TOTAL MAXIMUM DAILY LOAD (TMDL)

For

pH

In

North Chickamauga Creek

Located In The

Tennessee River Watershed (HUC 06020001)

Hamilton & Sequatchie County, Tennessee

Final

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LIST OF ABBREVIATIONS

AMD	Acid Mine Drainage
CFR	Code of Federal regulations
CFS	Cubic Feet per Second
DWPC	Division of Water Pollution Control
EPA	Environmental Protection Agency
HUC	Hydrologic Unit Code
LA	Load Allocation
MGD	Million Gallons per Day
MOS	Margin of Safety
MRLC	Multi-Resolution Land Characteristic
NPDES	National Pollutant Discharge Elimination System
Rf3	Reach File 3
RM	River Mile
TDEC	Tennessee Department of Environment & Conservation
TMDL	Total Maximum Daily Load
USGS	United States Geological Survey
WLA	Waste Load Allocation

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

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1) 303(d) Listed Waterbody Information

State: Tennessee
County: Hamilton & Sequatchie

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

Waterbody Name: North Chickamauga Creek
Waterbody ID: TN06020001067
Location: From Poe Branch to Hogskin Creek (segment 2000), from Mossy Creek to the headwaters (segment 4000), and Standifer Creek (segment 0400)
Impacted Stream Length: 29.4 miles Not Supporting
Watershed Area: 47.33 mi^2 (North Chickamauga Creek subwatershed)
Tributary to: Tennessee River

Constituent(s) of Concern: pH

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

2. TMDL Development

Analysis Methodology: Based on 2002 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

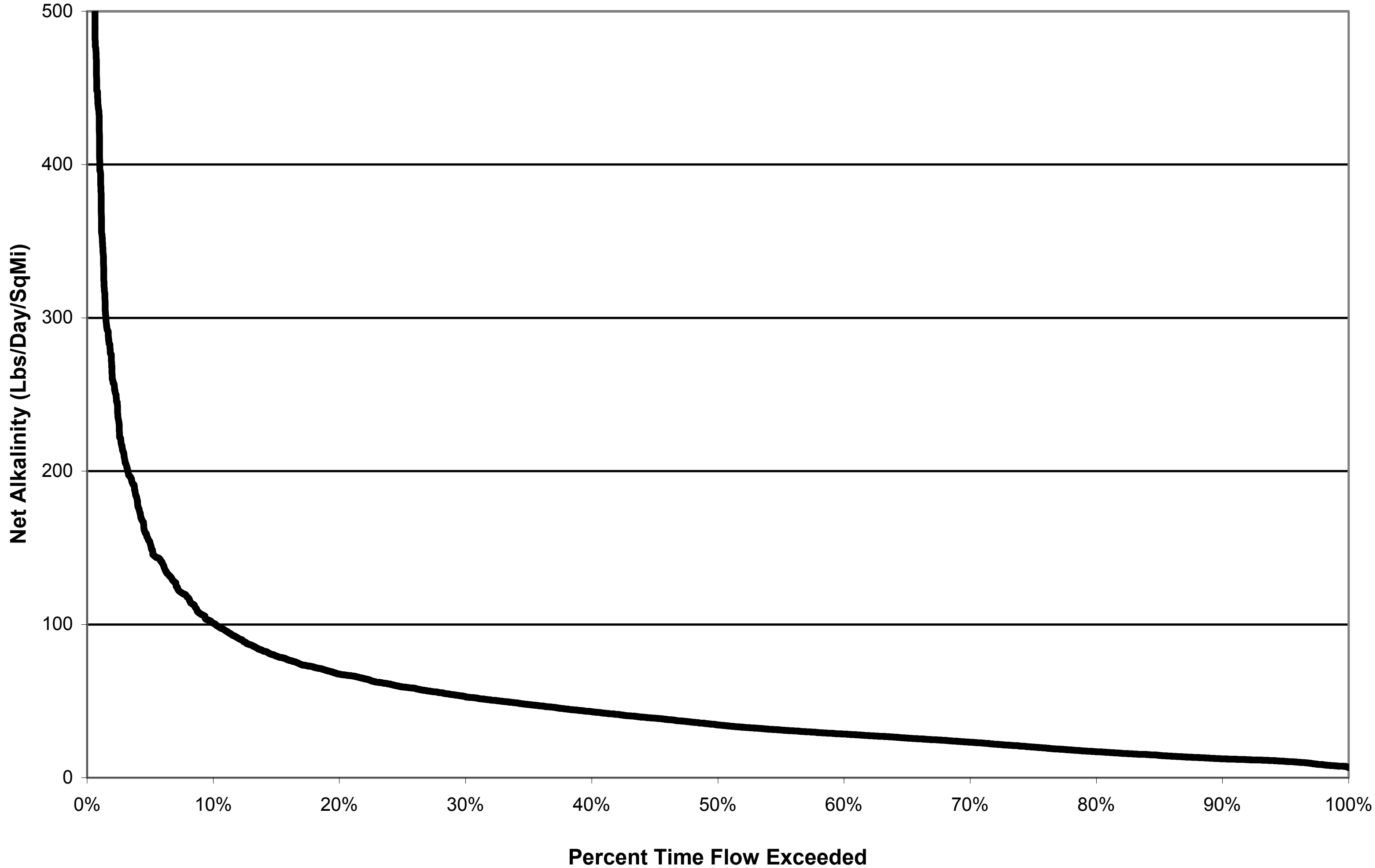
Margin of Safety (MOS): Implicit (conservative modeling assumptions)

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 for unimpaired tributary to North Chickamauga Creek (Cooper Creek - see Figure on next page)

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.



Target Load Duration Curve

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

North Chickamauga Creek – Mouth on Tennessee River to Headwaters (TN06020001067)

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 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 North Chickamauga Creek subwatershed contains three Level IV subecoregions (USEPA, 1997) as shown in Figure 2:

- **Southern Limestone/Dolomite Valleys and Low Rolling Hills (67f)** form a heterogeneous region composed predominantly of limestone and cherty dolomite. Landforms are mostly low rolling ridges and valleys, and the soils vary in their productivity. Landcover includes intensive agriculture, urban and industrial uses, as well as areas of thick forest. White oak forest, bottomland oak forest, and sycamore-ash-elm riparian forests are the common forest types. Grassland barrens intermixed with cedar-pine glades also occur here.

- **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 Tennessee River watershed has approximately 2,561 miles of streams (Rf3), 1,503 miles of which are in Tennessee, and drains a total area of 1,870 square miles, 1,201 square miles of which are in Tennessee. 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. Land use for the Tennessee River watershed is summarized in Table 1. Land use for the North Chickamauga Creek subwatershed is also summarized in Table 1 and shown in Figure 3.

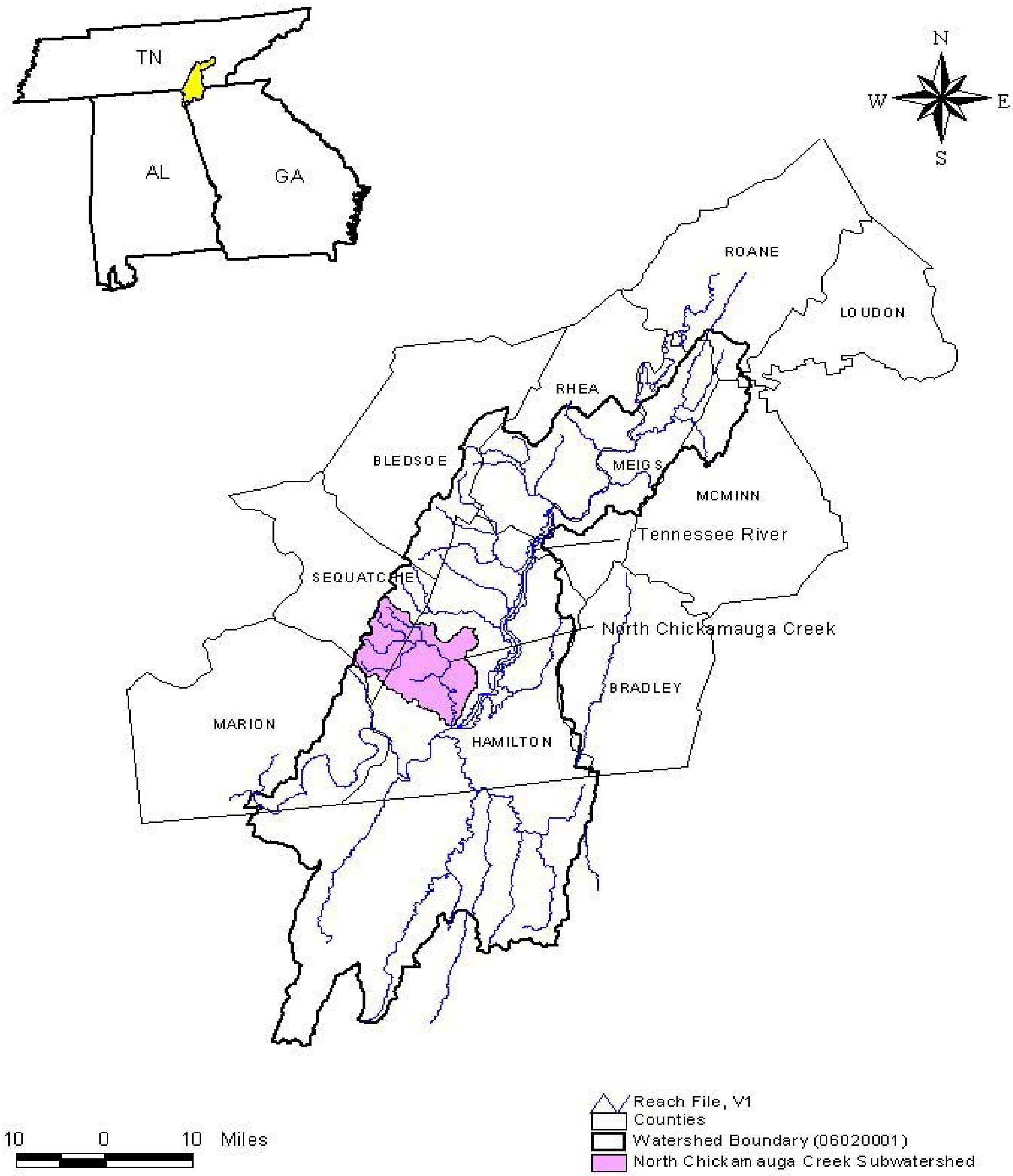


Figure 1 Location of Tennessee River Watershed

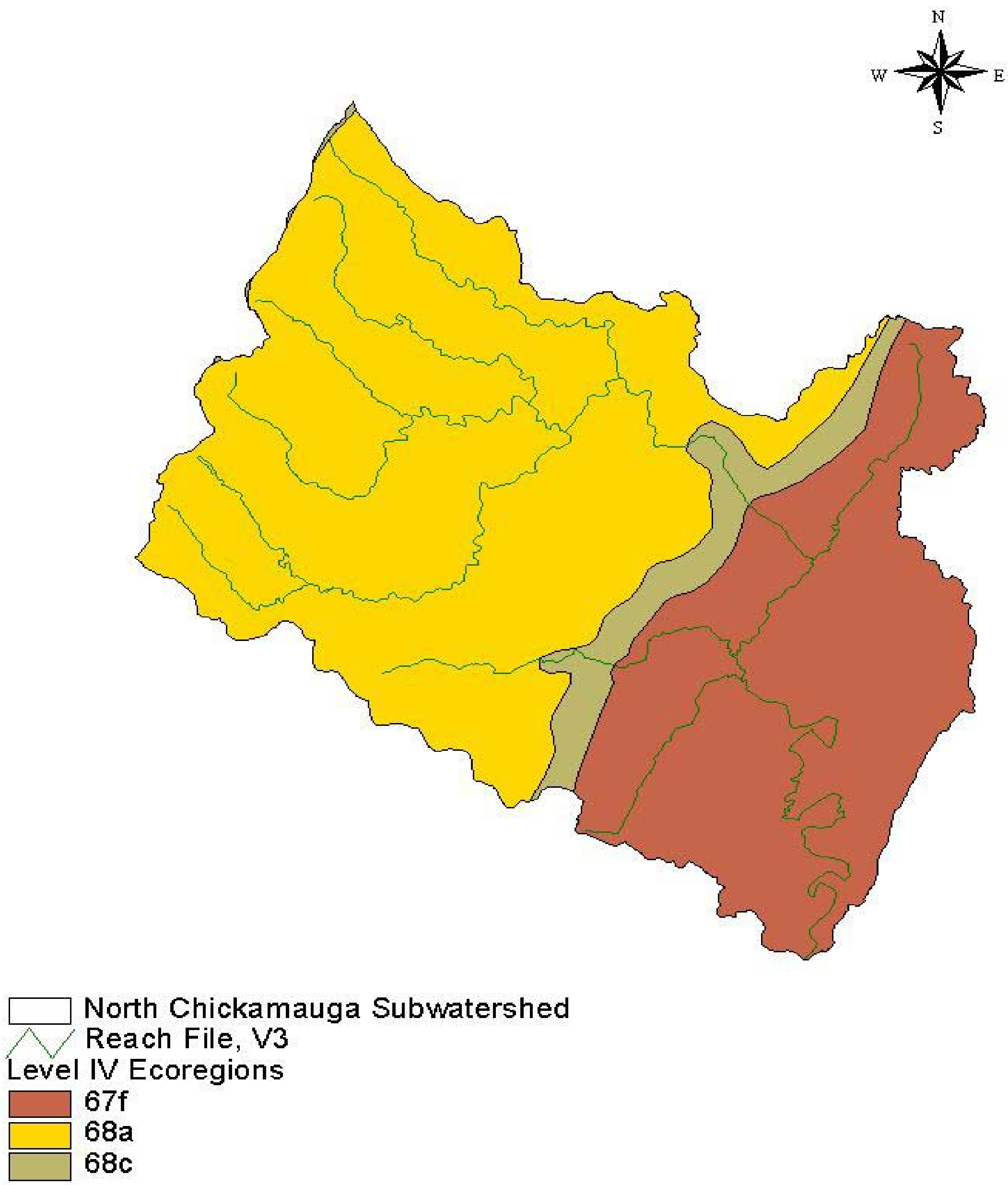


Figure 2 North Chickamauga Subwatershed Ecoregion Designation

Table 1 Land Use Distribution – Tennessee River Watershed & North Chickamauga Creek Subwatershed

Land use	North Chickamauga Creek Subwatershed (0602000107)		Total Tennessee River Watershed (06020001)	
	[acres]	[%]	[acres]	[%]
Bare Rock/Sand/Clay	0	0	1	0
Deciduous Forest	37,611	49.1	318,702	41.0
Emergent Herbaceous Wetlands	52	0.1	1,574	0.2
Evergreen Forest	8,496	11.1	97,306	12.5
High Intensity Commercial/Industrial/ Transportation	1,025	1.3	12,806	1.6
High Intensity Residential	626	0.8	5,446	0.7
Low Intensity Residential	4,211	5.5	30,910	4.0
Mixed Forest	17,497	22.8	145,997	18.8
Open Water	86	0.1	34,644	4.5
Other Grasses (Urban/recreational)	1,464	1.9	9,403	1.2
Pasture/Hay	3,352	4.4	79,986	10.3
Row Crops	1,083	1.4	26,455	3.4
Quarries/Strip Mines/Gravel Pits	52	0.1	1,172	0.2
Transitional	213	0.3	7,466	1.0
Woody Wetlands	858	1.1	5,068	0.7
Total	76,627	100.0	776,976	100.0

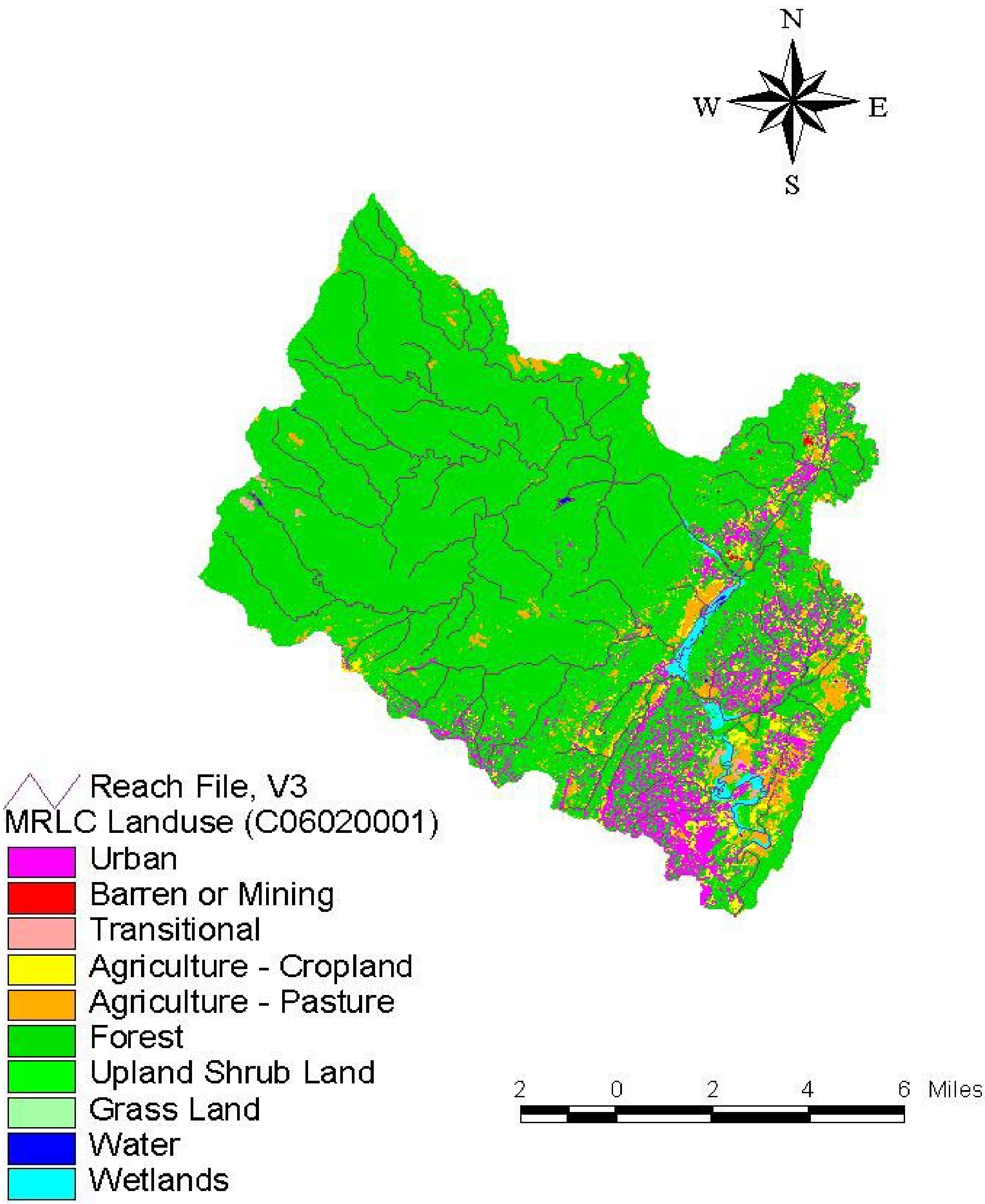


Figure 3 North Chickamauga Subwatershed Land Use Distribution

3.0 PROBLEM DEFINITION

EPA Region IV approved Tennessee's final 2002 303(d) list (TDEC, 2004) in January 2004. The list identified 25.5 miles of North Chickamauga Creek (from Poe Branch to Hogskin Creek and from Mossy Creek to the headwaters) and all of Standifer Creek (3.9 miles) as not supporting designated use classifications due, in part, to pH associated with abandoned mines. The designated use classifications for North Chickamauga Creek and its tributaries include fish and aquatic life, irrigation, livestock watering & wildlife, and recreation. A short, unimpaired portion of North Chickamauga Creek (Mile 13.2 to Mile 15.0) is also designated as a trout stream. The results of the 2002 303(d) list are summarized in Table 2.

Table 2 2002 303(d) List – North Chickamauga Creek Subwatershed

Waterbody ID	Impacted Waterbody	County	Partial	Not	CAUSE	Pollutant Source	COMMENTS
TN060200010 67 – 2000	N. Chickamauga Ck	Hamilton	4.1		pH Other Habitat Alterations	Abandoned Mining Hydromodification	
TN060200010 67 – 4000	N. Chickamauga Ck	Hamilton Sequatchie	21.4		pH	Abandoned Mining	Headwaters of stream
TN060200010 67– 0400	Standifer Creek	Sequatchie	3.9		pH	Abandoned Mining	

An updated 303(d) list for 2004 has been submitted to EPA Region IV, but has not yet been approved. Since the 2004 303(d) list, based on the latest field data (2003-2004), indicated no significant change from the 2002 303(d) list, the TMDL analysis will be based on the 2002 303(d) list. The primary cause of impairment is considered to be pH caused by acid mine drainage (AMD). Information regarding AMD formation is contained in Appendix A. There are no active mines in the North Chickamauga Creek subwatershed. The impaired segments and the approximate locations of abandoned mines affecting waterbodies in the North Chickamauga Creek subwatershed are shown in Figure 4.

4.0 TARGET IDENTIFICATION

The allowable instream range of pH for the North Chickamauga Creek subwatershed, is established in *State of Tennessee Water Quality Standards, Chapter 1200-4-3 General Water Quality Criteria, January, 2004 (Revised)* (TDEC, 2004) 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. The criteria were approved by the Environmental Protection Agency (EPA) in September 2004. Two specific revisions which could apply to the North Chickamauga Creek subwatershed are still under review by EPA. The criteria pH range for Fish & Aquatic Life use in subecoregion 68a (stream orders 1-3) is proposed to be 5.5 to 8.0. The criteria pH range for Recreation use is proposed to be 5.5 to 9.0. These specific issues are to be addressed by EPA at a later date.

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 North Chickamauga Creek subwatershed to fully supporting all of its designated use

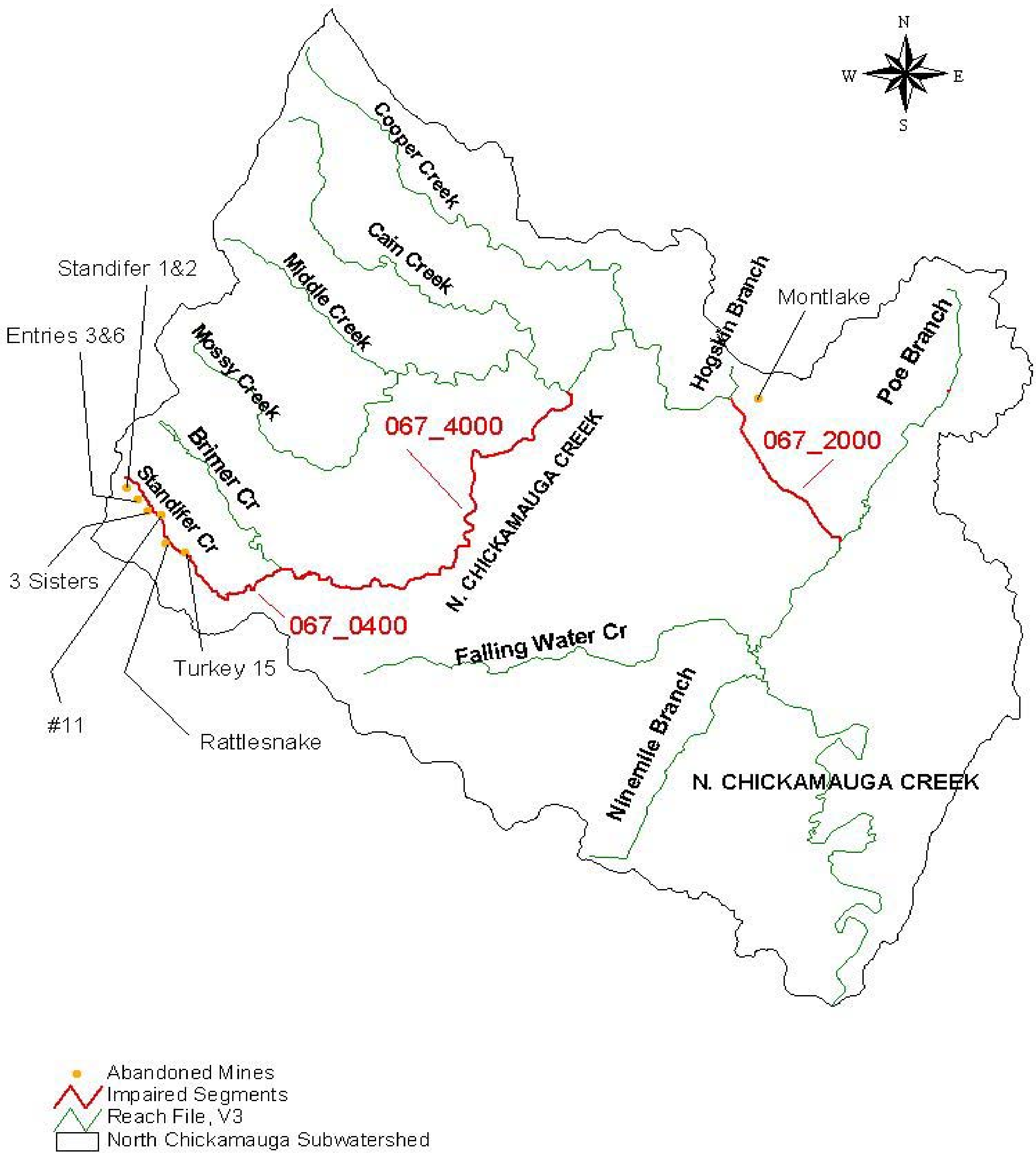


Figure 4 North Chickamauga Creek Subwatershed Impaired Segments and Abandoned Mine Locations

classifications, net alkalinity will be used as a surrogate parameter for TMDL development. For the purposes of this TMDL, the following terms are defined:

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 North Chickamauga Creek subwatershed was conducted by Division of Water Pollution Control (DWPC) personnel from the Chattanooga Environmental Assistance Center (EAC) during the period from 8/25/03 through 7/13/04 (See Appendix B & Table 3). Monitoring stations were located at several points in North Chickamauga Creek and near the mouth of major tributaries (see Figure 5). Since there is no specified numerical criterion for net alkalinity, the average net alkalinity (7.16 mg/l $CaCO_3$) of Cooper Creek, an unimpaired tributary of North Chickamauga Creek, was selected as the numerical target for this TMDL. Cooper Creek, Cain Creek, and Mossy Creek were all considered as potential reference streams for this TMDL. Cooper Creek was selected because it had the fewest pH values outside of the pH range criteria. Cooper Creek (segment 06020001067_0700) is assessed as fully supporting of its designated uses, as confirmed by the Water Quality Survey of the North Chickamauga Subwatershed conducted in 1995 (see Appendix C).

Water quality monitoring of the North Chickamauga Creek subwatershed was also conducted by Office of Surface Mining (USOSM) personnel during the period from 6/20/84 through 9/1/04 (See Appendix D & Table 4). Monitoring stations were located near abandoned mine sites along Standifer Creek and Hogskin Branch (see Figures 6 and 7).

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 Tables 5 and 6 and Figure 8. All samples with net alkalinity concentrations greater than 7.16 mg/L have pH that is in compliance with water quality standards.

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 E and shown in Figure 9, is typical of the load duration curves derived for the subwatersheds in the North Chickamauga Creek subwatershed. In order to meet Tennessee Water Quality Standards for pH, this TMDL requires that net alkalinity (as $CaCO_3$) loads of streams in the North Chickamauga Creek subwatershed meet, or exceed, the loads per unit area specified in the target load duration curve (Figure 9).

Table 3 North Chickamauga Creek Subwatershed Monitoring Data (TDEC)

Monitoring Site	Parameter	Units	Sample Date											
			8/25-26/03	9/16,24/03	10/13-14/03	11/17/03	12/1,16/03	1/21/04	2/19,23/04	3/15,17/04	4/19-20/04	5/10,13/04	6/10,17/04	7/12-13/04
N. Chickamauga Ck.	Flow	cfs	52.05	17.31	28.52	50.13	high		high	146.34	75.25	42.76	19.65	54.23
Boy Scout Rd.	Total Alkalinity	mg/L	68.20	80.70	82.80	60.80	17.10		17.10	33.10	37.30	47.10	74.30	56.10
(Mile 12.4)	Acidity	mg/L	3.40	4.23	2.92		2.20		2.61	1.57	1.84	2.64	1.43	U
N. Chickamauga Ck.	Flow	cfs	15.50	4.99	9.43	69.00	263.00	62.00	188.00	58.00	31.00	11.00	0.00	3.10
Pocket Wilderness	Total Alkalinity	mg/L	7.91	U	U	4.50	U		U	U	3.02	U	U	U
(Mile 19.3)	Acidity	mg/L	3.10	6.46	2.60		3.25		3.09	3.98	2.92	1.37		2.53
N. Chickamauga Ck.	Flow	cfs	2.34	0.75	1.44	7.40	38.14		36.24	12.95	8.08		2.02	3.97
Gray Fryar Rd.	Total Alkalinity	mg/L	11.80	U	11.20	5.99	U		U	U	4.18	U	U	U
(Mile 28.1)	Acidity	mg/L	2.14	6.38	3.44		2.67		1.83	U	1.08	1.83	1.43	1.73
Cain Ck.	Flow	cfs	0.55	4.06	1.37		22.61	11.51	9.87	24.84	9.33	3.15	0.28	4.65
	Total Alkalinity	mg/L	6.35	U	U		U	U	U	U	U	U	U	U
	Acidity	mg/L	U	1.13	3.64		1.38	1.21	2.32	1.57	U	U	U	1.84
Cooper Ck.	Flow	cfs	0.81	6.30	0.74		17.71	8.15		26.78	5.60	1.10	0.42	3.03
	Total Alkalinity	mg/L	10.10	U	14.40		12.10	U		U	U	10.90	10.90	U
	Acidity	mg/L		1.19	2.71		1.32	U		U	1.30	U	1.78	1.96
Mossy Ck.	Flow	cfs	2.22	15.67	3.07		43.24	18.71	22.66	37.73	12.67	4.38	0.69	6.46
	Total Alkalinity	mg/L	5.05	U	10.20		U	U	U	U	U	U	U	U
	Acidity	mg/L	2.36	1.07	2.81		2.63	1.09	3.47	U	1.08	U	U	1.15

Note: U denotes analyte requested but not detected. Detection limit is 10 mg/L for total alkalinity and 1 mg/L for acidity. Units of Total Alkalinity and Acidity are expressed in mg/L $CaCO_3$.

