

	North Suck Creek						**35 08' 48"N**						
	Mile 0.1						**85 23' 16"W**						
Test	*Units*	*3/7/00*	*7/28/04*	*8/11/04*	*9/9/04*	*10/11/04*	*11/9/04*	*12/16/04*	*2/1/05*	*3/22/05*	*4/6/05*	*5/3/05*	*5/31/05*
pH	--	5.53	6.39	6.42	6.24	5.81	5.55	5.27	5.80	5.80	6.50	6.50	6.44
Conductivity	uMHO	40.8	66	74	73	66			47	43	38	46	
Dissolved Oxygen	mg/L	11.40	8.66	8.14	8.90	9.47			11.50	11.80	11.50	11.40	
Temperature	Celsius	8.14	22.14	21.70	20.20	16.89			5.60	8.70	11.10	11.30	
Acidity	mg/L[a]		1.20	U[b]	U[b]	3.56	U[b]	1.15	1.40	U[b]	U[b]	1.10	1.20
Total Alkalinity	mg/L[a]	9.00	U[b]	U[b]	U[b]	U[b]	U[b]	U[b]	U[b]	19.00	U[b]	U[b]	15.00
Sulfate	mg/L	32.70	14.40	18.23	15.40	52.40	9.72	12.10	11.00	11.00	9.00	13.00	16.00
Total Hardness	mg/L	45.0	16.0	20.10	22.5	73.4	15.1	12.5	14.0	13.0	14.0	14.0	15.0
Turbidity	NTU	0.47	0.25	0.14	2.54	0.51	0.21	0.32	0.10	2.00	0.60	0.30	0.20
Total Dissolved Solids	mg/L	28.0	30.0	15.00	52.0	115.0	35.0	61.0	U	U	19.0	26.0	67.0
Aluminum	ug/L	U	U	328	232	482	U	U	U	U	U	342	U
Calcium	mg/L		4.5	6.00	5.1	13	3	3	4	3	3	5	4
Copper	ug/L	U	U	U	U	1	1	U	3	U	U	1	U
Iron	ug/L	U	25	U	48	U	U	U	U	U	26	U	U
Lead	ug/L	U	U	U	U	U	U	U	U	2	U	1	U
Manganese	ug/L	11	5	U	6	457	8	22	12	7	20	U	6
Nickel	ug/L	U	U	U	U	36	U	U	U	U	U	U	U
Sodium	mg/L		1.7	2.1	2.0	1.8	1.3	1.0	1.5	1.3	0.9	1.4	1.6
Zinc	ug/L	2.00	4.00	U	4	37	5	4	5	1	4	U	U

[a] mg/L $CaCO_3$

[b] U denotes analyte requested but not detected. Detection limit is 10 mg/L for total alkalinity and1 mg/L for acidity

Table B-2 South Suck Creek Monitoring Data

South Suck Creek
Mile 0.1

35 08' 44"N
85 23' 18"W

Test	*Units*	*7/28/04*	*8/11/04*	*9/9/04*	*10/11/04*	*11/4/04*	*12/16/04*	*2/1/05*	*3/22/05*	*4/6/05*	*5/3/05*	*5/31/05*
pH	--	5.50	6.59	5.20	4.97	5.13	4.37	4.90	4.90	5.20	5.10	5.14
Conductivity	uMHO	164	181	172	195			78	94	70	109	
Dissolved Oxygen	mg/L	9.04	8.49	4.23	9.83			11.50	12.20	11.40	11.80	
Temperature	Celsius	19.64	19.79	19.06	15.83			5.9	8.5	10.9	10.1	
Acidity	mg/L[a]	1.63	U[b]	2.44	1.08	3.60	5.99	5.50	3.00	2.40	4.40	3.10
Total Alkalinity	mg/L[a]	U[b]	U[b]	32.40	U[b]	U[b]	U[b]	U[b]	U[b]	U[b]	U[b]	20.00
Sulfate	mg/L	68.10	68.04	51.40	18.80	13.30	18.20	21.00	31.00	16.00	46.00	52.00
Total Hardness	mg/L	29.0	54.8	78.6	21.2	28.1	27.6	25.0	27.0	26.0	26.0	52.0
Turbidity	NTU	0.57	0.15	0.75	0.28	0.32	0.31	0.30	0.20	0.50	0.20	0.20
Total Dissolved Solids	mg/L	104.0	U	112.0	39.0	54.0	U	34.0	34.0	38.0	87.0	105.0
Aluminum	ug/L	309	U	419	184	536		754	728	508	743	443
Calcium	mg/L	10.4	13.0	11.4	5.0	5.0	5.0	U	5.0	4.0	7.0	10.0
Copper	ug/L	2	2	U	U	2	U	4	U	U	3	1
Iron	ug/L	U	U	U	U	35	U	U	U	U	U	U
Lead	ug/L	U	U	U	U	U	U		U	U	1	U
Manganese	ug/L	505	96	637	U	427	556	445	439	329	488	334
Nickel	ug/L	32	15	31	U	17	U	19	21	14	U	U
Sodium	mg/L	1.7	2	1.8	1.8	1.2	0.95	1.2	1.2	0.9	1.3	1.7
Zinc	ug/L	31	12	29	4	23	32	26	27	19	24	27

[a] mg/L $CaCO_3$

[b] U denotes analyte requested but not detected. Detection limit is 10 mg/L for total alkalinity and 1 mg/L for acidity

APPENDIX C

Development of Target Net Alkalinity

Since there is no numerical criterion for net alkalinity, all available monitoring data for the State of Tennessee was examined in an effort to develop a target net alkalinity.

Of the available monitoring data for waterbodies that are not impaired for pH, 47 data points existed for which numerical values for both acidity and total alkalinity were available. (See Figure C-1.) The highest calculated net alkalinity that fell outside of the desired pH range of 6.0 to 9.0 was 10.78 mg/L as $CaCO_3$ at a pH of 9.1. Therefore, a net alkalinity of 10.8 was selected as the target net alkalinity.

Analysis was then expanded to include monitoring data for waterbodies that are not impaired for pH and for which both total alkalinity and acidity were analyzed, but for which either acidity or total alkalinity, but not both, was not detected. (See Figure C-2.) For the purpose of calculating net alkalinity, the analyte concentrations were estimated to be one half of the appropriate detection limit (10 mg/L for total alkalinity and 1 mg/L for acidity). Of the 211 data points, only 3 points (or 1.4%) exceeded the target net alkalinity value of 10.8 mg/L $CaCO_3$ but were not within the required pH range.

Available monitoring data for waterbodies that are included on the 303(d) List as impaired for pH were also compared to the target net alkalinity. Of 41 data points for which numerical values for both acidity and total alkalinity were available, only 2 points (or 4.9%) exceeded the target net alkalinity value of 10.8 mg/L $CaCO_3$ but was not within the required pH range. These data points were for North Suck Creek on 5/21/2005 (pH 5.14, net alkalinity 16.9) and South Suck Creek on 9/9/2004 (pH 5.2, net alkalinity 29.96). When analysis was expanded to include data points for which both acidity and total alkalinity were analyzed, but for which either acidity or total alkalinity, but not both, was not detected, only 3 points (or 2.0%) exceeded the target net alkalinity value of 10.8 mg/L $CaCO_3$ but were not within the required pH range. These data points were the previously mentioned points for North and South Suck Creek and a data point for North Suck Creek on 3/22/2005 (pH 5.8, net alkalinity 18.5).

Therefore, based on analysis of all available monitoring data for the State of Tennessee, selection of a target net alkalinity of 10.8 mg/L as $CaCO_3$ should provide a pH within the criteria of 6.0 to 9.0 standard pH units for waterbodies with a designated use of Fish & Aquatic Life.

