Total Maximum Daily Load Document

Gills Creek Watershed

SCDHEC Monitoring Stations: C-048, C-017

(Hydrologic Unit Codes: 03050110-0201, -0202, -0203)

Dissolved Oxygen

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Cover photo courtesy of Jessica Artz, Gills Creek Watershed Association

Abstract

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. A TMDL is the maximum amount of pollutant a water body can assimilate while meeting water quality standards for the pollutant of concern. All TMDLs include a wasteload allocation (WLA) for all National Pollutant Discharge Elimination System (NPDES)-permitted discharges, a load allocation (LA) for all nonpoint sources, and an explicit and/or implicit margin of safety (MOS).

A dissolved oxygen (DO) TMDL was developed for two monitoring stations, C-048 and C-017, within the Gills Creek watershed in Richland County, South Carolina. The two stations, one along Gills Creek and one along Jackson Creek, are included as impaired on the state's 2008 §303(d) list due to low DO concentrations documented during the 2002–2006 assessment period. In addition, 25 percent and 13 percent of the samples collected by the South Carolina Department of Health and Environmental Control (SCDHEC/Department) between 1998 and 2006 at monitoring stations C-048 and C-017, respectively, violated the daily average water quality standard.

The possible causes of low DO include wildlife, failing septic systems, illicit connections, leaking sewers, sanitary sewer overflows, illicit dumping in water bodies, natural biochemical oxygen demand in swamps, agricultural runoff, pet wastes, and stormwater runoff. The watershed modeling system Loading Simulation Program in C++ (LSPC) was used to calculate existing and TMDL loads for each impaired segment. The existing pollutant loadings and proposed TMDL reductions for critical hydrologic conditions are presented in Table Ab-1. Critical hydrologic conditions were defined as moist, mid-range or dry depending on which condition demonstrated the highest load reductions necessary to meet water quality standards. To achieve the target load (water quality standards) for Gills Creek and tributaries, reductions in the existing 5-day biochemical oxygen demand and ammonia loads of up to 63 percent will be necessary at some stations. For SCDOT and existing and future NPDES MS4 permittees, compliance with terms and conditions of its NPDES MS4 permit is effective implementation of the WLA to the Maximum Extent Practicable (MEP). For existing and future NPDES construction and Industrial stormwater permittees, compliance with terms and conditions of its permit is effective implementation of the WLA. Required load reductions in the LA portion of this TMDL can be implemented through voluntary measures.

The Department recognizes that **adaptive management/implementation** of this TMDL might be needed to achieve the water quality standards, and the Department is committed towards targeting the load reductions to improve water quality in the Gills Creek watershed. As additional data and/or information becomes available, it might become necessary to revise and/or modify the TMDL target accordingly.

Table Ab-1. Total Maximum Daily Loads for the Gills Creek Watershed

Station	Pollutant	Existing Load (lb/day)	TMDL (lb/day)	Margin of Safety (MOS) (lb/day)	Wasteload Allocation (WLA)		Load Allocation (LA)	
					Continuous Sources[1] (lb/day)	Non-Continuous Sources[2] (% Reduction)	Load Allocation (lb/day)	% Reduction to Meet LA[3]
C-048	BOD5	26.6	10.6	0.5	See Note Below	62%	10.1	62%
C-048	Ammonia	0.7	0.34	0.02	See Note Below	55%	0.32	55%
C-017	BOD5	511.6	210.1	10.5	1.0	63%	191.9	63%
C-017	Ammonia	22.2	18.4	0.92	0.13	22%	17.3	22%

Table Notes:

1. WLAs are expressed as a daily maximum. Existing continuous discharges are required to meet the prescribed loading for the pollutants of concern. Future or relocated discharges may be modeled before they receive a permitted loading that meets the updated prescribed loading for the pollutants of concern.
2. Percent reduction applies to all NPDES-permitted stormwater discharges, including current and future MS4, construction and industrial discharges covered under permits numbered SCS & SCR. Stormwater discharges are expressed as a percentage reduction due to the uncertain nature of non-continuous discharge volumes and recurrence intervals. Stormwater discharges are required to meet the percentage reduction or the existing instream standard for the pollutant of concern in accordance with their NPDES Permit.
3. Percent reduction applies to existing instream load; where Percentage Reduction = (Existing Load - Load Allocation) / Existing Load
4. By implementing the best management practices that are prescribed in either the SCDOT annual SWMP or the SCDOT MS4 Permit to address dissolved oxygen, the SCDOT will comply with this TMDL and its applicable WLA to the maximum extent practicable (MEP) as required by its MS4 permit.

Contents

Tables

Figures

1.0 Introduction

1.1. BACKGROUND

Section 303(d) of the Clean Water Act and EPA's Water Quality Planning and Management Regulations (at 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 pollutant 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).