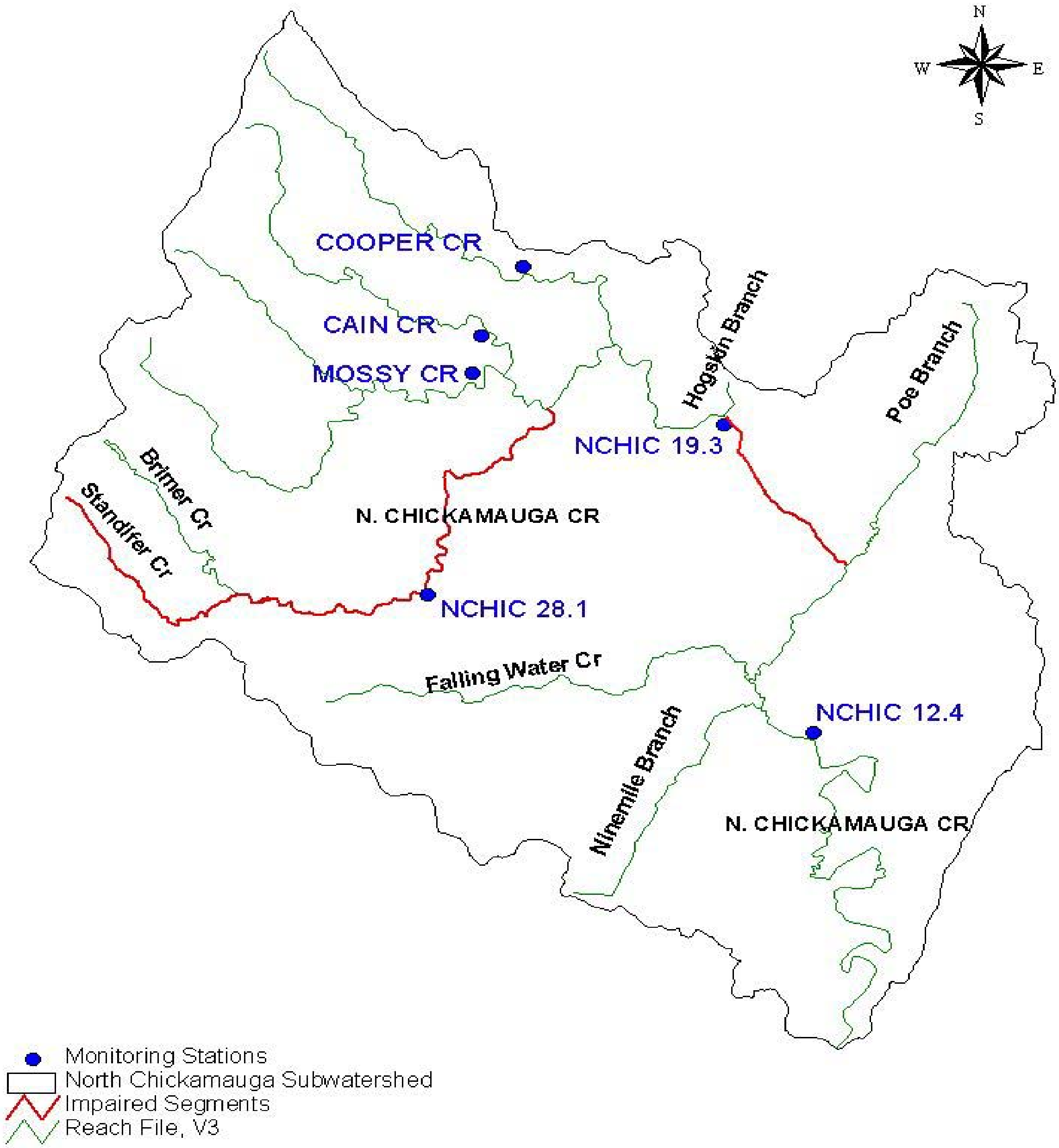


Figure 5 North Chickamauga Creek Subwatershed Monitoring Stations (TDEC)

Table 4 North Chickamauga Creek Subwatershed Monitoring Data (USOSM)

Monitoring Site	Parameter	Units	Sample Date										
			6/20/84	7/9/84	12/30/86	3/28/95	4/13/95	5/4,22/95	3/17-18/99	4/28-29/99	1/10-12/00	7/11-12/00	2/14/01
Entries 3 & 6	Flow	cfs				0.127				1.84	0.126	Slight	0.13
	Total Alkalinity	mg/L				<1.0				0.00	U		U
	Acidity	mg/L								75.00	119.00		102.00
Turkey 15 Highwall	Flow	cfs						0.056					
	Total Alkalinity	mg/L						<1.0		0.00	U		U
	Acidity	mg/L						69.00		87.00	130.00		111.00
Turkey 15 Discharge	Flow	cfs										0.00	
	Total Alkalinity	mg/L								89.00	44.00		56.00
	Acidity	mg/L								12.00	13.00		U
#11 Inflow	Flow	cfs					0.89			0.58	1.29	0.00	0.17
	Total Alkalinity	mg/L					<1.0			0.00	U		U
	Acidity	mg/L					86.00			46.00	34.00		
#11 Discharge	Flow	cfs									1.29	0.00	
	Total Alkalinity	mg/L								2.00	2.00		1.00
	Acidity	mg/L								21.00	34.00		
Standifer 1 & 2 Inflow	Flow	cfs								1.55		0.03	
	Total Alkalinity	mg/L								0.00	U		U
	Acidity	mg/L								65.00	68.00		107.00
Standifer 1 & 2 Discharge	Flow	cfs									0.31	0.01	
	Total Alkalinity	mg/L								0.00	U		U
	Acidity	mg/L								43.00	55.00		81.00
Rattlesnake Bypass	Flow	cfs				0.73					1.37	0.00	0.82
	Total Alkalinity	mg/L				<1.0			0.00	0.00	U		U
	Acidity	mg/L							16.70	26.00	25.00		28.00
Rattlesnake Discharge	Flow	cfs										Slight	
	Total Alkalinity	mg/L								6.00	U		U
	Acidity	mg/L								11.00	19.00		20.00

Note: U denotes analyte requested but not detected. Detection limit is 10 mg/L for total alkalinity and 1 mg/L for acidity.
Units of Total Alkalinity and Acidity are expressed in mg/L $CaCO_3$.

Table 4 (cont'd) North Chickamauga Creek Subwatershed Monitoring Data (USOSM)

Monitoring Site	Parameter	Units	Sample Date									
			6/19-20/01	10/30-31/01	3/25-28/02	5/2/02	5/30/02	6/27/02	7/24/02	8/13-14/02	9/26/02	10/31/02
Entries 3 & 6	Flow	cfs	0.04	DRY	0.03					DRY		
	Total Alkalinity	mg/L	U		U							
	Acidity	mg/L	213.00		152.00							
Turkey 15 Highwall	Flow	cfs								Trickle		
	Total Alkalinity	mg/L	U	U	U					U		
	Acidity	mg/L	123.00	142.00	98.00					74.00		
Turkey 15 Discharge	Flow	cfs		DRY	0.00					DRY		
	Total Alkalinity	mg/L			46.00							
	Acidity	mg/L			U							
#11 Inflow	Flow	cfs	0.73	0.03	0.36							
	Total Alkalinity	mg/L	U	U	U					U		
	Acidity	mg/L	58.00	75.00	27.00					78.00		
#11 Discharge	Flow	cfs	0.73							DRY		
	Total Alkalinity	mg/L	23.00		3.00							
	Acidity	mg/L	U		11.00							
Standifer 1 & 2 Inflow	Flow	cfs								Trickle		
	Total Alkalinity	mg/L	U	U	U					U		
	Acidity	mg/L	71.00	72.00	94.00					86.00		
Standifer 1 & 2 Discharge	Flow	cfs								Trickle		
	Total Alkalinity	mg/L	U	6.00	U					53.00		
	Acidity	mg/L	63.00	30.00	76.00					31.00		
Rattlesnake Bypass	Flow	cfs	0.14	0.01	1.19					0.01		
	Total Alkalinity	mg/L	U	U	U					U		
	Acidity	mg/L	47.00	81.00	22.00					82.00		
Rattlesnake Discharge	Flow	cfs		DRY						DRY		
	Total Alkalinity	mg/L										
	Acidity	mg/L										

Note: U denotes analyte requested but not detected. Detection limit is 10 mg/L for total alkalinity and 1 mg/L for acidity. Units of Total Alkalinity and Acidity are expressed in mg/L $CaCO_3$.

Table 4 (cont'd) North Chickamauga Creek Subwatershed Monitoring Data (USOSM)

Monitoring Site	Parameter	Units	Sample Date									
			12/2-3/02	1/8/03	1/30/03	2/28/03	3/12-13/03	4/29/03	5/29-6/3/03	8/18-19/03	11/19-20/03	8/31-9/1/04
Entries 3 & 6	Flow	cfs	0.09				0.04			0.02	0.11	0.00
	Total Alkalinity	mg/L	0.00				0.00		0.00	0.00	0.00	0.00
	Acidity	mg/L	410.00				200.00		196.00	130.00	108.00	270.00
Turkey 15 Highwall	Flow	cfs										
	Total Alkalinity	mg/L	0.00				0.00		0.00	0.00	130.00	6.00
	Acidity	mg/L	195.00				120.00		96.00	160.00	0.00	20.00
Turkey 15 Discharge	Flow	cfs	DRY				DRY		DRY	DRY	DRY	DRY
	Total Alkalinity	mg/L										
	Acidity	mg/L										
#11 Inflow	Flow	cfs	0.19				0.67			0.12	0.52	
	Total Alkalinity	mg/L	0.00				0.00		0.00	0.00	0.00	0.00
	Acidity	mg/L	96.00				80.00		80.00	70.00	80.00	92.00
#11 Discharge	Flow	cfs	0.19				0.67					
	Total Alkalinity	mg/L	3.00				3.00		24.00	14.00	16.00	62.00
	Acidity	mg/L	29.00				12.00		8.00	2.00	0.00	0.00
Standifer 1 & 2 Inflow	Flow	cfs										
	Total Alkalinity	mg/L	0.00				0.00		0.00	0.00	0.00	0.00
	Acidity	mg/L	116.00				110.00		120.00	103.00	82.00	106.00
Standifer 1 & 2 Discharge	Flow	cfs										
	Total Alkalinity	mg/L	0.00				0.00		0.00	0.00	50.00	82.00
	Acidity	mg/L	110.00				110.00		50.00	75.00	0.00	0.00
Rattlesnake Bypass	Flow	cfs	0.35				0.44			0.26	1.29	0.05
	Total Alkalinity	mg/L	0.00				0.00		0.00	0.00	30.00	6.00
	Acidity	mg/L	46.00				55.00		40.00	56.00	7.00	20.00
Rattlesnake Discharge	Flow	cfs	Trickle							0.26		
	Total Alkalinity	mg/L	0.00				2.00		14.00	7.00	52.00	62.00
	Acidity	mg/L	74.00				5.00		3.00	3.00	10.00	0.00

Note: U denotes analyte requested but not detected. Detection limit is 10 mg/L for total alkalinity and 1 mg/L for acidity.
Units of Total Alkalinity and Acidity are expressed in mg/L $CaCO_3$.

Table 4 (cont'd) North Chickamauga Creek Subwatershed Monitoring Data (USOSM)

Monitoring Site	Parameter	Units	Sample Date										
			6/20/84	7/9/84	12/30/86	3/28/95	4/13/95	5/4,22/95	3/17-18/99	4/28-29/99	1/10-12/00	7/11-12/00	2/14/01
Three Sisters In Left	Flow	cfs											
	Total Alkalinity	mg/L											
	Acidity	mg/L											
Three Sisters In Right	Flow	cfs											
	Total Alkalinity	mg/L											
	Acidity	mg/L											
Three Sisters Combined	Flow	cfs								1.15	0.21		
	Total Alkalinity	mg/L								0.00	U		U
	Acidity	mg/L								75.00	77.00		151.00
Three Sisters Discharge	Flow	cfs										Slight	
	Total Alkalinity	mg/L											3.00
	Acidity	mg/L											58.00
Standifer Creek Below Turkey 15	Flow	cfs											
	Total Alkalinity	mg/L								1.00	U		1.00
	Acidity	mg/L								12.00	27.00		16.00
Standifer Creek at Double Bridges	Flow	cfs			7.50								
	Total Alkalinity	mg/L			0.00			<1.0		3.00	2.00		
	Acidity	mg/L			29.20			16.00		0.00	U		
North Chickamauga Below Double Bridges	Flow	cfs			15.00								
	Total Alkalinity	mg/L	0.00	<1.0	0.00			1.00		2.00	3.00		
	Acidity	mg/L	26.00	7.00	39.21			10.00		0.00	U		
North Chickamauga Above Hogskin	Flow	cfs											
	Total Alkalinity	mg/L								2.00	2.00		3.00
	Acidity	mg/L								0.00	U		U

Note: U denotes analyte requested but not detected. Detection limit is 10 mg/L for total alkalinity and 1 mg/L for acidity. Units of Total Alkalinity and Acidity are expressed in mg/L $CaCO_3$.

Table 4 (cont'd) North Chickamauga Creek Subwatershed Monitoring Data (USOSM)

Monitoring Site	Parameter	Units	Sample Date									
			6/19-20/01	10/30-31/01	3/25-28/02	5/2/02	5/30/02	6/27/02	7/24/02	8/13-14/02	9/26/02	10/31/02
Three Sisters In Left	Flow	cfs										
	Total Alkalinity	mg/L										
	Acidity	mg/L										
Three Sisters In Right	Flow	cfs										
	Total Alkalinity	mg/L										
	Acidity	mg/L										
Three Sisters Combined	Flow	cfs		Trickle						DRY		
	Total Alkalinity	mg/L	U		U							
	Acidity	mg/L	138.00		152.00							
Three Sisters Discharge	Flow	cfs		Slight						DRY		
	Total Alkalinity	mg/L	32.00	30.00	3.00							
	Acidity	mg/L	15.00	24.00	18.00							
Standifer Creek Below Turkey 15	Flow	cfs										
	Total Alkalinity	mg/L	U	U	1.00					U		
	Acidity	mg/L	23.00	27.00	17.00					51.00		
Standifer Creek at Double Bridges	Flow	cfs										
	Total Alkalinity	mg/L	2.00	2.00	3.00					2.00		
	Acidity	mg/L	U	11.00	U					11.00		
North Chickamauga Below Double Bridges	Flow	cfs								Stagnant		
	Total Alkalinity	mg/L	3.00	1.00	3.00							
	Acidity	mg/L	U	U	U							
North Chickamauga Above Hogskin	Flow	cfs										
	Total Alkalinity	mg/L	4.00	5.00	3.00	0.00	4.00	14.00	10.00		10.00	10.00
	Acidity	mg/L	U	U	U	16.00	65.00	0.00	7.00		35.00	5.00

Note: U denotes analyte requested but not detected. Detection limit is 10 mg/L for total alkalinity and 1 mg/L for acidity. Units of Total Alkalinity and Acidity are expressed in mg/L $CaCO_3$.

Table 4 (cont'd) North Chickamauga Creek Subwatershed Monitoring Data (USOSM)

Monitoring Site	Parameter	Units	Sample Date									
			12/2-3/02	1/8/03	1/30/03	2/28/03	3/12-13/03	4/29/03	5/29-6/3/03	8/18-19/03	11/19-20/03	8/31-9/1/04
Three Sisters In Left	Flow	cfs										
	Total Alkalinity	mg/L									0.00	
	Acidity	mg/L									140.00	
Three Sisters In Right	Flow	cfs										
	Total Alkalinity	mg/L									0.00	0.00
	Acidity	mg/L									180.00	300.00
Three Sisters Combined	Flow	cfs									0.00	
	Total Alkalinity	mg/L	0.00				0.00		0.00	0.00	0.00	0.00
	Acidity	mg/L	280.00				200.00		256.00	400.00	160.00	190.00
Three Sisters Discharge	Flow	cfs	Slight									
	Total Alkalinity	mg/L	1.00				4.00		2.00	70.00	70.00	10.00
	Acidity	mg/L	132.00				25.00		65.00	0.00	0.00	3.00
Standifer Creek Below Turkey 15	Flow	cfs										
	Total Alkalinity	mg/L	0.00				0.00		0.00	5.00	15.00	5.00
	Acidity	mg/L	40.00				31.00		46.00	15.00	10.00	12.00
Standifer Creek at Double Bridges	Flow	cfs										
	Total Alkalinity	mg/L	2.00				0.00		1.00	4.00	17.00	11.00
	Acidity	mg/L	12.00				20.00		21.00	13.00	25.00	1.00
North Chickamauga Below Double Bridges	Flow	cfs										
	Total Alkalinity	mg/L	2.00				0.00		2.00	9.00	7.00	17.00
	Acidity	mg/L	18.00				10.00		11.00	37.00	16.00	0.00
North Chickamauga Above Hogskin	Flow	cfs										
	Total Alkalinity	mg/L	6.00	10.00	5.00	3.00		8.00	5.00	17.00	7.00	12.00
	Acidity	mg/L	4.00	5.00	25.00	12.00		15.00	21.00	24.00	10.00	0.00

Note: U denotes analyte requested but not detected. Detection limit is 10 mg/L for total alkalinity and 1 mg/L for acidity. Units of Total Alkalinity and Acidity are expressed in mg/L $CaCO_3$.

Table 4 (cont'd) North Chickamauga Creek Subwatershed Monitoring Data (USOSM)

Monitoring Site	Parameter	Units	Sample Date										
			6/20/84	7/9/84	12/30/86	3/28/95	4/13/95	5/4,22/95	3/17-18/99	4/28-29/99	1/10-12/00	7/11-12/00	2/14/01
Hogskin Br at North Chickamauga	Flow	cfs									1.99		
	Total Alkalinity	mg/L								0.00	U		U
	Acidity	mg/L								28.00	83.00		47.00
North Chickamauga Below Hogskin	Flow	cfs											
	Total Alkalinity	mg/L											
	Acidity	mg/L											
Entries Discharging into Hogskin Br	Flow	cfs						1.33			0.27	0.08	
	Total Alkalinity	mg/L						<1.0		0.00	U		U
	Acidity	mg/L						194.00		78.00	263.00		289.00
Hogskin Br Above Entries	Flow	cfs										0.00	
	Total Alkalinity	mg/L									2.00		
	Acidity	mg/L									U		
Drain Above Hogskin Br	Flow	cfs											
	Total Alkalinity	mg/L											
	Acidity	mg/L											
Combined East of Hogskin Discharge	Flow	cfs											
	Total Alkalinity	mg/L											
	Acidity	mg/L											
Brimer Creek at Double Bridges	Flow	cfs											
	Total Alkalinity	mg/L											
	Acidity	mg/L											
Upper Brimer Creek	Flow	cfs											
	Total Alkalinity	mg/L											
	Acidity	mg/L											

Note: U denotes analyte requested but not detected. Detection limit is 10 mg/L for total alkalinity and 1 mg/L for acidity.
Units of Total Alkalinity and Acidity are expressed in mg/L $CaCO_3$.

Table 4 (cont'd) North Chickamauga Creek Subwatershed Monitoring Data (USOSM)

Monitoring Site	Parameter	Units	Sample Date									
			6/19-20/01	10/30-31/01	3/25-28/02	5/2/02	5/30/02	6/27/02	7/24/02	8/13-14/02	9/26/02	10/31/02
Hogskin Br at North Chickamauga	Flow	cfs		Trickle	1.22	0.55	0.21	0.05	0.00			0.33
	Total Alkalinity	mg/L	U		U	0.00	0.00	0.00	0.00		0.00	0.00
	Acidity	mg/L	225.00		132.00	170.00	228.00	291.00	360.00		164.00	224.00
North Chickamauga Below Hogskin	Flow	cfs										
	Total Alkalinity	mg/L			1.00	0.00	5.00	3.00	0.00		0.00	0.00
	Acidity	mg/L			14.00	14.00	39.00	19.00	60.00		77.00	60.00
Entries Discharging into Hogskin Br	Flow	cfs	0.79		0.24	0.55	0.16	0.08	0.02			0.05
	Total Alkalinity	mg/L	U	U	U	0.00	0.00	0.00	0.00		0.00	0.00
	Acidity	mg/L	551.00	794.00	330.00	470.00	520.00	620.00	642.00		760.00	505.00
Hogskin Br Above Entries	Flow	cfs		DRY	0.50	0.23	0.09	DRY	DRY			0.16
	Total Alkalinity	mg/L			2.00	0.00	3.00				2.00	2.00
	Acidity	mg/L			U	36.00	30.00				38.00	21.00
Drain Above Hogskin Br	Flow	cfs			0.02	0.00	DRY	DRY	DRY		DRY	DRY
	Total Alkalinity	mg/L				0.00						
	Acidity	mg/L				13.00						
Combined East of Hogskin Discharge	Flow	cfs			0.05	0.06	No Flow	DRY	DRY		Trickle	
	Total Alkalinity	mg/L			U	0.00					0.00	
	Acidity	mg/L			57.00	86.00					140.00	
Brimer Creek at Double Bridges	Flow	cfs								Stagnant		
	Total Alkalinity	mg/L	5.00	11.00	4.00							
	Acidity	mg/L	U	U	U							
Upper Brimer Creek	Flow	cfs								DRY		
	Total Alkalinity	mg/L		9.00								
	Acidity	mg/L		U								

Note: U denotes analyte requested but not detected. Detection limit is 10 mg/L for total alkalinity and 1 mg/L for acidity. Units of Total Alkalinity and Acidity are expressed in mg/L $CaCO_3$.

Table 4 (cont'd) North Chickamauga Creek Subwatershed Monitoring Data (USOSM)

Monitoring Site	Parameter	Units	Sample Date									
			12/2-3/02	1/8/03	1/30/03	2/28/03	3/12-13/03	4/29/03	5/29-6/3/03	8/18-19/03	11/19-20/03	8/31-9/1/04
Hogskin Br at North Chickamauga	Flow	cfs	0.41	0.71	0.46	4.65		0.33	0.54	0.48	0.95	0.09
	Total Alkalinity	mg/L	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00
	Acidity	mg/L	320.00	310.00	156.00	44.00		160.00	209.00	221.00	120.00	360.00
North Chickamauga Below Hogskin	Flow	cfs										
	Total Alkalinity	mg/L	0.00	0.00	0.00	0.00		0.00	0.00	0.00	5.00	0.00
	Acidity	mg/L	20.00	10.00	27.00	150.00		50.00	46.00	36.00	0.00	20.00
Entries Discharging into Hogskin Br	Flow	cfs	0.37	0.18	0.10	0.48		0.18	0.26	0.17	0.12	
	Total Alkalinity	mg/L	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00
	Acidity	mg/L	590.00	600.00	400.00	420.00		380.00	290.00	430.00	36.00	520.00
Hogskin Br Above Entries	Flow	cfs	0.06	0.39	0.53	1.00		0.18	0.29	0.12	0.20	
	Total Alkalinity	mg/L	3.00	0.00	0.00	4.00		0.00	0.00	7.00	2.00	0.00
	Acidity	mg/L	25.00	16.00	40.00	12.00		20.00	40.00	20.00	265.00	26.00
Drain Above Hogskin Br	Flow	cfs	DRY	DRY	DRY	0.48		DRY	DRY	DRY	DRY	DRY
	Total Alkalinity	mg/L				4.00						
	Acidity	mg/L				21.00						
Combined East of Hogskin Discharge	Flow	cfs	Trickle	0.08	0.03	0.64		0.01	0.07	0.05	0.20	DRY
	Total Alkalinity	mg/L		0.00	0.00	0.00		0.00	0.00	0.00		
	Acidity	mg/L		190.00	100.00	80.00		100.00	164.00	130.00		
Brimer Creek at Double Bridges	Flow	cfs										
	Total Alkalinity	mg/L	3.00				3.00		4.00	7.00	10.00	18.00
	Acidity	mg/L	29.00				5.00		23.00	3.00	0.00	0.00
Upper Brimer Creek	Flow	cfs										
	Total Alkalinity	mg/L	4.00				4.00			11.00	7.00	0.00
	Acidity	mg/L	27.00				15.00			15.00	12.00	19.92

Note: U denotes analyte requested but not detected. Detection limit is 10 mg/L for total alkalinity and 1 mg/L for acidity. Units of Total Alkalinity and Acidity are expressed in mg/L $CaCO_3$.