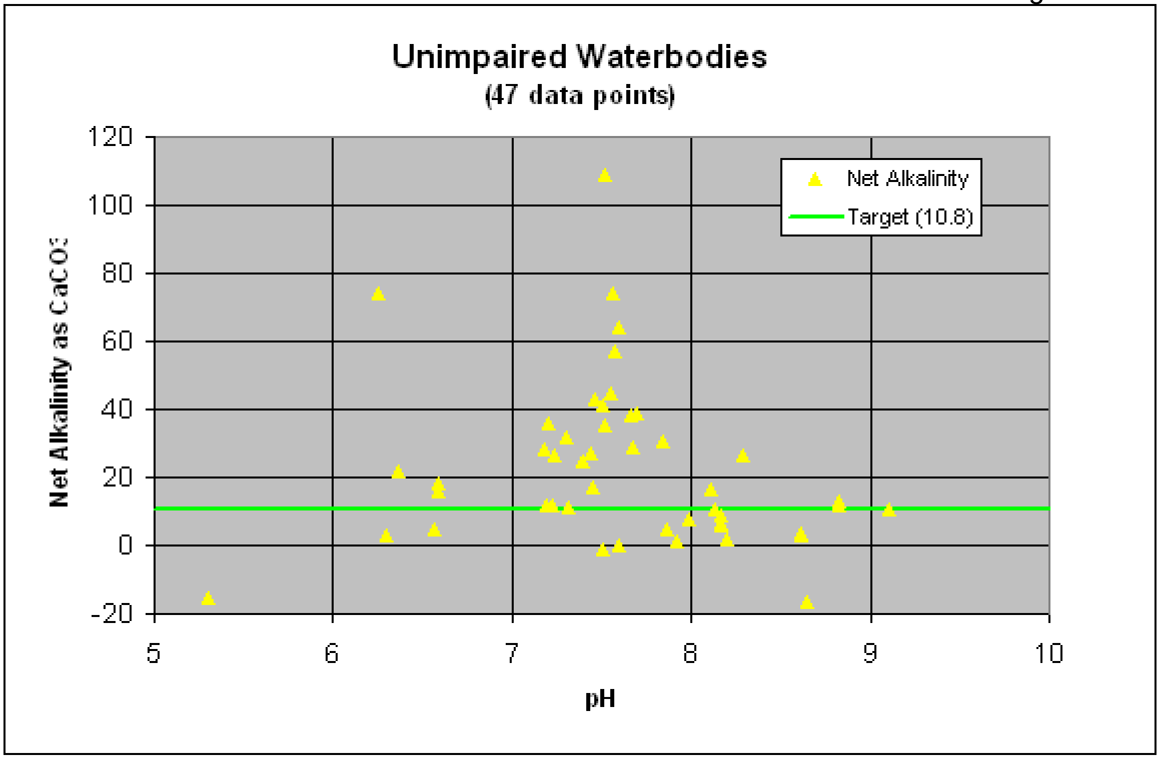

Figure C-1 pH and Net Alkalinity for Unimpaired Waterbodies in Tenneessee (no non-detects for either acidity or total alkalinity)

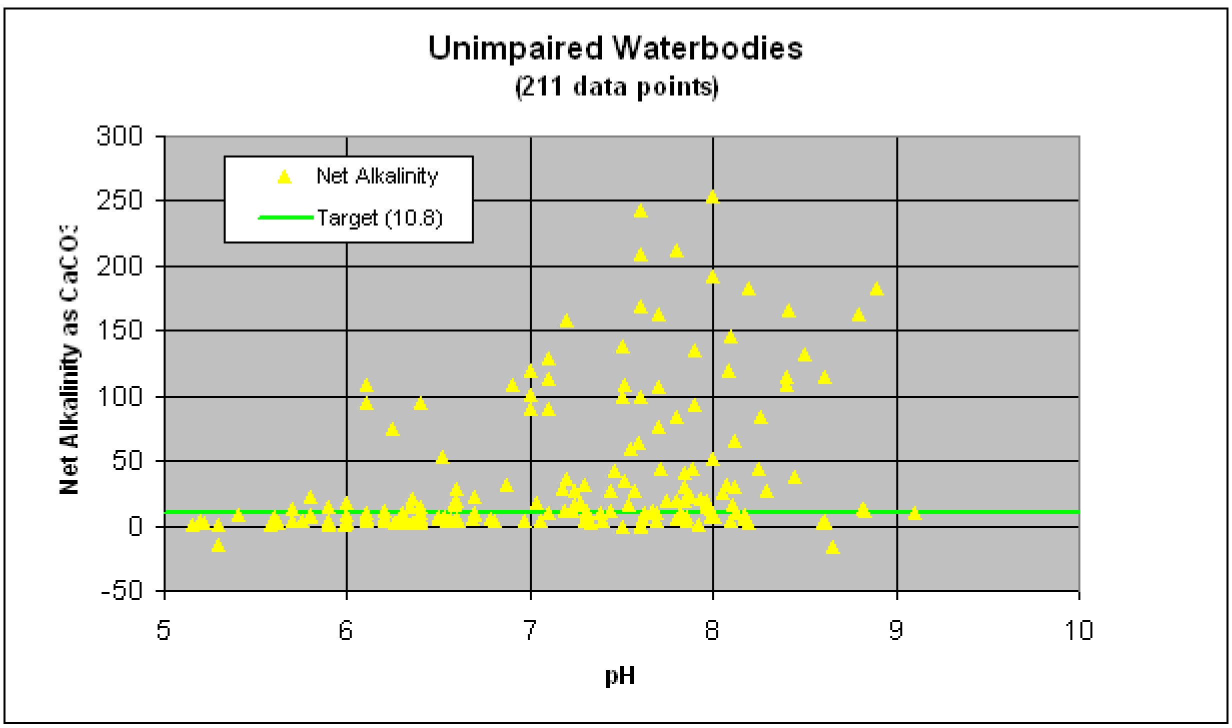

Figure C-2 pH and Net Alkalinity for Unimpaired Waterbodies in Tenneessee (acidity or total alkalinity was not detected; 0.5 x detection limit used for non detects)

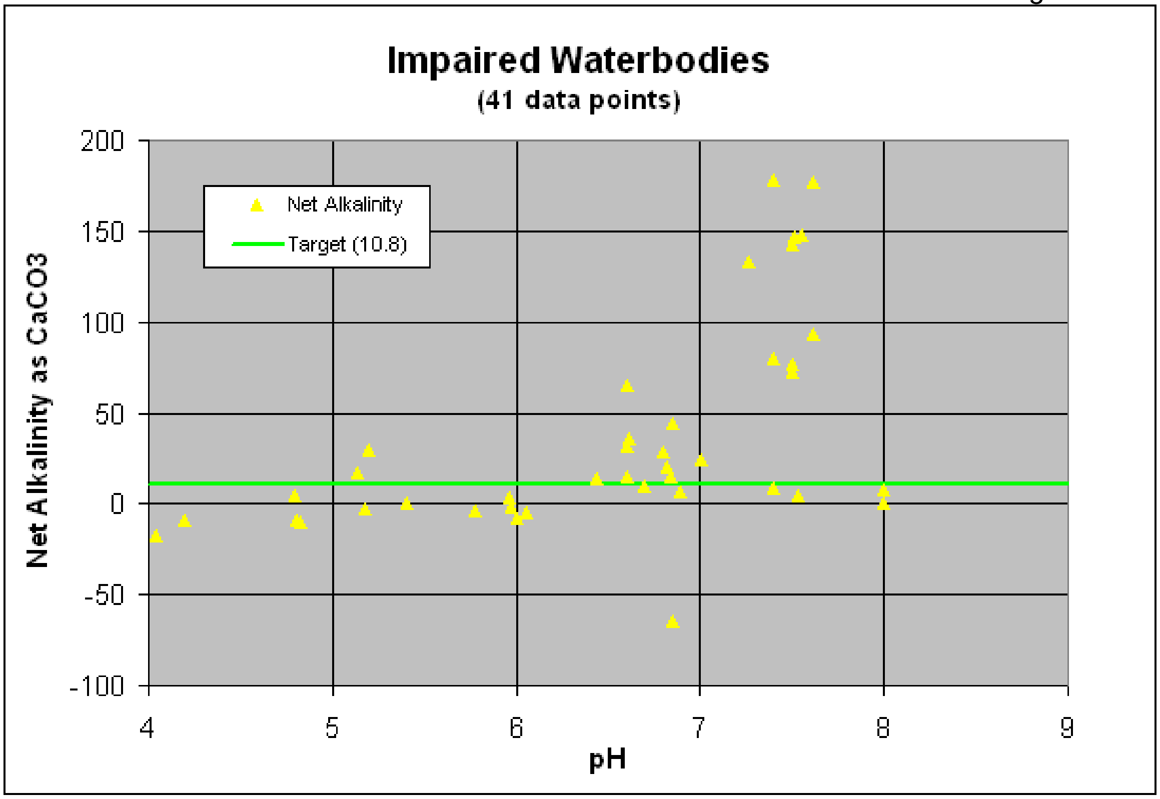

Figure C-3 pH and Net Alkalinity for Impaired Waterbodies in Tenneessee
(no non-detects for either acidity or total alkalinity)

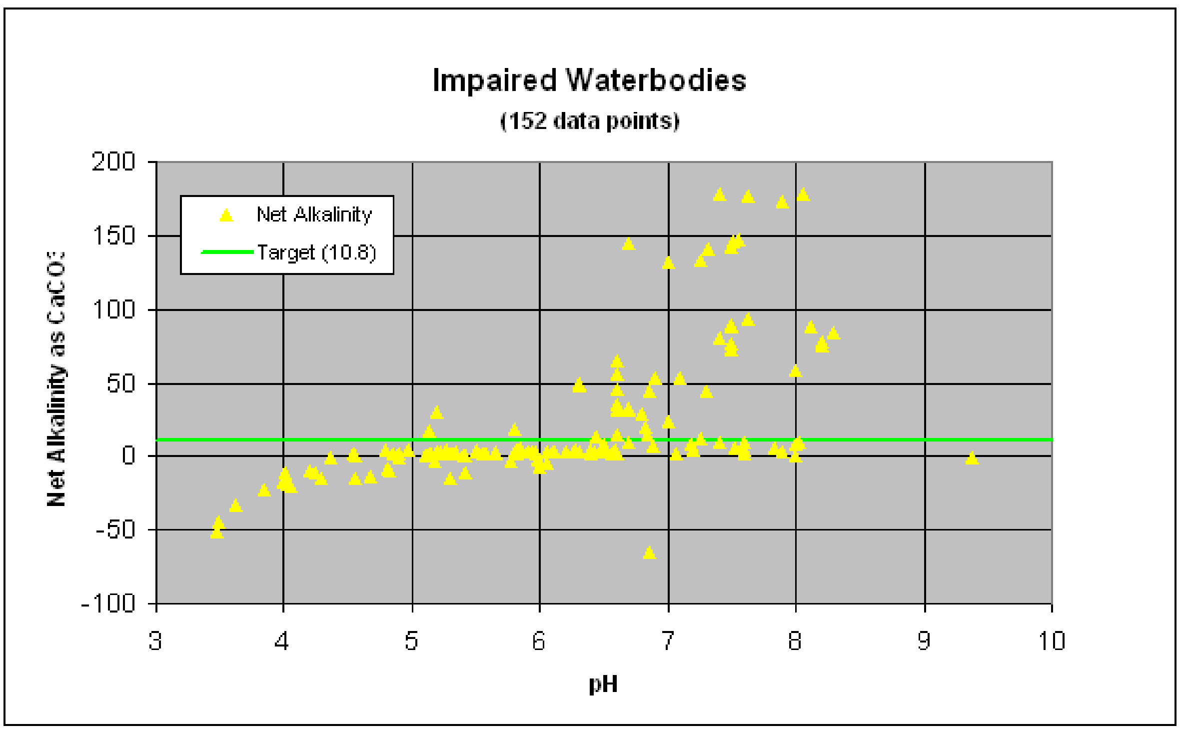

Figure C-4 pH and Net Alkalinity for Impaired Waterbodies in Tenneessee
(acidity or total alkalinity was not detected; 0.5 x detection limit used for non detects)

