Total Maximum Daily Load (TMDL) for Cedar Creek: Station B-320 Fecal Coliform Bacteria

Hydrologic Unit
03050106-090

South Carolina Department of
Health and Environmental Control
Bureau of Water

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Abstract

Cedar Creek, a class freshwater (FW) stream, was placed on South Carolina's 1998 303(d) list (listed as Big Cedar Creek) because of partially supporting recreational use. Cedar Creek, located in Fairfield and Richland Counties, violated of the fecal coliform bacteria water quality standard during the 1991-1995 period, as 25 % of the samples collected as B-320 exceed the 400 counts/100 ml standard. Forest (82 %) and agriculture (17 %) are the dominant land uses in the Cedar Creek watershed. Both land uses can be sources of fecal coliform bacteria. Targeting agricultural land for reduction of bacteria is the most effective strategy for this watershed.

The geometric mean for this site is 335 counts/100 ml. Flow information for Cedar Creek was estimated using the Borders method. Using a target level of bacteria of 175 counts/100ml, the target loading for Cedar Creek is $2.57 \bullet 10^{11}$ counts/day. This translates to an agricultural reduction of 52 % or a final agricultural loading of $2.13 \bullet 10^{11}$ counts/day. Forested lands are not targeted for reduction, as forested lands are generally not important sources of fecal coliform bacteria.

There are several tools available for implementing this TMDL, such as a NPS pollution outreach materials. DHEC will continue to monitor water quality in Cedar Creek to evaluate the effectiveness of these measures.

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South Carolina Department of Health and Environmental Control

State of South Carolina 303(d) List for 1998

Priority Ranked Waterbodies Targeted for Water Quality Management Action

EPA Approved June 1998

	SITE	STATION NUMBER	IMPAIRED USE	CAUSE	HYDROLOGIC UNIT	BASIN
	ALLISON CK AT US 321 3.1 MI S OF CLOVER	CW-171	REC	FC	03050101200	CATAWBA
*	***ASHLEY RVR AT MAGNOLIA GARDENS***	MD-049	AL	***DO***	03050202040	SANTEE
	ASHLEY RVR AT SALRR BRDG	MD-052	REC	FC	03050202040	SANTEE
*	***ASHLEY RVR AT SC 7 (N BRDG)***	MD-135	AL	***DO***	03050202040	SANTEE
	AWENDAW CREEK AT US 17	MD-250	REC	FC	03050202060	SANTEE
	BEAR CK AT S-29-292 1.6 MI W OF LANCASTER	CW-131	REC	FC	03050103042	CATAWBA
	BEAR CK AT S-29-362 3.5 MI SE OF LANCASTER	CW-151	REC	FC	03050103042	CATAWBA
	BEAR CK AT S-40-82	CW-229	REC	FC	03050104060	CATAWBA
	BEAR SWAMP AT S-26-110	PD-638	AL	BIO	03040206140	PEE DEE
	BEAUFORT RVR AB BEAUFORT AT CHANNEL MARKER 231	MD-001	AL	DO	03050208100	SALKEHATCHIE
	BEAUFORT RVR AT DRAWBRDG ON US 21	MD-002	AL	DO	03050208100	SALKEHATCHIE
	BEAUFORT RVR AT JCT WITH BATTERY CK NR MARKER 42	MD-004	AL	DO	03050208100	SALKEHATCHIE
	BEAVER DAM CK AT S-31-313	PD-636	AL	BIO	03040205030	PEE DEE
	BEAVERDAM CK AT RD 1967	BE-039	REC	FC	03050108010	BROAD
	BEAVERDAM CK AT S-30-97, 7 MI NE OF GRAY COURT	B-246	REC	FC	03050108030	BROAD
	BEAVERDAM CREEK AT FOREST SERVICE ROAD 621 OFF S-19-68	SV-353	REC	FC	03060107030	SAVANNAH
	BIG BRANCH AT S-14-41	CW-243	REC	FC	03050111030	CATAWBA
	BIG CEDAR CK AT SC 215	B-320	REC	FC	03050106090	BROAD
	BIG EASTATOE CREEK AT S-39-143	SV-230	AL	ZN	03060101030	SAVANNAH
	BIG GENEROSTEE CK AT SC 187	SV-101	AL	BIO	03060103030	SAVANNAH
	BIG POPLAR CK AT S-38-105	SC-011	AL	DO	03050111010	SANTEE
	BIG SWP AT S-21-360 1.1 MI W OF PAMPLICO	PD-168	REC	FC	03040202130	PEE DEE
	BIG WATEREE CK AT US 21	CW-072	REC	FC	03050104020	CATAWBA
	BLACK CK AT HWY 15 BYPASS	PD-330	REC	FC	03040201110	PEE DEE
	BLACK CK AT S-16-18 1 MI NNE HARTSVILLE	PD-021	REC	FC	03040201110	PEE DEE
	BLACK RVR AT US 76 1.5 MI NE OF MAYESVILLE	PD-186	REC	FC	03040205010	PEE DEE