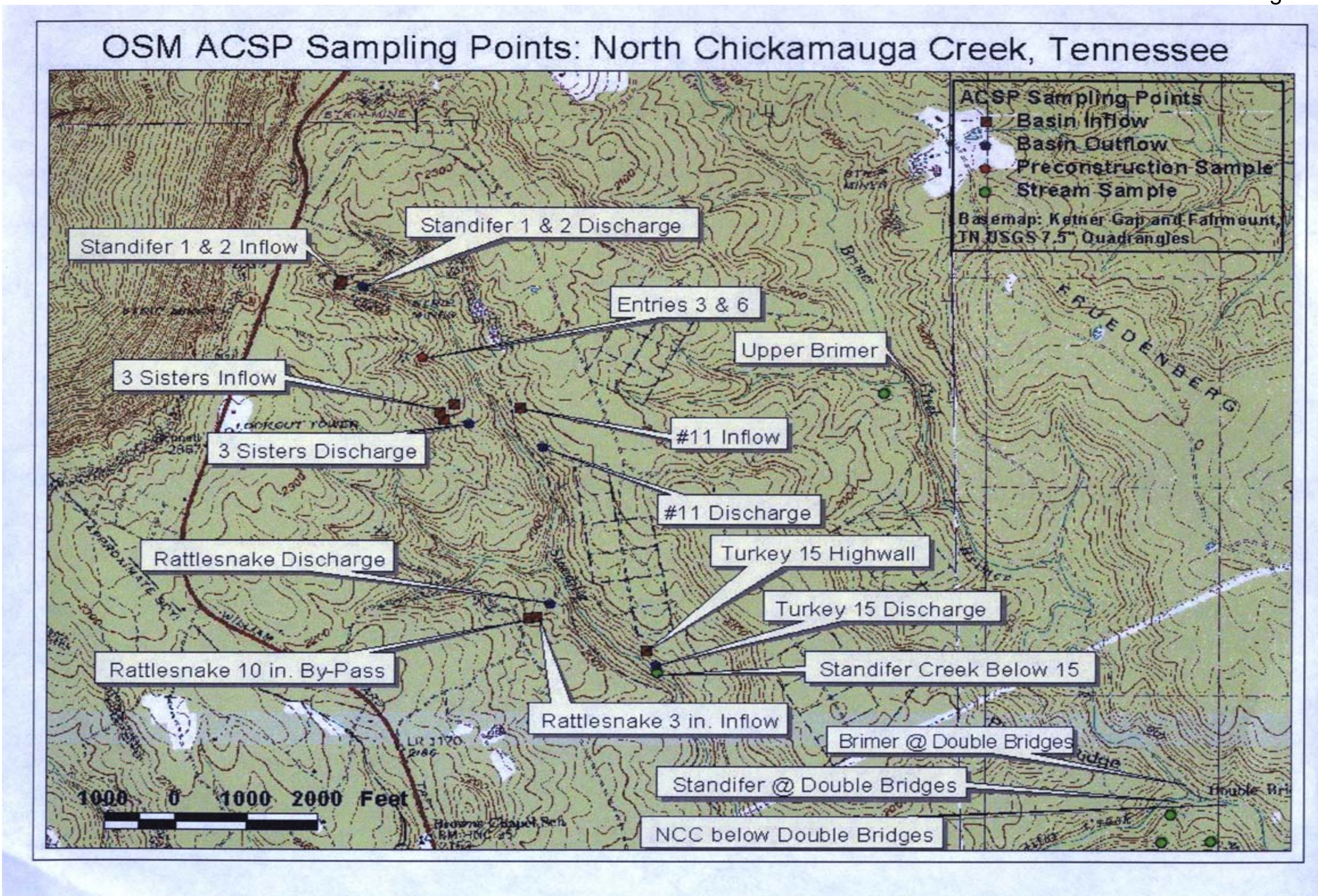


Figure 6 North Chickamauga Creek Monitoring Stations (USOSM)

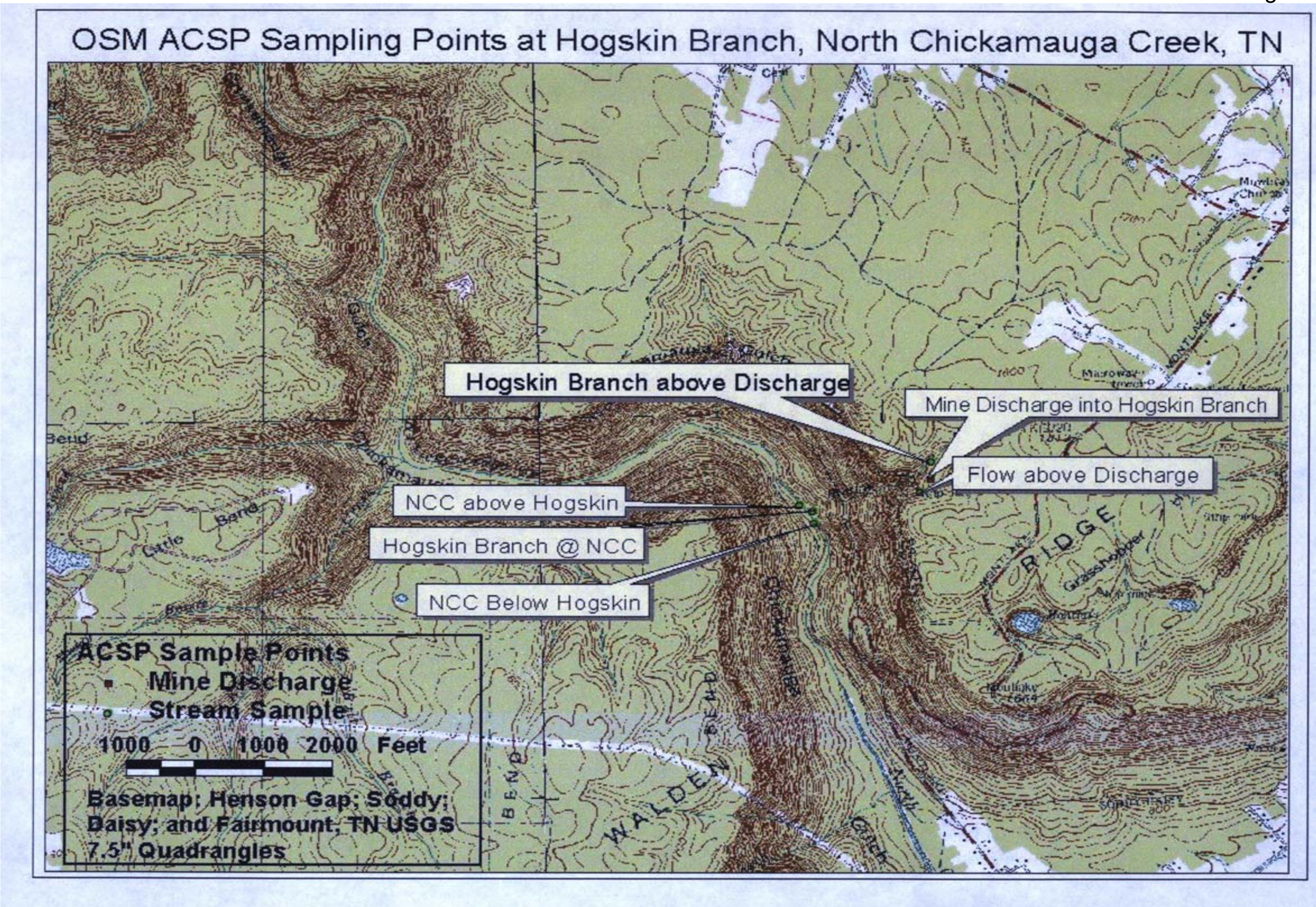


Figure 7 Hogskin Branch Monitoring Stations (USOSM)

Table 5 Comparison of North Chickamauga Creek Subwatershed pH & Net Alkalinity (TDEC)

Monitoring Site	Parameter	Units	Sample Date											
			8/25-26/03	9/16,24/03	10/13-14/03	11/17/03	12/1,16/03	1/21/04	2/19,23/04	3/15,17/04	4/19-20/04	5/10,13/04	6/10,17/04	7/12-13/04
N. Chickamauga Ck.	pH	--	6.60	7.50	7.40	7.53	6.84		6.60	6.60	6.61	6.85	7.50	6.61
Boy Scout Rd.	Net Alkalinity	mg/L	64.80	76.47	79.88	60.80	14.90		14.49	31.53	35.46	44.46	72.87	55.60
N. Chickamauga Ck.	pH	--	4.80	4.90	7.90	8.40	6.56		5.57	5.41	5.40	6.05	6.30	5.35
Pocket Wilderness	Net Alkalinity	mg/L	4.81	-1.46	2.40	4.50	1.75		1.91	1.02	0.10	3.63	5.00	2.47
N. Chickamauga Ck.	pH	--	6.70	9.38	8.00	8.40	7.06		6.20	6.40	5.96	6.53	6.50	5.86
Gray Fryar Rd.	Net Alkalinity	mg/L	9.66	-1.38	7.76	5.99	2.33		3.17	4.50	3.10	3.17	3.57	3.27
Cain Ck.	pH	--	6.20	6.30	7.60		8.10	7.06	5.62	5.75	6.40	6.97	6.97	5.90
	Net Alkalinity	mg/L	5.85	3.87	1.36		3.62	3.79	2.68	3.43	4.50	4.50	4.50	3.16
Cooper Ck.	pH	--	7.10	7.16	8.83		9.10	6.80		6.30	6.54	7.69	7.69	6.40
	Net Alkalinity	mg/L	10.10	3.81	11.69		10.78	4.50		4.50	3.70	10.40	9.12	3.04
Mossy Ck.	pH	--	6.30	6.56	7.99		8.60	7.30	5.90	5.75	7.30	7.38	7.38	6.61
	Net Alkalinity	mg/L	2.69	3.93	7.39		2.37	3.91	1.53	4.50	3.92	4.50	4.50	3.85

Note: Units of Net Alkalinity are expressed in mg/L $CaCO_3$.

Table 6 Comparison of North Chickamauga Creek Subwatershed pH & Net Alkalinity (USOSM)

Monitoring Site	Parameter	Units	Sample Date										
			6/20/84	7/9/84	12/30/86	3/28/95	4/13/95	5/4,22/95	3/17-18/99	4/28-29/99	1/10-12/00	7/11-12/00	2/14/01
Entries 3 & 6	pH	--				2.8				2.83	2.5	2.68	2.87
	Net Alkalinity	mg/L				0.5				-75.00	-114.00		-97.00
Turkey 15 Highwall	pH	--						3.2		3.07	2.83	3.50	3.10
	Net Alkalinity	mg/L						-68.50		-87.00	-125.00		-106.00
Turkey 15 Discharge	pH	--								6.6	6.03	6.27	5.54
	Net Alkalinity	mg/L								77.00	31.00		55.50
#11 Inflow	pH	--					3.2			3.11	3.15	2.90	3.19
	Net Alkalinity	mg/L					-85.50			-46.00	-29.00		5.00
#11 Discharge	pH	--								4.54	4.11	6.26	3.96
	Net Alkalinity	mg/L								-19.00	-32.00		1.00
Standifer 1 & 2 Inflow	pH	--								2.91	2.73	2.83	2.98
	Net Alkalinity	mg/L								-65.00	-63.00		-102.00
Standifer 1 & 2 Discharge	pH	--								4.01	3.21	5.26	3.36
	Net Alkalinity	mg/L								-43.00	-50.00		-76.00
Rattlesnake Bypass	pH	--				3.9			3.92	3.69	3.05	2.83	3.53
	Net Alkalinity	mg/L				0.50			-16.70	-26.00	-20.00		-23.00
Rattlesnake Discharge	pH	--								5.4	3.31	5.29	4.03
	Net Alkalinity	mg/L								-5.00	-14.00		-15.00
Three Sisters In Left	pH	--											
	Net Alkalinity	mg/L											
Three Sisters In Right	pH	--											
	Net Alkalinity	mg/L											
Three Sisters Combined	pH	--								2.88	3.65	2.67	2.82
	Net Alkalinity	mg/L								-75.00	-72.00		-146.00
Three Sisters Discharge	pH	--										5.86	4.83
	Net Alkalinity	mg/L											-55.00

Note: Units of Net Alkalinity are expressed in mg/L $CaCO_3$.

Table 6 (cont'd) Comparison of North Chickamauga Creek Subwatershed pH & Net Alkalinity (USOSM)

Monitoring Site	Parameter	Units	Sample Date									
			6/19-20/01	10/30-31/01	3/25-28/02	5/2/02	5/30/02	6/27/02	7/24/02	8/13-14/02	9/26/02	10/31/02
Entries 3 & 6	pH	--	2.99	DRY	4.48					DRY		
	Net Alkalinity	mg/L	-208.00		-147.00							
Turkey 15 Highwall	pH	--	3.51	2.11	4.23					4.03		
	Net Alkalinity	mg/L	-118.00	-137.00	-93.00					-69.00		
Turkey 15 Discharge	pH	--		DRY	6.58					DRY		
	Net Alkalinity	mg/L			45.50							
#11 Inflow	pH	--	3.16	1.79	4.69					3.30		
	Net Alkalinity	mg/L	-53.00	-70.00	-22.00					-73.00		
#11 Discharge	pH	--	5.57	DRY	5.59					DRY		
	Net Alkalinity	mg/L	22.50	0.00	-8.00							
Standifer 1 & 2 Inflow	pH	--	2.75	2.13	4.29					3.01		
	Net Alkalinity	mg/L	-66.00	-67.00	-89.00					-81.00		
Standifer 1 & 2 Discharge	pH	--	3.34	3.86	4.75					6.37		
	Net Alkalinity	mg/L	-58.00	-24.00	-71.00					22.00		
Rattlesnake Bypass	pH	--	4.09	2.37	4.48					2.97		
	Net Alkalinity	mg/L	-42.00	-76.00	-17.00					-77.00		
Rattlesnake Discharge	pH	--		DRY						DRY		
	Net Alkalinity	mg/L										
Three Sisters In Left	pH	--										
	Net Alkalinity	mg/L										
Three Sisters In Right	pH	--										
	Net Alkalinity	mg/L										
Three Sisters Combined	pH	--	3.43	Trickle	4.08					DRY		
	Net Alkalinity	mg/L	-133.00		-147.00							
Three Sisters Discharge	pH	--	6.50	3.95	5.85					DRY		
	Net Alkalinity	mg/L	17.00	6.00	-15.00							

Note: Units of Net Alkalinity are expressed in mg/L $CaCO_3$.

Table 6 (cont'd) Comparison of North Chickamauga Creek Subwatershed pH & Net Alkalinity (USOSM)

Monitoring Site	Parameter	Units	Sample Date									
			12/2-3/02	1/8/03	1/30/03	2/28/03	3/12-13/03	4/29/03	5/29-6/3/03	8/18-19/03	11/19-20/03	8/31-9/1/04
Entries 3 & 6	pH	--	2.93				3.50		2.81	2.78	3.17	2.86
	Net Alkalinity	mg/L	-410.00				-200.00		-196.00	-130.00	-108.00	-270.00
Turkey 15 Highwall	pH	--	3.70				4.00		3.36	3.77	6.16	5.50
	Net Alkalinity	mg/L	-195.00				-120.00		-96.00	-160.00	130.00	-14.00
Turkey 15 Discharge	pH	--	DRY				DRY		DRY	DRY	DRY	DRY
	Net Alkalinity	mg/L										
#11 Inflow	pH	--	3.54				4.00		3.46	3.46	4.38	3.36
	Net Alkalinity	mg/L	-96.00				-80.00		-80.00	-70.00	-80.00	-92.00
#11 Discharge	pH	--	5.01				5.00		6.48	6326.00	6.22	7.73
	Net Alkalinity	mg/L	-26.00				-9.00		16.00	12.00	16.00	62.00
Standifer 1 & 2 Inflow	pH	--	3.46				4.00		3.06	3.29	3.37	3.30
	Net Alkalinity	mg/L	-116.00				-110.00		-120.00	-103.00	-82.00	-106.00
Standifer 1 & 2 Discharge	pH	--	3.83				4.00		4.48	4.13	6.07	6.80
	Net Alkalinity	mg/L	-110.00				-110.00		-50.00	-75.00	50.00	82.00
Rattlesnake Bypass	pH	--	3.96				4.00		3.48	3.68	6.40	3.30
	Net Alkalinity	mg/L	-46.00				-55.00		-40.00	-56.00	23.00	-14.00
Rattlesnake Discharge	pH	--	5.37				5.00		5.85	5.32	6.19	7.46
	Net Alkalinity	mg/L	-74.00				-3.00		11.00	4.00	42.00	62.00
Three Sisters In Left	pH	--									3.28	
	Net Alkalinity	mg/L									-140.00	
Three Sisters In Right	pH	--									3.30	2.79
	Net Alkalinity	mg/L									-180.00	-300.00
Three Sisters Combined	pH	--	2.80				3.50		2.66	2.71	3.29	3.01
	Net Alkalinity	mg/L	-280.00				-200.00		-256.00	-400.00	-160.00	-190.00
Three Sisters Discharge	pH	--	4.61				5.00		4.76	6.56	6.48	5.42
	Net Alkalinity	mg/L	-131.00				-21.00		-63.00	70.00	70.00	7.00

Note: Units of Net Alkalinity are expressed in mg/L $CaCO_3$.

Table 6 (cont'd) Comparison of North Chickamauga Creek Subwatershed pH & Net Alkalinity (USOSM)

Monitoring Site	Parameter	Units	Sample Date										
			6/20/84	7/9/84	12/30/86	3/28/95	4/13/95	5/4,22/95	3/17-18/99	4/28-29/99	1/10-12/00	7/11-12/00	2/14/01
Standifer Creek	pH	--								4.43	3.77	4.04	3.60
Below Turkey 15	Net Alkalinity	mg/L								-11.00	-22.00		-15.00
Standifer Creek	pH	--			3.50			4.36		4.93	3.72	4.42	
at Double Bridges	Net Alkalinity	mg/L			-29.20			-15.50		3.00	1.50		
North Chickamauga	pH	--	3.8	3.6	3.70			4.59		5.25	4.03	4.79	
Below Double Bridges	Net Alkalinity	mg/L	-26.00	-6.50	-39.21			-9.00		2.00	2.50		
North Chickamauga	pH	--								5.08	4.61	4.73	4.30
Above Hogskin	Net Alkalinity	mg/L								2.00	1.50		2.50
Hogskin Br at	pH	--								3.41	2.62	2.91	2.72
North Chickamauga	Net Alkalinity	mg/L								-28.00	-78.00		-42.00
North Chickamauga	pH	--											
Below Hogskin	Net Alkalinity	mg/L											
Entries Discharging	pH	--						2.8		2.91	2.46	2.52	2.55
Into Hogskin Br	Net Alkalinity	mg/L						-193.50		-78.00	-258.00		-284.00
Hogskin Br	pH	--									4.58		
Above Entries	Net Alkalinity	mg/L									1.50		
Drain Above	pH	--											
Hogskin Br	Net Alkalinity	mg/L											
Combined East of	pH	--											
Hogskin Discharge	Net Alkalinity	mg/L											
Brimer Creek	pH	--										5.02	
at Double Bridges	Net Alkalinity	mg/L											
Upper	pH	--											
Brimer Creek	Net Alkalinity	mg/L											

Note: Units of Net Alkalinity are expressed in mg/L $CaCO_3$.

Table 6 (cont'd) Comparison of North Chickamauga Creek Subwatershed pH & Net Alkalinity (USOSM)

Monitoring Site	Parameter	Units	Sample Date									
			6/19-20/01	10/30-31/01	3/25-28/02	5/2/02	5/30/02	6/27/02	7/24/02	8/13-14/02	9/26/02	10/31/02
Standifer Creek	pH	--	4.17	2.83	4.84					3.67		
Below Turkey 15	Net Alkalinity	mg/L	-18.00	-22.00	-16.00					-46.00		
Standifer Creek	pH	--	5.15	3.78	5.30					4.52		
at Double Bridges	Net Alkalinity	mg/L	1.50	-9.00	2.50					-9.00		
North Chickamauga	pH	--	5.47	4.34	5.20					Stagnant		
Below Double Bridges	Net Alkalinity	mg/L	2.50	0.50	2.50							
North Chickamauga	pH	--	4.16	4.70	4.34	4.33	5.26	6.30	6.14		6.42	6.03
Above Hogskin	Net Alkalinity	mg/L	3.50	4.50	2.50	-16.00	-61.00	14.00	3.00		-25.00	5.00
Hogskin Br at	pH	--	2.80	Trickle	3.16	2.91	3.40	4.30	2.91		3.19	3.02
North Chickamauga	Net Alkalinity	mg/L	-220.00		-127.00	-170.00	-228.00	-291.00	-360.00		-164.00	-224.00
North Chickamauga	pH	--			3.63	3.45	5.40	5.00	4.56		3.75	4.54
Below Hogskin	Net Alkalinity	mg/L			-13.00	-14.00	-34.00	-16.00	-60.00		-77.00	-60.00
Entries Discharging	pH	--	2.69	3.01	2.96	2.66	3.55	4.50	2.48		2.48	2.64
Into Hogskin Br	Net Alkalinity	mg/L	-546.00	-789.00	-325.00	-470.00	-520.00	-620.00	-642.00		-760.00	-505.00
Hogskin Br	pH	--		DRY	3.90	3.77	5.15	DRY	DRY		4.91	4.82
Above Entries	Net Alkalinity	mg/L			1.50	-36.00	-27.00				-36.00	-19.00
Drain Above	pH	--			3.70	3.44	DRY	DRY	DRY		DRY	DRY
Hogskin Br	Net Alkalinity	mg/L				-13.00						
Combined East of	pH	--			3.49	2.91	No Flow	DRY	DRY		3.19	DRY
Hogskin Discharge	Net Alkalinity	mg/L			-52.00	-86.00					-140.00	
Brimer Creek	pH	--	5.68	4.72	5.45					Stagnant		
at Double Bridges	Net Alkalinity	mg/L	4.50	10.50	3.50							
Upper	pH	--		4.31						DRY		
Brimer Creek	Net Alkalinity	mg/L		8.50								

Note: Units of Net Alkalinity are expressed in mg/L $CaCO_3$.

Table 6 (cont'd) Comparison of North Chickamauga Creek Subwatershed pH & Net Alkalinity (USOSM)

Monitoring Site	Parameter	Units	Sample Date									
			12/2-3/02	1/8/03	1/30/03	2/28/03	3/12-13/03	4/29/03	5/29-6/3/03	8/18-19/03	11/19-20/03	8/31-9/1/04
Standifer Creek	pH	--	4.40				4.00		4.41	5.05	5.49	5.29
Below Turkey 15	Net Alkalinity	mg/L	-40.00				-31.00		-46.00	-10.00	5.00	-7.00
Standifer Creek	pH	--	4.98				4.50		4.75	5.15	6.27	5.12
at Double Bridges	Net Alkalinity	mg/L	-10.00				-20.00		-20.00	-9.00	-8.00	10.00
North Chickamauga	pH	--	5.20				4.50		5.06	5.74	6.06	6.11
Below Double Bridges	Net Alkalinity	mg/L	-16.00				-10.00		-9.00	-28.00	-9.00	17.00
North Chickamauga	pH	--	5.62	5.53	5.59	5.35		5.79	5.50	6.24	5.59	6.35
Above Hogskin	Net Alkalinity	mg/L	2.00	5.00	-20.00	-9.00		-7.00	-16.00	-7.00	-3.00	12.00
Hogskin Br at	pH	--	3.13	2.92	3.13	3.69		3.15	3.03	6.24	3.34	2.94
North Chickamauga	Net Alkalinity	mg/L	-320.00	-310.00	-156.00	-44.00		-160.00	-209.00	-221.00	-120.00	-360.00
North Chickamauga	pH	--	4.27	4.20	4.47	4.19		4.30	4.06	4.26	4.99	4.84
Below Hogskin	Net Alkalinity	mg/L	-20.00	-10.00	-27.00	-150.00		-50.00	-46.00	-36.00	5.00	-20.00
Entries Discharging	pH	--	2.83	2.62	2.73	2.68		2.79	2.75	2.61	2.87	2.62
Into Hogskin Br	Net Alkalinity	mg/L	-590.00	-600.00	-400.00	-420.00		-380.00	-290.00	-430.00	-36.00	-520.00
Hogskin Br	pH	--	5.33	4.40	4.57	5.71		4.70	4.21	5.16	5.60	5.15
Above Entries	Net Alkalinity	mg/L	-22.00	-16.00	-40.00	-8.00		-20.00	-40.00	-13.00	-263.00	-26.00
Drain Above	pH	--	DRY	DRY	DRY	4.63		DRY	DRY	DRY	DRY	DRY
Hogskin Br	Net Alkalinity	mg/L				-17.00						
Combined East of	pH	--	Trickle	3.00	3.32	3.25		3.24	3.17	3.03	3.67	DRY
Hogskin Discharge	Net Alkalinity	mg/L		-190.00	-100.00	-80.00		-100.00	-164.00	-130.00		
Brimer Creek	pH	--	5.99				5.00		5.80	5.50	6.34	6.32
at Double Bridges	Net Alkalinity	mg/L	-26.00				-2.00		-19.00	4.00	10.00	18.00
Upper	pH	--	5.76				5.00			6.06	5.46	6.35
Brimer Creek	Net Alkalinity	mg/L	-23.00				-11.00			-4.00	-5.00	-19.92

Note: Units of Net Alkalinity are expressed in mg/L $CaCO_3$.

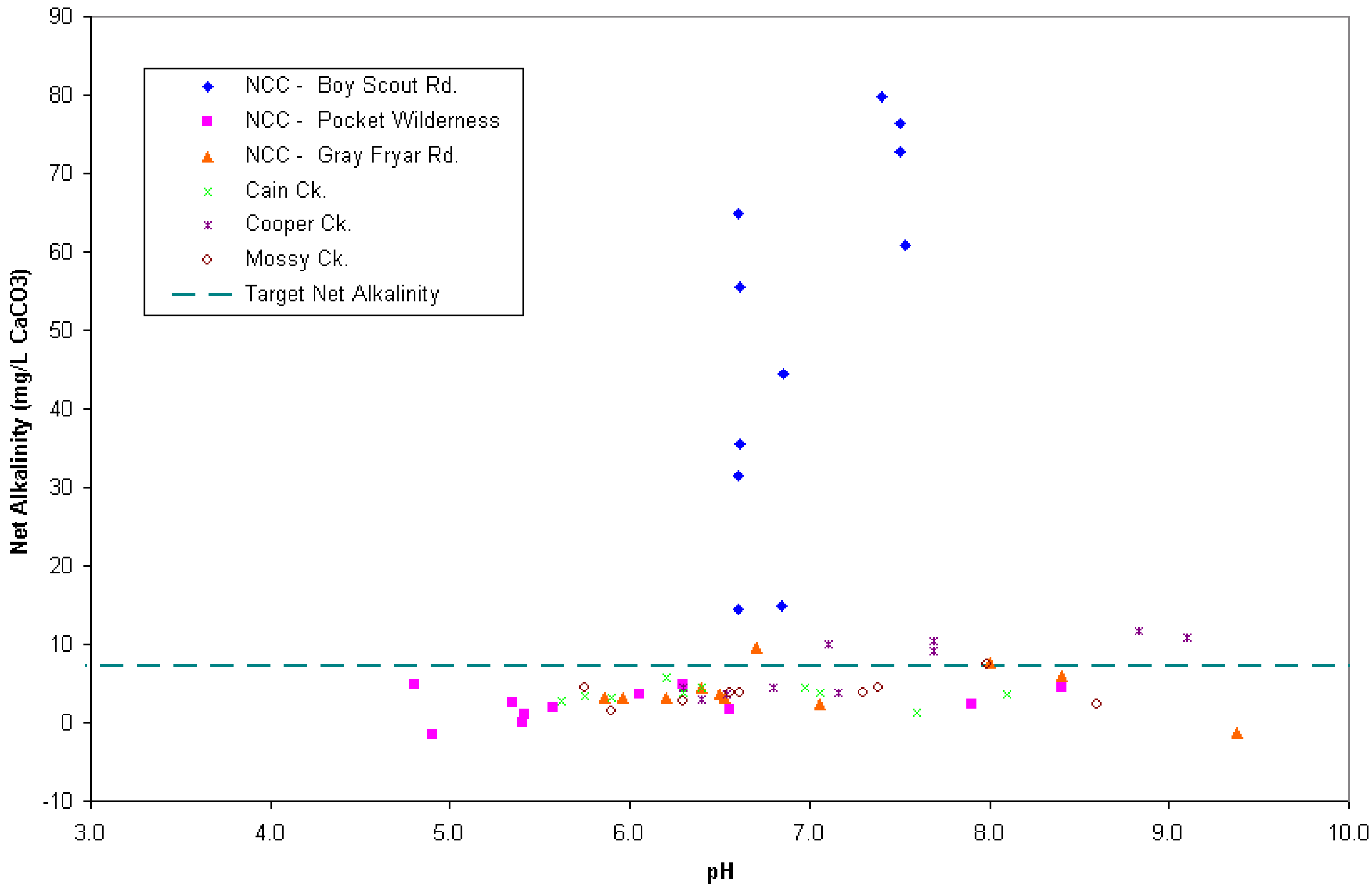


Figure 8 Relationship Between Net Alkalinity and pH in North Chickamauga Subwatershed

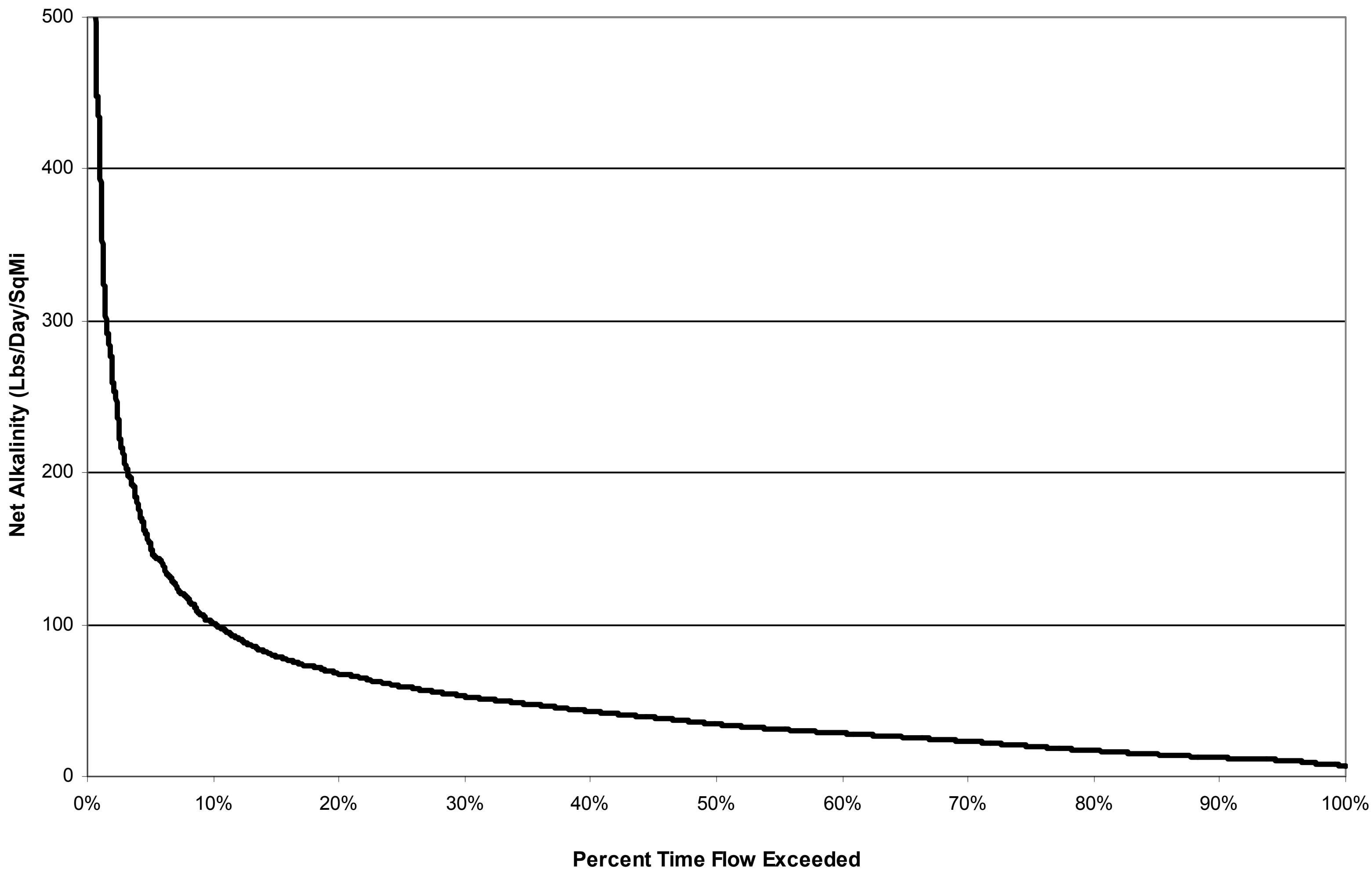


Figure 9 Target Load Duration Curve

5.0 WATER QUALITY ASSESSMENT AND DIFFERENCE FROM TARGET

The flow, acidity, and total alkalinity data collected at each monitoring site (ref: Appendices B and D) in the North Chickamauga Creek subwatershed are tabulated in Tables 3 and 4. For each site, net alkalinity was calculated using the methodology described in Appendix G. 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 Tables 5 and 6.