APPENDIX D

Development of Target Load Duration Curve for Suck Creek Subwatershed

A flow duration curve is a cumulative frequency graph, constructed from historic flow data at a particular location, that represents the percentage of time a particular flow rate is equaled or exceeded. When a water quality target (or criteria) concentration is applied to the flow duration curve, the resulting load duration curve (LDC) represents the allowable pollutant loading in a waterbody over the entire range of flow. Pollutant monitoring data, plotted on the LDC, provides a visual depiction of stream water quality as well as the frequency and magnitude of any exceedances. Load duration curve intervals can be grouped into several broad categories or zones, in order to provide additional insight about conditions and patterns associated with the impairment. For example, the duration curve could be divided into five zones: high flows (exceeded 0-10% of the time), moist conditions (10-40%), median or mid-range flows (40-60%), dry conditions (60-90%), and low flows (90-100%). Impairments observed in the low flow zone typically indicate the influence of point sources, while those further left on the LDC (representing zones of higher flow) generally reflect potential nonpoint source contributions (Stiles, 2003).

D.1 Development of Flow Duration Curves

Flow duration curves are developed for a waterbody from daily discharges of flow over a period of record. In general, there is a higher level of confidence that curves derived from data over a long period of record correctly represent the entire range of flow. The preferred method of flow duration curve computation uses daily mean data from USGS continuous-record stations located on the waterbody of interest. For ungaged streams, alternative methods must be used to estimate daily mean flow. These include: 1) regression equations (using drainage area as the independent variable) developed from continuous record stations in the same ecoregion; 2) drainage area extrapolation of data from a nearby continuous-record station of similar size and topography; and 3) calculation of daily mean flow using a dynamic computer model, such as the Loading Simulation Program C++ (LSPC).

Flow duration curves for pH-impaired waterbodies in the Lower Tennessee were derived from LSPC hydrologic simulations based on parameters derived from calibration at USGS Station No. 03566525, located on North Chickamauga Creek near Montlake, Tennessee, in the Lower Tennessee (see Appendix E for details of calibration). For example, a flow-duration curve for North Suck Creek at RM 0.1 was constructed using simulated daily mean flow for the period from 10/1/95 through 8/31/05 (RM 0.1 corresponds to the location of monitoring station NSUCK000.1MI). This flow duration curve is shown in Figure D-1 and represents the cumulative distribution of daily discharges arranged to show percentage of time specific flows were exceeded during the period of record (the highest daily mean flow during this period is exceeded 0% of the time and the lowest daily mean flow is equaled or exceeded 100% of the time). The flow duration curve for South Suck Creek was derived using a similar procedure and is shown in Figure D-2.

D.2 Development of Target Load Duration Curve

The target net alkalinity load duration curve for the Suck Creek subwatershed was developed from the flow duration curve for North Suck Creek developed in Section D.1. The net alkalinity target concentration of 10.8 mg/L was applied to each of the ranked flows used to generate the flow duration curve and the results were plotted. The net alkalinity target load corresponding to each ranked daily mean flow is:

$$\text{Target Load}_{\text{Suck}} = (\text{Average Net Alkalinity})_{\text{Suck}} \times (Q/A) \times (UCF)$$

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

The target load duration curve, on a unit drainage area basis, is presented in Figures D-3 and D-4. Figure D-3 is presented in semi-log scale format while Figure D-4 is presented in non-log scale format. Because the calculated net alkalinity of the Suck Creek subwatershed is often negative and negative values cannot be plotted on a log or semi-log scale format, the non-log scale format will be used for load duration curves in this TMDL.