Cedar Creek
03050106-090
BASIS FOR 303(d) LISTING

INTRODUCTION:

Levels of fecal coliform bacteria can be elevated in water bodies as the result of both point and nonpoint sources of pollution. Section 303(d) of the Clean Water Act and EPA's Water Quality Planning and Management Regulations (40 CFR Part 130) require states to develop total maximum daily loads (TMDLs) for water bodies that are not meeting designated uses under technology-based pollution controls. The TMDL process establishes the allowable loadings of pollutants or other quantifiable parameters for a water body 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 and restore and maintain the quality of water resources (USEPA 1991).

PROBLEM DEFINITION:

Impaired Waterbody: Cedar Creek (listed as Big Cedar Creek)

Location: Fairfield and Richland Counties S.C., **Lat**: 34° 9' 44" N; **Long**: 81° 6' 52" W

Water Classification: Freshwater

The impaired stream segment, Cedar Creek, is designated as Class Freshwater. Waters of this class are described as follows:

> "Freshwaters suitable for primary and secondary contact recreation and as a source for drinking water supply after conventional treatment in accordance with the requirements of the Department. Suitable for fishing and the survival and propagation of a balanced indigenous aquatic community of fauna and flora. Suitable also for industrial and agricultural uses." (R.61-68)

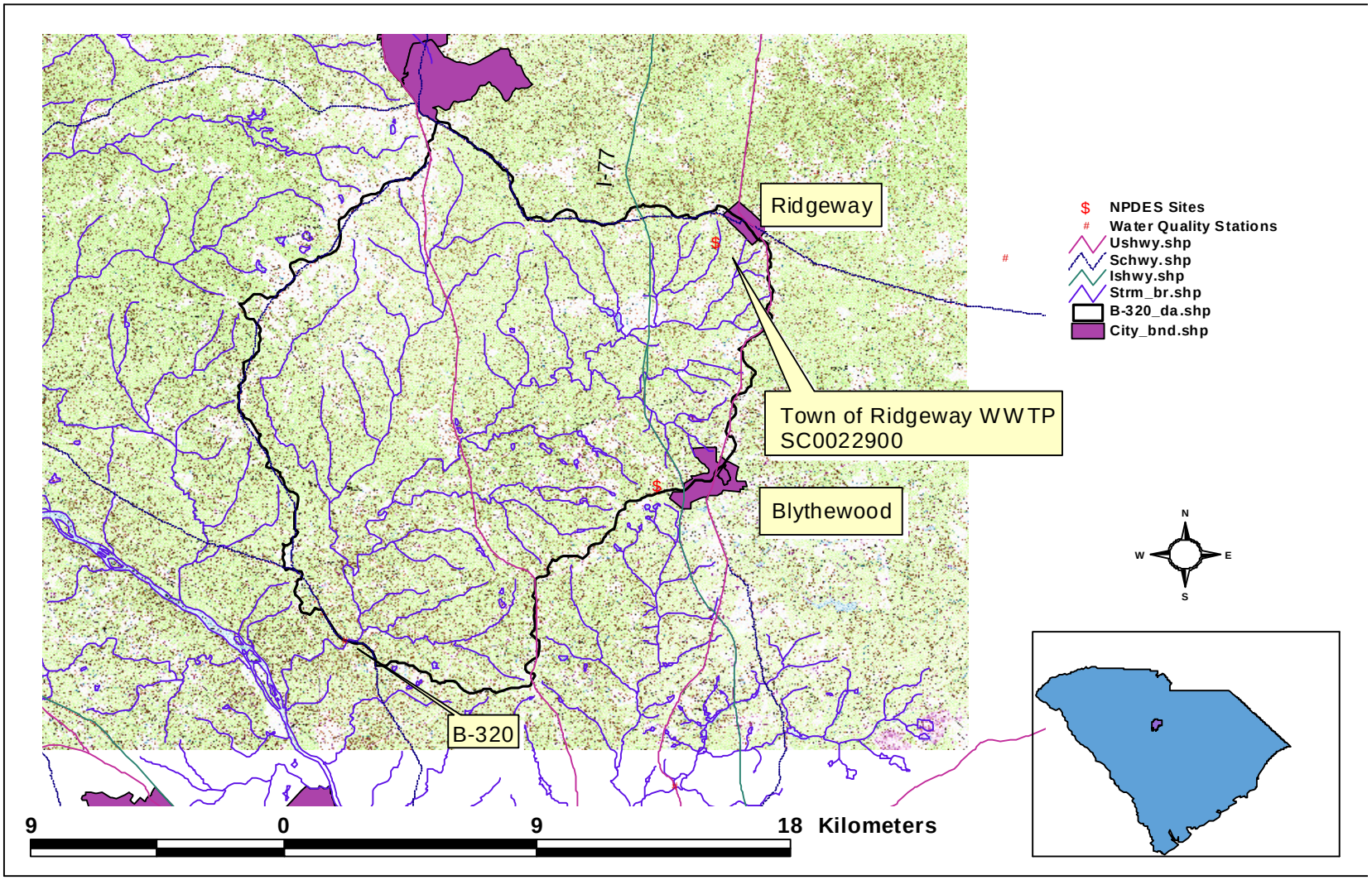
Water Quality Standard Being Violated: Fecal Coliform Bacteria

Pollutant of Concern: Fecal Coliform Bacteria

Fecal Coliform Criteria:

> "Not to exceed a geometric mean of 200/100 ml, based on five consecutive samples during any 30 day period; nor shall more than 10% of the total samples during any 30 day period exceed 400/100 ml." (R.61-68)

Figure 1 Cedar Creek Watershed, Fairfied and Richland Counties



The *South Carolina Watershed Water Quality Assessment:*

Watershed Water Quality Management Strategy Broad Basin (SCDHEC 1998) was used to identify this stream segment as impaired and for listing the water body on the 1998 South Carolina 303(d) list. Waters in which no more than 10% of the samples collected over a five year period are greater than 400 fecal coliforms/100 ml are considered to comply with the South Carolina water quality standard for fecal coliform bacteria. Waters with more than 10 percent of samples greater than 400 fecal coliforms/100 ml are considered impaired and listed for fecal coliform bacteria on South Carolina's 303(d) List. There is one SCDHEC ambient monitoring station, B-320, on Cedar Creek at SC-215 in Richland County. Data from this station show that recreational uses are partially supported due to violations of the 400/100 ml fecal coliform criterion. During the assessment period (1991-1995), 25% of the samples did not meet the fecal coliform criterion.

TMDL TECHNICAL BASIS

TARGET IDENTIFICATION:

Target levels for fecal coliform bacteria in water bodies are those levels established in South Carolina's Water Quality Standards, Regulation 61-68, as described earlier. The criterion used in this TMDL will be "not to exceed a geometric mean of 175/100 ml," allowing an explicit margin of safety of 25/100 ml to ensure that the 200/100 ml criterion will be met.