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 G. The results are summarized in Tables G-5 through G-8. 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 G-1 through G-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 Chickamauga Creek at river miles 12.4, 19.3, and 28.1 and for Standifer Creek clearly reflect the use support status in the 2002 303(d) List (ref.: Table 2).

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 North Chickamauga Creek subwatershed.

6.2 Non-point Sources

There are a number of abandoned surface mining sites in the North Chickamauga Creek subwatershed that are susceptible to the formation of acid mine drainage as discussed in Appendix A. In the 2002 303(d) List (ref.: Table 2), abandoned mining was identified as the source of low pH in impaired waterbodies in the subwatershed (ref.: Figure 4). Monitoring data collected by USOSM for Standifer Creek and Hogskin Branch (ref.: Table 4) confirm the designation of runoff associated with abandoned mines as the source of low pH.

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 North Chickamauga Creek subwatershed is considered to correspond to the target load duration curve as developed in Appendix E.

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 7.16 mg/L based on an unimpaired, fully supporting tributary of North Chickamauga Creek (Cooper Creek).

7.3 Determination of Total Maximum Daily Loads

The TMDL for net alkalinity in the North Chickamauga Creek subwatershed is defined by the target load duration curve developed in Appendix E (ref: Figure E-2). 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 E-2); 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 North Chickamauga Creek subwatershed in all seasons.

8.0 IMPLEMENTATION PLAN

Monitoring conducted in 2003 and 2004 has identified a number of waterbodies in the North Chickamauga 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. 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 North Chickamauga Creek subwatershed meet, or exceed, the loads per unit area specified in the target load duration curve (ref.: Figure 9).

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.

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 North Chickamauga Creek subwatershed.

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

The University of Tennessee at Chattanooga (UTC) Environmental Research and Mapping Facility (ERMF) has created a fully functional GIS basemap consisting of aerial photography, parcel data, land use data, road coverage, and stream coverage. Stream sampling and monitoring locations and the corresponding analytical results have been incorporated into the GIS basemap. The locations of AMD mitigation pond outfalls and mining and coal seams have been documented. Satellite images depicting watershed conditions during 1977, 1988, and 2000 were obtained and integrated into the GIS project database.

ERMF has tested two pilot software applications based upon ESRI software platforms. A watershed specific property application was created using Arcview 3.3 and an internet mapping extension that creates a Java scripted interactive map in hypertext markup language (HTML) format. A second application was created using the ESRI ArcReader program. Applications developed by ERMF will be available for use during the TMDL implementation process. Information regarding the status of this project is available in Appendix H.

9.0 PUBLIC PARTICIPATION

In accordance with 40 CFR §130.7, the proposed pH TMDL for North Chickamauga 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.

3) Notice of the availability of the Proposed TMDL was sent to the North Chickamauga Creek Conservancy in Hixson, Tennessee. The North Chickamauga Creek Conservancy (NCCC) is a citizen-created nonprofit 501(c)(3) organization that provides a structured, dedicated framework for constructive, pro-active citizen involvement and support in conserving the significant natural, historic, and cultural resources located within and near the watershed area of North Chickamauga Creek.

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, 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

North Chickamauga Creek Monitoring Data (TDEC)

Table B-1 North Chickamauga Creek (Mile 12.4) Monitoring Data

North Chickamauga Creek
Boy Scout Road **35 10' 33"N**
Mile 12.4 **85 13' 44"W**

Test	*Units*	*8/25/03*	*9/16/03*	*10/14/03*	*11/17/03*	*12/16/03*	*1/21/04*	*2/19/04*	*3/15/04*	*4/20/04*	*5/10/04*	*6/10/04*	*7/13/04*
pH	--	6.60	7.50	7.40	7.53	6.84		6.60	6.60	6.61	6.85	7.50	6.61
Conductivity	uMHO	171	191	196	176	63		76	71	113	134	189	162
Dissolved Oxygen	mg/L	9.90	9.10	8.00	8.91	12.04		11.90	10.84	9.40	9.06	10.09	8.48
Temperature	Celsius	19.20	17.30	16.90	14.49	8.06		7.04	11.62	15.60	17.25	19.27	18.80
Acidity	mg/L	3.40	4.23	2.92		2.20		2.61	1.57	1.84	2.64	1.43	U
Total Alkalinity	mg/L	68.20	80.70	82.80	60.80	17.10		17.10	33.10	37.30	47.10	74.30	56.10
Sulfate	mg/L	10.20	11.90	U	12.20	8.24		9.71	9.11	7.45	9.34	20.00	9.01
Total Hardness	mg/L	74.0	115.0	U	90.2	23.9		24.7	46.2	61.4	42.6	103.0	29.3
Turbidity	NTU	1.80	1.27	0.44	0.80	1.10		1.04	0.99	1.36	1.24	1.19	1.18
Aluminum	mg/L	U	43	U	U	U		U	U	U	101	1060	U
Calcium	mg/L	27	30	U	26	7		9	14	14.6	17.7	28.4	22.9
Copper	mg/L	1	U	U	U	U		U	U	U	2	4	U
Iron	mg/L	164	148	78	113	77		81	105	117	175	159	166
Lead	mg/L	U	U	U	U	U		U	U	U	U	1	U
Manganese	mg/L	51	33	43	45	22		30	47	34	46	30	50
Nickel	mg/L	U	U	U	U	U		U	U	U	U	U	U
Sodium	mg/L	1.7		1.8	1.5	0.5		1	1.4	1.4	1.6	1.8	1.7
Zinc	mg/L	U	U	5	2	2		1	u	u	3	1	4
Flow	cfs	52.05	17.31	28.52	50.13	high		high	146.34	75.25	42.76	19.65	54.23

Note: U denotes analyte requested but not detected. Detection limit is 10 mg/L for total alkalinity and 1 mg/L for acidity. Units of Total Alkalinity and Acidity are expressed in mg/L $CaCO_3$.

Table B-2 North Chickamauga Creek (Mile 19.3) Monitoring Data

North Chickamauga Creek
Pocket Wilderness **35 14' 14"N**
Mile 19.3 **85 14' 06"W**

Test	*Units*	*8/25/03*	*9/16/03*	*10/14/03*	*11/17/03*	*12/16/03*	*1/21/04*	*2/19/04*	*3/15/04*	*4/20/04*	*5/10/04*	*6/10/04*	*7/13/04*
pH	--	4.80	4.90	7.90	8.40	6.56		5.57	5.41	5.40	6.05	6.30	5.35
Conductivity	uMHO	43	57	38	29	28		30	37	34	36	47	44
Dissolved Oxygen	mg/L	9.20	9.40	9.75	11.64	13.34		12.80	11.96	10.40	9.27	8.47	8.45
Temperature	Celsius	25.7	20.3	17.4	10.97	7.32		5.08	9.67	14.8	19.3	24.53	23.13
Acidity	mg/L	3.10	6.46	2.60		3.25		3.09	3.98	2.92	1.37		2.53
Total Alkalinity	mg/L	7.91	U	U	4.50	U		U	U	3.02	U	U	U
Sulfate	mg/L	13.4	20.6	U	7.8	7.1		7.6	9.0	10	9.8	25.5	10.7
Total Hardness	mg/L	15.1	20.3	U	9.2	6.9		U	12.8	11.9	10.8	12.6	12.6
Turbidity	NTU	0.75	0.23	0.45	0.34	0.68		0.50	0.45	0.59	0.27	0.11	0.88
Aluminum	mg/L	317	445	U	U	102		117	201	131	134	118	256
Calcium	mg/L	2.8	3	U	U	U		U	U	2	2.2	2.9	2.5
Copper	mg/L	2	U	U	U	U		U	U	U	1	2	1
Iron	mg/L	68	53	36	39	34		38	53	32	29	U	62
Lead	mg/L	U	U	U	U	U		U	1.5	U	U	U	U
Manganese	mg/L	60	94	39	11	16		20	26	18	21	38	44
Nickel	mg/L	U	U	U	U	U		U	U	U	U	U	U
Sodium	mg/L	1	2	1.1	0.7	0.7		0.8	0.8	0.9	0.9	1.2	0.9
Zinc	mg/L	7	3	5	3	2		7	U	U	5	4	7
Flow[b]	cfs	15.50	4.99	9.43	69.00	263.00	62.00	188.00	58.00	31.00	11.00	0.00	3.10

Note: U denotes analyte requested but not detected. Detection limit is 10 mg/L for total alkalinity and 1 mg/L for acidity.
Units of Total Alkalinity and Acidity are expressed in mg/L $CaCO_3$.
Flow readings for 11/17/03 through 7/13/04 taken from USGS gaging station

Table B-3 North Chickamauga Creek (Mile 28.1) Monitoring Data

North Chickamauga Creek
Gray Fryar Road **35 12' 29"N**
Mile 28.1 **85 19' 58"W**

Test	*Units*	*8/25/03*	*9/16/03*	*10/14/03*	*11/17/03*	*12/16/03*	*1/21/04*	*2/19/04*	*3/15/04*	*4/20/04*	*5/10/04*	*6/10/04*	*7/13/04*
pH	--	6.7	9.38	8	8.4	7.06		6.2	6.4	5.96	6.53	6.5	5.86
Conductivity	uMHO	72	70	83	92	52		53	66	67	75	92	90
Dissolved Oxygen	mg/L	9.6	8.9	9.24	10.96	12.87		12.3	11.74	10.5	9.83	8.56	8.43
Temperature	Celsius	20.5	16.1	15.2	10.9	7.6		4.4	8.98	12.7	15.47	18.94	20.05
Acidity	mg/L	2.14	6.38	3.44		2.67		1.83	U	1.08	1.83	1.43	1.73
Total Alkalinity	mg/L	11.8	U	11.2	5.99	U		U	U	4.18	U	U	U
Sulfate	mg/L	29.2	23.3	U	28.3	14.3		17.3	19.4	17.1	25.2	36.7	21.0
Total Hardness	mg/L	26.7	27.5	11.4	30.0	17.5		15.2	21.9	23.6	24.7	27.6	28.1
Turbidity	NTU	0.83	0.68	0.57	0.43	1.10		0.35	0.57	1.20	0.68	0.39	0.47
Aluminum	mg/L	U	U	U	U	U		U	U	U	393	U	169
Calcium	mg/L	7.0	6.0	3.0	8.0	4.0		4.0	5.0	5.2	6.5	7.6	7.8
Copper	mg/L	U	U	U	U	U		U	U	U	2	3	1
Iron	mg/L	44	57	U	28	39		32	37	38	52	46	49
Lead	mg/L	U	U	U	U	U		U	U	U	U	U	U
Manganese	mg/L	31	31	31	13	55		58	58	23	16	29	20
Nickel	mg/L	U	U	U	U	U		U	U	U	U	U	U
Sodium	mg/L	1.3		2.0	1.5	1.1		1.3	1.4	1.5	1.6	1.8	1.7
Zinc	mg/L	3	U	2	4	4		4	1	U	8	2	3
Flow	cfs	2.34	0.75	1.44	7.40	38.14		36.24	12.95	8.08		2.02	3.97

Note: U denotes analyte requested but not detected. Detection limit is 10 mg/L for total alkalinity and 1 mg/L for acidity. Units of Total Alkalinity and Acidity are expressed in mg/L $CaCO_3$.

Table B-4 Cain Creek Monitoring Data

Cain Creek

35 15' 49"N
85 17' 26"W

Test	*Units*	*8/26/03*	*9/24/03*	*10/13/03*	*11/17/03*	*12/1/03*	*1/21/04*	*2/23/04*	*3/17/04*	*4/19/04*	*5/13/04*	*6/17/04*	*7/12/04*
pH	--	6.20	6.30	7.60		8.10	7.06	5.62	5.75	6.40	6.97	6.97	5.90
Conductivity	uMHO	16	16	18		15	17	17	19	18	19	19	15
Dissolved Oxygen	mg/L	9.11	9.84	10.08		12.31	11.6	12.46	11.39	10.8	9.79	9.79	9.27
Temperature	Celsius	21.3	17.1	15.6		8.19	2.35	5.69	8.86	12.9	16.85	16.85	21.75
Acidity	mg/L	U	1.13	3.64		1.38	1.21	2.32	1.57	U	U	U	1.84
Total Alkalinity	mg/L	6.35	U	U		U	U	U	U	U	U	U	U
Sulfate	mg/L	3.22	U	7.01		3.71	3.87	3.76	3.51	2.28	2.32	U	2.17
Total Hardness	mg/L	3.29	5.1	139		21.6	U	U	U	U	7.54	3.78	U
Turbidity	NTU	0.52	1.31	3.3		0.46	0.34	0.31	0.71	0.45	0.45	0.61	1.03
Aluminum	mg/L	U	U	U		U	U	U	U	U	100	176	U
Calcium	mg/L	U	U	31		U	U	U	U	U	U	U	U
Copper	mg/L	U	U	1		U	U	U	U	1	U	3	U
Iron	mg/L	271	770	164		35	37	29	56	32	115	272	247
Lead	mg/L	U	U	U		U	U	U	U	U	U	U	U
Manganese	mg/L	18	13	10		19	6	13	21	8	11	54	13
Nickel	mg/L	U	U	U		U	U	U	U	U	U	U	U
Sodium	mg/L	U	0.5	0.7		0.4	0.4	0.4	0.4	1.0		0.9	0.5
Zinc	mg/L	90	3	3		U	2	1	5	7	U	1	3
Flow	cfs	0.55	4.06	1.37		22.61	11.51	9.87	24.84	9.33	3.15	0.28	4.65

Note: U denotes analyte requested but not detected. Detection limit is 10 mg/L for total alkalinity and 1 mg/L for acidity. Units of Total Alkalinity and Acidity are expressed in mg/L $CaCO_3$.

Table B-5 Cooper Creek Monitoring Data

Cooper Creek

35 16' 59"N
85 16' 21"W

Test	*Units*	*8/26/03*	*9/24/03*	*10/13/03*	*11/17/03*	*12/1/03*	*1/21/04*	*2/23/04*	*3/17/04*	*4/19/04*	*5/13/04*	*6/17/04*	*7/12/04*
pH	--	7.10	7.16	8.83		9.10	6.80		6.30	6.54	7.69	7.69	6.40
Conductivity	uMHO	26	32	31		22	24		25	24	27	27	24
Dissolved Oxygen	mg/L	8.99	9.58	9.48		12.15	12.20		11.88	10.30	9.76	9.76	8.57
Temperature	Celsius	20.5	15.1	14.7		7.83	2.95		9.01	13.8	16.12	16.12	20.07
Acidity	mg/L		1.19	2.71		1.32	U		U	1.3	U	1.78	1.96
Total Alkalinity	mg/L	10.1	U	14.4		12.1	U		U	U	10.9	10.9	U
Sulfate	mg/L	4.20	U	25.70		4.25	5.10		4.02	3.92	4.69	2.85	3.38
Total Hardness	mg/L	9.98	12.70	28.50		36.60	U		U	U	10.75	9.12	7.34
Turbidity	NTU	0.42	1.20	0.56		0.48	0.48		1.18	0.52	0.39	0.45	0.80
Aluminum	mg/L	645	U	U		U	U		U	U	U	U	U
Calcium	mg/L	5	3	8		U	U		U	2	U	2.8	2
Copper	mg/L	4	U	U		U	U		U	1	U	3	U
Iron	mg/L	58	130	29		U	U		31	32	29	68	51
Lead	mg/L	2	U	U		28	U		U	U	U	U	U
Manganese	mg/L	13	11	8		6	U		9	8	8	58	11
Nickel	mg/L	U	U	U		U	U		U	U	U	U	U
Sodium	mg/L		0.8	0.8		0.6	0.6		0.6	1		1.1	0.7
Zinc	mg/L	90	3	2		U	5		3	7	U	1	3
Flow	cfs	0.81	6.30	0.74		17.71	8.15		26.78	5.60	1.10	0.42	3.03

Note: U denotes analyte requested but not detected. Detection limit is 10 mg/L for total alkalinity and 1 mg/L for acidity. Units of Total Alkalinity and Acidity are expressed in mg/L $CaCO_3$.

Table B-6 Mossy Creek Monitoring Data

Mossy Creek

35 16' 47"N
85 17' 34"W

Test	*Units*	*8/26/03*	*9/24/03*	*10/13/03*	*11/17/03*	*12/1/03*	*1/21/04*	*2/23/04*	*3/17/04*	*4/19/04*	*5/13/04*	*6/17/04*	*7/12/04*
pH	--	6.30	6.56	7.99		8.60	7.30	5.90	5.75	7.30	7.38	7.38	6.61
Conductivity	uMHO	14	17	16		16	17	18	21	19	20	20	14
Dissolved Oxygen	mg/L	8.80	9.72	10.00		12.20	11.80	12.42	12.15	10.80	10.19	10.19	9.09
Temperature	Celsius	24.90	17.10	16.85		8.28	2.20	5.38	8.63	12.90	17.42	17.42	22.89
Acidity	mg/L	2.36	1.07	2.81		2.63	1.09	3.47	U	1.08	U	U	1.15
Total Alkalinity	mg/L	5.05	U	10.20		U	U	U	U	U	U	U	U
Sulfate	mg/L	2.93	U	8.39		3.16	3.68	3.53	3.33	2.81	3.82	U	2.25
Total Hardness	mg/L	3.79	5.69	13.20		46.00	U	U	U	U	5.59	3.25	2.37
Turbidity	NTU	0.46	1.00	0.51		0.47	0.26	0.42	0.89	0.43	0.44	0.65	1.07
Aluminum	mg/L	U	U	176		U	U	U	U	U	U	143	U
Calcium	mg/L	U	U	3		U	U	U	U	U	U	U	U
Copper	mg/L	U	U	U		U	U	U	U	1	u	3	1
Iron	mg/L	79	64	U		U	U	U	35	32	35	82	62
Lead	mg/L	U	U	U		U	U	U	U	U	U	U	U
Manganese	mg/L	16	10	U		U	U	U	9	8	6	17	8
Nickel	mg/L	U	U	U		U	U	U	U	U	U	U	U
Sodium	mg/L		0.5	0.5		0.4	0.5	0.5	0.5	1		0.8	0.5
Zinc	mg/L	32	3	2		U	2	1	4	7	U	U	3
Flow	cfs	2.22	15.67	3.07		43.24	18.71	22.66	37.73	12.67	4.38	0.69	6.46

Note: U denotes analyte requested but not detected. Detection limit is 10 mg/L for total alkalinity and 1 mg/L for acidity. Units of Total Alkalinity and Acidity are expressed in mg/L $CaCO_3$.

APPENDIX C

Biorecon of Cooper Creek

Table C-1 Benthic Biorecon of Cooper Creek

BENTHIC MACROINVERTEBRATE DATA
(3co) Cooper Creek
North Chickamauga Creek Survey
May 31,1986

TAXA:
PHYLUM
Class
Order
Family
Genus species

TAXA	TOLERANCE VALUE (TV)	FUNCT. FEEDING GROUP (FFG)	RIFFLE SUBSTRATE QUANTITAT. ABUND. (RSA)	LEAF PACK QUALITAT. ABUND.	UNDERCUT BANKS & ROOTS QUALITAT. ABUND.	SELECTED PICK QUALITAT. ABUND.	TOLERANCE VALUE X RSA
TAXA	TV	FFG	RSA				TV X RSA
ARTHROPODA							
Insecta							
Ephemeroptera							
Baetidae	6.10		22			1	134.2
Baetis sp.	6.40	SCRA	129			7	696.6
Pseudocloeon sp.	4.02	SCRA	16				64.32
Centroptilum sp.	6.60	SCRA	1				6.6
Ephemerellidae	1.90			1			0
Eurylophella sp.	4.34	COLL	1				4.34
Ephemerella sp.	2.04	COLL	1				2.04
Drunella sp.	0.26	SCRA	3				0.78
Serratella sp.	1.67	COLL	1				1.57
Dannella sp.	1.80	COLL	2				3.6
Heptageniidae	1.60		3				4.5
Epeorus sp.	1.27	SCRA				5	0
Stenonema sp.	3.46	COLL	29			8	100.05
Stenacron sp.	3.58	SCRA				4	0
Heptagenia sp.	2.67	SCRA	11			4	28.27
Plecoptera			5				
Leuctridae							
Leuctra sp.	0.67	PRED	29			2	19.43
Perlidae	1.60	PRED	3				4.5
Acroneuria sp.	2.30	PRED	13			11	29.9
Agnetina sp.	0.00	PRED	26	1			0
Perlodidae							
Isoperla sp.	1.60	PRED	2			3	3
Nemouridae							
Amphinemura sp.	3.30	SHRE	4				13.2
Nemoura sp.		SHRE	1				0

TAXA: PHYLUM / Class / Order / Family / *Genus species*	TOLERANCE VALUE (TV)	FUNCT. FEEDING GROUP (FFG)	RIFFLE SUBSTRATE QUANTITAT. ABUND. (RSA)	LEAF PACK QUALITAT. ABUND.	UNDERCUT BANKS & ROOTS QUALITAT. ABUND.	SELECTED PICK QUALITAT. ABUND.	TOLERANCE VALUE X RSA
Megaloptera							
Corydalidae							
Nigronia sp.	6.25	PRED	3				15.75
Coleoptera							
Elmidae							
Microcyloepus sp.	2.11	SCRA	2				4.22
Oulimnius sp.	1.83	SCRA	9				16.47
Ptilodactylidae							
Anchytarsus sp.	0.00		1	1			0
Psephenidae							
Psephenus sp.	2.35	SCRA	1			1	2.35
Odonata							
Aeshnidae							
Boyeri sp.	5.97	PRED	4				23.88
Gomphidae							
Lanthus sp.	5.97	PRED	11	1			65.67
Trichoptera							
Limnephilidae	2.00	PRED					0
Pychnopsyche sp.	2.25	SHRE	2	1			4.5
Pseudostenophylax sp.	0.00	SHRE				2	0
Lepidostomatidae							
Lepidostoma sp.	0.90	SHRE	6	1			5.4
Philopotamidae							
Wormaldia sp.	0.65	PRED				1	0
Rhyacophilidae							
Rhyacophila sp.	0.73	PRED	9				6.57
Hydropsychidae	2.90		29				84.1
Hydropsyche sp.	4.30	COLL	79	1		28	339.7
Cheumatopsyche sp.	6.22	FF	9			8	55.98
Ceratopsyche sp.	3.11	FF				2	0
Diplectrona sp.	2.21	COLL	1				2.21
Hydroptilidae							
Hydroptila sp.	6.22	HERB				1	0
Isopoda							
Asellidae	8.50	COLL	1				8.5

TAXA: PHYLUM / Class / Order / Family / *Genus species*	TOLERANCE VALUE (TV)	FUNCT. FEEDING GROUP (FFG)	RIFFLE SUBSTRATE QUANTITAT. ABUND. (RSA)	LEAF PACK QUALITAT. ABUND.	UNDERCUT BANKS & ROOTS QUALITAT. ABUND.	SELECTED PICK QUALITAT. ABUND.	TOLERANCE VALUE X RSA
Diptera							
Chironomidae							
Chironominae	6.30	COLL	99	1		1	623.7
Tipulidae	4.90		1				4.9
Hexatoma sp.	4.31	PRED	6				25.86
Limnophila sp.	0.00	HERB	4				0
Limnonia sp.	9.64	HERB	1				9.64
Dixidae							0
Dixa sp.	2.55	COLL	1				2.55
Simuliidae	3.60						0
Simulium sp.	4.00	FF	10				40
Empididae	7.60	PRED	10				76
		TOTALS=	601	8	0	89	2534.85

TOTAL TAXA= 40
TOTAL EPT TAXA= 28

BIOTIC INDEX= 4.231803
WATER QUALITY= GOOD

FUNCTIONAL FEEDING GROUPS	
HERB=HERBIVORE	SCRA=SCRAPER
SHRE=SHREDDER	PRED=PREDATOR
FF=FILTER FEEDER	OMNI=OMNIVORE
COLL=COLLECTOR	DEPF=DEPOSIT FEEDER

Table C-2 Fish Collected from Cooper Creek

FISH SURVEY DATA
(3co) Cooper Creek
North Chickamauga Creek
May 31, 1995

COMMON NAME	SCIENTIFIC NAME	COUNT	ANOMALIES	TROPHIC LEVEL	GROUP	TOLERANCE
Creek Chub	*Semotilus atromaculatus*	12		IN	MISC	TO
Bluegill	*Lepomis macrochirus*	2		IN	SUNFISH	TO
Blacknose Dace	*Semotilus Atromaculatum*	3		SP	MISC	
		17				

Table C-3 Habitat Assessment Field Data for Cooper Creek

STREAM Cooper Creek (3Co) DATE 5-31-95

SITE 9 INVESTIGATOR JDF, GDR

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 14	20 19 18 17 16	15 (14) 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Epifaunal Substrate	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 12	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 13	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 reac channelized and disrupted.
SCORE 17	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 thar 50% of the bottom changing frequently; pools almost absent du to substantial sediment deposition.
SCORE 14	20 19 18 17 16	15 (14) 13 12 11	10 9 8 7 6	5 4 3 2 1 C

RIFFLE/RUN PREVALENT STR

Habitat Parameter	Category: Optimal	Category: Suboptimal	Category: Marginal	Category: Poor
6. Frequency of Riffles	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 w or shallow riffles; p habitat; distance between riffles div by the width of the stream is between >25.
SCORE 12	20 19 18 17 16	15 14 13 (12) 11	10 9 8 7 6	5 4 3 2
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 i channel and mos present as stand pools.
SCORE 10	20 19 18 17 16	15 14 13 12 11	(10) 9 8 7 6	5 4 3 2
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% c streambank surf covered by vege disruption of stre vegetation is ve vegetation has b removed to 2 inches or less average stubble
SCORE 9 (LB)	Left Bank 10 (9)	8 7 6	5 4 3	2 1
SCORE 9 (RB)	Right Bank 10 (9)	8 7 6	5 4 3	2 1
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 areas; "raw" ar frequent along sections and b obvious bank s 60-100% of ba erosional scar
SCORE 9 (LB)	Left Bank 10 (9)	8 7 6	5 4 3	2 1
SCORE 9 (RB)	Right Bank 10 (9)	8 7 6	5 4 3	2 1
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 ripar <6 meters: litt riparian veget to human act
SCORE 9 (LB)	Left Bank 10 (9)	8 7 6	5 4 3	2 1
SCORE 9 (RB)	Right Bank 10 (9)	8 7 6	5 4 3	2 1

APPENDIX D

North Chickamauga Creek Monitoring Data (USOSM)

North Chickamauga Creek Watershed Monitoring Data (USOSM)

Entries 3 & 6	pH	Conductivity	DO (%)	DO (mg/L)	Temp. (C)	Acidity	Alkalinity	Sulfate (mg/L)	Aluminum (mg/L)	Arsenic (mg/L)	Calcium (mg/L)	Copper (mg/L)	Manganese (mg/L)	Zinc (mg/L)	Ttl Iron (mg/L)	Flow (cfs)
8/31/04	2.86	1007		12.65	17.64	270.00	0.00	321.00	0.72		86.00		3.84		5.40	0.003
11/19/03	3.17	507		6.90	13.10	108.00	0.00	120.50	0.86		36.40		27		12.70	0.11039
8/18/03	2.78	1032			18.40	130.00	0.00	252.00	0.25		160.00		1.84		3.00	0.018
6/3/03	2.81	796.3		7.99	14.40	196.00	0.00	187.50	0.21		50.00		0.62		3.60	
3/13/03	3.5	840		8.30	12.30	200.00	0.00	173.75	0.14		72.00		0.92		3.90	0.042
12/2/02	2.93	1250		5.77	10.06	410.00	0.00	415.00	0.49		142.00		1.68		6.00	0.09
8/13/02	DRY															
3/25/02	4.48	663		7.06	13.22	152.00	U	176.00	9.81		6.27		0.718		3.07	0.033
10/30/01	DRY															
6/19/01	2.99	990		12.70	16.44	213.00	U	459.00	16.6		16.90		1.4			0.042
2/14/01	2.87	341.9		1.04	9.90	102.00	U	137.00	7.21		5.83		0.376		1.93	0.131
7/11/00	2.68	260.5		1.90	19.07				0.2				2.28		7.10	Slight
1/11/00	2.5	125.2		9.33	10.28	119.00	U	144.00	9.04	U	6.84	0.01	0.626	0.103	2.18	0.126
4/28/99	2.83	472	112.1	33.90	15.09	75.00	0.00	95.00	4.38	0	4.87	0.007	0.446	0.069	1.07	1.84
3/28/95	2.8	1286	-----	9.40	12.40	-----	<1.0	382.00	18.7	<.001	20.70	0.02	1.03	0.341	12.70	0.127
Turkey 15 Highwall	**pH**	**Conductivity**	**DO (%)**	**DO (mg/L)**	**Temp. (C)**	**Acidity**	**Alkalinity**	**Sulfate (mg/L)**	**Aluminum (mg/L)**	**Arsenic (mg/L)**	**Calcium (mg/L)**	**Copper (mg/L)**	**Manganese (mg/L)**	**Zinc (mg/L)**	**Ttl Iron (mg/L)**	**Flow (cfs)**
8/31/04	5.5	553		9.60	29.86	20.00	6.00	38.40	0.12		50.60		2.2		0.16	------
11/19/03	6.16	456		3.90	13.70	0.00	130.00	137.50	0.77		34.00		30		10.40	
8/18/03	3.77	533			19.60	160.00	0.00	204.00	0.22		40.00		1.99		1.12	
6/3/03	3.36	454.4		5.09	16.52	96.00	0.00	80.00	0.17		44.70		0.37		3.00	
3/12/03	4	490		6.60	15.20	120.00	0.00	135.00	0.06		40.00		1.25		1.06	
12/2/02	3.7	511		2.90	10.30	195.00	0.00	85.00	0.2		50.00		1.22		2.07	
8/13/02	4.03	572		0.58	23.30	74.00	U	291.00	1.87		59.00		1.36		4.63	Trickle
3/25/02	4.23	475		9.13	13.97	98.00	U	159.00	3.86		13.50		0.708		0.72	-----
10/30/01	2.11	1036		5.44	9.67	142.00	U	411.00	11.8		41.80		2.23		3.36	-----
6/19/01	3.51	504		13.03	19.96	123.00	U	239.00	5.92		25.80		1.38		2.53	-----
2/14/01	3.1	263.9		1.90	13.40	111.00	U	221.00	4.6		25.60		0.853		1.02	-----
7/11/00	3.5	117.2		2.25	25.06				0.06				1.93		5.80	
1/12/00	2.83	131.6		5.63	11.24	130.00	U	264.00	6.65	U	25.20	0.008	1.69	0.15	2.23	------
4/28/99	3.07	480	53	31.80	15.14	87.00	0.00	154.00	3.69	0	18.20	0.004	0.98	0.088	0.94	-------
5/4/95	3.2	935		2.40	13.00	69.00	<1.0	182.00	6.87	<.001	36.50	<.02	1.67	0.161	1.72	0.056