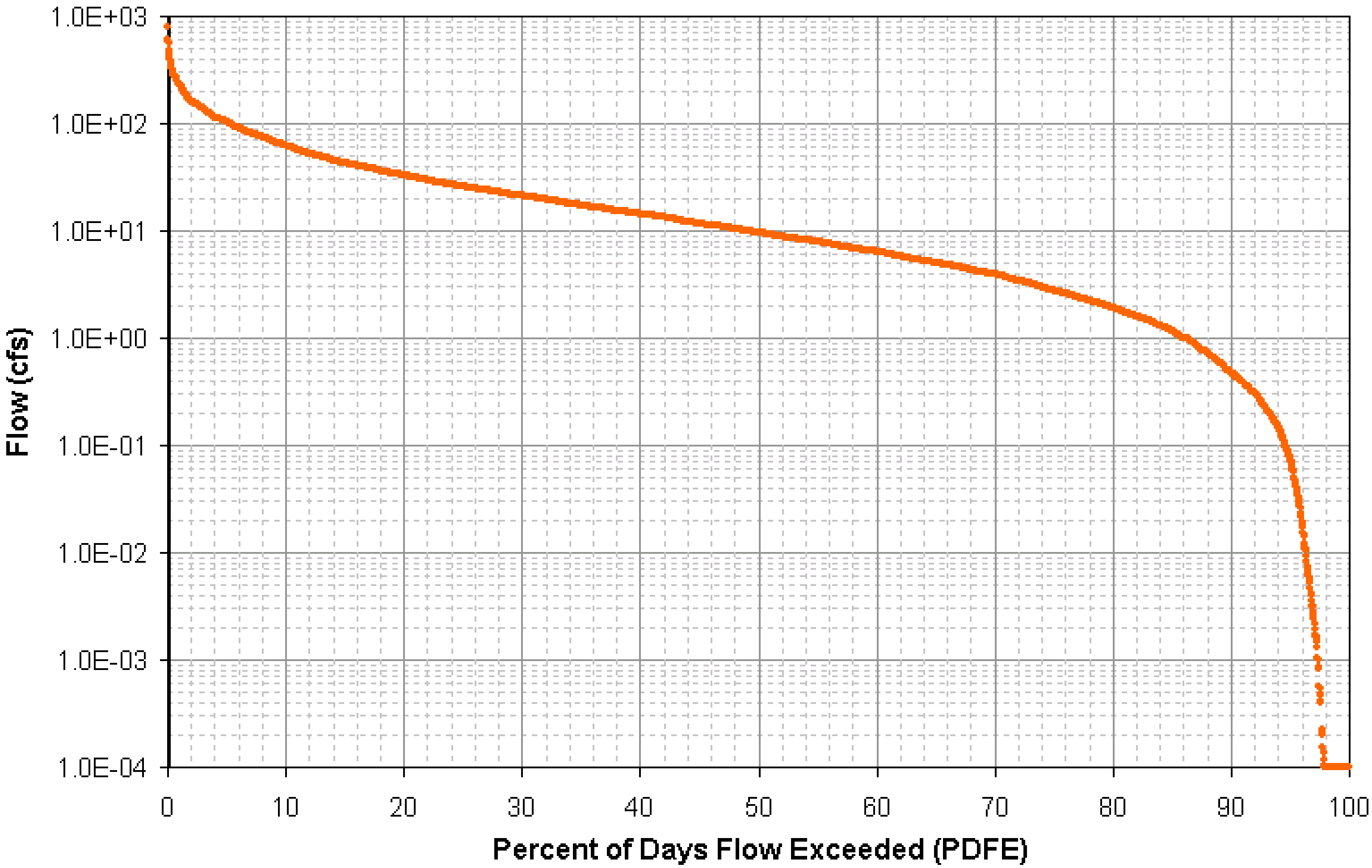

Figure D-1 North Suck Creek Flow Duration Curve

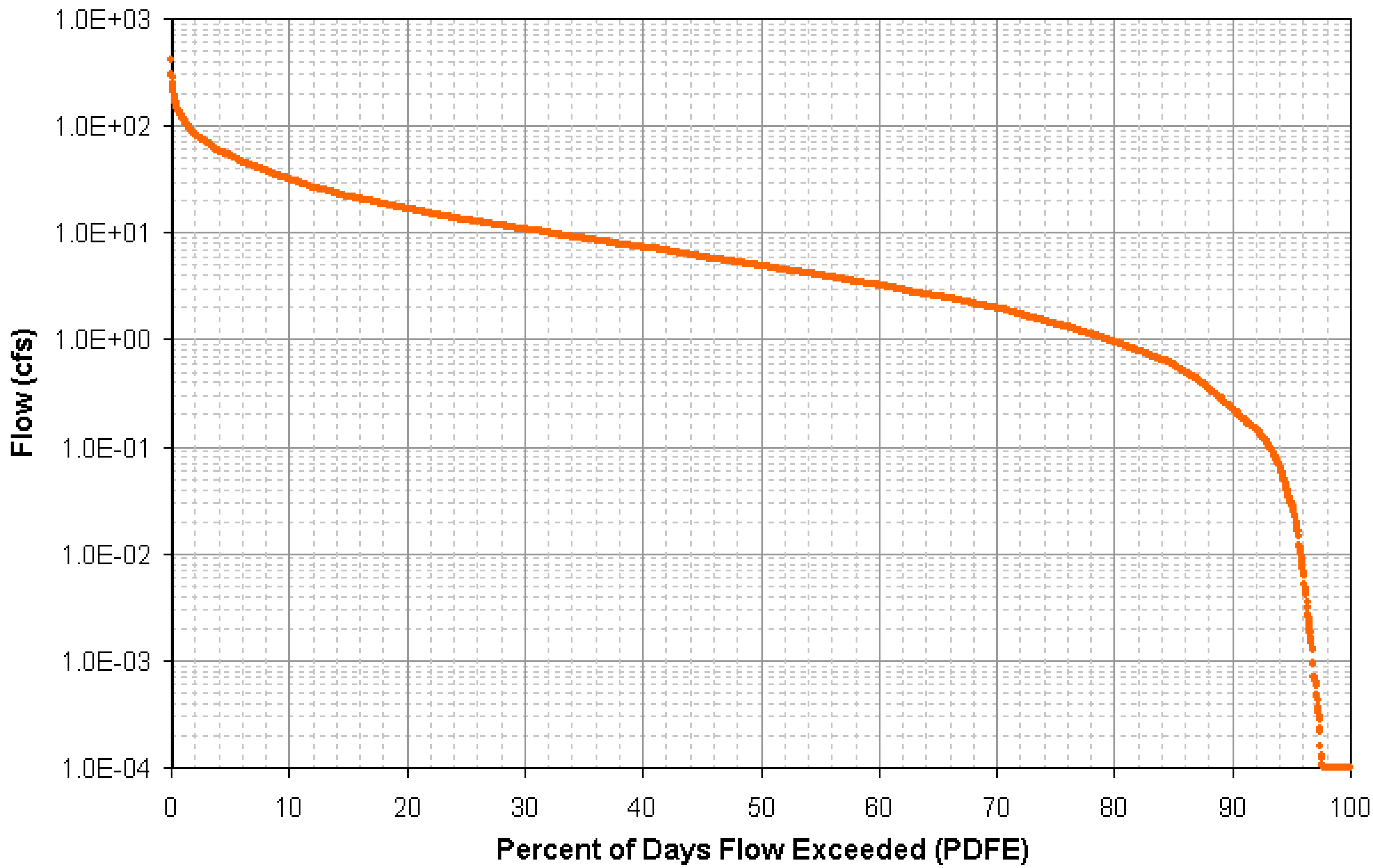

Figure D-2 South Suck Creek Flow Duration Curve

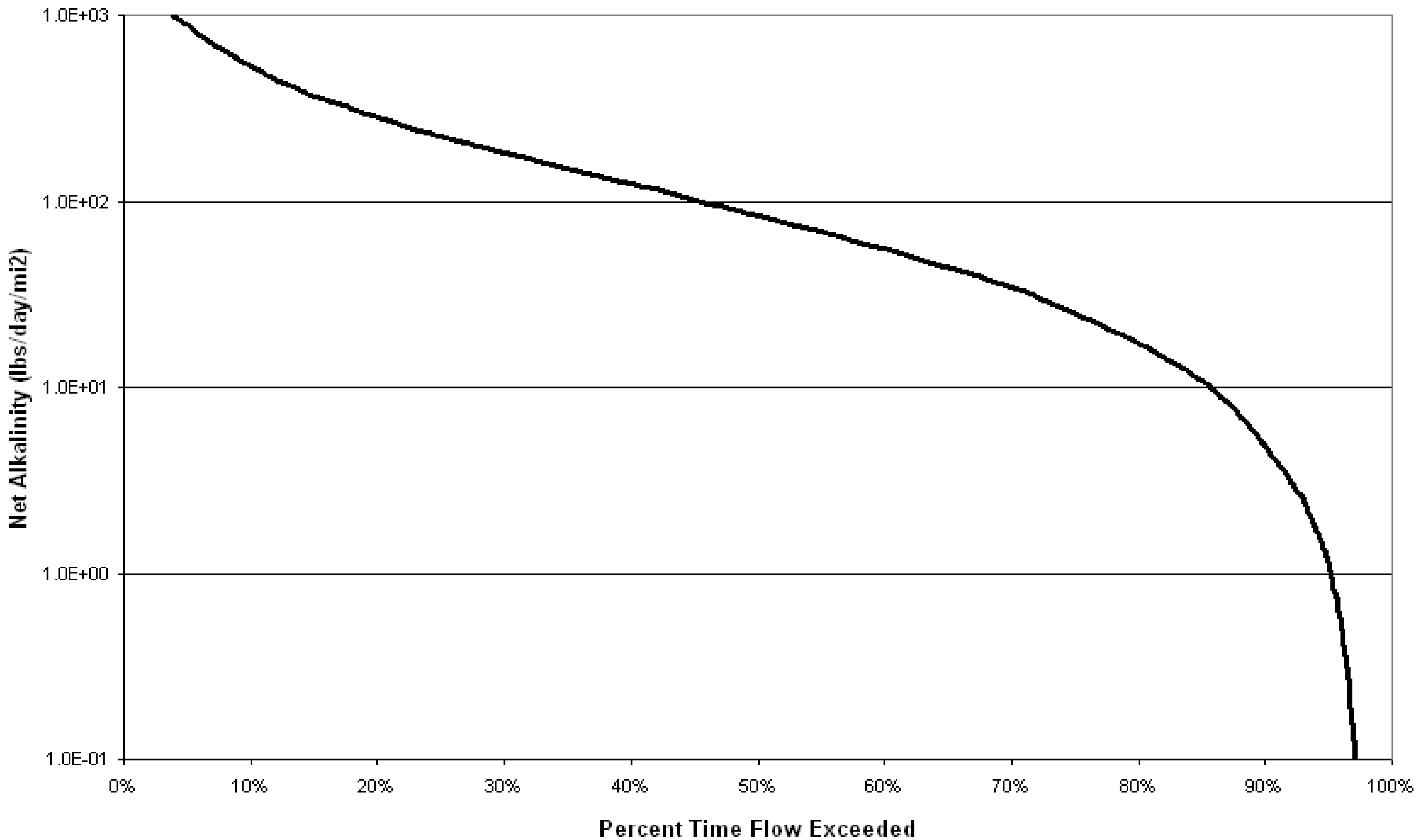

Figure D-3 Target Load Duration Curve (semi-log-scale)