SCDHEC has identified the Gills Creek watershed (03050110-02), Richland County (Figure 1-1), as being impacted by low dissolved oxygen (DO) based on assessment at two ambient water quality monitoring stations. These stations are C-017 (Gills Creek at SC-48, Bluff Road South of I-77) and C-048 (Windsor Lake Spillway on Windsor Lake Boulevard) on Jackson Creek (Figure 1-2). Accordingly, the associated stream segments have been included in South Carolina's 2008 §303(d) list due to low dissolved oxygen documented during the 2002–2006 assessment period.

Dissolved oxygen can be depressed in surface water as the result of both point and nonpoint sources of pollution, 5-day biochemical oxygen demand (BOD5), and nutrients. Natural conditions can also cause low DO. Violations of the DO standard can indicate conditions that are stressful for aquatic life. The objective of this study is to develop an allowable load of pollutants that protects existing uses of the waterbody and achieves state water quality standards (WQSs).

1.2. WATERSHED DESCRIPTION

The Gills Creek watershed is in Richland County, South Carolina, and includes over 70 miles of streams in three 12-digit Hydrologic Unit Codes (HUCs) within one 10-digit HUC (0305011002). The watershed consists primarily of Gills Creek and its tributaries and waterbodies—Jackson Creek, Bynum Creek, Rose Creek, Mack Creek, Wildcat Creek, Carys Lake, Windsor Lake, and Spring Lake. The Gills Creek watershed covers 74.5 square miles (47,681 acres), including parts of Columbia, Forest Acres, and Fort Jackson, a U.S. Army basic combat training center. The project watershed, upstream of monitoring station C-017, is 66.3 square miles. Originating near Sesquicentennial State Park, Gills Creek flows through the northeastern section of the City of Columbia and eventually drains into the Congaree River. In Columbia, the Broad and Saluda rivers join to form the Congaree River. Downstream, the Congaree River joins the Wateree River, forming the Santee River, which ultimately discharges into the Atlantic Ocean.

Figure 1-3 and Table 1-1 show the 2001 National Land Cover Database (NLCD) land use coverage in square miles and by percentage for the Gills Creek watershed. About 55 percent of the watershed is developed; the remaining area is largely composed of forest. Agriculture represents a small percentage of the watershed, about 2 percent.