North Chickamauga Creek Watershed Monitoring Data (USOSM)

Turkey 15 Discharge	pH	Conductivity	DO (%)	DO (mg/L)	Temp. (C)	Acidity	Alkalinity	Sulfate (mg/L)	Aluminum (mg/L)	Arsenic (mg/L)	Calcium (mg/L)	Copper (mg/L)	Manganese (mg/L)	Zinc (mg/L)	Ttl Iron (mg/L)	Flow (cfs)
8/31/04	DRY															
11/19/03	DRY															
8/18/03	DRY															
6/3/03	DRY															
3/12/03	DRY															
12/2/02	DRY															
8/13/02	DRY															
3/25/02	In-Pond 6.58	398		6.98	14.46	U	46.00	142.00	1.15		56.80		0.17		0.51	0
10/30/01	DRY															
6/19/01	-----	------														-----
2/14/01	5.54	254		2.40	8.60	U	56.00	199.00	U		50.90		0.009		0.03	
7/11/00	6.27	103.8		5.08	27.70				<.001				0.52		0.20	0
1/12/00	6.03	81.3		8.38	8.80	13.00	44.00	216.00	0.629	U	69.20	U	0.185	0.011	0.23	-----
4/28/99	6.6	523	89.9	33.90	17.45	12.00	89.00	163.00	0	0	72.00	0	0.645	0.002	2.12	-----
#11 Inflow	**pH**	**Conductivity**	**DO (%)**	**DO (mg/L)**	**Temp. (C)**	**Acidity**	**Alkalinity**	**Sulfate (mg/L)**	**Aluminum (mg/L)**	**Arsenic (mg/L)**	**Calcium (mg/L)**	**Copper (mg/L)**	**Manganese (mg/L)**	**Zinc (mg/L)**	**Ttl Iron (mg/L)**	**Flow (cfs)**
8/31/04	3.36	401		13.74	19.30	92.00	0.00	139.50	0.17		36.70		0.94		1.65	-----
11/19/03	4.38	442		6.70	13.50	80.00	0.00	141.50	1.64		44.00		34.2		17.00	0.52182
8/18/03	3.46	370			13.50	70.00	0.00	128.00	0.22		26.20		0.46		4.20	0.123
6/3/03	3.46	316.2		7.98	13.67	80.00	0.00	77.50	0.2		21.40		0.1		4.40	
3/12/03	4	350		10.90	12.90	80.00	0.00	77.50	0.08		27.20		0.31		3.50	0.669
12/2/02	3.54	390.3		6.04	13.28	96.00	0.00	82.50	0.24		37.00		0.31		3.52	0.19
8/13/02	3.3	498		8.80	14.10	78.00	U	204.00	5.85		23.60		0.648		3.23	
3/25/02	4.69	170		9.11	12.80	27.00	U	69.00	2.5		8.62		0.349		1.53	0.355
10/30/01	1.79	780		11.20	13.70	75.00	U	262.00	7.67		28.00		0.786		3.40	0.031
6/20/01	3.16	366		23.70	14.40	58.00	U	130.00	3.49		18.00		0.434		2.46	0.732
2/14/01	3.19	220.4		3.70	12.50		U	143.00	4.87		15.30		0.4		2.39	0.166
7/11/00	2.9	107.9		6.70	13.60				0.09				0.92		1.79	0.0024
1/11/00	3.15	76.54		11.84	12.86	34.00	U	139.00	4.59	U	18.80	0.005	0.549	0.081	2.68	1.29
4/28/99	3.11	340	105.4	32.90	12.49	46.00	0.00	104.00	2.98	0	12.70	0.005	0.454	0.066	1.60	0.58
4/13/95	3.2	546	-----	-----	12.00	86.00	<1.0	163.00	6.14	<.001	19.10	0.009	0.87	0.14	7.49	0.89

North Chickamauga Creek Watershed Monitoring Data (USOSM)

#11 Discharge	pH	Conductivity	DO (%)	DO (mg/L)	Temp. (C)	Acidity	Alkalinity	Sulfate (mg/L)	Aluminum (mg/L)	Arsenic (mg/L)	Calcium (mg/L)	Copper (mg/L)	Manganese (mg/L)	Zinc (mg/L)	Ttl Iron (mg/L)	Flow (cfs)
8/31/04	7.73	402		14.20	23.24	0.00	62.00	67.50	<.10		40.00		0.1		0.24	----
11/19/03	6.22	296		7.00	13.50	0.00	16.00	116.50	0.37		22.00		9		3.52	
8/18/03	6.26	332			22.60	2.00	14.00	125.00	0.05		22.90		0.18		0.36	
6/3/03	6.48	240.5		9.74	18.70	8.00	24.00	68.00	0.05		18.20		0.15		0.26	
3/12/03	5	250		9.80	15.00	12.00	3.00	77.50	0.001		17.90		0.35		1.00	0.669
12/2/02	5.01	303		6.79	6.38	29.00	3.00	81.00	0.07		33.00		0.19		0.90	0.19
8/13/02	DRY															DRY
3/25/02	5.59	221		5.93	15.57	11.00	3.00	92.00	1.75		9.22		0.191		0.54	
10/30/01	DRY															
6/20/01	5.57	171		15.20	22.60	U	23.00	145.00	0.611		31.70		0.106		0.14	0.732
2/14/01	3.96	173.1		5.27	11.70		1.00	124.00	3.5		26.40		0.324		0.46	
7/11/00	6.26	103.8		5.08	27.70				<.001				0.07		0.12	0.0024
1/11/00	4.11	68.16		12.35	11.31	34.00	2.00	173.00	3.96	U	23.50	0.003	0.459	0.07	1.15	1.29
4/28/99	4.54	244	112.5	33.90	14.05	21.00	2.00	94.00	2.34	0.001	20.70	0.003	0.337	0.056	0.69	-----
Standifer 1 & 2 Inflow	**pH**	**Conductivity**	**DO (%)**	**DO (mg/L)**	**Temp. (C)**	**Acidity**	**Alkalinity**	**Sulfate (mg/L)**	**Aluminum (mg/L)**	**Arsenic (mg/L)**	**Calcium (mg/L)**	**Copper (mg/L)**	**Manganese (mg/L)**	**Zinc (mg/L)**	**Ttl Iron (mg/L)**	**Flow (cfs)**
8/31/04	3.3	453		18.00	15.18	106.00	0.00	165.50	0.18		43.30		0.9		0.30	-----
11/19/03	3.37	427		7.60	12.60	82.00	0.00	119.50	1.11		39.00		23		1.60	
8/18/03	3.29	460			14.80	103.00	0.00	126.50	0.05		31.90		0.6		0.44	
6/3/03	3.06	586.7		10.96	13.88	120.00	0.00	81.00	0.05		60.00		0.21		0.51	
3/12/03	4	650		11.60	13.80	110.00	0.00	160.00	0.07		43.00		0.9		1.06	
12/2/02	3.46	498.4		6.25	11.62	116.00	0.00	155.00	0.09		41.00		0.55		0.57	
8/13/02	3.01	593.1		1.44	16.91	86.00	U	206.00	8.05		10.20		0.797		0.59	Trickle
3/25/02	4.29	606		8.40	14.33	94.00	U	210.00	9.08		9.37		..784		0.90	
10/30/01	2.13	808		10.50	13.24	72.00	U	239.00	7.68		14.50		0.976		0.32	-----
6/20/01	2.75	573		23.50	14.10	71.00	U	171.00	5.99		12.30		0.646		0.53	
2/14/01	2.98	391.1		0.55	12.80	107.00	U	206.00	9.73		14.10		0.699		0.97	
7/11/00	2.83	140.3		5.30	15.94				0.08				1.1		0.76	0.0257
1/11/00	2.73	95.8		10.51	12.13	68.00	U	239.00	5.66	U	10.80	0.007	0.892	0.123	0.53	
4/28/99	2.91	495	115	33.90	14.52	65.00	0.00	122.00	4.6	0	7.82	0.01	0.572	0.101	0.44	1.55

North Chickamauga Creek Watershed Monitoring Data (USOSM)

Standifer 1 & 2 Discharge	pH	Conductivity	DO (%)	DO (mg/L)	Temp. (C)	Acidity	Alkalinity	Sulfate (mg/L)	Aluminum (mg/L)	Arsenic (mg/L)	Calcium (mg/L)	Copper (mg/L)	Manganese (mg/L)	Zinc (mg/L)	Ttl Iron (mg/L)	Flow (cfs)
8/31/04	6.8	527		5.00	20.73	0.00	82.00	160.00	0.6		48.40		2.46		8.30	----
11/13/03	6.07	432		3.20	12.40	0.00	50.00	156.00	1.99		34.40		37		25.80	
8/18/03	4.15	396			23.10	75.00	0.00	134.50	0.16		28.40		0.88		1.15	
6/3/03	4.48	359.4		10.40	17.00	50.00	0.00	80.00	0.05		28.40		0.23		0.90	
3/12/03	4	480		11.40	16.40	110.00	0.00	147.50	0.1		36.70		0.95		2.20	
12/2/02	3.83	437.4		6.21	6.04	110.00	0.00	160.00	0.14		39.00		1.01		4.18	
8/13/02	6.37	385.5		----	23.70	31.00	53.00	234.00	0.831		71.60		1.52		3.27	Trickle
3/25/02	4.75	504		8.60	15.10	76.00	U	182.00	8.54		15.40		0.008		1.55	
10/30/01	3.86	581		14.80	8.90	30.00	6.00	217.00	8.63		40.50		1.52		3.15	-----
6/20/01	3.34	434		26.30	18.30	63.00	U	160.00	6.14		27.70		1.02		1.89	-----
2/14/01	3.36	289.5		1.89	11.41	81.00	U	217.00	8.54		27.00		0.775		1.58	-----
7/11/00	5.26	115.2		5.26	23.45				0.15				1.52		4.36	0.0138
1/11/00	3.21	76		12.87	10.19	55.00	U	130.00	5.72	U	19.70	0.007	1.09	0.114	1.15	0.31
4/28/99	4.01	295	112.4	33.90	15.30	43.00	0.00	107.00	4.28	0.001	20.20	0.008	0.716	0.084	1.69	------
Rattlesnake By-Pass	**pH**	**Conductivity**	**DO (%)**	**DO (mg/L)**	**Temp. (C)**	**Acidity**	**Alkalinity**	**Sulfate (mg/L)**	**Aluminum (mg/L)**	**Arsenic (mg/L)**	**Calcium (mg/L)**	**Copper (mg/L)**	**Manganese (mg/L)**	**Zinc (mg/L)**	**Ttl Iron (mg/L)**	**Flow (cfs)**
8/31/04	3.3	490		17.70	13.89	20.00	6.00	38.40	0.12		50.60		2.2		0.16	0.052
11/16/03	6.4	301		6.40	13.60	7.00	30.00	104.00	1.19		17.00		18.4		32.20	1.29452
8/18/03	3.68	283			16.70	56.00	0.00	113.00	0.1		25.00		0.39		2.12	0.264
6/3/03	3.48	390.3		10.23	12.72	40.00	0.00	80.00	0.12		30.60		0.22		2.90	
3/13/03	4	290		8.60	11.00	55.00	0.00	75.00	0.06		23.00		0.24		2.86	0.438
12/3/02	3.96	271.5		8.73	12.46	46.00	0.00	77.50	0.04		27.00		0.11		1.90	0.35
8/13/02	2.97	425.8		----	13.26	82.00	U	378.00	4.86		47.10		1.12		3.09	0.01
3/25/02	4.48	263		11.89	11.48	22.00	U	93.00	1.29		14.50		0.279		1.48	1.19
10/31/01	2.37	983		9.93	12.65	81.00	U	501.00	4.79		52.00		1.61		3.10	0.009
6/19/01	4.09	396		13.91	12.83	47.00	U	171.00	1.59		26.50		0.559		4.92	0.137
2/14/01	3.53	151		5.84	9.89	28.00	U	83.00	1.31		16.80		0.262		2.34	0.823
7/12/00	2.83	96.5		6.90	12.71				0.07				0.65		8.20	0.0006
1/11/00	3.05	29.5		13.90	11.00	25.00	U	68.00	0.873	U	11.00	0.001	0.255	0.082	1.74	1.37
4/28/99	3.69	232	105.7	33.90	14.17	26.00	0.00	625.00	1.13	0.001	13.90	0.001	0.282	0.026	2.30	-----
3/17/99	3.92	140			10.50	16.70	0.00	52.50	0.902				0.199		1.33	
3/28/95	3.9	274	10.9	-----	11.20	-----	<1.0	76.00	1.51	<.001	18.00	<.02	0.4	0.038	2.53	0.73

North Chickamauga Creek Watershed Monitoring Data (USOSM)

Rattlesnake Discharge	pH	Conductivity	DO (%)	DO (mg/L)	Temp. (C)	Acidity	Alkalinity	Sulfate (mg/L)	Aluminum (mg/L)	Arsenic (mg/L)	Calcium (mg/L)	Copper (mg/L)	Manganese (mg/L)	Zinc (mg/L)	Ttl Iron (mg/L)	Flow (cfs)
8/31/04	7.46	475		10.60	23.03	0.00	62.00	90.00	<.10		40.60		0.15		0.18	----
11/19/03	6.19	389		7.70	13.00	10.00	52.00	131.00	0.7		19.90		26		18.60	
8/18/03	5.32	232			18.00	3.00	7.00	101.50	0.14		19.70		0.7		2.00	0.257
6/3/03	5.85	100.5		5.80	19.38	3.00	14.00	23.00	0.05		6.70		0.06		1.22	
3/13/03	5	130		5.20	12.80	5.00	2.00	37.00	0.02		8.20		0.27		0.76	
12/3/02	5.37	222.4		5.80	5.57	74.00	0.00	77.50	0.15		21.00		0.42		7.00	trickle
8/13/02	DRY															DRY
10/31/01	DRY															DRY
6/19/01	----	----														----
2/14/01	4.03	117.1		6.20	9.65	20.00	U	69.00	1.85		16.70		0.514		0.81	
7/12/00	5.29	32.5		6.09	26.05				0.06				0.58		2.60	Slight
1/11/00	3.31	40.63		13.10	10.61	19.00	U	74.00	0.908	U	12.90	0.001	0.362	0.022	0.57	-----
4/28/99	5.4	132	83.6	32.90	18.56	11.00	6.00	47.00	0.145	0	12.40	0	0.683	0.009	0.30	-----
Three Sisters In Left	**pH**	**Conductivity**	**DO (%)**	**DO (mg/L)**	**Temp. (C)**	**Acidity**	**Alkalinity**	**Sulfate (mg/L)**	**Aluminum (mg/L)**	**Arsenic (mg/L)**	**Calcium (mg/L)**	**Copper (mg/L)**	**Manganese (mg/L)**	**Zinc (mg/L)**	**Ttl Iron (mg/L)**	**Flow (cfs)**
11/19/03	3.28	765		4.50	13.00	140.00	0.00	195.00	3.04		47.90		32.6		38.80	
Three Sisters In Right	**pH**	**Conductivity**	**DO (%)**	**DO (mg/L)**	**Temp. (C)**	**Acidity**	**Alkalinity**	**Sulfate (mg/L)**	**Aluminum (mg/L)**	**Arsenic (mg/L)**	**Calcium (mg/L)**	**Copper (mg/L)**	**Manganese (mg/L)**	**Zinc (mg/L)**	**Ttl Iron (mg/L)**	**Flow (cfs)**
8/31/04	2.79	970		18.20	13.50	300.00	0.00	325.00	0.35		75.00		1.6		5.90	
11/19/03	3.3	653		7.60	13.10	180.00	0.00	180.00	6.2		44.00		29.5		77.50	

North Chickamauga Creek Watershed Monitoring Data (USOSM)

Three Sisters Combined	pH	Conductivity	DO (%)	DO (mg/L)	Temp. (C)	Acidity	Alkalinity	Sulfate (mg/L)	Aluminum (mg/L)	Arsenic (mg/L)	Calcium (mg/L)	Copper (mg/L)	Manganese (mg/L)	Zinc (mg/L)	Ttl Iron (mg/L)	Flow (cfs)
8/31/04	3.01	640		16.25	13.80	190.00	0.00	205.00	<.10		51.90		0.72		4.06	
11/19/03	3.29	709	0	6.05	13.05	160	0	187.5	4.62	0	45.95	0	31.05	0	58.15	0
8/18/03	2.71	1220			13.30	400.00	0.00	316.00	0.55		175.00		1.06		10.60	
6/3/03	2.66	532		9.77	13.37	256.00	0.00	212.50	0.25		39.00		0.37		7.70	
3/13/03	3.5	850		7.90	12.40	200.00	0.00	176.25	0.19		56.00		0.52		4.97	
12/3/02	2.8	1446		7.90	12.58	280.00	0.00	330.00	0.23		119.00		0.56		5.40	
8/13/02	DRY															DRY
3/25/02	4.08	787		8.07	12.71	152.00	U	285.00	11.5		7.15		0.499		4.97	
10/30/01		TRICKLE														
6/19/01	3.43	703		12.00	12.90	138.00	U	241.00	11.6		12.90		0.558		4.54	
2/14/01	2.82	450		0.21	12.18	151.00	U	238.00	12.4		9.99		0.398		4.23	
7/11/00	2.67	292.5		1.90	16.74				0.29				1.14		14.90	-----
1/11/00	3.65	88.4		11.60	11.21	77.00	U	201.00	8.39	U	32.80	0.009	1.2	0.137	2.41	0.21
4/28/99	2.88	457	109.2	33.90	14.80	75.00	0.00	82.00	4.88	0	5.76	0.007	0.406	0.088	1.77	1.15
Three Sisters Discharge	**pH**	**Conductivity**	**DO (%)**	**DO (mg/L)**	**Temp. (C)**	**Acidity**	**Alkalinity**	**Sulfate (mg/L)**	**Aluminum (mg/L)**	**Arsenic (mg/L)**	**Calcium (mg/L)**	**Copper (mg/L)**	**Manganese (mg/L)**	**Zinc (mg/L)**	**Ttl Iron (mg/L)**	**Flow (cfs)**
8/31/04	5.42	577		5.93	23.82	3.00	10.00	245.00	0.13		48.60		3.3		0.37	----
11/19/03	6.48	689		3.98	13.30	0.00	70.00	262.50	0.74		52.20		40		11.80	
8/18/03	6.56	710			24.40	0.00	70.00	200.00	0.05		54.00		1.4		1.62	
6/3/03	4.76	488		6.94	18.04	65.00	2.00	84.75	0.11		40.60		0.66		0.56	
3/13/03	5	470		8.20	13.10	25.00	4.00	187.50	0.1		40.00		1.02		1.52	
12/3/02	4.61	638.7		9.06	7.17	132.00	1.00	275.00	0.14		77.00		1.77		2.77	Slight
8/13/02	DRY															DRY
3/25/02	5.85	445		7.09	13.45	18.00	3.00	216.00	4.58		59.90		0.864		1.34	
10/30/01	3.95	1530		12.40	13.50	24.00	30.00	637.00	1.38		147.00		4.33		5.71	Slight
6/19/01	6.5	494		9.22	26.07	15.00	32.00	200.00	0.601		75.70		1.66		1.37	-----
2/14/01	4.83	291.2		1.60	8.50	58.00	3.00	267.00	7.33		37.80		1.24		3.19	
7/11/00	5.86	155.6		1.30	26.20				0.08				1.19		1.53	Slight

North Chickamauga Creek Watershed Monitoring Data (USOSM)

Standifer Creek below Turkey 15	pH	Conductivity	DO (%)	DO (mg/L)	Temp. (C)	Acidity	Alkalinity	Sulfate (mg/L)	Aluminum (mg/L)	Arsenic (mg/L)	Calcium (mg/L)	Copper (mg/L)	Manganese (mg/L)	Zinc (mg/L)	Ttl Iron (mg/L)	Flow (cfs)
8/31/04	5.29	307		13.65	19.48	12.00	5.00	78.00	0.14		23.50		1.6		0.77	
11/19/03	5.49	188.8		8.90	13.20	10.00	15.00	59.00	0.44		10.60		20.6		6.40	
8/18/03	5.05	240			18.90	15.00	5.00	92.00	0.05		19.00		0.97		0.70	
6/3/03	4.41	241.8		4.72	16.09	46.00	0.00	59.50	0.05		22.20		0.12		0.88	
3/12/03	4	180		8.20	12.50	31.00	0.00	55.50	0.02		20.00		0.56		0.62	
12/2/02	4.4	264.5		6.70	6.30	40.00	0.00	147.50	0.16		30.00		0.86		1.01	
8/13/02	3.67	529		----	17.60	51.00	U	253.00	1.92		44.50		1.6		3.27	
3/25/02	4.84	194		8.41	10.50	17.00	1.00	71.00	2.08		11.10		0.463		0.42	
10/30/01	2.83	598		11.65	6.89	27.00	U	228.00	2.49		34.80		2.31		1.92	------
6/19/01	4.17	285		12.80	16.30	23.00	U	128.00	1.74		10.20		0.952		0.80	
2/14/01	3.6	92.3		8.50	9.10	16.00	1.00	56.00	1.97		9.46		0.395		0.44	
7/11/00	4.04	76.5		6.10	21.35				0.05				1.98		2.44	
1/12/00	3.77	41.6		13.00	8.60	27.00	U	78.00	2.17	U	4.00	0.002	0.582	0.039	0.72	-----
4/28/99	4.43	120	109.6	33.90	14.50	12.00	1.00	37.00	1.08	0	8.13	0.002	0.309	0.02	0.58	-----
Standifer Creek at Double Bridges	**pH**	**Conductivity**	**DO (%)**	**DO (mg/L)**	**Temp. (C)**	**Acidity**	**Alkalinity**	**Sulfate (mg/L)**	**Aluminum (mg/L)**	**Arsenic (mg/L)**	**Calcium (mg/L)**	**Copper (mg/L)**	**Manganese (mg/L)**	**Zinc (mg/L)**	**Ttl Iron (mg/L)**	**Flow (cfs)**
8/31/04	5.12	238		13.10	18.70	1.00	11.00	67.50	<.10		20.60		0.22		0.10	
11/19/03	6.27	72.2		7.40	13.20	25.00	17.00	23.50	0.19		3.16		7		3.02	
8/18/03	5.15				18.75	13.00	4.00	41.00	0.05		10.00		0.28		0.10	
6/3/03	4.75	147.45		9.97	14.67	21.00	1.00	37.50	0.05		11.20		0.17		0.06	
3/13/03	4.5	120		8.40	9.20	20.00	0.00	35.00	0.001		8.00		0.16		0.30	
12/3/02	4.98	147.2		10.90	5.16	12.00	2.00	49.00	0.09		5.10		0.22		0.42	
8/14/02	4.52	154.2		-----	18.54	11.00	2.00	78.00	0.549		10.60		0.85		0.27	
3/25/02	5.3	108		10.30	8.40	U	3.00	39.00	1.08		6.94		0.249		0.07	------
10/31/01	3.78	299		10.01	5.63	11.00	2.00	90.00	0.758		17.40		0.827		0.05	-----
6/19/01	5.15	179		10.00	16.50	U	2.00	77.00	0.95		11.80		0.575		0.24	
7/12/00	4.42	44.1		6.90	21.60				<.001				0.49		0.16	
1/10/00	3.72	12.72		16.30	9.96	U	2.00	18.00	0.529	U	4.26	0.001	0.167	0.012	0.32	-----
4/29/99	4.93	55	110.3	33.90	12.63	0.00	3.00	15.00	0.3785	0	4.06	0	0.122	0.012	0.14	-----
5/22/95	4.36	107	-----	8.50	17.70	16.00	<1.0	41.00	1.3	<1.0	7.74	<.005	0.423	0.026	0.18	-----
12/30/86	3.5	300	-----	-----	5.00	29.20	0.00	63.00	2.91	-----	-----	-----	0.49	-----	0.92	7.5

North Chickamauga Creek Watershed Monitoring Data (USOSM)

NCC Below Double Bridges	pH	Conductivity	DO (%)	DO (mg/L)	Temp. (C)	Acidity	Alkalinity	Sulfate (mg/L)	Aluminum (mg/L)	Arsenic (mg/L)	Calcium (mg/L)	Copper (mg/L)	Manganese (mg/L)	Zinc (mg/L)	Ttl Iron (mg/L)	Flow (cfs)
8/31/04	6.11	150		16.30	19.00	0.00	17.00	42.60	<.10		13.40		0.12		0.08	
11/19/2003	6.06	79		8.55	13.2	16	7	21.4	0.17		3.24		5.2		1.77	
8/18/03	5.74				19.05	37.00	9.00	29.00	0.05		4.52		0.05		0.09	
6/3/03	5.06	110.6		7.47	15.03	11.00	2.00	32.00	0.05		9.00		0.04		0.12	
3/13/03	4.5	90		9.60	8.60	10.00	0.00	31.00	0.001		5.10		0.1		0.40	
12/3/02	5.2	105.9		9.65	4.65	18.00	2.00	34.75	0.05		4.14		0.14		1.12	
8/14/02	Stagnant															Stagnant
3/25/02	5.2	102		10.10	8.30	U	3.00	31.00	0.877		5.76		0.21		0.06	------
10/31/01	4.34	222		10.39	6.24	U	1.00	65.00	0.487		13.60		0.519		0.07	------
6/19/01	5.47	129		10.70	17.10	U	3.00	49.00	0.499		10.90		0.38		0.09	
7/12/00	4.79	28.1		7.60	21.40				<.001				0.12		0.10	
1/10/00	4.03	125.2		9.33	10.28	U	3.00	17.00	0.554	U	3.84	U	0.125	0.01	0.29	-----
4/29/99	5.25	46	108.6	33.90	12.67	0.00	2.00	13.00	0.305	0	3.26	0	0.098	0.008	0.15	-----
5/22/95	4.59	18.1	-----	8.50	18.10	10.00	1.00	25.00	0.66	<1	4.72	<.005	0.237	0.014	0.10	-----
12/30/86	3.7	200	-----	-----	5.00	39.20	0.00	49.00	2.54	-----	-----	-----	0.42	-----	0.72	15
6/20/84	3.8	-----	-----	-----	-----	26.00	0.00	-----	1.85	-----	-----	-----	0.53	-----	0.29	-----
7/9/84	3.6	-----	-----	-----	16.00	7.00	0.00	-----	1.6	-----	-----	-----	0.19	-----	0.44	-----
6/1/05	3.4	-----	-----	9.20	18.00	28.00	<1.0	60.00	-----	-----	-----	0.08	0.62	0.06	0.40	-----

North Chickamauga Creek Watershed Monitoring Data (USOSM)