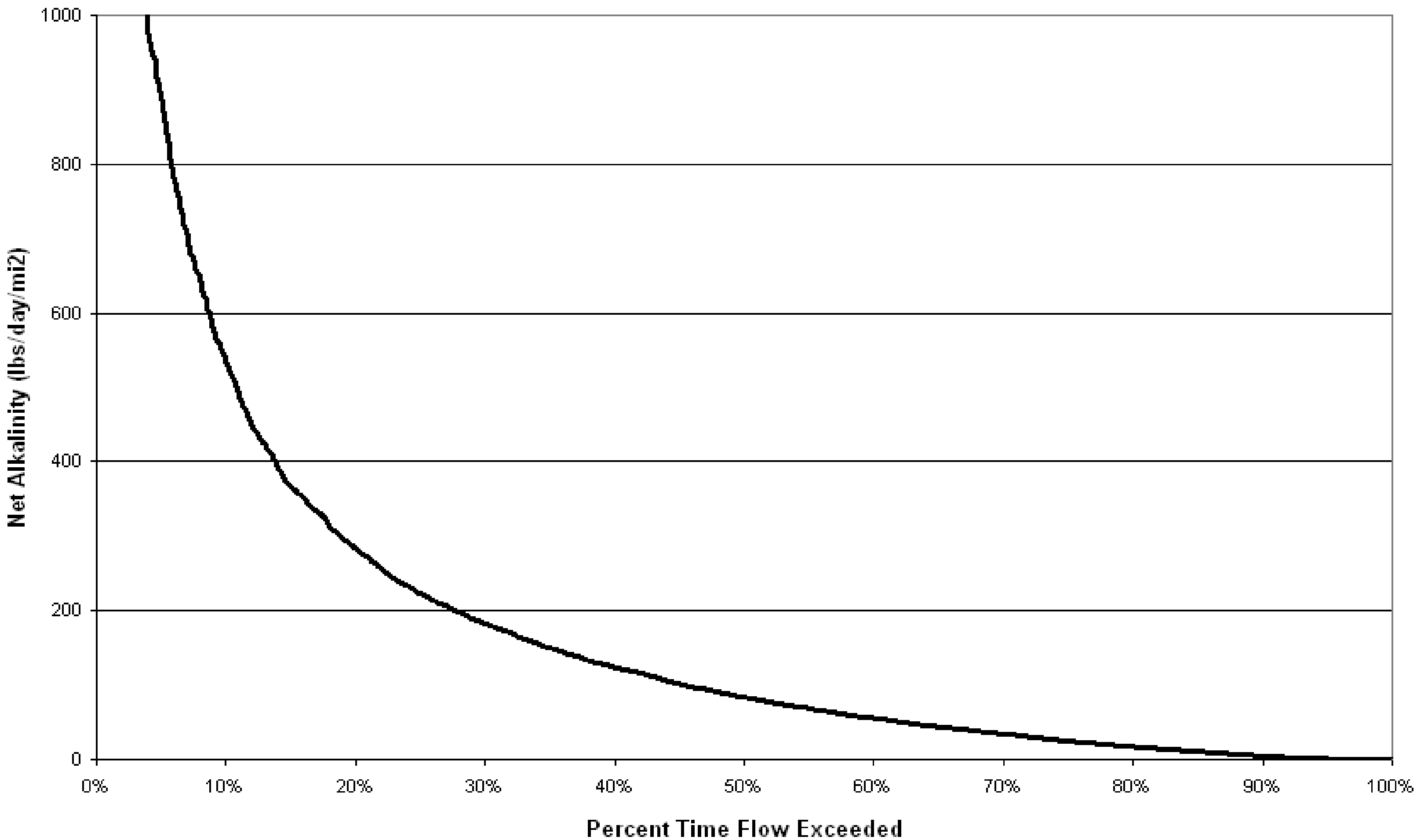

Figure D-4 Target Load Duration Curve (non-log scale)

APPENDIX E

Hydrodynamic Modeling Methodology

E.1 Model Selection

The Loading Simulation Program C++ (LSPC) was selected for TMDL analyses of pH-impaired waters in the Suck Creek subwatershed. LSPC is a watershed model capable of performing flow routing through stream reaches. LSPC is a dynamic watershed model based on the Hydrologic Simulation Program – Fortran (HSPF).

E.2 Model Set Up

The Suck Creek subwatershed was delineated into subwatersheds in order to facilitate model hydrologic calibration. Boundaries were constructed so that subwatershed "pour points" coincided with HUC-12 delineations, impaired waterbodies, and water quality monitoring stations. Watershed delineation was based on the NHD stream coverage and Digital Elevation Model (DEM) data. This discretization facilitates simulation of daily flows at water quality monitoring stations.

Several computer-based tools were utilized to generate input data for the LSPC model. The Watershed Characterization System (WCS), a geographic information system (GIS) tool, was used to display, analyze, and compile available information to support hydrology model simulations for the Suck Creek subwatershed. This information includes land use categories, point source dischargers, soil types and characteristics, population data (human and livestock), and stream characteristics.

An important factor influencing model results is the precipitation data contained in the meteorological data file used in the simulation. Weather data from the Chattanooga meteorological station were available for the time period from January 1980 through August 2005. Meteorological data for a selected 11-year period were used for all simulations. The first year of this period was used for model stabilization with simulation data from the subsequent 10-year period (10/1/95 – 8/31/05) used for TMDL analysis.

E.3 Model Calibration

Hydrologic calibration of the watershed model involves comparison of simulated streamflow to historic streamflow data from U.S. Geological Survey (USGS) stream gaging stations for the same period of time. A USGS continuous record station located in the Lower Tennessee River Watershed with a sufficiently long and recent historical record was selected as a basis of the hydrology calibration. The USGS station was selected based on similarity of drainage area, Level IV ecoregion, land use, and topography. The calibration involved comparison of simulated and observed hydrographs until statistical stream volumes and flows were within acceptable ranges as reported in the literature (Lumb, et al., 1994).

Initial values for hydrologic variables were taken from an EPA developed default data set. During the calibration process, model parameters were adjusted within reasonable constraints until acceptable agreement was achieved between simulated and observed streamflow. Model parameters adjusted include: evapotranspiration, infiltration, upper and lower zone storage, groundwater storage, recession, losses to the deep groundwater system, and interflow discharge.

The results of the hydrologic calibration for North Chickamauga Creek near Montlake, USGS Station 03566525, are shown in Table E-1 and Figure E-1.

Table E-1 Hydrologic Calibration Summary of North Chickamauga Creek at USGS Station 03566525

Simulation Name:	3566525	**Simulation Period:**	
	N. Chick @ Montlake	**Watershed Area (ac):**	38215.91
Period for Flow Analysis			
Begin Date:	**11/01/00**	**Baseflow PERCENTILE:**	2.5
End Date:	**09/30/04**	*Usually 1%-5%*	
Total Simulated In-stream Flow:	**117.44**	Total Observed In-stream Flow:	**123.59**
Total of highest 10% flows:	**72.24**	Total of Observed highest 10% flows:	**71.15**
Total of lowest 50% flows:	**6.71**	Total of Observed Lowest 50% flows:	**6.92**
Simulated Summer Flow Volume (months 7-9):	**18.43**	Observed Summer Flow Volume (7-9):	**14.42**
Simulated Fall Flow Volume (months 10-12):	**28.40**	Observed Fall Flow Volume (10-12):	**25.18**
Simulated Winter Flow Volume (months 1-3):	**43.53**	Observed Winter Flow Volume (1-3):	**55.73**
Simulated Spring Flow Volume (months 4-6):	**27.08**	Observed Spring Flow Volume (4-6):	**28.26**
Total Simulated Storm Volume:	**117.40**	Total Observed Storm Volume:	**123.28**
Simulated Summer Storm Volume (7-9):	**18.42**	Observed Summer Storm Volume (7-9):	**14.34**
Errors (Simulated-Observed)		*Recommended Criteria*	Last run
Error in total volume:	**-4.98**	10	
Error in 50% lowest flows:	**-3.11**	10	
Error in 10% highest flows:	**1.53**	15	
Seasonal volume error - Summer:	**27.85**	30	
Seasonal volume error - Fall:	**12.79**	30	
Seasonal volume error - Winter:	**-21.90**	30	
Seasonal volume error - Spring:	**-4.20**	30	
Error in storm volumes:	**-4.77**	20	
Error in summer storm volumes:	**28.46**	50	

Criteria for Median Monthly Flow Comparisons	
Lower Bound (Percentile):	25
Upper Bound (Percentile):	75

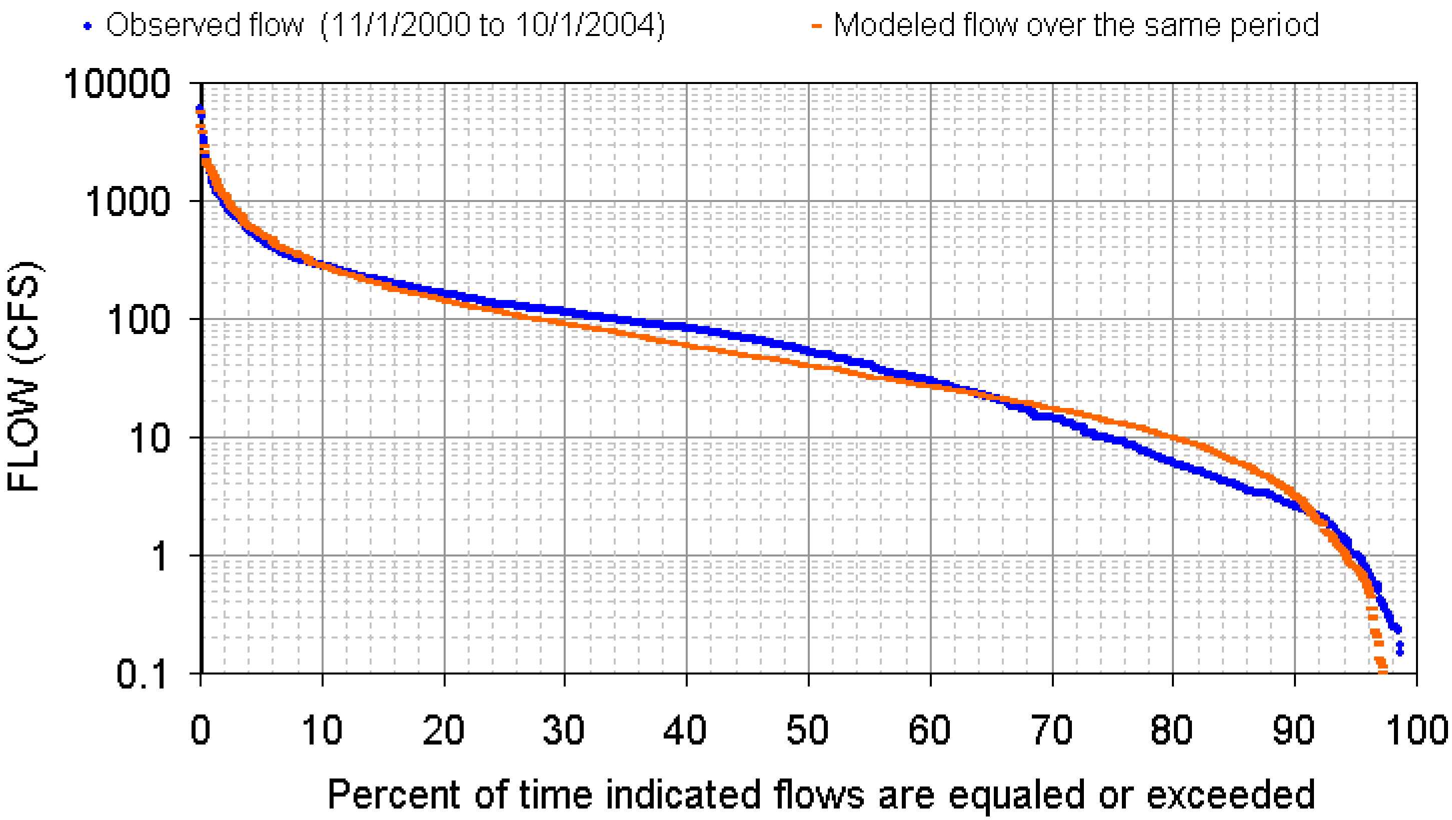

Figure E-1 Comparison of Simulated Flow vs. Observed Flow at USGS 03566525

APPENDIX F

Methodology for the Determination of Subwatershed Net Alkalinity Difference from Target Load Duration Curve