This target of a geometric mean of 175/100 ml is expected also to satisfy the criterion, "nor shall more than 10% of the total samples during any 30 day period exceed 400/100 ml." Based on a review of water quality assessments in South Carolina, over 75% of waters that have a fecal coliform geometric mean of 175/100ml or less, also meet the criterion "not more that 10% of samples exceed 400/100ml" (SCDHEC unpublished data). Most of the data in those assessments, however, reflect fecal coliform concentrations in areas that do not have sufficient best management practices (BMPs) in place. Thus, implementation of BMPs as described in this TMDL will likely achieve an even greater rate of compliance with the latter criterion since the BMPs are generally focused on reducing fecal loadings during runoff events, the condition most likely to result in an exceedence of the 400/100ml criterion.

Source Assessment:

General Sources of Fecal Coliform:

Both point and nonpoint sources may contribute fecal coliform to a given water body. Potential sources of fecal coliform are numerous and often occur in combination. Nationwide, poorly treated municipal sewage is a major source of fecal coliform, but data presented below suggest this is not the case here. Urban storm water runoff, sanitary sewer overflows, and combined sewer overflows can be sources of fecal coliform. Rural storm water runoff can transport significant loads of fecal coliform from livestock pastures and animal feedlots. Failing septic systems and wildlife can also be sources of bacteria. Sources of fecal coliform loads to water bodies can be assigned to two broad classes: point source loads and nonpoint source loads.

Point Sources in the Cedar Creek Watershed:

There are two permitted point sources in the Cedar Creek watershed. The Town of Ridgeway operates a wastewater treatment facility on a headwater tributary of Cedar Creek. This facility has a permited discharge of 0.12 mgd (455 m^3/d; 0.186 cfs) and has been in compliance of its fecal coliform limits. This facility is 31 km upstream of the impaired stream station and is unlikely to be a contributor to fecal coliform excursions in Cedar Creek. Dilution alone would reduce concentration of fecal coliform to < 1colony / 100ml at B-320. King's Laboratories discharges non-contact cooling water into another tributary of Cedar Creek. This point source will be included in this TMDL.

Nonpoint Sources in Cedar Creek Watershed:

Fecal coliform loadings in this watershed can also be attributed to nonpoint sources. The land use in the watershed is essentially 82% forested, 17% agricultural, and <1% urban. The urban land use is along the upper edges of the watershed, far removed from the sampling station. Due to the small percentage and location the urban land use is unlikely to be a significant contributor to the loading.

Agricultural land can be a source of fecal coliform bacteria. Runoff from pastures, animal operations, the improper land application of animal wastes, and animals with access to creeks are all sources of fecal coliform. Agricultural Best Management Practices or BMPs such as buffer strips, alternative watering sources, fencing cattle out of creeks, and the proper land application of animal wastes reduce fecal coliform loading to waterbodies.

Fecal coliform also originate in forested areas. Generally the sources are wild animals such as deer, racoons, wild turkeys, water fowl, etc. Controls of these sources will be limited to land management BMPs, although forested areas are not specifically targeted in this TMDL.

Linkage Between Numeric Targets and Sources:

Land use analysis of this watershed indicates that the major sources of fecal coliform are necessarily derived from agricultural areas. Various effective Best Management Practices exist for agricultural lands that can successfully reduce fecal coliform levels in adjacent water bodies. Therefore, load reductions in this TMDL will be allocated to agricultural landuses.

The loading from the forested lands will be considered background conditions. The geometric mean of fecal coliform concentration in water bodies flowing through forested areas in South Carolina during all flow conditions is estimated to be 30 fecal coliforms/100 ml (SCDHEC unpublished data). The 30 fecal coliforms/100 ml observed in South Carolina falls well within the range reported by Schueler (1999) of 10 to100 fecal coliforms/100 ml from forested lands. Thus, 30 counts/100 ml will be considered the background condition.

Data Availability and Analysis:

Watershed Characteristics:

Cedar Creek, located in the lower Broad River basin within the Piedmont region of South Carolina, is a tributary to the Broad River. The drainage area of concern for this TMDL is located in watershed 03050106-090 in Fairfield and Richland Counties and consists of the area of land (253 km^2 or 98 mi^2)

draining to station B-320. All references to the Cedar Creek watershed in this TMDL refer specifically to the area draining to B-320.