NCC Above Hogskin	pH	Conductivity	DO (%)	DO (mg/L)	Temp. (C)	Acidity	Alkalinity	Sulfate (mg/L)	Aluminum (mg/L)	Arsenic (mg/L)	Calcium (mg/L)	Copper (mg/L)	Manganese (mg/L)	Zinc (mg/L)	Ttl Iron (mg/L)	Flow (cfs)
9/1/04	6.35	34		8.05	22.70	0.00	12.00	10.10	<.10		2.49		0.1		0.27	
11/20/03	5.59	19.8		10.52	11.80	10.00	7.00	11.30	0.26		0.85		0.82		11.40	
8/19/03	6.24	22		7.60	23.80	24.00	17.00	28.00	0.05		1.35		0.06		0.13	
5/29/03	5.5	27.63		8.51	16.81	21.00	5.00	6.00	0.01		2.24		0.16		0.75	
4/29/03	5.79	32		9.60	14.62	15.00	8.00	<5.0	<.001		2.86		0.17		0.36	
2/28/03	5.35	25.54		11.80	8.45	12.00	3.00	5.00	0.04		8.60		0.15		0.94	
1/30/03	5.59	31.3		12.20	2.72	25.00	5.00	8.50	0.16		1.90		0.3		0.12	
1/8/03	5.53	28.35		10.50	4.31	5.00	10.00	5.00	0.03		1.45		0.09		0.10	
12/3/02	5.62	34.1		13.70	4.53	4.00	6.00	9.00	0.001		1.06		0.09		0.37	
10/31/02	6.03	31.75		9.65	13.65	5.00	10.00	7.50	0.001		1.79		0.09		0.17	
9/26/02	6.42	33		9.50	19.50	35.00	10.00		0.001		1.90		0.1		0.08	
7/24/02	6.14	47.46		6.37	25.34	7.00	10.00	7.00	0.02		3.22		0.1		0.33	
6/27/02	6.3	48		7.69	25.03	0.00	14.00	10.50	0.01		4.00		0.08		0.35	
5/30/02	5.28	24		10.20	18.20	65.00	4.00	<5	0.08		5.00		1.2		0.22	
5/2/02	4.33	27		10.58	16.00	16.00	0.00	<5	0.05		1.90		0.12		0.70	
3/28/02	4.34	27			9.74	U	3.00	7.00	U		1.43		0.008		U	-----
10/31/01	4.7	69		10.10	10.40	U	5.00	11.00	0.485		3.33		0.006		0.07	------
6/20/01	4.16	48		18.50	25.70	U	4.00	11.00	U		2.44		0.013		0.19	
2/14/01	4.3	15.4		10.80	9.40	U	3.00	7.00	0.609		1.64		0.029		0.03	
7/12/00	4.73	6.8		7.70	29.85				0.09				0.27		2.38	
1/12/00	4.61	5.2		18.88	7.44	U	2.00	6.00	0.178	U	1.58	U	U	0.002	0.04	
4/29/99	5.08	20	114.8	33.90	13.40	0.00	2.00	4.00	0	0	1.22	0	0.026	0.002	0.06	-----

North Chickamauga Creek Watershed Monitoring Data (USOSM)

Hogskin at NCC	pH	Conductivity	DO (%)	DO (mg/L)	Temp. (C)	Acidity	Alkalinity	Sulfate (mg/L)	Aluminum (mg/L)	Arsenic (mg/L)	Calcium (mg/L)	Copper (mg/L)	Manganese (mg/L)	Zinc (mg/L)	Ttl Iron (mg/L)	Flow (cfs)
9/1/04	2.94	1067		9.60	19.92	360.00	0.00	362.50	0.71		81.00		4.28		1.20	0.09
11/20/03	3.34	391		9.44	13.30	120.00	0.00	95.50	0.72		32.60		23.3		5.16	0.95333
8/19/03	6.24	654		8.50	21.60	221.00	0.00	239.00	0.38		47.20		2.05		2.40	0.48
5/29/03	3.03	820.5		9.30	15.14	209.00	0.00	207.50	0.45		58.20		2.4		8.00	0.539
4/29/03	3.15	933		9.50	15.01	160.00	0.00	170.00	0.17		82.00		1.4		2.90	0.333
2/28/03	3.69	499.7		11.50	9.21	44.00	0.00	22.00	0.06		17.70		0.12		1.39	4.65
1/30/03	3.13	538.8		10.60	4.96	156.00	0.00	84.75	0.4		50.00		1.15		0.62	0.46
1/8/03	2.92	803.3		11.20	6.58	310.00	0.00	205.00	0.16		62.00		0.3		1.40	0.71
12/3/02	3.13	884.2		11.50	8.02	320.00	0.00	260.00	0.41		100.00		2.2		4.82	0.41
10/31/02	3.02	603.7		10.00	11.67	224.00	0.00	198.75	0.1		50.00		1.26		1.30	0.334
9/26/02	3.19	360		8.50	17.87	164.00	0.00	xxx	0.17		30.00		1.26		0.60	
7/24/02	2.91	1196		0.00	21.80	360.00	0.00	405.00	0.14		94.00		5.04		1.15	0.002
6/27/02	4.3	1076		8.05	20.32	294.00	0.00	205.00	0.3		126.00		4.18		1.19	0.047
5/30/02	3.4	918		10.38	15.51	228.00	0.00	347.50	0.22		80.00		2.86		2.90	0.21
5/2/02	2.91	640		9.91	17.20	170.00	0.00	185.00	0.19		60.00		1.42		1.40	0.55
3/28/02	3.16	619			11.88	132.00	U	286.00	13.7		9.68		1.25		3.23	1.22
10/31/01		TRICKLE														
6/20/01	2.8	48		18.50	20.60	225.00	U	527.00	26.3		20.20		2.59		1.03	-----
2/14/01	2.72	153.9		5.15	11.10	47.00	U	91.00	4.22		5.42		0.458		0.81	
7/12/00	2.91	232.8		2.40	23.50				0.18				2.7		0.82	
1/12/00	2.62	88.85		12.70	8.17	83.00	U	168.00	7.02	U	7.11	0.004	1.04	0.076	1.36	1.99
4/29/99	3.41	160	112.6	33.90	12.98	28.00	0.00	41.00	1.93	0	3.22	0.001	0.303	0.026	0.23	-----

North Chickamauga Creek Watershed Monitoring Data (USOSM)

NCC below Hogskin	pH	Conductivity	DO (%)	DO (mg/L)	Temp. (C)	Acidity	Alkalinity	Sulfate (mg/L)	Aluminum (mg/L)	Arsenic (mg/L)	Calcium (mg/L)	Copper (mg/L)	Manganese (mg/L)	Zinc (mg/L)	Ttl Iron (mg/L)	Flow (cfs)
9/1/04	4.84	53		8.68	22.66	20.00	0.00	17.00	<.10		3.07		0.12		0.22	
11/20/03	4.99	33.9		10.60	11.90	0.00	5.00	8.60	< 0.10		0.92		1.7		1.59	
8/19/03	4.26	66		8.02	23.80	36.00	0.00	31.70	0.05		4.75		0.3		0.26	
5/29/03	4.06	95.7		9.59	16.53	46.00	0.00	26.50	<0.001		3.52		0.1		1.16	
4/29/03	4.3	77.5		9.80	14.40	50.00	0.00	16.00	< .001		3.10		0.22		0.31	
2/28/03	4.19	67.25		12.05	8.56	150.00	0.00	82.50	0.33		46.00		0.77		4.22	
1/30/03	4.47	56.5		12.60	2.76	27.00	0.00	15.00	0.03		4.01		0.31		0.10	
1/8/03	4.2	76.84		11.20	4.48	10.00	0.00	20.00	0.04		4.10		0.12		0.13	
12/3/02	4.27	118.7		12.70	5.05	20.00	0.00	22.00	0.05		1.79		0.14		0.44	
10/31/02	4.54	64.6		8.50	13.63	60.00	0.00	20.00	0.001		2.45		0.08		0.22	
9/26/02	3.75	146		8.40	19.10	77.00	0.00	xxx	0.05		14.70		0.24		0.09	
7/24/02	4.56	109.3		4.65	25.07	60.00	0.00	41.50	0.03		4.60		0.16		0.07	
6/27/02	5	79		7.80	24.99	19.00	3.00	9.50	0.02		6.70		0.14		0.10	
5/30/02	5.4	44		2.91	18.40	39.00	5.00		0.14		26.75		0.19		0.12	
5/2/02	3.45	58		9.60	16.30	14.00	0.00	5.00	0.04		3.10		0.17		0.75	
3/28/02	3.63	84			10.10	14.00	1.00	23.00	1.06		2.19		0.122		0.24	

North Chickamauga Creek Watershed Monitoring Data (USOSM)

Entries Discharging into Hogskin	pH	Conductivity	DO (%)	DO (mg/L)	Temp. (C)	Acidity	Alkalinity	Sulfate (mg/L)	Aluminum (mg/L)	Arsenic (mg/L)	Calcium (mg/L)	Copper (mg/L)	Manganese (mg/L)	Zinc (mg/L)	Ttl Iron (mg/L)	Flow (cfs)
9/1/04	2.62	1533		11.50	14.29	520.00	0.00	574.00	1.44		120.00		5.42		9.40	-----
11/20/03	2.87	1066		6.77	14.20	36.00	0.00	362.00	2.47		97.50		75		53.80	0.12042
8/19/03	2.61	1078		6.40	14.40	430.00	0.00	492.00	0.7		155.00		4.0		10.00	0.168
5/29/03	2.75	1607		6.23	14.29	290.00	0.00	58.00	1.04		174.00		3.9		19.00	0.261
4/29/03	2.79	2050		7.60	13.76	380.00	0.00	387.50	2.19		200.00		2.8		10.20	0.18
2/28/03	2.68	1546		8.10	13.48	420.00	0.00	370.00	1.16		124.00		3.38		27.50	0.48
1/30/03	2.73	1466		8.20	13.36	400.00	0.00	500.00	1.39		142.00		2.6		6.10	0.1
1/8/03	2.62	1635		7.00	13.84	600.00	0.00	450.00	0.6		165.00		1.16		7.60	0.18
12/3/02	2.83	1799		6.65	14.14	590.00	0.00	687.50	1.15		169.00		4.12		16.60	0.37
10/31/02	2.64	1445		6.60	14.57	505.00	0.00	500.00	1.14		160.00		3.72		9.60	0.045
9/26/02	2.48	1810		3.60	14.28	760.00	0.00	xxx	2.7		160.00		4.5		15.50	
7/24/02	2.48	2088		-----	14.24	642.00	0.00	850.00	3.15		160.00		5.16		14.30	0.019
6/27/02	4.5	1974		6.90	14.20	620.00	0.00	775.00	2.05		190.00		5.4		17.70	0.077
5/30/02	3.55	1690		8.87	14.28	520.00	0.00	662.50	2.75		200.00		5.13		12.50	0.16
5/2/02	2.66	1554		7.58	14.03	470.00	0.00	250.00	0.59		175.00		3.28		11.80	0.55
3/28/02	2.96	1460			13.70	330.00	U	637.00	38.5		31.40		2.83		16.30	0.24
10/31/01	3.01	3288		5.60	14.27	794.00	U	1268.00	88.2		57.50		7.28		26.60	-----
6/20/01	2.69	1215		20.94	14.20	551.00	U	1047.00	60.7		48.60		5.38		20.30	0.79
2/14/01	2.55	674		0.00	12.60	289.00	U	515.00	32.9		26.40		1.89		10.10	
7/12/00	2.52	419		0.15	14.25				0.76				8.8		20.90	0.0767
1/12/00	2.46	242		3.60	13.40	263.00	U	452.00	22.2	0.002	24.80	0.013	3.16	0.235	7.75	0.27
4/29/99	2.91	435	104.4	32.90	13.18	78.00	0.00	109.00	5.91	0.002	7.27	0.003	0.872	0.064	1.48	-----
5/5/95	2.8	882	----	----	13.30	194.00	<1.0	273.00	21.8	----	21.40	----	2.37	0.218	7.76	1.33

North Chickamauga Creek Watershed Monitoring Data (USOSM)

Hogskin Br. Above Entries	pH	Conductivity	DO (%)	DO (mg/L)	Temp. (C)	Acidity	Alkalinity	Sulfate (mg/L)	Aluminum (mg/L)	Arsenic (mg/L)	Calcium (mg/L)	Copper (mg/L)	Manganese (mg/L)	Zinc (mg/L)	Ttl Iron (mg/L)	Flow (cfs)
9/1/04	5.15	54		9.50	18.38	26.00	0.00	6.60	<.10		3.12		0.25		0.16	-----
11/20/03	5.6	27.2		8.90	13.80	265.00	2.00	10.40	0.16		1.10		3.5		1.01	0.2007
8/19/03	5.16	40		7.20	20.60	20.00	7.00	21.10	0.05		3.22		0.17		0.39	0.12
5/29/03	4.21	75.33		7.85	15.22	40.00	0.00	8.50	0.04		3.94		0.19		0.94	0.291
4/29/03	4.7	79.9		8.60	14.30	20.00	0.00	5.00	< .001		3.40		0.11		0.15	0.18
2/28/03	5.71	28.3		10.15	8.15	12.00	4.00	9.00	0.08		156.00		0.12		1.22	1
1/30/03	4.57	49.3		11.30	4.95	40.00	0.00	8.50	0.04		3.14		0.39		0.24	0.53
1/8/03	4.4	54.09		10.40	6.57	16.00	0.00	5.00	0.02		3.00		0.1		0.15	0.39
12/3/02	5.33	32.33		9.79	8.02	25.00	3.00	5.00	0.02		1.29		0.11		0.52	0.06
10/31/02	4.82	42.9		8.00	14.39	21.00	2.00	5.00	0.001		2.06		0.07		0.14	0.156
9/26/02	4.91	59		8.20	18.14	38.00	2.00	xxxx	0.04		2.44		0.09		0.21	
7/24/02	DRY															DRY
6/27/02	DRY															DRY
5/30/02	5.15	42		6.05	14.07	30.00	3.00	5.00	0.05		5.25		0.22		0.26	0.09
5/2/02	3.77	36		8.10	15.29	36.00	0.00	7.00	0.09		2.18		0.1		0.80	0.23
3/28/02	3.9	33			10.71	U	2.00	10.00	0.233		1.39		0.017		0.06	0.5
10/31/01	DRY															
7/12/00	----	-----		----	----											0
1/12/00	4.58	4.97		16.87	10.31	U	2.00	7.00	0.196	U	1.44	U	U	0.002	0.04	----

North Chickamauga Creek Watershed Monitoring Data (USOSM)

Drain above Hogskin	pH	Conductivity	DO (%)	DO (mg/L)	Temp. (C)	Acidity	Alkalinity	Sulfate (mg/L)	Aluminum (mg/L)	Arsenic (mg/L)	Calcium (mg/L)	Copper (mg/L)	Manganese (mg/L)	Zinc (mg/L)	Ttl Iron (mg/L)	Flow (cfs)
9/1/04	DRY															
11/20/03	DRY															
8/19/03	DRY															
5/29/03	DRY															
4/29/03	DRY															
2/28/03	4.63	21.6		10.40	8.92	21.00	4.00	5.00	0.05		7.70		0.1		0.82	0.022
1/30/03	DRY															
1/8/03	DRY															
12/3/02	DRY															
10/31/02	DRY															DRY
9/26/02	DRY															DRY
7/24/02	DRY															DRY
6/27/02	DRY															DRY
5/30/02	DRY					DRY										DRY
5/2/02	3.44	15		6.85	16.32	13.00	0.00	<5	0.06		1.15		0.15		0.65	0.004
3/28/02	3.7				11.78											0.022

North Chickamauga Creek Watershed Monitoring Data (USOSM)

Combined East of Hogskin Discharge	pH	Conductivity	DO (%)	DO (mg/L)	Temp. (C)	Acidity	Alkalinity	Sulfate (mg/L)	Aluminum (mg/L)	Arsenic (mg/L)	Calcium (mg/L)	Copper (mg/L)	Manganese (mg/L)	Zinc (mg/L)	Ttl Iron (mg/L)	Flow (cfs)
9/1/04	DRY															
11/20/03	3.67	176.7		7.90	13.30											0.2
8/19/03	3.03	419		5.20	18.80	130.00	0.00	154.00	0.34		41.10		1.52		1.88	0.048
5/29/03	3.17	596.3		5.99	14.67	164.00	0.00	160.00	0.45		64.00		1.67		3.00	0.072
4/29/03	3.24	656		7.80	14.15	100.00	0.00	80.00	0.22		50.00		0.76		1.19	0.01
2/28/03	3.25	332.5		1.07	9.85	80.00	0.00	60.00	0.39		36.00		0.6		2.96	0.64
1/30/03	3.32	291.2		10.20	5.08	100.00	0.00	68.00	0.12		27.70		0.7		0.33	0.03
1/8/03	3	596.2		8.60	8.18	190.00	0.00	133.75	0.15		49.00		0.32		0.27	0.082
12/3/02	Trick															trickle
10/31/02	DRY															
9/26/02	3.19	628		6.20	16.89	140.00	0.00	xxx	0.28		60.00		1.9		1.47	trickle
7/24/02	DRY															DRY
6/27/02	DRY															DRY
No Flow																No Flow
5/2/02	2.91	360		7.34	16.41	86.00	0.00	36.50	0.12		41.00		0.6		1.40	0.06
3/28/02	3.47	401			11.51	57.00	U	131.00	6.606		7.41		0.902		1.07	0.048

North Chickamauga Creek Watershed Monitoring Data (USOSM)

Brimer Creek at Double Bridges	pH	Conductivity	DO (%)	DO (mg/L)	Temp. (C)	Acidity	Alkalinity	Sulfate (mg/L)	Aluminum (mg/L)	Arsenic (mg/L)	Calcium (mg/L)	Copper (mg/L)	Manganese (mg/L)	Zinc (mg/L)	Ttl Iron (mg/L)	Flow (cfs)
8/31/04	6.32	38.6		14.25	19.10	0.00	18.00	8.80	<.10		3.04		0.08		0.07	
11/19/03	6.34	43.9		7.60	13.20	0.00	10.00	7.20	< 0.10		1.90		3.6		0.90	
8/18/03	5.5				19.44	3.00	7.00	7.10	0.05		3.16		0.07		0.14	
6/3/03	5.8	30.95		8.81	15.33	23.00	4.00	5.50	0.05		2.06		0.09		0.10	
3/13/03	5	40		8.70	8.60	5.00	3.00	5.50	0.001		3.16		0.08		0.36	
12/3/02	5.99	31.74		12.00	4.30	29.00	3.00	7.50	0.001		1.10		0.09		0.29	----
8/13/02	Stag															Stag
3/25/02	5.45	34		10.20	8.50	U	4.00	8.00	0.229		0.94		0.021		0.03	-----
10/31/01	4.72	50		10.10	5.77	U	11.00	6.00	0.125		2.67		0.012		0.15	-----
6/19/01	5.68	22		13.03	19.96	U	5.00	5.00	0.27		2.29		0.024		0.13	
7/12/00	5.02	4.9		7.90	21.90				<.001				0.1		0.12	
Upper Brimer Creek	**pH**	**Conductivity**	**DO (%)**	**DO (mg/L)**	**Temp. (C)**	**Acidity**	**Alkalinity**	**Sulfate (mg/L)**	**Aluminum (mg/L)**	**Arsenic (mg/L)**	**Calcium (mg/L)**	**Copper (mg/L)**	**Manganese (mg/L)**	**Zinc (mg/L)**	**Ttl Iron (mg/L)**	**Flow (cfs)**
8/31/04	6.35	41		13.80		19.92	0.00	21.00	9.1		2.94		0.08		0.29	
11/19/03	5.46	60.65		7.50	13.40	12.00	7.00	10.40	0.25		1.77		7		1.60	
8/18/03	6.06	51			20.00	15.00	11.00	10.90	0.05		2.70		0.09		0.16	
3/12/03	5	40		8.80		15.00	4.00	8.00	0.001		3.25		0.1		0.24	-----
12/2/02	5.76	45.6		8.03	3.48	27.00	4.00	10.00	0.001		2.00		0.09		0.10	----
8/13/02	DRY															DRY
10/30/01	4.31	54		10.74	5.35	U	9.00	7.00	0.13		2.40		0.414		0.49	-----
7/25/01	5.16	70			23.58											

**LaMotte wide range colorimetric pH test equipment was used to take field pH measurements 3/12 - 3/13/03

APPENDIX E

Development of Target Load Duration Curve for North Chickamauga Creek Subwatershed

E1 Definition of Duration Curve

A duration curve is a cumulative frequency graph that represents the percentage of time during which the value of a given parameter is equaled or exceeded. Load duration curves are developed from flow duration curves and are useful for TMDL analysis:

- Load duration curves can serve as TMDL targets, thereby establishing allowable loading to waterbodies over the entire range of flow.
- Pollutant monitoring data, plotted on a load duration curve, provides a visual depiction of stream water quality with respect to allowable loads. The frequency and magnitude of exceedances are also illustrated.
- Load duration curves can be used to characterize the flow conditions under which exceedances occur. For example, exceedances that occur in the 0% to 10% area of the curve may be considered to represent extreme high flow problems that may be beyond feasible management solutions. Exceedances in the 99% to 100% area reflect extreme drought conditions.

E2 Development of Flow Duration Curve

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 Loading Simulation Program in C^{++} (LSPC).

Because there are no currently operating or historical USGS gages with more than three years of streamflow data in the North Chickamauga Creek subwatershed, flow duration curves for subwatersheds within the North Chickamauga Creek subwatershed were derived using the calculated daily mean flow data generated by LSPC. The model parameters used for the Lookout Creek subwatershed as described in Appendix F were applied to the North Chickamauga Creek subwatersheds and adjusted based on physical characteristics and best professional judgment.

The LSPC model simulation was run for each subwatershed for an 11-year period, with the first year allowed for model stabilization. Simulated daily mean flow data for the remaining 10 years (10/1/90 – 9/30/00) were sorted and ranked from highest flow to lowest flow. 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. The percent of days flow exceeded (PDFE) associated with each simulated flow rate was calculated by subtracting one from the ranking and dividing the result by the number of flow data points. (In this example, the number of data points was 3,653.) A flow duration curve was constructed by plotting PDFE on the x-axis and simulated daily mean flow on the y-axis.

The flow duration curve for Cooper Creek is presented in Figure E-1. Flow duration curves for monitoring sites along the North Chickamauga Creek are similar.

E3 Development of Target Load Duration Curve

The target net alkalinity load duration curve for the North Chickamauga Creek subwatershed was developed from the flow duration curve for Cooper Creek developed in Section E2. The net alkalinity target concentration of 7.16 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:

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

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 Figure E-2. Figure E-2 is presented in non-log scale format while Figure E-1 was presented in semi-log scale format. Because the calculated net alkalinity of North Chickamauga Creek subwatersheds 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.

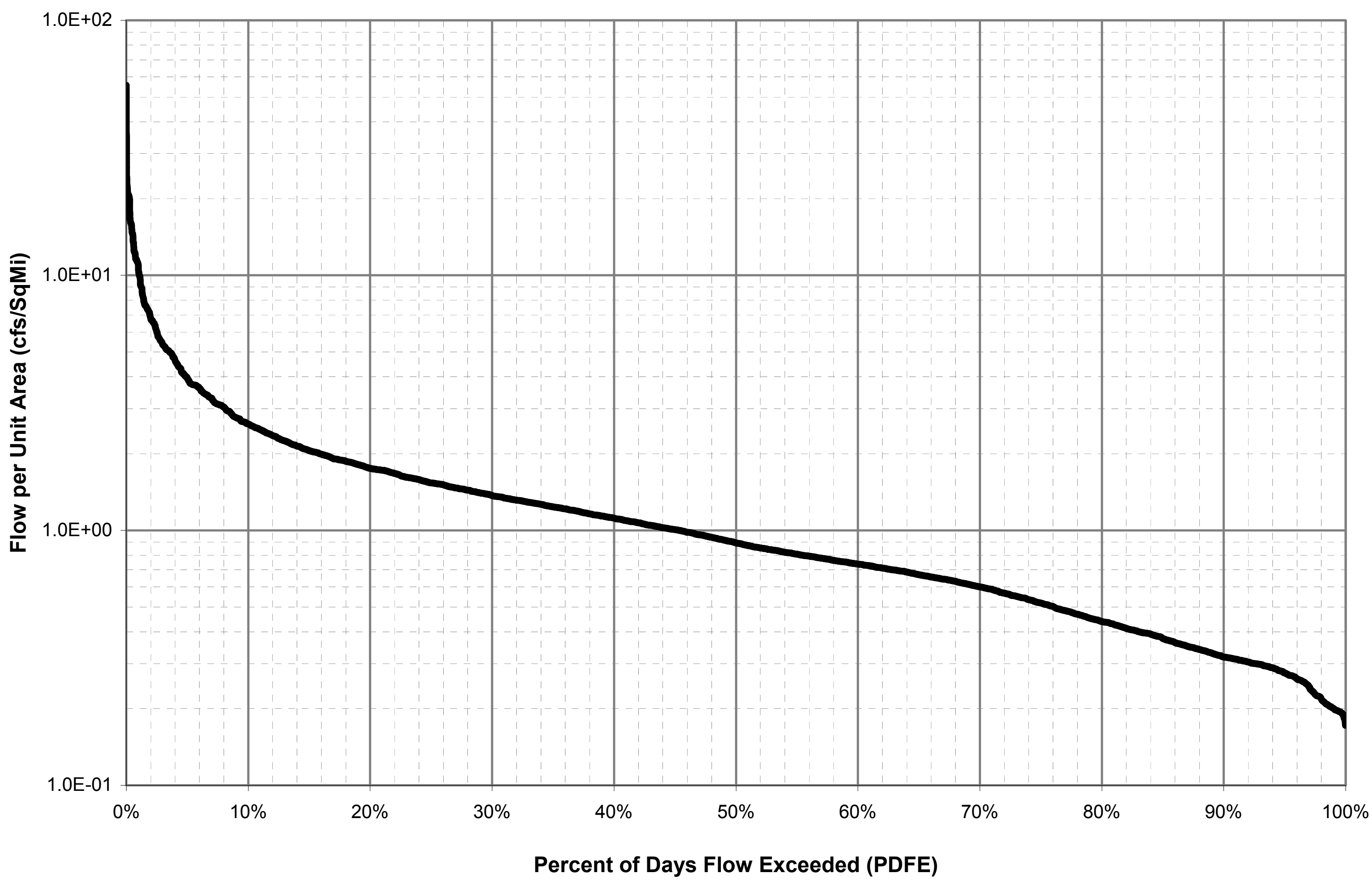


Figure E-1 Cooper Creek Flow Duration Curve

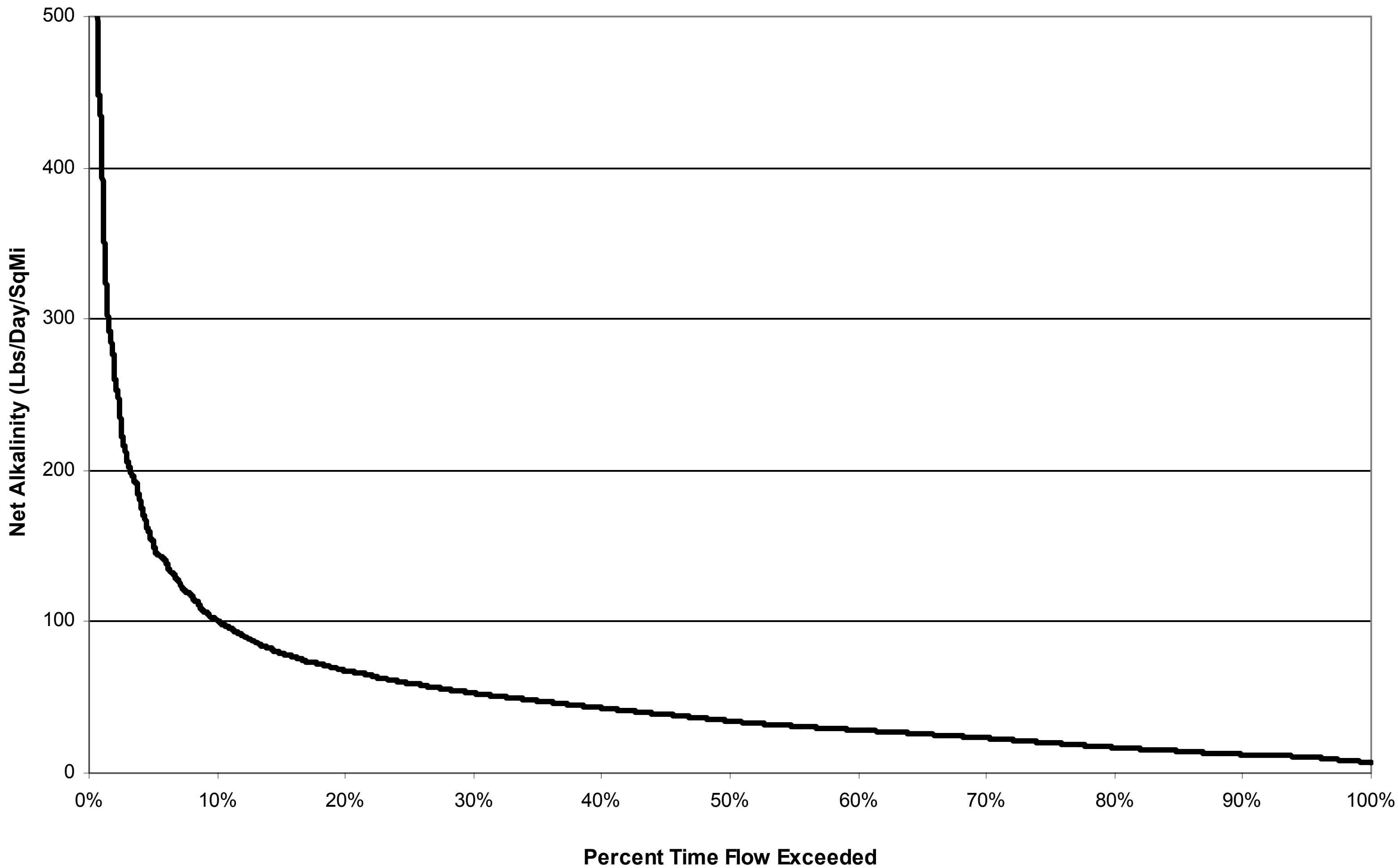


Figure E-2 Target Load Duration Curve

APPENDIX F

Dynamic Loading Model Methodology

F1 Model Selection

The Loading Simulation Program C++ (LSPC) was selected for TMDL analyses of pH impaired waters in the North Chickamauga Creek subwatershed. LSPC is a watershed model capable of simulating nonpoint source runoff and associated pollutant loadings and performing flow routing through stream reaches. LSPC is a dynamic watershed model based on the Hydrologic Simulation Program – Fortran (HSPF).