Sampling was conducted at several sites in the Suck Creek subwatershed by TDEC. Net alkalinity load duration curves were developed for the North and South Suck Creek subwatersheds from the target load duration curves developed in Section D.2 and water quality monitoring data collected by TDEC. Load duration curves were developed using the following procedure (North Suck Creek, Mile 0.1, is shown as an example; South Suck Creek is similar):

1. Daily net alkalinity loads were calculated for each of the water quality samples collected at the North Suck Creek monitoring station by multiplying the calculated net alkalinity by the measured ("instantaneous") flow for the sampling date and the required unit conversion factor, and dividing by the subwatershed drainage area. Net Alkalinity Calculations for subwatersheds within the Suck Creek subwatersheds are summarized in Tables F-1 and F-2.

   Example – 12/16/04 sampling event:

   Calculated Net Alkalinity = 3.85 mg/L $CaCO_3$
   North Suck Creek flow = 18.35 cfs
   Drainage area of North Suck Creek subwatershed = 13.32 mi^2

   Net Alkalinity Load = 28.62 lbs $CaCO_3$/day/mi^2

2. Using the flow duration curve developed in Figure D-1, the "percent of days the flow was exceeded" (PDFE) was determined for each sampling event.

   Example – 12/16/04 sampling event:

   North Suck Creek flow = 18.35 cfs
   Drainage area of North Suck Creek subwatershed = 13.32 mi^2
   North Suck Creek flow per unit area = 1.378 cfs/mi^2

   PDFE from flow duration curve for North Suck Creek monitoring site corresponding to 1.378 cfs/mi^2 = 34.0%

3. Each sample load was then plotted on the target load duration curve developed in Section D.2 according to the PDFE. The resulting curve is presented in Figure F-1. (The load duration curve for South Suck Creek is presented in Figure F-2.)

4. The magnitude of the difference between the target net alkalinity load and each calculated net alkalinity load is calculated by:

   $$\text{Net Alkalinity}_{\text{Difference}} = (\text{Net Alkalinity}_{\text{North Suck Creek}}) - (\text{Net Alkalinity}_{\text{Target}})$$

   where:
   Net Alkalinity is in lbs $CaCO_3$/day/mi^2

Example – 12/16/04 sampling event:

North Suck Creek net alkalinity = 28.62 lbs $CaCO_3$/day/mi^2

Target net alkalinity = 80.29 lbs $CaCO_3$/day/mi^2

Net alkalinity$_{Difference}$ = (28.62 lbs $CaCO_3$/day/mi^2) – (80.29 lbs $CaCO_3$/day/mi^2)

Net alkalinity$_{Difference}$ = -51.67 lbs $CaCO_3$/day/mi^2

The difference between the target net alkalinity load and the calculated net alkalinity load for the North and South Suck Creek subwatersheds are summarized in Tables F-3 and F-4.

A negative sign indicates that the net alkalinity load must be increased to meet the target.

5. Each net alkalinity difference was then plotted on the target load duration curve developed in Section D.2 according to the PDFE. The resulting curve is presented in Figure F-3. (The curve for South Suck Creek is presented in Figure F-4.)

   A data point below the target line indicates that the net alkalinity difference must be increased to meet the target.

Table F-1 Calculated Net Alkalinity at North Suck Creek

Sample	North Suck Creek Flow		Acidity	Total Alkalinity	Net Alkalinity	
Date	(cfs)	(cfs/mi^2)	(mg/L)[b]	(mg/L)[b]	(mg/L)[b]	($lbs/day/mi^2$)[b]
3/7/00	10.67	0.802	0.5	9.00	8.50	36.76
7/28/04	11.01	0.827	1.2	5.00	3.80	16.95
8/11/04	6.51	0.489	0.5	5.00	4.50	11.87
9/9/04	12.32	0.925	0.5	5.00	4.50	22.46
10/11/04	1.74	0.131	3.56	5.00	1.44	1.01
11/9/04	20.36	1.529	0.50	5.00	4.50	37.12
12/16/04	18.35	1.378	1.15	5.00	3.85	28.62
2/1/05	15.23	1.144	1.40	5.00	3.60	22.21
3/22/05	6.85	0.514	0.50	19.00	18.50	51.33
4/6/05	27.59	2.073	0.50	5.00	4.50	50.31
5/3/05	17.17	1.290	1.1	5.00	3.90	27.13
5/31/05	0.98	0.074	1.2	15.00	13.80	5.49
a	Reported as not detected; value shown is 1/2 sample quantitation limit.					
b	Acidity, total alkalinity, & net alkalinity are reported as mg/L $CaCO_3$ or lbs $CaCO_3/day/mi^2$.					

Table F-2 Calculated Net Alkalinity at South Suck Creek

Sample	South Suck Creek Flow		Acidity	Total Alkalinity	Net Alkalinity	
Date	(cfs)	(cfs/mi^2)	(mg/L)[b]	(mg/L)[b]	(mg/L)[b]	($lbs/day/mi^2$)[b]
07/28/04	5.60	0.822	1.63	5.0	3.37	14.93
08/11/04	3.30	0.484	0.50	5.0	4.5	11.74
09/09/04	6.28	0.922	2.44	32.4	29.96	148.97
10/11/04	0.88	0.129	1.08	5.0	3.92	2.73
11/04/04	33.77	4.956	3.70	5.0	1.3	34.75
12/16/04	9.35	1.373	5.99	5.0	-0.99	-7.33
02/01/05	7.78	1.143	5.50	5.0	-0.5	-3.08
03/22/05	3.45	0.506	3.00	5.0	2	5.46
04/06/05	14.06	2.064	2.40	5.0	2.6	28.95
05/03/05	8.75	1.284	4.40	5.0	0.6	4.16
05/31/05	0.50	0.073	3.10	20.0	16.9	6.65
a	Reported as not detected; value shown is 1/2 sample quantitation limit.					
b	Acidity, total alkalinity, & net alkalinity are reported as mg/L $CaCO_3$ or lbs $CaCO_3/day/mi^2$.					

Table F-3 Net Alkalinity Difference Relative to Target
North Suck Creek

Sample Date	N Suck Ck Flow (cfs/mi^2)	N Suck Ck Net Alkalinity Load (lbs/day/mi^2)[b]	PDFE[a] (%)	Target Net Alkalinity Load (lbs/day/mi^2)[b]	Net Alkalinity Load Difference (lbs/day/mi^2)[b]
3/7/00	0.802	36.76	48.0%	46.70	-9.95
7/28/04	0.827	16.95	47.2%	48.18	-31.23
8/11/04	0.489	11.87	60.1%	28.49	-16.62
9/9/04	0.925	22.46	44.3%	53.91	-31.45
10/11/04	0.131	1.01	81.8%	7.60	-6.59
11/9/04	1.529	37.12	31.4%	89.09	-51.97
12/16/04	1.378	28.62	34.0%	80.29	-51.67
2/1/05	1.144	22.21	38.6%	66.64	-44.43
3/22/05	0.514	51.33	58.7%	29.97	21.37
4/6/05	2.073	50.31	23.8%	120.74	-70.43
5/3/05	1.290	27.13	35.7%	75.13	-48.00
5/31/05	0.074	5.49	87.1%	4.30	1.19

[a] Percent of Days Flow Is Exceeded

[b] Net alkalinity is reported as lbs $CaCO_3$/day/mi^2.

Table F-4 Net Alkalinity Difference Relative to Target
South Suck Creek

Sample Date	S Suck Ck Flow (cfs/mi^2)	S Suck Ck Net Alkalinity Load (lbs/day/mi^2)[b]	PDFE[a] (%)	Target Net Alkalinity Load (lbs/day/mi^2)[b]	Net Alkalinity Load Difference (lbs/day/mi^2)[b]
07/28/04	0.822	14.93	47.2%	47.86	-32.93
08/11/04	0.484	11.74	60.1%	28.18	-16.44
09/09/04	0.922	148.97	44.3%	53.70	95.27
10/11/04	0.129	2.73	81.6%	7.52	-4.79
11/04/04	4.956	34.75	9.3%	288.71	-253.96
12/16/04	1.373	-7.33	33.9%	79.97	-87.30
02/01/05	1.143	-3.08	38.6%	66.56	-69.64
03/22/05	0.506	5.46	58.8%	29.48	-24.02
04/06/05	2.064	28.95	23.8%	120.24	-91.29
05/03/05	1.284	4.16	35.8%	74.82	-70.66
05/31/05	0.073	6.65	86.9%	4.25	2.40

[a] Percent of Days Flow Is Exceeded

[b] Net alkalinity is reported as lbs $CaCO_3$/day/mi^2.