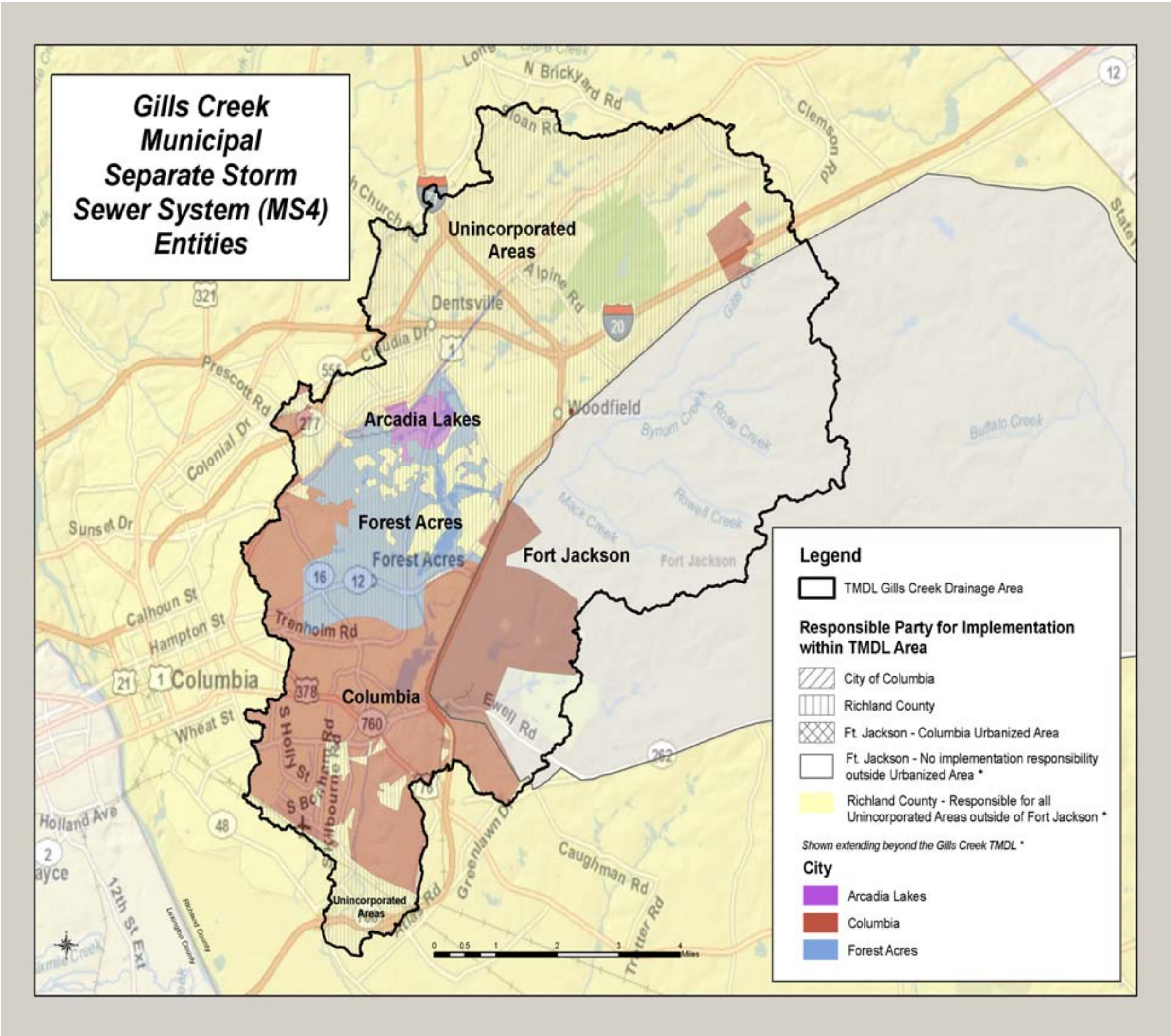

Figure 1-1. **Gills Creek watershed in Richland County, South Carolina.**

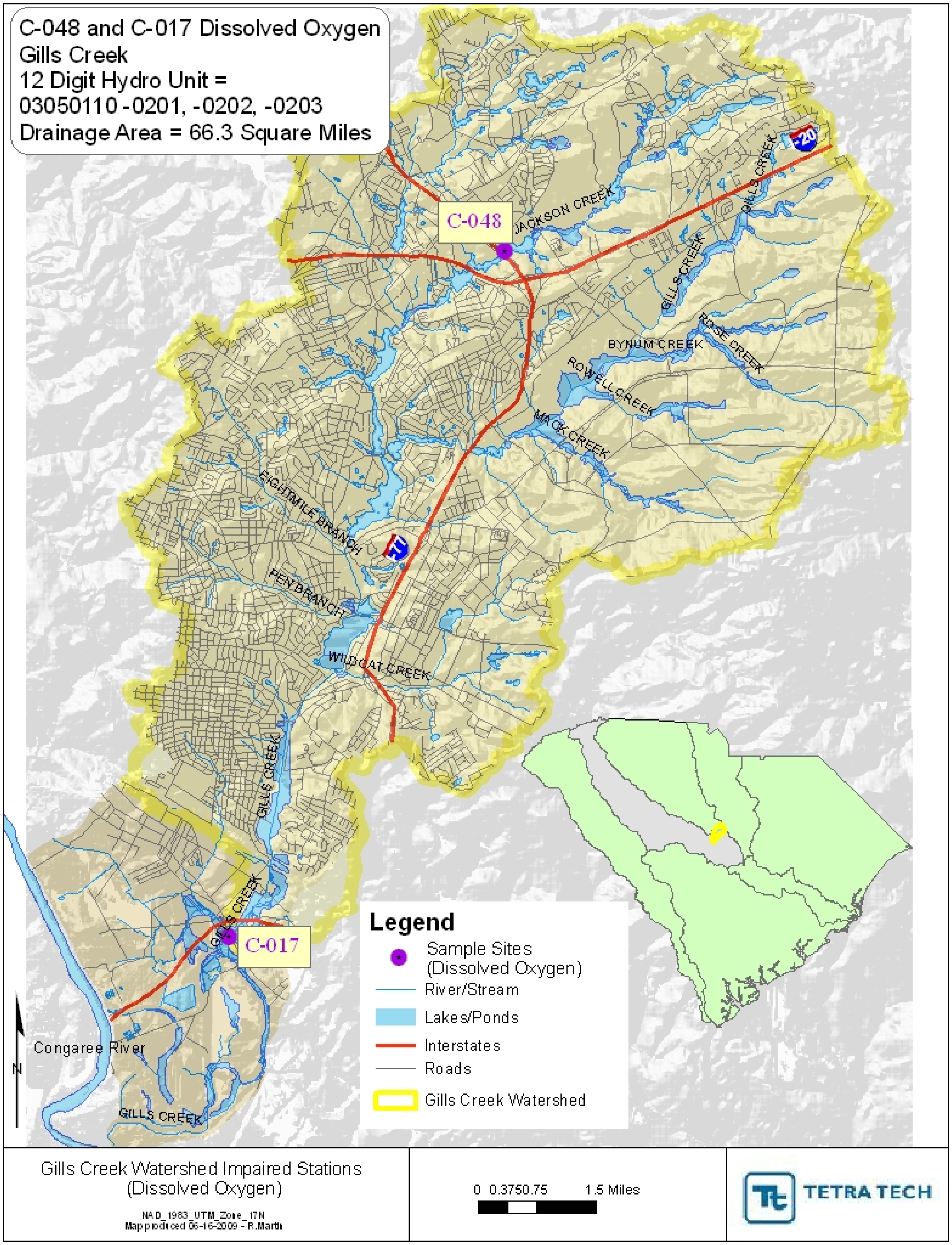

Figure 1-2. Gills Creek watershed stations indicating dissolved oxygen impairment.