F2 Model Set Up

The North Chickamauga Creek subwatershed was delineated into subwatersheds in order to facilitate model hydrologic calibration. Boundaries were constructed so that subwatershed "pour points" coincided with water quality monitoring stations. Watershed delineation was based on the Reach File 3 (RF3) stream coverage and Digital Elevation Model (DEM) data. This discretization allows management and load reduction alternatives to be varied by subwatershed.

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 North Chickamauga Creek subwatershed. This information includes land use categories, point source dischargers, soil types and characteristics, population data (human and livestock), and stream characteristics. WCS was used to provide GIS and watershed data to the LSPC model.

An important factor influencing model results is the precipitation data contained in the meteorological data file used in the simulation. The pattern and intensity of rainfall affects the dilution potential of the stream. Weather data from the Chattanooga meteorological station were available for the time period from January 1970 through August 2004. 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 (10/1/90 – 9/30/00) used for TMDL analysis.

F3 Model Calibration

Hydrologic calibration of the watershed model involves comparison of simulated stream flow to historic stream flow data from USGS stream gaging stations for the same period of time. Because there are no currently operating or historical USGS gages with more than three years of streamflow data in the North Chickamauga Creek subwatershed, the USGS continuous record station located in Lookout Creek near New England, Georgia (USGS 03568933) was used for hydrology calibration. This gaging station is located in the Tennessee River watershed and also is located in the same Level IV ecoregions as the North Chickamauga Creek subwatershed.

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 stream flow. 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 Lookout Creek at USGS Station 03568933 are shown in Table F-1 and Figure F-1.

Table F-1 Hydrologic Calibration Summary of Lookout Creek at USGS Station 03568933

Simulation Name:	Lookout Creek	**Simulation Period:**	
		Watershed Area (ac):	93274.24
Period for Flow Analysis			
Begin Date:	**10/01/90**	**Baseflow PERCENTILE:**	2.5
End Date:	**09/30/00**	*Usually 1%-5%*	
Total Simulated In-stream Flow:	**228.88**	Total Observed In-stream Flow:	**249.77**
Total of highest 10% flows:	**121.42**	Total of Observed highest 10% flows:	**127.26**
Total of lowest 50% flows:	**21.11**	Total of Observed Lowest 50% flows:	**20.77**
Simulated Summer Flow Volume (months 7-9):	**19.30**	Observed Summer Flow Volume (7-9):	**13.18**
Simulated Fall Flow Volume (months 10-12):	**44.89**	Observed Fall Flow Volume (10-12):	**44.91**
Simulated Winter Flow Volume (months 1-3):	**113.38**	Observed Winter Flow Volume (1-3):	**132.90**
Simulated Spring Flow Volume (months 4-6):	**51.32**	Observed Spring Flow Volume (4-6):	**58.77**
Total Simulated Storm Volume:	**221.17**	Total Observed Storm Volume:	**235.85**
Simulated Summer Storm Volume (7-9):	**17.37**	Observed Summer Storm Volume (7-9):	**9.73**
Errors (Simulated-Observed)		*Recommended Criteria*	Last run
Error in total volume:	**-8.36**	10	
Error in 50% lowest flows:	**1.64**	10	
Error in 10% highest flows:	**-4.59**	15	
Seasonal volume error - Summer:	**46.36**	30	
Seasonal volume error - Fall:	**-0.06**	30	
Seasonal volume error - Winter:	**-14.69**	30	
Seasonal volume error - Spring:	**-12.68**	30	
Error in storm volumes:	**-6.22**	20	
Error in summer storm volumes:	**78.55**	50	

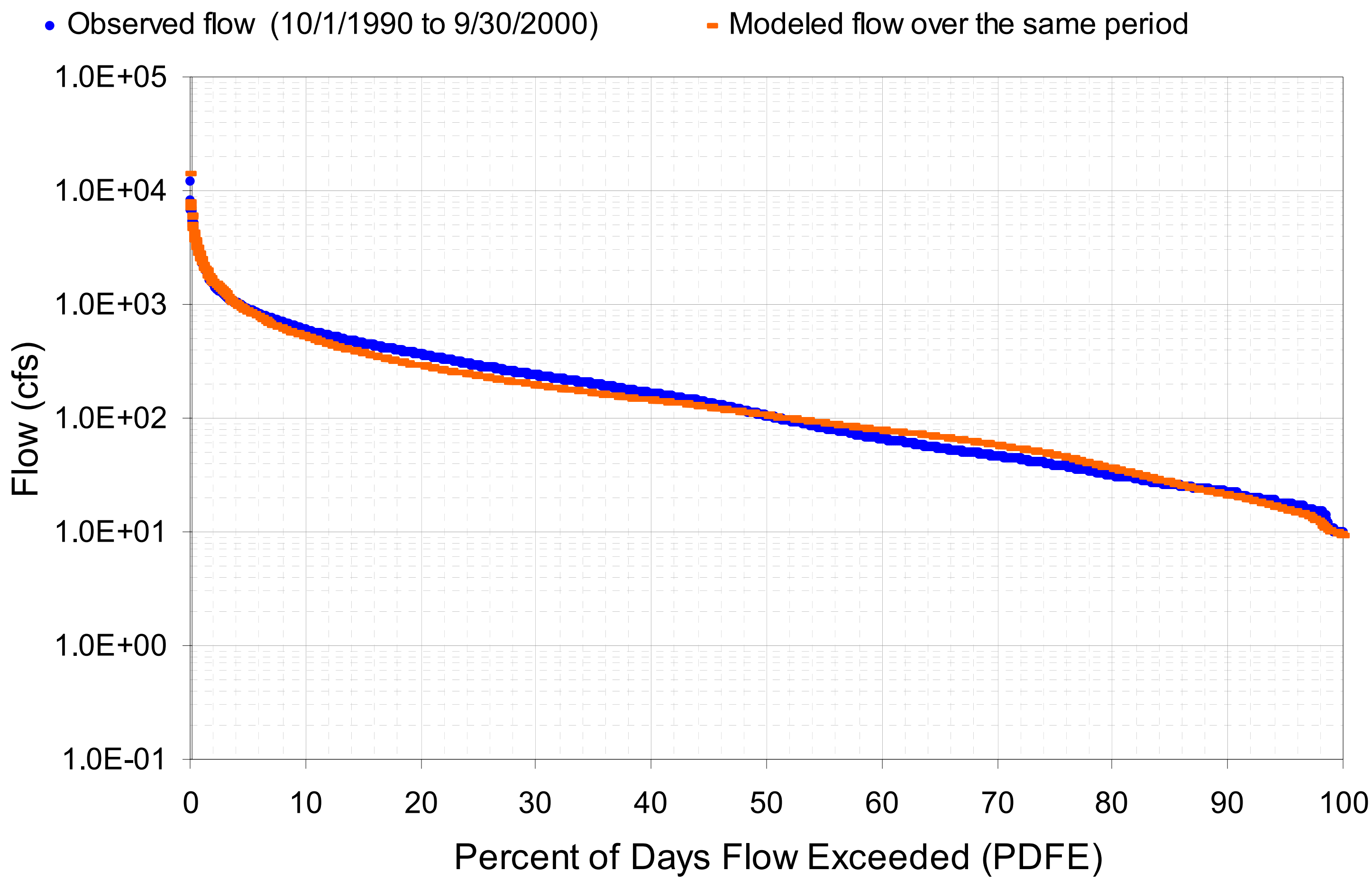


Figure F-1 Comparison of Simulated Flow vs. Observed Flow at USGS 03568933

APPENDIX G

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

Sampling was conducted at several sites in the North Chickamauga Creek subwatershed by TDEC and USOSM. Net alkalinity load duration curves were developed for the North Chickamauga Creek subwatersheds from the target load duration curve developed in Section E2 and water quality monitoring data collected by TDEC and USOSM. Load duration curves were developed using the following procedure (North Chickamauga Creek, Mile 12.4, at Boy Scout Road, is shown as an example; others are similar):

1. Daily net alkalinity loads were calculated for each of the water quality samples collected at the Boy Scout Road 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 North Chickamauga Creek subwatershed are summarized in Tables G-1 through G-4.

   Example – 3/15/04 sampling event:

   Calculated Net Alkalinity = 31.53 mg/L $CaCO_3$
   N. Chick Ck. At Boy Scout Road flow = 146.34 cfs
   Drainage area of the North Chickamauga Creek subwatershed,
   upstream of Boy Scout Road = 97.47 mi^2

   Net Alkalinity Load = 255.35 lbs $CaCO_3$/day/mi^2

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

   Example – 3/15/04 sampling event:

   Boy Scout Road flow = 146.34 cfs
   Drainage area upstream of Boy Scout Road = 97.47 mi^2
   Boy Scout Road flow per unit area = 1.501 cfs/mi^2

   PDFE from flow duration curve for Boy Scout Road monitoring site
   corresponding to 1.501 cfs/mi^2 = 26.06%

3. Each sample load was then plotted on the target load duration curve developed in Section E3 according to the PDFE. The resulting curve is presented in Figure G-1. (Load duration curves for other impaired waterbodies are presented in Figures G-2 through G-4.)

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

   $$\text{Net Alkalinity}_{\text{Difference}} = (\text{Net Alkalinity}_{\text{Boy Scout Road}}) - (\text{Net Alkalinity}_{\text{Target}})$$

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

Example – 3/15/04 sampling event:

Boy Scout Road net alkalinity = 255.35 lbs $CaCO_3$/day/mi^2

Net alkalinity$_{Difference}$ = (255.35 lbs $CaCO_3$/day/mi^2) – (57.99 lbs $CaCO_3$/day/mi^2)

Net alkalinity$_{Difference}$ = 197.36 lbs $CaCO_3$/day/mi^2

The difference between the target net alkalinity load and the calculated net alkalinity load for the subwatersheds within the North Chickamauga Creek subwatershed are summarized in Tables G-5 through G-8.

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

The net alkalinity difference as calculated for North Chickamauga Creek at Boy Scout Road (RM 12.4) and illustrated in Figure G-1 is consistent with its assessment as fully supporting.

Table G-1 Calculated Net Alkalinity at North Chickamauga Creek (Mile 12.4)

Sample	N. Chickamauga Ck. Flow At Mile 12.4		Acidity	Total Alkalinity	Net Alkalinity	
Date	(cfs)	(cfs/mi^2)	(mg/L)[b]	(mg/L)[b]	(mg/L)[b]	($lbs/day/mi^2$)[b]
8/25/03	52.05	0.534	3.40	68.2	64.8	186.65
9/16/03	17.31	0.178	4.23	80.7	76.47	73.26
10/14/03	28.52	0.293	2.92	82.8	79.88	126.08
11/17/03	50.13	0.514		60.8	60.8	168.67
12/16/03	high		2.20	17.1	14.9	
1/21/04						
2/19/04	high		2.61	17.1	14.49	
3/15/04	146.34	1.501	1.57	33.1	31.53	255.35
4/20/04	75.25	0.772	1.84	37.3	35.46	147.67
5/10/04	42.76	0.439	2.64	47.1	44.46	105.21
6/10/04	19.65	0.202	1.43	74.3	72.87	79.22
7/13/04	54.23	0.556	0.50[a]	56.1	55.6	166.86

a Reported as not detected; value shown is ½ sample quantitation limit.
b Acidity, total alkalinity, & net alkalinity are reported as mg/l $CaCO_3$ or $lbs/day/mi^2$.

Table G-2 Calculated Net Alkalinity at North Chickamauga Creek (Mile 19.3)

Sample	N. Chickamauga Ck. Flow At Mile 19.3		Acidity	Total Alkalinity	Net Alkalinity	
Date	(cfs)	(cfs/mi^2)	(mg/L)[b]	(mg/L)[b]	(mg/L)[b]	($lbs/day/mi^2$)[b]
8/25/03	15.50	0.261	3.10	7.91	4.81	6.76
9/16/03	4.99	0.084	6.46	5.00[a]	-1.46	-0.66
10/14/03	9.43	0.158	2.60	5.00[a]	2.40	2.05
11/17/03	69.00	1.160		4.50	4.50	28.15
12/16/03	263.00	4.420	3.25	5.00[a]	1.75	41.72
1/21/04	62.00	1.042				
2/19/04	188.00	3.159	3.09	5.00[a]	1.91	32.55
3/15/04	58.00	0.975	3.98	5.00[a]	1.02	5.36
4/20/04	31.00	0.521	2.92	3.02	0.10	0.28
5/10/04	11.00	0.185	1.37	5.00[a]	3.63	3.62
6/10/04	0.00	0.000		5.00[a]	5.00	0.00
7/13/04	3.10	0.052	2.53	5.00[a]	2.47	0.69

a Reported as not detected; value shown is ½ sample quantitation limit.
b Acidity, total alkalinity, & net alkalinity are reported as mg/l $CaCO_3$ or $lbs/day/mi^2$.

Table G-3 Calculated Net Alkalinity at North Chickamauga Creek (Mile 28.1)

Sample	N. Chickamauga Ck. Flow At Mile 28.1		Acidity	Total Alkalinity	Net Alkalinity	
Date	(cfs)	(cfs/mi^2)	(mg/L)[b]	(mg/L)[b]	(mg/L)[b]	(lbs/day/mi^2)[b]
8/25/03	2.34	0.228	2.14	11.80	9.66	11.87
9/16/03	0.75	0.073	6.38	5.00[a]	-1.38	-0.54
10/14/03	1.44	0.140	3.44	11.20	7.76	5.88
11/17/03	7.40	0.720		5.99	5.99	23.26
12/16/03	38.14	3.710	2.67	5.00[a]	2.33	46.63
1/21/04						
2/19/04	36.24	3.526	1.83	5.00[a]	3.17	60.29
3/15/04	12.95	1.260	0.50[a]	5.00[a]	4.50	30.58
4/20/04	8.08	0.786	1.08	4.18	3.10	13.15
5/10/04			1.83	5.00[a]	3.17	
6/10/04	2.02	0.196	1.43	5.00[a]	3.57	3.78
7/13/04	3.97	0.386	1.73	5.00[a]	3.27	6.81

a Reported as not detected; value shown is ½ sample quantitation limit.
b Acidity, total alkalinity, & net alkalinity are reported as mg/l $CaCO_3$ or lbs/day/mi^2.

Table G-4 Calculated Net Alkalinity at Standifer Creek (Double Bridges)

Sample	Standifer Creek Flow		Acidity	Total Alkalinity	Net Alkalinity	
Date	(cfs)[a]	(cfs/mi^2)	(mg/L)[c]	(mg/L)[c]	(mg/L)[c]	(lbs/day/mi^2)[c]
12/30/86	4.28	1.264	29.20	0.00	-29.20	-199.12
5/22/95	1.47	0.434	16.00	0.50b	-15.50	-36.30
4/29/99	9.64	2.847	0.00	3.00	3.00	46.08
1/10/00	55.40	16.364	0.50b	2.00	1.50	132.40
7/12/00	0.58	0.171				
6/19/01	2.05	0.606	0.50b	2.00	1.50	4.90
10/31/01	1.04	0.307	11.00	2.00	-9.00	-14.91
3/25/02	3.28	0.969	0.50b	3.00	2.50	13.06
8/14/02	0.31	0.092	11.00	2.00	-9.00	-4.45
12/3/02	2.22	0.656	12.00	2.00	-10.00	-35.37
3/13/03	3.96	1.170	20.00	0.00	-20.00	-126.18
6/3/03	2.74	0.809	21.00	1.00	-20.00	-87.31
8/18/03	1.34	0.396	13.00	4.00	-9.00	-19.21
11/19/03	25.40	7.502	25.00	17.00	-8.00	-323.74
8/31/04	1.52	0.449	1.00	11.00	10.00	24.22

a Measured flow data was not available; modeled flow (LSPC) was used.
b Reported as not detected; value shown is ½ sample quantitation limit.
c Acidity, total alkalinity, & net alkalinity are reported as mg/l $CaCO_3$ or lbs/day/mi^2.

Table G-5 Net Alkalinity Difference Relative to Target
North Chickamauga Creek at Mile 12.4

Sample Date	N Chick Ck Flow at Mile 12.4 (cfs/mi^2)	N Chick 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]
8/26/03	0.534	186.65	74.02	20.62	166.03
9/24/03	0.178	73.26	99.95	6.86	66.40
10/13/03	0.293	126.08	93.51	11.30	114.78
11/17/03	0.514	168.67	75.20	19.86	148.81
12/1/03					
1/21/04					
2/23/04					
3/17/04	1.501	255.35	26.06	57.99	197.37
4/19/04	0.772	147.67	57.30	29.82	117.85
5/13/04	0.439	105.21	79.96	16.94	88.27
6/17/04	0.202	79.22	98.88	7.78	71.44
7/12/04	0.556	166.86	72.52	21.49	145.37

a Percent of Days Flow Is Exceeded
b Net alkalinity is reported as lbs/day/mi^2.

Table G-6 Net Alkalinity Difference Relative to Target
North Chickamauga Creek at Mile 19.3

Sample Date	N Chick Ck Flow at Mile 19.3 (cfs/mi^2)	N Chick 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]
8/26/03	0.261	6.76	96.03	10.06	-3.30
9/24/03	0.084	-0.66	99.97	3.24	-3.90
10/13/03	0.158	2.05	99.97	6.12	-4.07
11/17/03	1.160	28.15	38.02	44.78	-16.64
12/1/03	4.420	41.72	4.24	170.70	-128.98
1/21/04					
2/23/04	3.159	32.55	7.28	122.02	-89.47
3/17/04	0.975	5.36	46.43	37.65	-32.28
4/19/04	0.521	0.28	74.46	20.12	-19.84
5/13/04	0.185	3.62	99.86	7.14	-3.52
6/17/04					
7/12/04	0.052	0.69	99.97	2.01	-1.32

a Percent of Days Flow Is Exceeded
b Net alkalinity is reported as lbs/day/mi^2.

Table G-7 Net Alkalinity Difference Relative to Target
North Chickamauga Creek at Mile 28.1

Sample Date	N Chick Ck Flow at Mile 28.1 (cfs/mi²)	N Chick Ck Net Alkalinity Load (lbs/day/mi²)[b]	PDFE[a] (%)	Target Net Alkalinity Load (lbs/day/mi²)[b]	Net Alkalinity Load Difference (lbs/day/mi²)[b]
8/26/03	0.228	11.87	97.45	8.80	3.07
9/24/03	0.073	-0.54	99.97	2.82	-3.37
10/13/03	0.140	5.88	99.97	5.42	0.45
11/17/03	0.720	23.26	61.32	27.80	-4.54
12/1/03	3.710	46.63	5.58	143.30	-96.67
1/21/04					
2/23/04	3.526	60.29	6.13	136.18	-75.89
3/17/04	1.260	30.58	34.11	48.66	-18.08
4/19/04	0.786	13.15	56.42	30.37	-17.22
5/13/04					
6/17/04	0.196	3.78	99.32	7.58	-3.80
7/12/04	0.386	6.81	84.40	14.91	-8.10

a Percent of Days Flow Is Exceeded
b Net alkalinity is reported as lbs/day/mi².

Table G-8 Net Alkalinity Difference Relative to Target
Standifer Creek at Double Bridges

Sample Date	Standifer Ck Flow (cfs/mi2)	Standifer Ck Net Alkalinity Load (lbs/day/mi²)[b]	PDFE[a] (%)	Target Net Alkalinity Load (lbs/day/mi²)[b]	Net Alkalinity Load Difference (lbs/day/mi²)[b]
12/30/86	1.264	-199.12	34.03	48.82	-247.94
5/22/95	0.434	-36.30	80.56	16.77	-53.07
4/29/99	2.847	46.08	8.68	109.97	-63.89
1/10/00	16.364	132.40	0.33	631.98	-499.58
7/12/00					
6/19/01	0.606	4.90	69.59	23.39	-18.49
10/31/01	0.307	-14.91	91.73	11.86	-26.78
3/25/02	0.969	13.06	46.59	37.42	-24.35
8/14/02	0.092	-4.45	99.97	3.54	-7.98
12/3/02	0.656	-35.37	66.00	25.32	-60.69
3/13/03	1.170	-126.18	37.61	45.17	-171.36
6/3/03	0.809	-87.31	54.75	31.26	-118.57
8/18/03	0.396	-19.21	83.44	15.29	-34.50
11/19/03	7.502	-323.74	1.67	289.75	-613.50
8/31/04	0.449	24.22	79.25	17.34	6.88

a Percent of Days Flow Is Exceeded
b Net alkalinity is reported as lbs/day/mi².

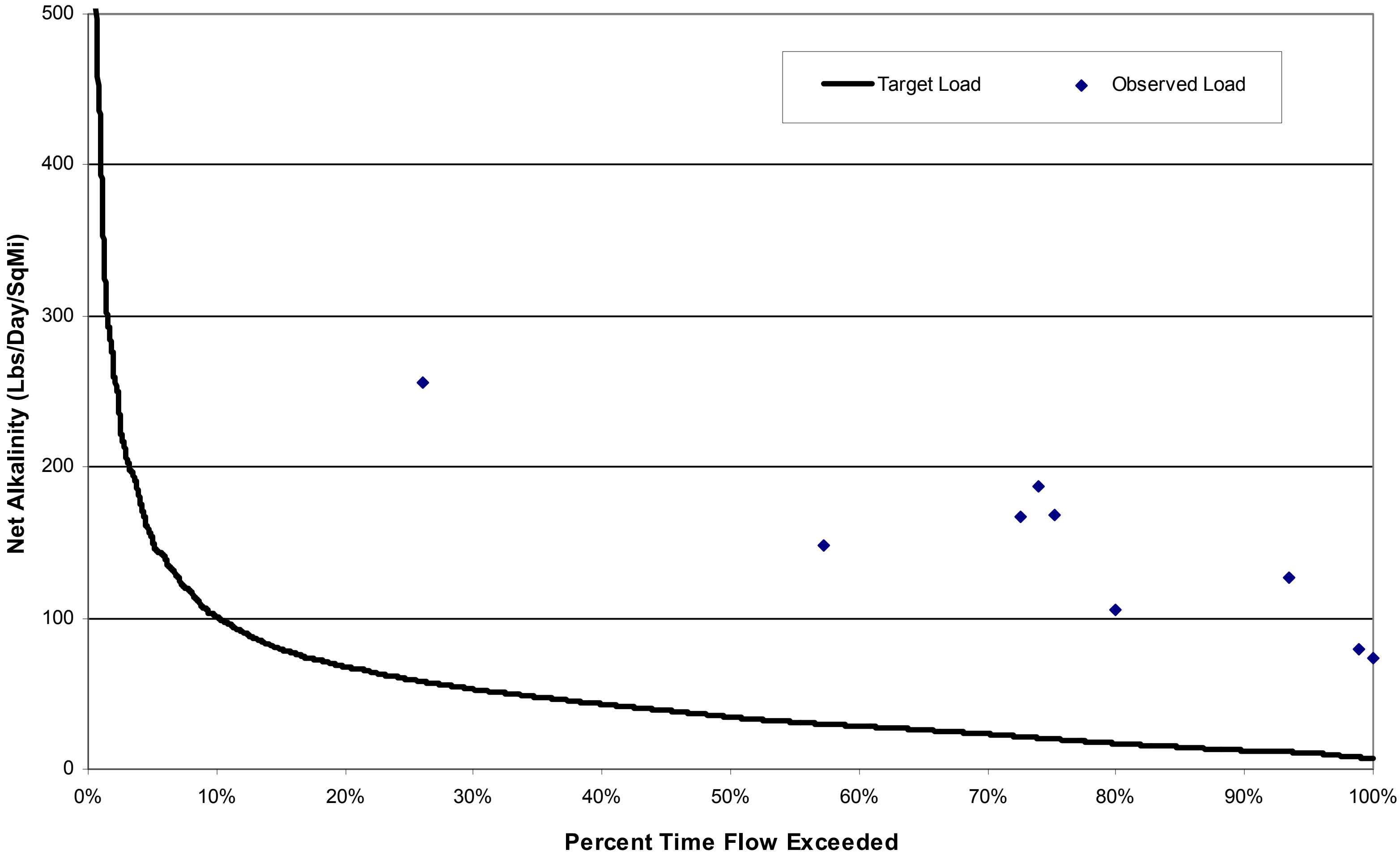


Figure G-1 Net Alkalinity Difference from Target -- North Chickamauga Creek (Mile 12.4)

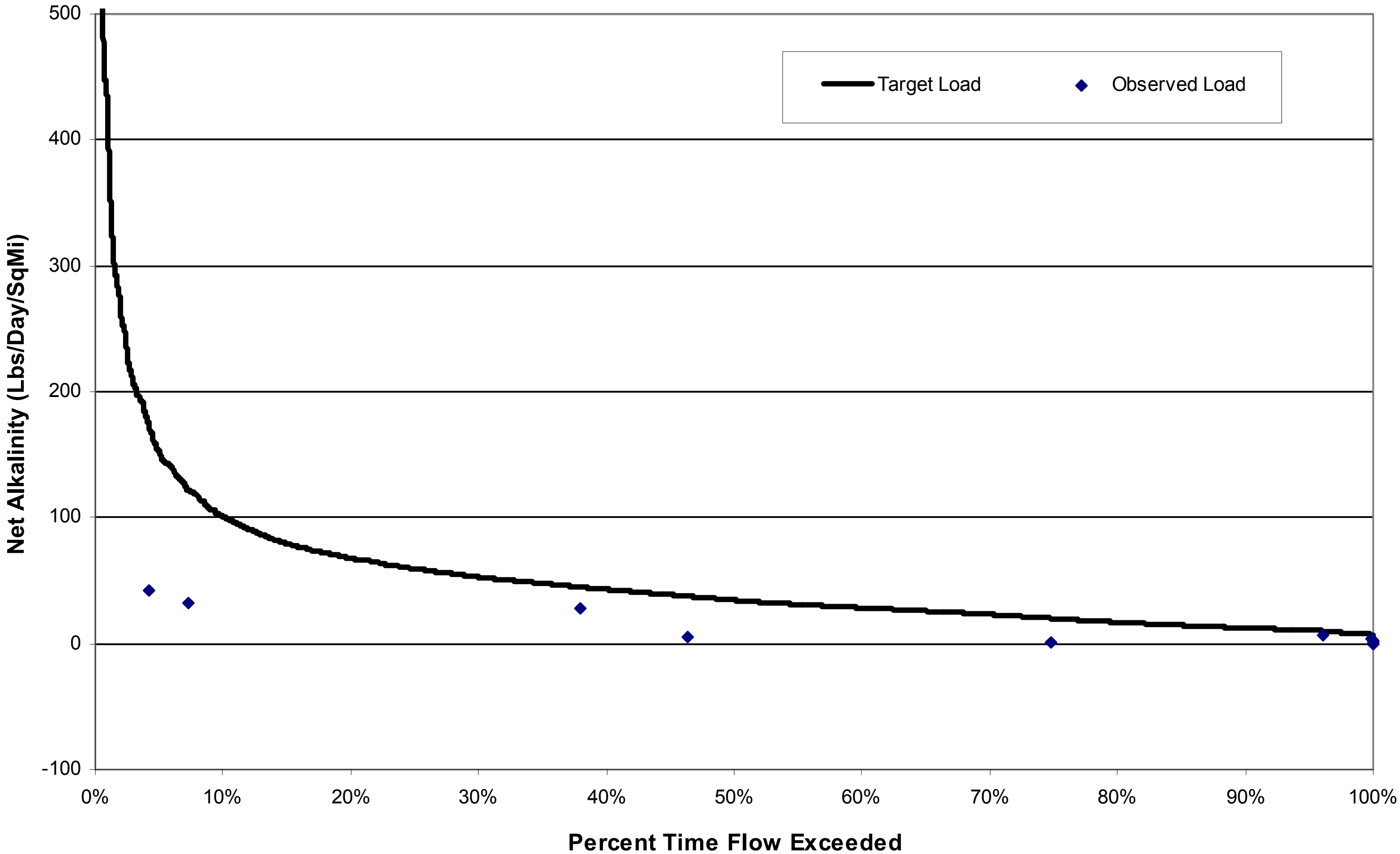


Figure G-2 Net Alkalinity Difference from Target -- North Chickamauga Creek (Mile 19.3)