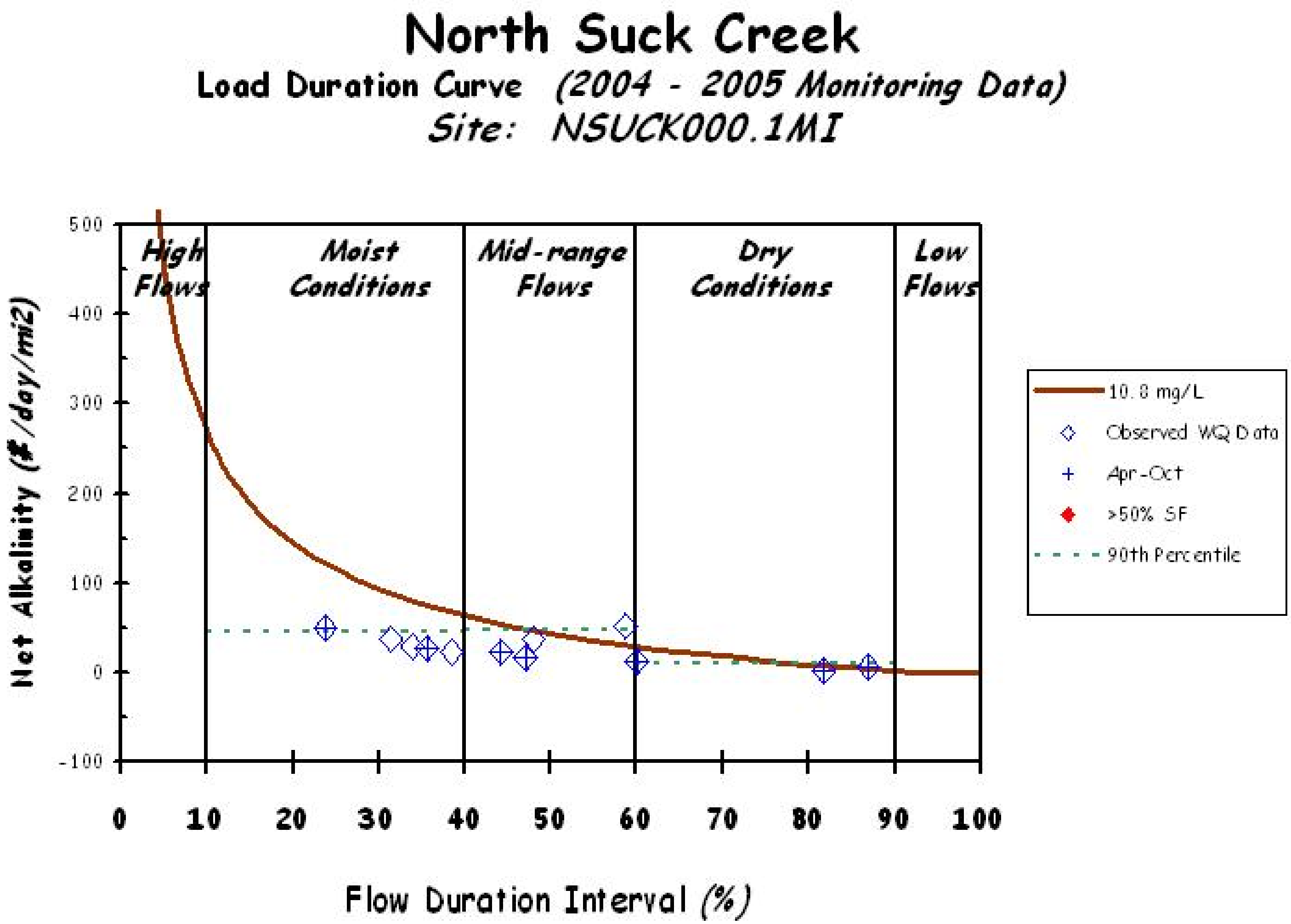

Figure F-1 Load Duration Curve -- North Suck Creek

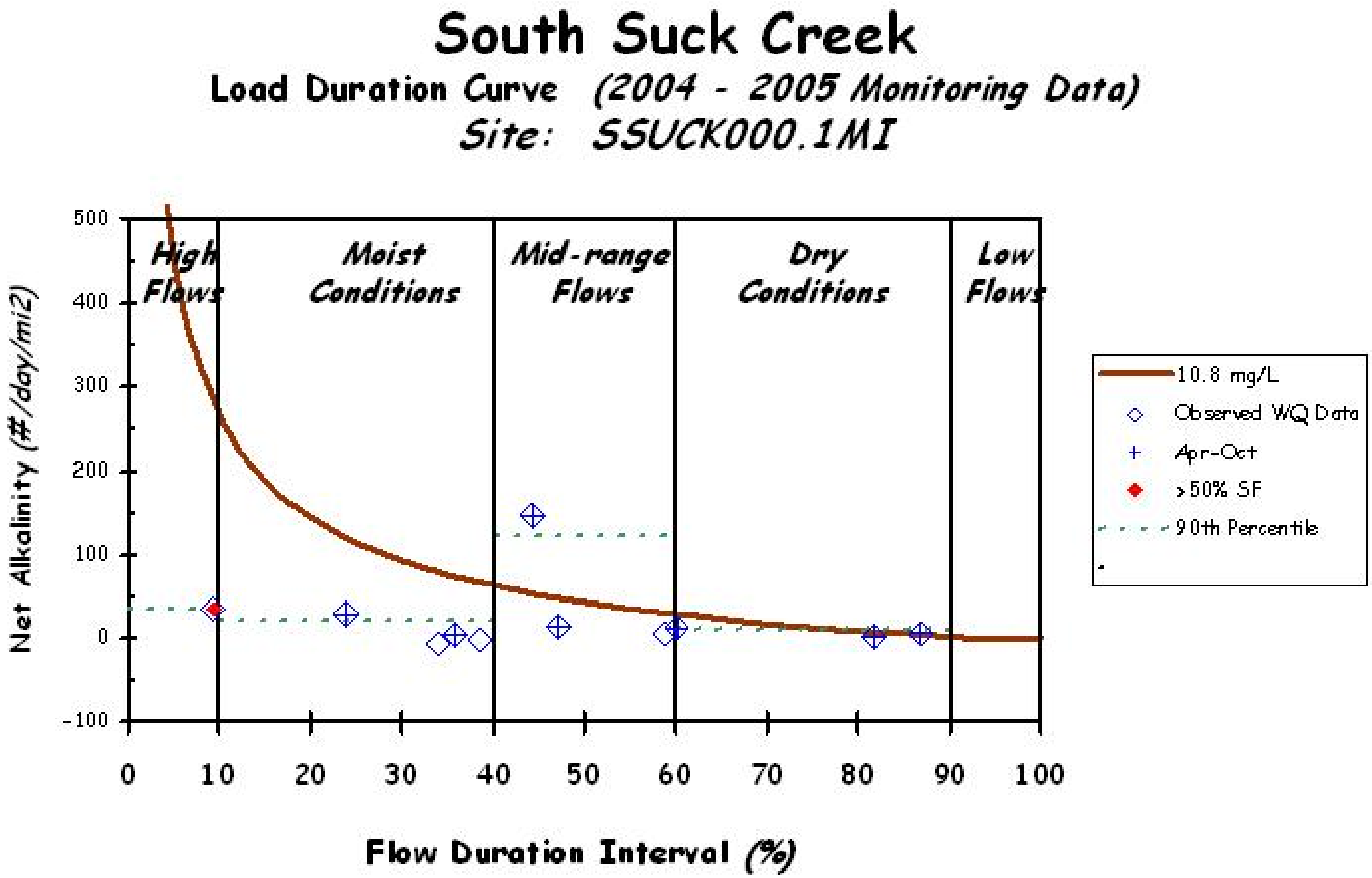

Figure F-2 Load Duration Curve -- South Suck Creek

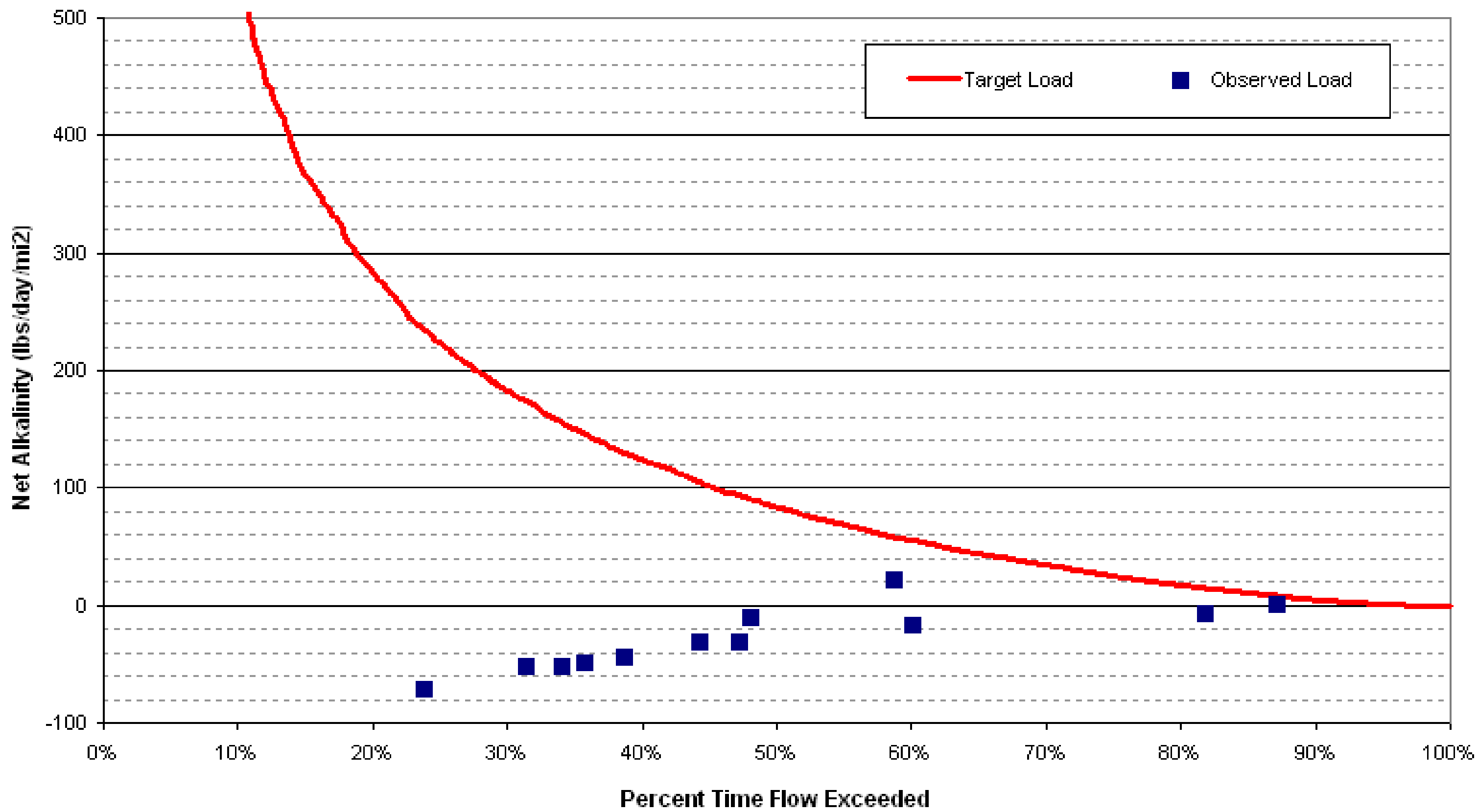

Figure F-3 Net Alkalinity Difference from Target -- North Suck Creek

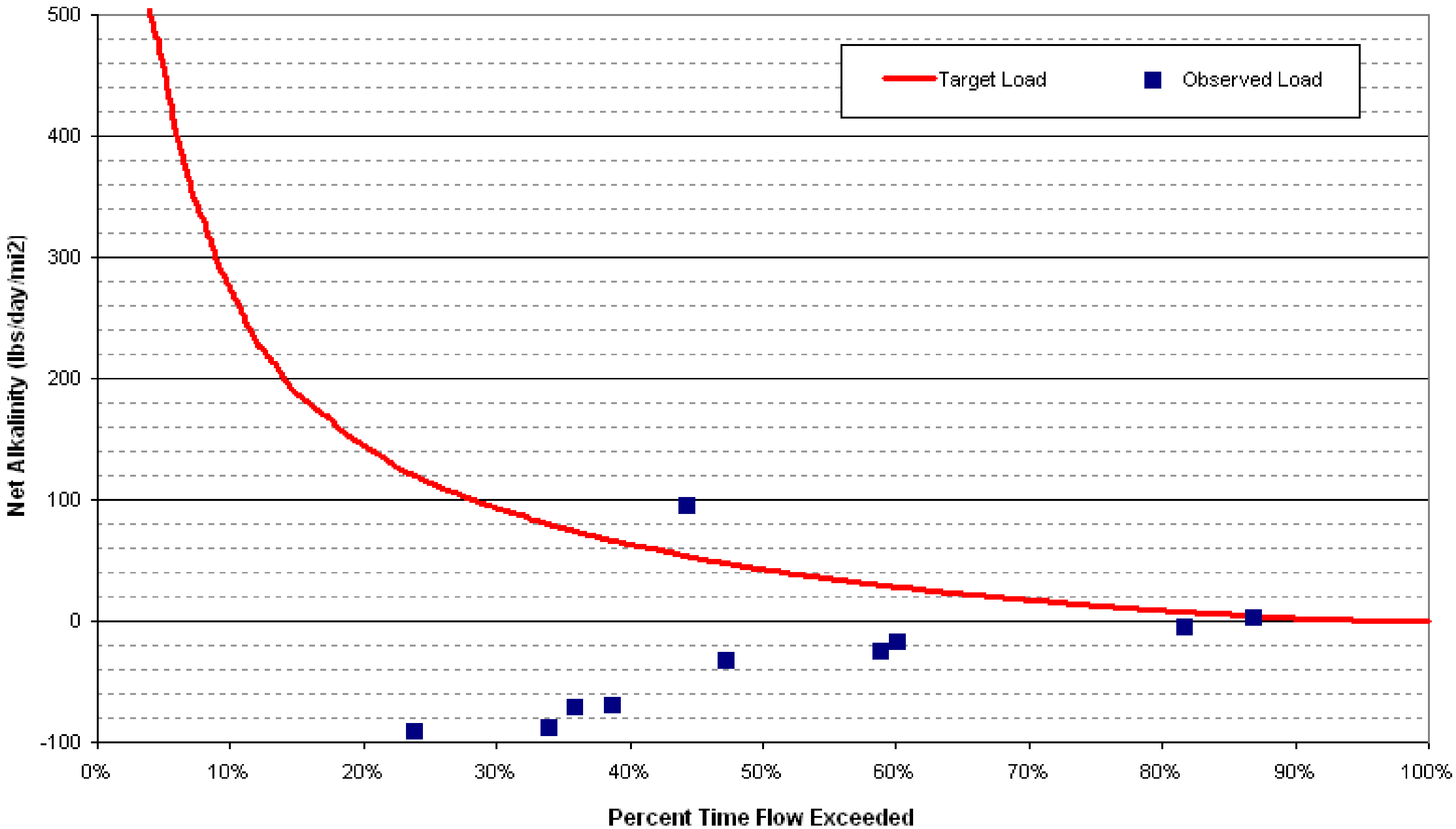

Figure F-4 Net Alkalinity Difference from Target – South Suck Creek

APPENDIX G

Public Notice Announcement

STATE OF TENNESSEE
DEPARTMENT OF ENVIRONMENT AND CONSERVATION
DIVISION OF WATER POLLUTION CONTROL

PUBLIC NOTICE OF AVAILABILITY OF PROPOSED TOTAL MAXIMUM DAILY LOAD (TMDL) FOR pH and Iron IN THE SUCK CREEK SUBWATERSHED LOWER TENNESSEE RIVER WATERSHED (HUC 06020001), TENNESSEE

Announcement is hereby given of the availability of Tennessee's proposed Total Maximum Daily Load (TMDL) for pH and iron in the Suck Creek subwatershed, located in eastern Tennessee. Section 303(d) of the Clean Water Act requires states to develop TMDLs for waters on their impaired waters list. TMDLs must determine the allowable pollutant load that the water can assimilate, allocate that load among the various point and nonpoint sources, include a margin of safety, and address seasonality.

North Suck Creek and South Suck Creek are listed on Tennessee's final 2004 303(d) list as not supporting designated use classifications due, in part, to low pH and iron associated with abandoned mines. The TMDL utilizes Tennessee's general water quality criteria, net