Cedar Creek Watershed Land Use

Land Use	km^2	Percentage
Forest	140	82%
Agriculture/Grass	29.4	17%
Urban	0.8	< 1%

Fecal Coliform

SCDHEC monitors water quality on Cedar Creek at ambient monitoring station B-320 monthly for a year once every fifth year. Existing data from this monitoring station is available through STORET and is included in the data appendix. The geometric mean of fecal coliform using the most current data (94-95 and 98-99) is 335 counts/100ml.

Critical Conditions:

Novotny & Olem (1994) find statistically lower fecal coliform counts in cold weather urban runoff samples than in warmer weather urban runoff. To substantiate this, winter and summer fecal coliform values were compared at ambient water quality monitoring stations thought to be impacted by nonpoint sources in the Piedmont Region of South Carolina. This analysis showed summer fecal levels to be generally higher than or approximately the same as winter levels. Therefore, summer months (May-October) are generally considered critical conditions. This can be explained by the nature of summer and winter storm events. Thunderstorms are typical in the summer months. This pattern of rainfall allows for the accumulation and washing off of fecal coliforms into the streams resulting in spikes of fecal coliform concentrations. In the winter, longer and slower rain events are the norm. This pattern of rainfall does not allow for the high build-up of coliform that characterizes the summer. This, coupled with the increased winter flows that provide more dilution, usually results in lower winter fecal coliform concentrations.

In the Cedar Creek watershed however, the fecal coliform geometric mean for warm weather months are substantially lower than for the cool weather months. Only two years (24 samples) of data are available for Cedar Creek. Since the amount of data is limited and using cold weather as a critical period for recreational use is counter intuitive, we will use as the year round data for this TMDL.

Flow

Annual flows for Cedar Creek will be based on Borders (1980):

$$Q_a = \frac{\text{Runoff (in)} \bullet \text{Drainage area (mi}^2\text{)}}{13.58} = \frac{12.5 \bullet 65.7}{13.58} = 60 \text{ cfs}$$

Load Calculations:

With the observed annual geometric mean of 335 counts/100 ml and the average critical period flow of 60 cfs, the current loading at B-320 is determined to be 4.9 X 10^{11} counts/day using the following equation:

Fecal Coliform * Q_a * Factor = Loading

where: Fecal Coliform = # counts/100ml
Q_a = average critical period flow in cfs
Factor = conversion factor = 24468984
Loading = # fecal coliform counts/day

Using the standard, a geometric mean of 200 counts/100 ml, the allowable load during average critical period flow is 2.9 E+11 counts/day.

TMDL Development:

A total maximum daily load (TMDL) for a given pollutant and waterbody is comprised of the sum of individual wasteload allocations (WLAs) for point sources, and load allocations (LAs) for both nonpoint sources and natural background levels. In addition, the TMDL must include a margin of safety (MOS), either implicitly or explicitly, to account for the uncertainty in the relationship between pollutant loads and the quality of the receiving water body. Conceptually, this definition is represented by the equation:

$$\text{TMDL} = \sum \text{WLAs} + \sum \text{LAs} + \text{MOS}$$

The TMDL is the total amount of pollutant that can be assimilated by the receiving water body while still achieving water quality standards. In TMDL development, allowable loadings from all pollutant sources that cumulatively amount to no more than the TMDL must be established and thereby provide the basis to establish water quality-based controls.

For some pollutants, TMDLs are expressed on a mass loading basis (e.g., pounds per day). For bacteria, however, TMDLs can be expressed in terms of organism counts (or resulting concentration), in accordance with 40 CFR 130.2(l).

Since there are no contributing point sources, the TMDL for Cedar Creek is equal to the load allocations from nonpoint sources and background conditions plus the MOS.

$$\text{Cedar Creek TMDL} = \sum \text{WLAs} + \sum \text{LAs} + \text{MOS}$$

Margin of Safety:
There are two basic methods for incorporating the MOS (USEPA 1991): 1) implicitly incorporate the MOS using conservative model assumptions to develop allocations, or 2) explicitly specify a portion of the total TMDL as the MOS; use the remainder for allocations.