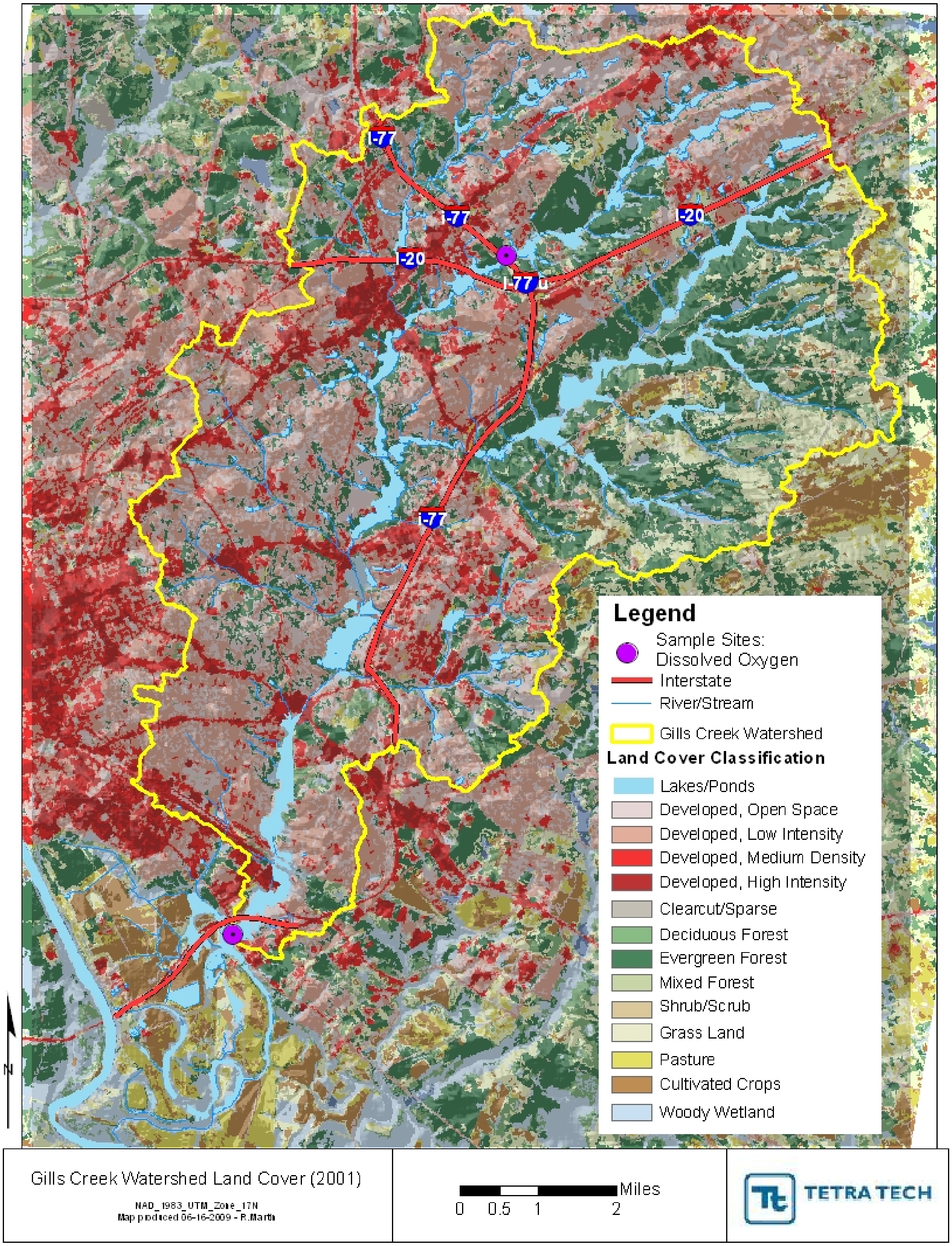

Figure 1-3. Gills Creek watershed land cover.

Table 1-1. Gills Creek Watershed Land Use/ Land Cover to C-017 (USGS 2001)

2001 NLCD	Area (mi^2)	Percent (%)
Open Water	1.4	2%
Developed, Open Space	12.1	18%
Low Intensity Development	16.1	24%
Medium Intensity Development	6.2	9%
High Intensity Development	2.1	3%
Barren	0.0	0%
Deciduous Forest	2.7	4%
Evergreen Forest	13.9	21%
Mixed Forest	1.1	2%
Shrubland	0.1	0%
Grassland	4.4	7%
Pasture and Hay	0.6	1%
Cropland	1.2	2%
Woody Wetland	4.1	6%
Emergent Wetland	0.2	0%
Watershed Total	66.3	