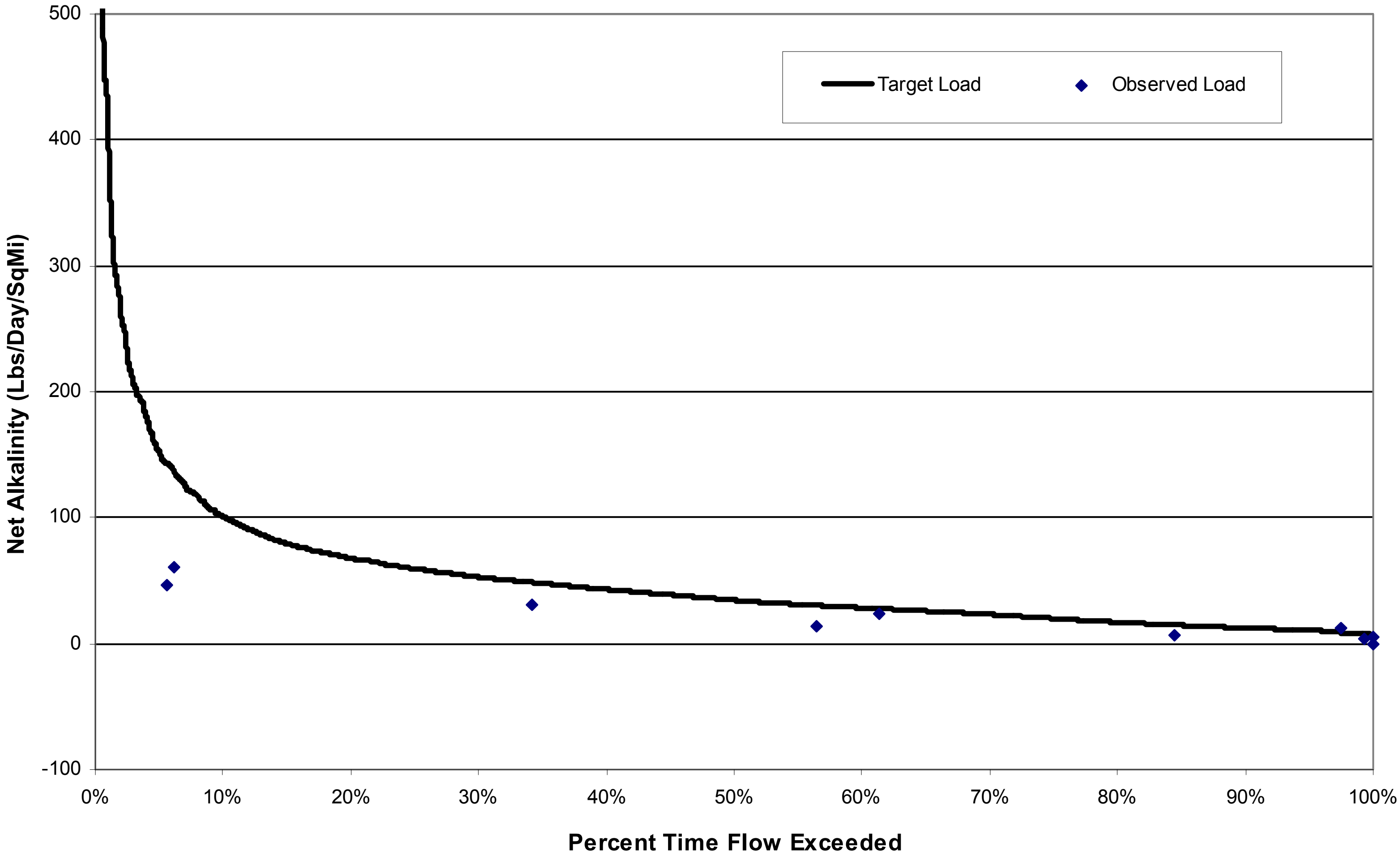


Figure G-3 Net Alkalinity Difference from Target -- North Chickamauga Creek (Mile 28.1)

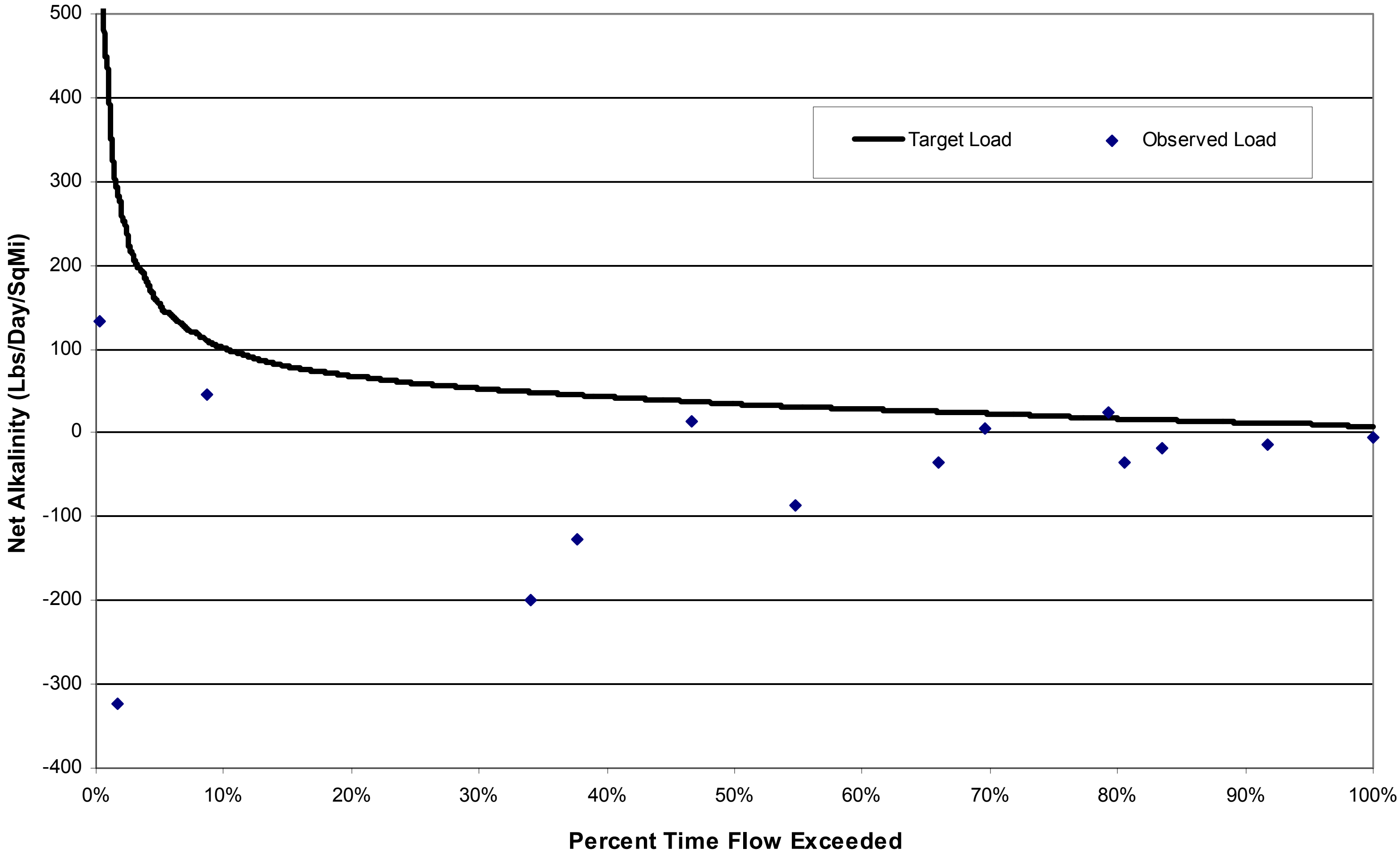


Figure G-4 Net Alkalinity Difference from Target -- Standifer Creek at Double Bridges

APPENDIX H

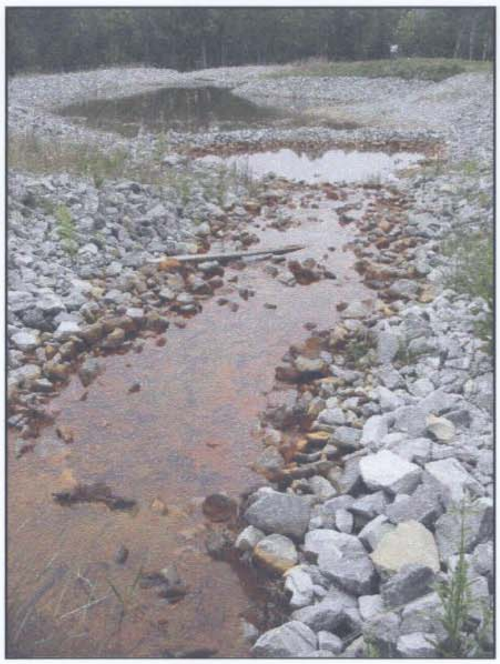
Status of UTC - ERMF Research Project

THIRD QUARTER REPORT
(UTC CONTRACT NO. R041011016)

PREPARED FOR:

THE TENNESSEE DEPARTMENT OF ENVIRONMENT AND CONSERVATION, DIVISION OF WATER POLLUTION CONTROL

TOTAL MAXIMUM DAILY LOAD (TMDL) DESIGN AND IMPLEMENTATION SUPPORT FOR NORTH CHICKAMAUGA CREEK WATERSHED



THE UNIVERSITY OF TENNESSEE AT CHATTANOOGA
Environmental Research and Mapping Facility

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Chattanooga, TN 37403-2598

INTRODUCTION

The University of Tennessee at Chattanooga (UTC) Environmental Research and Mapping Facility (ERMF) submits the following document to fulfill the third quarterly report requirements as designated and agreed upon with the Tennessee Department of Environment and Conservation (TDEC) Division of Water Pollution Control (WPC). As described in previous project documents, the third quarter report shall update Geographic Information Systems (GIS) development and the acquisition of imagery datasets.

PROJECT STATUS

Current land use datasets for Sequatchie and Hamilton Counties were acquired and processed for analysis during the project third quarter. Land use classifications were derived from previously ERMF created property parcel datasets. Three satellite images depicting watershed conditions during 1977, 1988, and 2000 were obtained and processed. This remotely sensed data was incorporated into the existing GIS project database and will serve as the base layer for the study of change over time for the watershed. Initial software applications depicting all watershed properties and associated ownership information were developed. These applications will be distributed to TDEC WPC for use during the TMDL implementation process. Updated environmental monitoring datasets and modeled scenarios will be added to these applications.

MATERIAL AND METHODS

GIS Datasets

The development of present day land use data for the North Chickamauga Creek watershed required that ERMF staff develop a uniform method for the classification of parcel datasets from differing counties. This was accomplished through a two-step data preparation process. First, ERMF staff classified all property parcels based upon assigned tax assessor's land use codes obtained from property deed records. Second, classified properties were assigned to newly created categories that accounted for the discrepancies between the two county systems. For example, Hamilton County classified commercial, warehouse, retail, and specialty services into unique, individual categories. Sequatchie County assigned the same property types to a broad "services" classification. To compare these datasets, ERMF developed a new, watershed-wide category by assuming the encompassing classification set by Sequatchie County (*Fig. 1*). The resulting file depicts present-day land use for the parcels of the entire watershed.

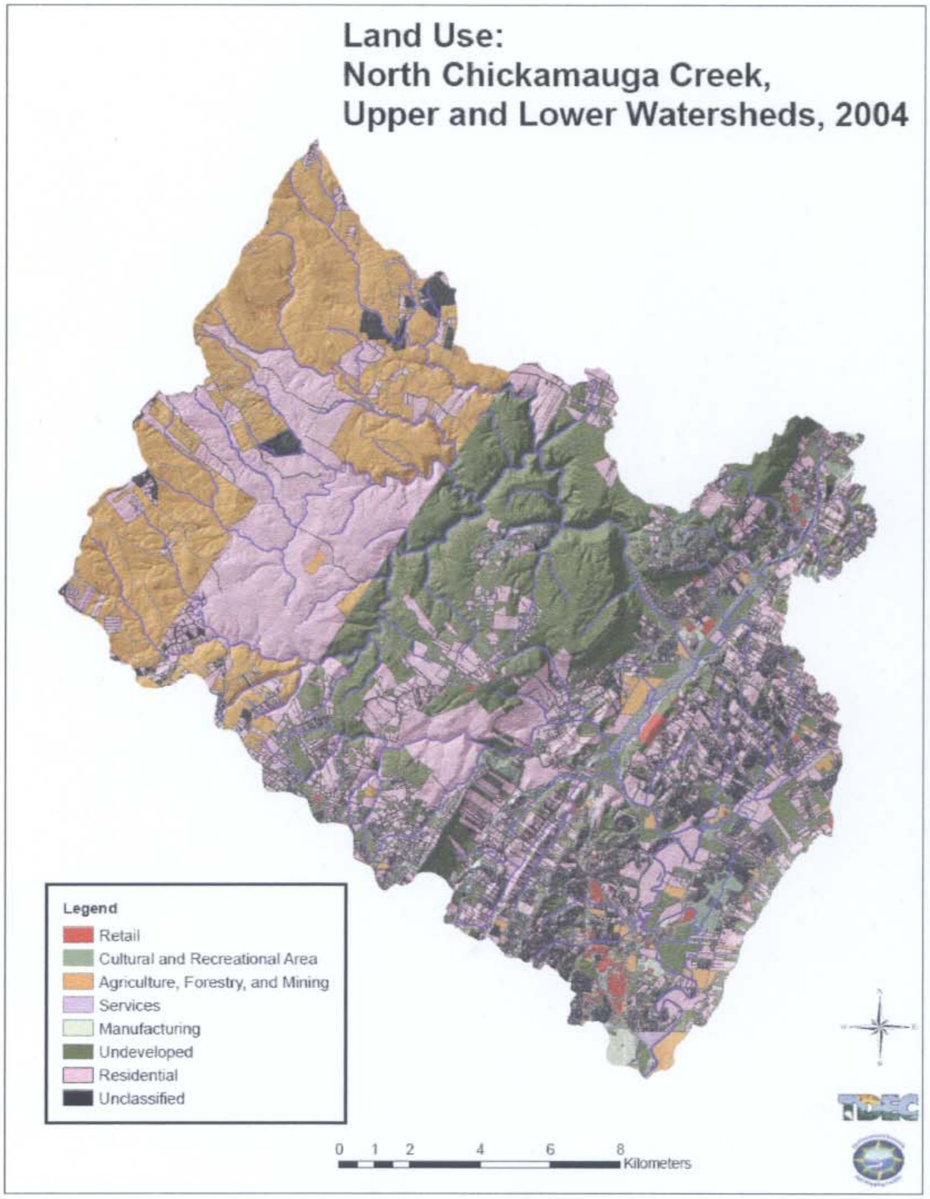

Fig. 1. Parcel based (2004) land use model for North Chickamauga Creek watershed.

Satellite imagery files, specifically color infrared (CIR) LANDSAT images, covering the geographic extent of the project area were acquired. These images were cropped to fit the extent of the upper and lower North Chickamauga Creek watersheds. Additional image processing steps were not necessary for analysis though quality and resolution discrepancies existed between imagery obtained in 1977 and 2000. All images were added to the existing GIS database for landscape analysis (*Fig. 2 & 3*).

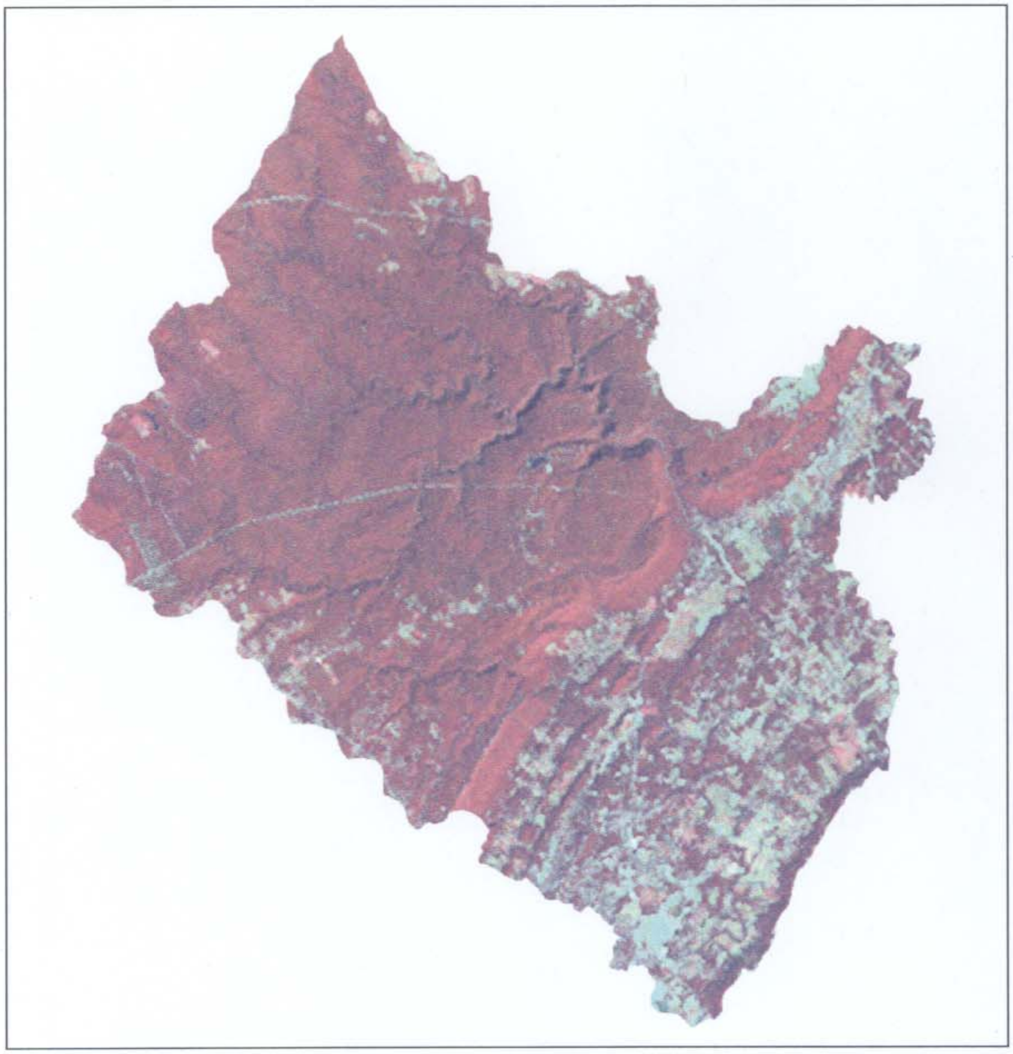

Fig.2. LANDSAT imagery (1977) of North Chickamauga Creek watershed.

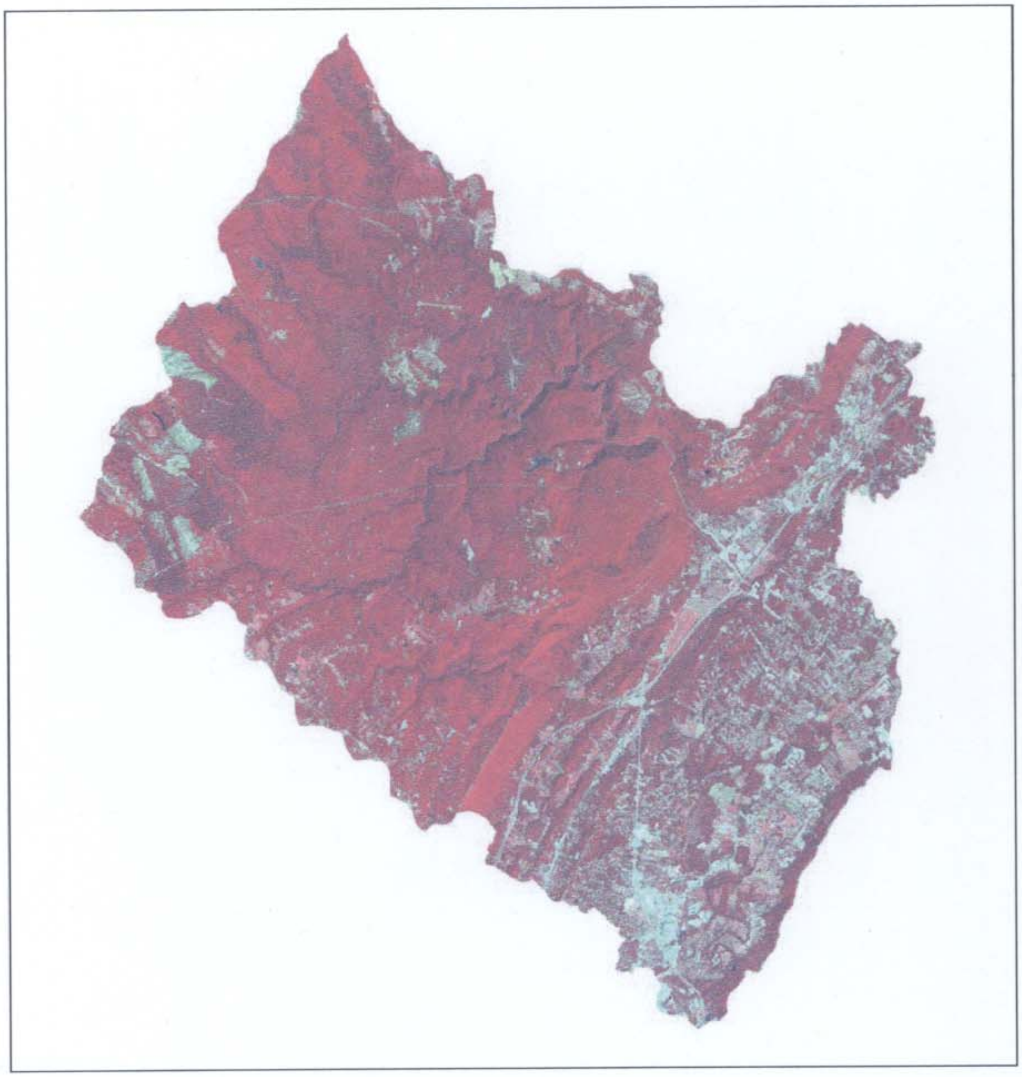

Fig.3. LANDSAT imagery (2000) of North Chickamauga Creek watershed.

Software Application

ERMF tested two pilot software applications or "analysis toolkits" during the third quarter of project work. The toolkits were both based upon ESRI software platforms. A watershed specific property application was created using Arcview 3.3 and an internet mapping extension that creates a Java scripted interactive map in hypertext markup language (HTML) format. The HTML document was copied to a DVD and tested on ERMF computer hardware (*Fig. 4*).

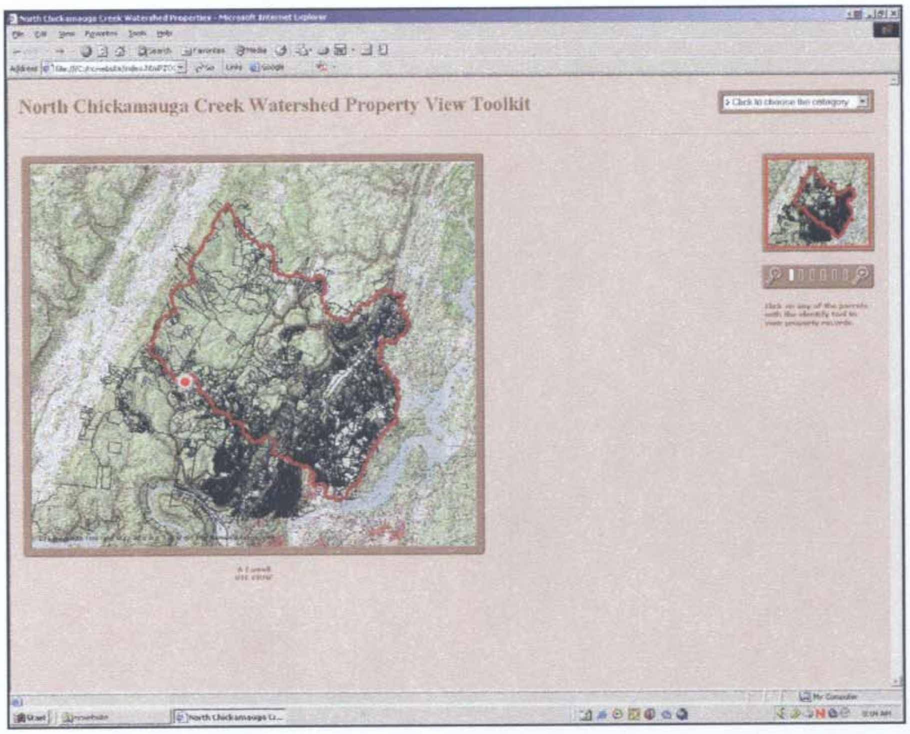

Fig.4. Map display for HTML software application.

A second application was created by using the ESRI ArcReader program. Imagery, monitoring data, land use datasets, acid mine drainage (AMD) source areas, and hydrologic datasets were published from the "in-house" ERMF ArcMap project to an ArcReader format. The published file was tested on ERMF computer hardware.

DISCUSSION

Present-day land use scenarios created during the third quarter require additional adjustment and refining prior to their implementation into final watershed models. Sequatchie County contained approximately 11 unclassified land use properties. These properties represent sizable areas in the upper watershed. Since a majority of TMDL concern focuses on upper watershed source areas, appropriate classifications for these parcels should be applied.

After meeting with representatives from the Hamilton County-Chattanooga Regional Planning Agency (RPA) on 24 JAN 05, ERMF staff became aware of present-day land use datasets for the Hamilton County portion of the watershed. This RPA model further defines the "undeveloped" land classification into "protected" and "disturbed" categories. Incorporating this file will depict a more accurate portrayal of land use since large portions of undeveloped land in the upper watershed in Hamilton County have a "protected" status. Similar efforts are required for the Sequatchie County sections of the watershed to maintain the consistency of the watershed parcel approach.

ERMF has planned additional watershed model enhancements by adding the updated present-day land use data and AMD source areas and coal seam distributions. During the third quarter, ERMF staff contacted the Tennessee Valley Authority (TVA) and received approval for access to mining and coal seam distribution maps. These maps will assist in defining areas sensitive to future development and areas likely to contain previously unmapped, small AMD seeps.

As mentioned in previous documents, the delivery of models, scenarios, and GIS data in a "user friendly format", proves to be the underlying goal of software and toolkit design. The applications developed during the third quarter demonstrate the ability to deliver watershed data in two unique packages. The interactive HTML application appears to be the easiest to use. Most routines and queries require only one click on the map's display to activate a command. However, the Java scripted HTML environment requires 3.4 gigabytes of disk space.

The ArcReader application requires a much smaller amount of disk space (approx. 1 gigabyte). However, the ArcReader project requires the user to possess a higher level of GIS knowledge. Data queries require multiple steps but the user maintains control over the displayed environment. ERMF will pursue both application approaches anticipating that either product may be appealing in a given situation (*Fig.5.)*.

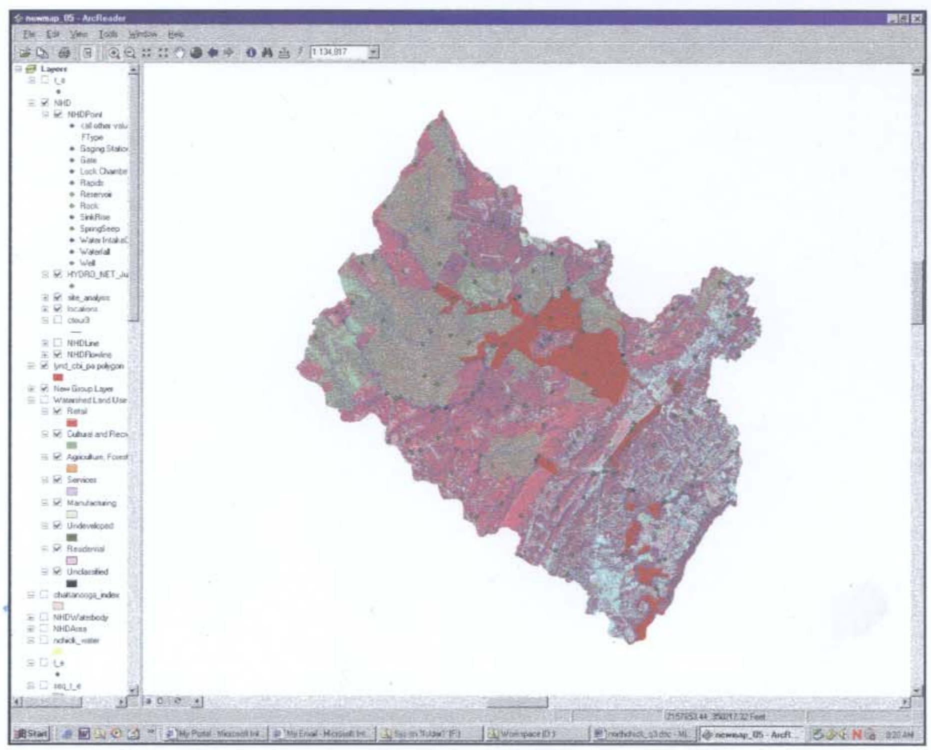

Fig.5. ArcReader software application for the North Chickamauga Creek Watershed.

FUTURE PROJECT DEVELOPMENTS

The final quarter of project efforts will involve the successful completion of modeling efforts and application design. ERMF will obtain final land use datasets from Hamilton and Sequatchie Counties. These datasets will be incorporated into the final watershed sensitivity model. Sensitivity properties and areas derived from models will be added to current software applications. These applications and a comprehensive final report will be delivered to all project partners.

APPENDIX I

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 IN NORTH CHICKAMAUGA CREEK TENNESSEE RIVER WATERSHED (HUC 06020001), TENNESSEE

Announcement is hereby given of the availability of Tennessee's proposed Total Maximum Daily Load (TMDL) for pH in the North Chickamauga Creek subwatershed, part of the Tennessee River watershed, 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 Chickamauga Creek is listed on Tennessee's final 2002 303(d) list as not supporting designated use classifications due, in part, to low pH 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 pH TMDL may be downloaded from the Department of Environment and Conservation website:

http://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:

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 TMDLs are invited to submit their comments in writing no later than February 20, 2005 to:

Division of Water Pollution Control
Watershed Management Section
6th 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.