This MOS is implicit through the use of a critical period and by establishing a target concentration level of 175 fecal coliforms/ 100 ml. This level is below the state standard of 200 fecal coliforms/ 100 ml.

TMDL

TMDL calculation:

The target level of fecal coliform is 175 colonies/100ml. This equates to a loading of 2.57 E+11 colonies per day. The load from agricultural lands plus the load from forest lands must equal the target loading of 2.57 E+11 colonies per day. Realistically only one land use, agriculture, in this watershed is appropriate for fecal coliform reductions. Therefore, the loading attributable to the forested lands, 4.4 E+10, assuming average flow from forest lands and a background level of 30 colonies/100ml, is subtracted from the target load of 2.57 E+11 colonies per day to obtain a target load from agricultural lands of 2.13 E+11 colonies per day. At an average flow of 60 cfs, this loading equates to an in-stream concentration from agricultural lands of 145 colonies/100ml.

Allocation of Wasteload:

Point Source	Current Loading	% Reduction	Final Loading
Town of Ridgeway WWTP	9.1 E+9 counts/day	0	9.1 E+9 counts/day

Allocation of Load:

The existing load of 4.92 E+11 colonies/day must be reduced by 48% to obtain the TMDL of 2.57 E+11 colonies/day (loading at 175 colonies/ 100 ml).

An allocation strategy that will allow the target TMDL of 175 colonies/100ml to be maintained is as follows:

52% reduction in fecal coliform loading and/or resultant in-stream concentrations from agricultural/grass land uses.

Cedar Creek Land Use

Land use	Current Loading	% Reduction	Final Loading
Forest (Background)	4.4 E+10 counts/day	0	4.4 E+10 counts/day
Agriculture/Grass	4.48 E+11 counts/day	52	2.13 E+11 counts/day
Total	4.92 E+11 counts/day	48	2.57 E+11 counts/day

Implementation Strategy:

As discussed in the *Implementation Plan for Achieving Total Maximum Daily Load Reductions From Nonpoint Sources for the State of South Carolina*, 1998, South Carolina has several tools available for implementing this nonpoint source TMDL. Specifically, SCDHEC's animal agriculture permitting program addresses animal operations and land application of animal wastes. In addition, SCDHEC will work with the existing agencies in the area to provide nonpoint source education in the Cedar Creek watershed. Local sources of nonpoint source education include Clemson Extension Service, the Natural Resource Conservation Service (NRCS) and the South Carolina Department of Natural Resources. Clemson Extension Service offers a 'Farm-A-Syst' package to farmers. Farm-A-Syst allows the farmer to evaluate practices on their property and determine the nonpoint source impact they may be having. It recommends best management practices (BMPs) to correct nonpoint source problems on the farm. NRCS can provide cost share money to land owners installing BMPs. SCDHEC employs a nonpoint source educator who can also provide BMP information.

SCDHEC is empowered under the State Pollution Control Act to perform investigations of and pursue enforcement for activities and conditions which threaten the quality of waters of the state. In addition, other interested parties (universities, local watershed groups, etc.) may apply for section 319 grants to install BMPs that will reduce fecal coliform loading to Cedar Creek.

In conjunction with county efforts related to the stormwater NPDES permit SCDHEC will work with existing agencies in this area to provide nonpoint source education in the Cedar Creek watershed. Local sources of nonpoint source education include Clemson Extension Service, the Natural Resource Conservation Service (NRCS), the Fairfield and Richland County Soil and Water Conservation Districts, and the South Carolina Department of Natural Resources. In addition, Clemson Extension has developed a Home-A-Syst handbook that can help urban or rural homeowners reduce sources of NPS pollution on their property. This document guides homeowners through a self-assessment, including information on proper maintenance practices for septic tanks. SCDHEC also employs a nonpoint source educator who can assist with distribution of these tools as well as provide additional BMP information.