Soil types within or near the Gills Creek watershed in Richland County vary according to location within the watershed. In the northeastern section of the watershed, the predominant soil types are Lakeland soils, which are gently sloping to steep soils and are found within the Southern Piedmont Ecoregion. Lakeland soils are excessively drained soils that are sandy throughout. Soils in the central portion of the watershed are predominately Pelion-Johnston-Vaucluse soils. These soils are also gently sloping to steep soils found within the Southern Piedmont Ecoregion, and they can be moderately well drained soils that have a sandy surface layer and a loamy subsoil, very poorly drained soils that are loamy throughout, and/or well-drained soils that have a sandy surface layer and a fragipan in the loamy subsoil. In the southernmost part of the Gills Creek watershed, the soils are the nearly level to sloping soils found within the floodplains in the Coastal Plain Ecoregion. The three soil types in this area are Orangeburg-Norfolk-Marlboro, Persanti-Cantey-Goldsboro, and Congaree-Tawcaw-Chastain. Orangeburg-Norfolk-Marlboro soils are well-drained soils that have a sandy or loamy surface layer and can have a loamy or clayey subsoil. Persanti-Cantey-Goldsboro soils are moderately well drained soils or poorly drained soils. Within this soil type, the well-drained soils have a loamy surface layer and a clayey or loamy subsoil, and the poorly drained soils have a loamy surface layer and a clayey subsoil. The Congaree-Tawcaw-Chastain soils, which are nearly level soils on floodplains, are well-drained to moderately well drained soils that are loamy throughout. These soils can also be somewhat poorly drained soils that have a loamy surface layer and a clayey subsoil.

1.3. WATER QUALITY STANDARD

The impaired stream segments of the Gills Creek watershed are classified as Freshwaters, according to SCDHEC R.61-69 (SCDHEC 2008). Waters of this class are described as follows:

> Freshwaters (FW) are 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.61-69]

South Carolina's WQS for DO in freshwater is a daily average of not less than 5.0 mg/L with a minimum of 4.0 mg/L.

The lower portion of Gills Creek, in the vicinity of compliance point C-017, exhibits hydrology typical of swamp ecosystems, which have naturally occurring low DO. The Antidegradation Rules of South Carolina's WQS (R.61-68.D.4) recognize that natural conditions may cause a depression of DO in surface waters below the numeric standard while existing and classified uses are still maintained. This section states:

> 4(1) Under these conditions the quality of the surface waters shall not be cumulatively lowered more than 0.1 mg/l for dissolved oxygen from point sources and other activities, or
>
> 4(2) Where natural conditions alone create dissolved oxygen concentrations less than 110 percent of the applicable water quality standard established for that waterbody, the minimum acceptable concentration is 90 percent of the natural condition. Under these circumstances, an anthropogenic dissolved oxygen depression greater than 0.1 mg/l shall not be allowed unless it is demonstrated that resident aquatic species shall not be adversely affected. The Department [SCDHEC] may modify permit conditions to require appropriate instream biological monitoring.
>
> 4(3) The dissolved oxygen concentrations shall not be cumulatively lowered more than the deficit described above utilizing a daily average unless it can be demonstrated that resident aquatic species shall not be adversely affected by an alternate averaging period.

Section 4(1) is referred to as the "0.1 Rule"; section 4(2) is referred to as the "10% Rule."

2.0 Water Quality Assessment

Two locations in the watershed are considered impaired due to DO that is low enough to violate the WQS for DO. Table 2-1 provides a summary of the number of samples collected, the number of violations of the WQS, and the percentage of violations. Figures 2-1 and 2-2 illustrate samples exceeding the WQS (daily average) for DO monitoring conducted at C-017 and C-048 between 1999 and 2006, as well as temperature. For C-017, correlations between observed DO and temperature were strongly negative (R^2 = 0.67). However, observed DO and temperature at C-048 show a weakly negative correlation (R^2 = 0.33). Illustrations of these relationships are provided in Appendix A. Appendix A presents measured DO data at C-001 and C-017 between 1999 and 2006 in Tables A-1 and A-2.

C-017 is an integrator station, which is a station sampled every month in every year. Prior to 2001, C-048 was a secondary station (sampled May–October every year). In 2001, its status changed to a Saluda-Edisto Basin station, which means that C-048 is sampled every fifth year for all 12 months in that year.

Table 2-1. Dissolved Oxygen Data Summary for Impaired Stations (1999–2006)

Station	Waterbody	Number of Samples	Count/% < 5 mg/L WQS	Count/% < 4 mg/L WQS
C-048	Windsor Lake Spillway on Windsor Lake Blvd. (Jackson Creek)	32	8 (25%)	3 (9%)
C-017	Gills Creek at SC48	93	12 (13%)	2 (2%)