alkalinity (as $CaCO_3$) as a surrogate for pH, USGS continuous record station flow data, in-stream water quality monitoring data, a calibrated dynamic water quality model, load duration curves, and an appropriate Margin of Safety (MOS) to establish loadings of net alkalinity (as $CaCO_3$) which will result in the attainment of water quality standards for pH.

The proposed Suck Creek pH and Iron TMDL may be downloaded from the Department of Environment and Conservation website:

http://www.state.tn.us/environment/wpc/tmdl/

Technical questions regarding this TMDL should be directed to the following members of the Division of Water Pollution Control staff:

Vicki S. Steed, P.E., Watershed Management Section
Telephone: 615-532-0707

Sherry H. Wang, Ph.D., Watershed Management Section
Telephone: 615-532-0656

Persons wishing to comment on the proposed TMDLs are invited to submit their comments in writing no later than July 24, 2006 to:

Division of Water Pollution Control
Watershed Management Section
7th Floor, L & C Annex
401 Church Street
Nashville, TN 37243-1534

All comments received prior to that date will be considered when revising the TMDL for final submittal to the U.S. Environmental Protection Agency.

The TMDL and supporting information are on file at the Division of Water Pollution Control, 6th Floor, L & C Annex, 401 Church Street, Nashville, Tennessee. They may be inspected during normal office hours. Copies of the information on file are available on request.