Using existing authorities and mechanisms, these measures will be implemented in the Cedar Creek Watershed in order to bring about a 48% reduction in fecal coliform bacteria to Cedar Creek.

DHEC will continue to monitor water quality in Cedar Creek, according to the basin monitoring schedule, in order to evaluate use support and the effectiveness of implementation measures. If it is determined that these implementation actions are not sufficient to improve water quality, this TMDL will be revised, incorporating more extensive water quality modeling.

Funding:

Potential funding options:

Local governments have a variety of funding options available for application towards water resource protection including: General revenue, issuance of bonds, special taxes, utility fees, and impact fees. Additionally, the State Clean Water Revolving Fund makes low interest loans available to local governments for water quality improvement projects.

Another available tool for addressing nonpoint sources in this watershed is implementation of NPS reduction projects through DHEC's Section 319 program. Funded by EPA through the Clean Water Act, this program provides resources for implementing projects that address NPS pollution problems. DHEC uses some of these funds internally for NPS projects and also provides funds for outside NPS projects through a competitive grants program.

SCDHEC and many of the natural resource protection partners in the area currently have funded staff available for education, planning and technical assistance. These personnel are expected to be available for efforts aimed at the reduction of bacterial inputs to Cedar Creek.

References

Borders, Terry. 1980. Runoff Map and Equation for Calculating Average Annual Flow in South Carolina. Unpublished.

Doran, J.W., J.S. Schepers, and N.P. Swanson. 1981. Chemical and Bacteriological Quality of Pasture Runoff. J. Soil Water Conserv. May-June:166-171.

Novotny, V. and H. Olem. 1994. Water Quality Prevention, Identification, and Management of Diffuse Pollution. Van Nostrand Reinhold, New York.

SCDHEC. 1997. Watershed Water Quality Assessment: Savannah and Salkehatchie River Basins. Technical Report No. 003-97.

SCDHEC. 1998. Implementation Plan for Achieving Total Maximum Daily Load Reductions From Nonpoint Sources for the State of South Carolina.

Scheuler, T. R. 1999. Microbes and Urban Watersheds: Concentrations, Sources, and Pathways. Watershed Protection Techniques 3(1): 554-565.

United States Environmental Protection Agency (USEPA). 1991. Guidance for Water Quality-Based Decisions: The TMDL Process. Office of Water, EPA 440/4-91-001.

Water Resources Data - South Carolina: Water Year 1995. 1995. United States Geological Survey