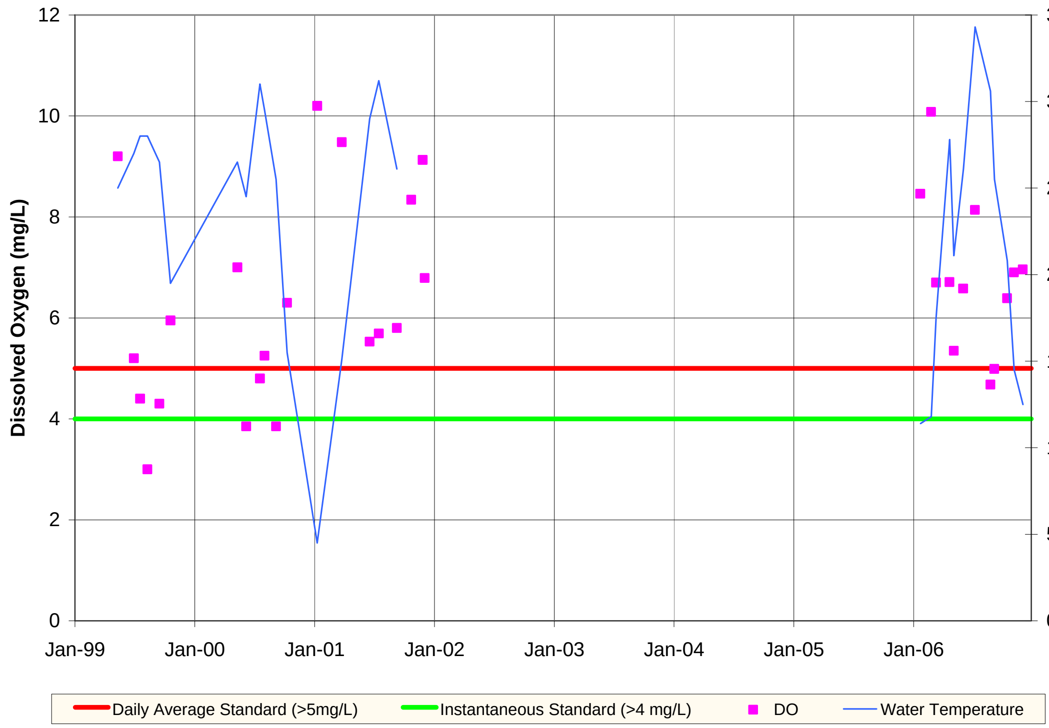

Figure 2-1. Dissolved oxygen and water temperature observed in the Gills Creek watershed at C-048.

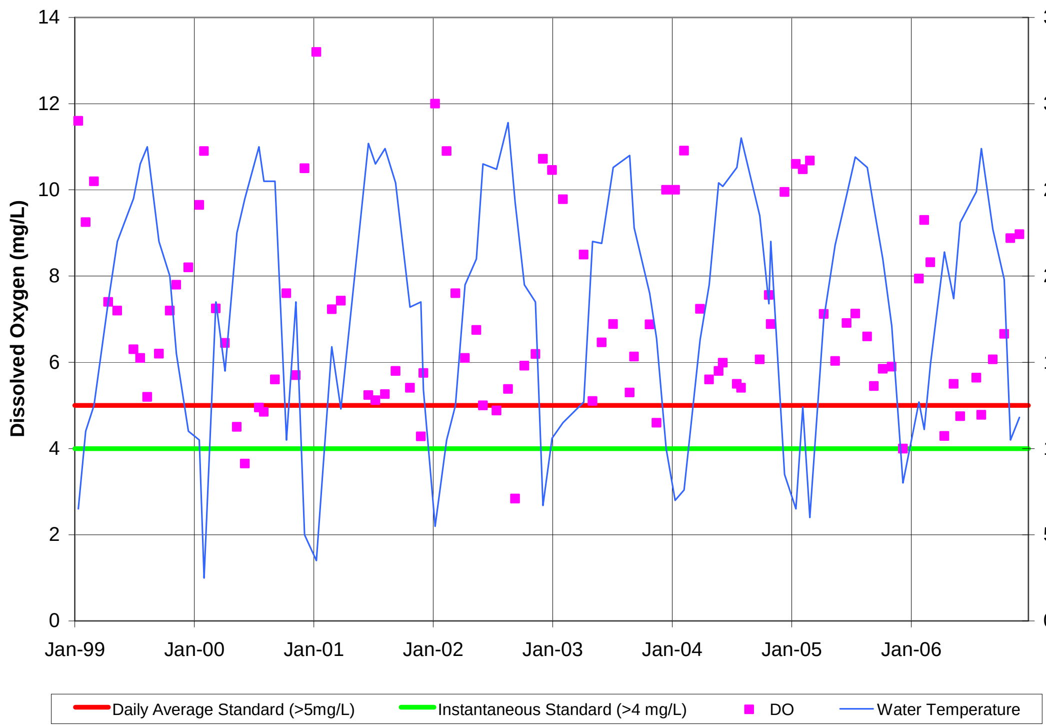

Figure 2-2. Dissolved oxygen and water temperature observed in the Gills Creek watershed at C-017.