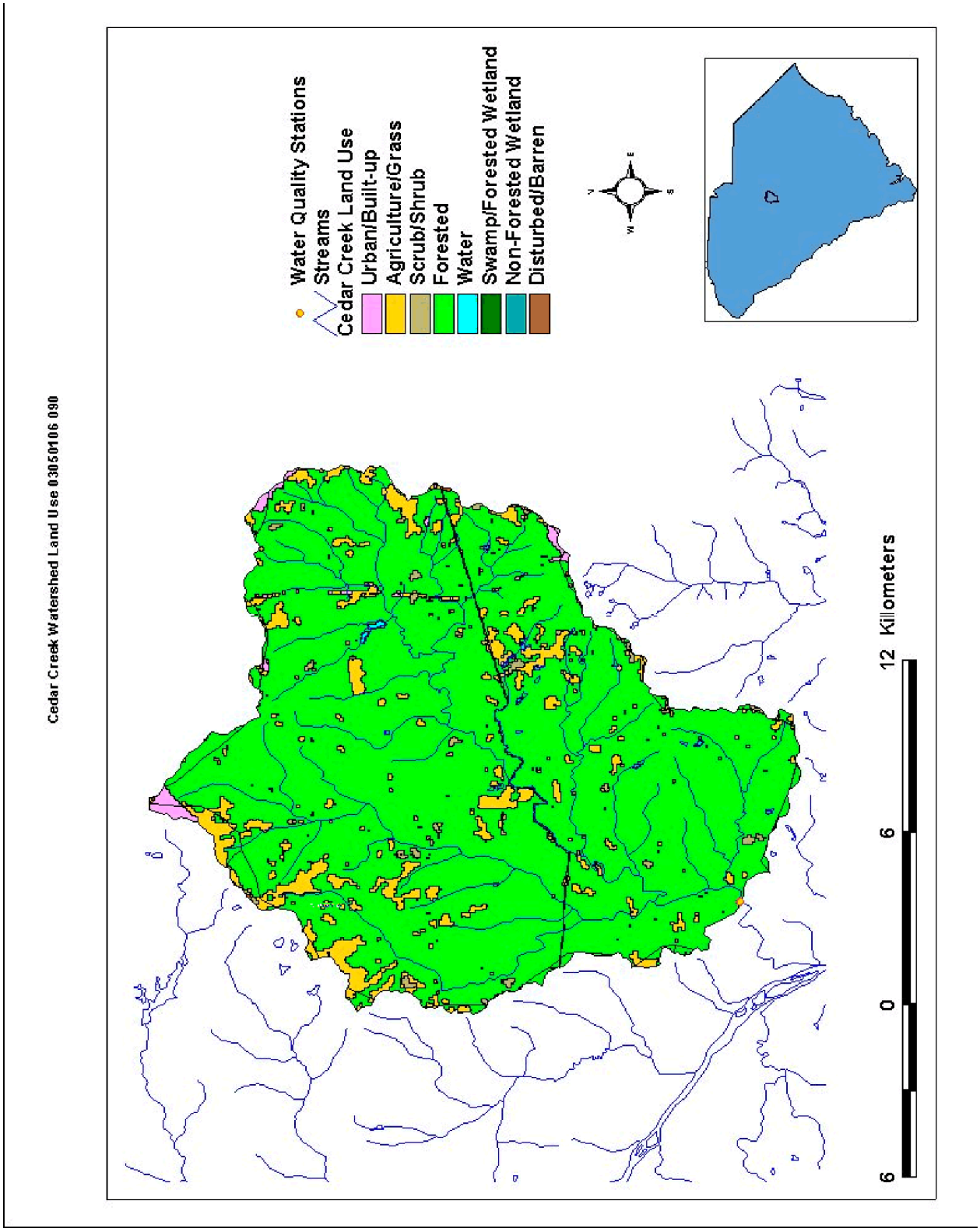
Attachments

A. Map: Cedar Creek Watershed Landuse

B. Calculations Sheet: B-320 Cedar Creek TMDL

C. Data Sheet: B-320, Fecal Coliform

Attachment A



Attachment B

LOADING CALCULATIONS						
		Conversion	**Qa**	**FC**		
	FC geo mean	**Factor**	**flow in cfs**	**#/day**		
Current level	335.00	24468984	60	4.9183E+11		
Standard	200	24468984	60	2.9363E+11		
			difference	1.982E+11		
			% difference	40.2985075		
TMDL target	175	24468984	60	2.5692E+11		
			difference	2.349E+11		
			% difference	47.76%		

Attachment C

Water Quality in Cedar Creek at SC-215 (Richland County)
B-320 03050106 090

Date	Time	FC #/100ml		Flow at 2162010 * cfs
11/17/94	1015	200		8.6
12/9/94	1039	230		8.6
1/25/95	845	140		42
2/17/95	1119	700	J	504
3/9/95	1225	1300	J	99
4/18/95	815	260		12
5/9/95	1250	290		5.7
5/18/95	815			5.5
6/28/95	1300	530		5.4
7/11/95	1030	220		4.3
8/8/95	1300	160		2.1
9/18/95	1340	320		3.6
10/3/95	1350	160		4.9
11/17/98	1350	5000	J	
12/17/98	900	2200		
1/13/99	945	380		
2/17/99	945	270		
3/16/99	1205	210		
4/7/99	910	180		
5/10/99	1240	120		
6/22/99	855	230		
7/20/99	1045	320		
8/18/99	840	210		
9/14/99	1355	440		
10/28/99	910	280		

USGS Station is upstream of DHEC sampling station