The correlation of DO and temperature confirms seasonal trends (Table 2-2). Low DO generally occurs in the summer months. This relationship is most apparent at the Windsor Lake spillway. It should be noted that data for C-048 were collected only from 1999 through 2001 and again in 2006. A few violations occurred outside the growing season at C-017. Because these violations occurred during periods of low precipitation, they might have been due to nutrient sources that are not correlated with rainfall.

Table 2-2. Percent of Monthly Dissolved Oxygen Samples Violating the WQS

Month	< 5 mg/L		< 4 mg/L	
	C-017	C-048	C-017	C-048
Jan	0%	0%	0%	0%
Feb	0%	0%	0%	0%
Mar	0%	0%	0%	0%
Apr	14%	0%	0%	0%
May	14%	0%	0%	0%
Jun	25%	25%	0%	25%
Jul	25%	50%	0%	0%
Aug	25%	67%	0%	33%
Sep	13%	75%	13%	25%
Oct	0%	0%	0%	0%
Nov	25%	0%	0%	0%
Dec	13%	0%	0%	0%

The occurrence of fish kills has been reported in the watershed, and some of these events are attributed to low DO. At least 17 fish kills were reported in the watershed between 1978 and 2006, according to available data from SCDHEC. The locations of all fish kills reported in Richland County were not available; it is therefore assumed that more fish kills could have occurred in the Gills Creek watershed during this time period. All but three of the fish kills occurred in a pond or lake, including Clark Lake (3 events), Lake Katherine (2 events), Legion Lake, Springwood Lake (2 events), North Springs Lake, Semmes Lake, Drexel Lake, and several unnamed ponds. Reported potential causes of the fish kills were algal blooms, draining, pesticides, raw sewage, turnover, and sediment from construction.

Turnover is a likely cause of fish kills in ponds four feet deep or deeper. This phenomenon occurs when the surface layer of a pond cools and mixes with the bottom, less oxygenated layer, which decreases the DO in the water near the surface. Turnover most commonly occurs in the fall or late summer, but it can also occur due to rain or cloud cover that decreases the temperature of the surface layer (GADNR 2009).

Of the three additional fish kills, one event occurred in a ditch upstream of a stormwater pond and two occurred in Gills Creek. The Gills Creek fish kills occurred in 1980 and 1986, and the potential cause reported was low DO. Specific location information was not available for the Gills Creek events. No fish kills were reported in Windsor Lake or just downstream. Although these occurrences indicate that low DO might have affected fish populations in Gills Creek in the past, these reports do not provide conclusive indicators of the causes of low DO in Gills Creek.

Table 2-3 summarizes relevant chemical parameters at the four SCDHEC monitoring stations in the watershed. Generally, freshwater inland systems like the Gills Creek watershed may be phosphorus-limited. Although there may be loading of phosphorus into Gills Creek along its entire length, the strongest signal of input appears between stations C-001 and C-017, with the caveat that far fewer data are available upstream of C-001 compared to downstream. Table 2-3 summarizes only data from 1997 and later, but data from the 1970s indicate potential excess input of phosphorus upstream of C-001: Each station reports similar magnitudes and ranges for that period (mean total phosphorus was 0.08 mg/L in the 1970s at C-001 and C-017). This phosphorus input might have been retained in lakes and ponds to some degree and might still be affecting DO downstream of these waterbodies. Also, in the 1970s higher mean BOD5 concentrations were reported for C-048, C-001, and C-017, with means ranging from 4.7 to 7.2 mg/L BOD5.

Table 2-3. Summary of Relevant Chemical Parameters at SCDHEC Four Monitoring Stations collected from 1997 through 2006

Station	Station Name	Parameter Name	Count	Mean	Minimum	Maximum	First Date	Last Date
C-048	Windsor Lake Spillway on Windsor Lake Blvd. on Jackson Creek	5-day Biochemical Oxygen Demand (BOD5) mg/L	21	2.68	1.30	4.90	5/12/99	11/8/06
		Ammonia (NH_3) as N mg/L	10	0.15	0.04	0.35	6/19/01	12/5/06
		Nitrite (NO_2) + Nitrate (NO_3) as N mg/L	9	0.06	0.02	0.16	1/10/01	12/5/06
		Total Kjeldahl Nitrogen (TKN) mg/L	16	0.53	0.22	0.94	4/3/01	12/5/06
		pH	32	6.45	5.36	7.94	5/12/99	12/5/06
		Total Phosphorus (TP) mg/L	5	0.03	0.02	0.04	5/8/06	11/8/06
		Total Nitrogen (TN) mg/L	6	0.73	0.44	0.97	1/26/06	12/5/06
C-068	Forest Lake at Dam at an Abandoned Fort Jackson Water Intake	5-day Biochemical Oxygen Demand (BOD5) mg/L	41	2.64	0.80	5.10	1/13/99	11/8/06
		Ammonia (NH_3) as N mg/L	24	0.10	0.04	0.28	1/13/99	12/5/06
		Nitrite (NO_2) + Nitrate (NO_3) as N mg/L	14	0.08	0.02	0.20	1/13/99	12/5/06
		Total Kjeldahl Nitrogen (TKN) mg/L	38	0.52	0.10	1.05	1/13/99	12/5/06
		pH	46	7.19	5.34	9.56	1/13/99	12/5/06
		Total Phosphorus (TP) mg/L	7	0.02	0.02	0.03	1/26/06	11/8/06
		Total Nitrogen (TN) mg/L	10	0.60	0.30	0.98	1/13/99	12/5/06
C-001	Gills Creek at US 76	5-day Biochemical Oxygen Demand (BOD5) mg/L	44	3.34	1.20	5.40	1/13/99	12/5/06
		Ammonia (NH_3) as N mg/L	34	0.11	0.04	0.30	1/13/99	12/5/06
		Nitrite (NO_2) + Nitrate (NO_3) as N mg/L	44	0.08	0.02	0.23	1/13/99	12/5/06
		Total Kjeldahl Nitrogen (TKN) mg/L	39	0.62	0.13	1.22	1/13/99	12/5/06

Station	Station Name	Parameter Name	Count	Mean	Minimum	Maximum	First Date	Last Date
		pH	46	6.95	5.36	9.35	1/13/99	12/5/06
		Total Phosphorus (TP) mg/L	7	0.04	0.03	0.06	3/15/06	11/8/06
		Total Nitrogen (TN) mg/L	36	0.68	0.20	1.09	1/13/99	12/5/06
C-017	Gills Creek at SC 48	5-day Biochemical Oxygen Demand (BOD5) mg/L	65	2.74	1.10	7.00	1/12/99	12/4/06
		Ammonia (NH_3) as N mg/L	72	0.21	0.07	0.51	1/12/99	12/4/06
		Nitrite (NO_2) + Nitrate (NO_3) as N mg/L	94	0.16	0.02	0.37	1/12/99	12/4/06
		Total Kjeldahl Nitrogen (TKN) mg/L	75	0.73	0.15	1.8[1]	1/12/99	12/4/06
		pH	93	6.68	5.17	8.78	1/12/99	12/4/06
		Total Phosphorus (TP) mg/L	55	0.06	0.02	0.15[1]	1/9/02	12/4/06
		Total Nitrogen (TN) mg/L	75	0.89	0.23	1.91[1]	1/12/99	12/4/06
		Total Suspended Solids (TSS) mg/L	5	4.96	1.20	8.00	2/3/99	2/8/05

TABLE 2-4 Continued.

[1]Outliers greater than 70 mg/L were removed from the TKN, TN, and TP data; for most of these outliers, a second measurement on the same date provided a value with an expected range for the parameter.

Nitrogen presents the clearest signal of increasing value moving from upstream to downstream. The average ammonia value in the headwater station (C-048) is 0.15 mg/L, whereas the average value at the downstream station (C-017) is 0.21 mg/L. Considering the same two stations, the average nitrate plus nitrite (NO_x) value goes from 0.06 to 0.16 mg/L and the average TKN value increases from 0.53 to 0.73 mg/L.

The average DO decreases slightly moving downstream from C-001 to C-017, and there may be numerous considerations related to this occurrence. Among them are water temperature, BOD5, nutrients/algal response, impoundments/velocities. DO values have a strong inverse correlation to water temperature. BOD5 demand on oxygen might also stress the DO levels in Gills Creek and might or might not be the primary stressor. There is a strong signal of nitrogen input and a slight signal of phosphorus input, and collectively these may cause algal response in the system, which could adversely affect DO levels. Currently, there is no information regarding algal response in Gills Creek except that algae have been visually observed by SCDHEC in Windsor Lake.

Lastly, the numerous impoundments might affect DO levels. These impoundments might be releasing anoxic waters (if a dam is leaking or designed to release deep water) or waters with elevated temperatures to downstream reaches. The impoundments might also affect the connecting reaches by creating segments that have effectively zero stream velocity, which might depress DO levels. Given that a number of lakes and ponds have been implicated over time for fish kills reportedly due to low DO, the impoundments are an important consideration.

3.0 Source Assessment

The DO concentration in natural waters reflects a balance between sources and sinks. Aquatic microorganisms produce and/or consume oxygen in surface waters. At low temperatures the solubility of oxygen is increased, so that in winter, concentrations as high as 20 mg/L may be found in natural waters; during hot summer conditions, saturation levels can be as low as 6 mg/L. A variety of factors can influence the DO concentrations in a water body, including (but not limited to) the climate, temporal conditions, volume and velocity of flow, types and numbers of organisms present in the waterbody, dissolved or suspended solids, amount of nutrients present, organic wastes, riparian vegetation, and groundwater inflow. As is suggested here, attaining adequate concentrations of DO might require quite a specific set of conditions because many factors might influence DO.

The source assessment phase of this study involved identifying and quantifying the pollutant loads that contribute to DO impairment. The accuracy and precision of estimated loading rates may be reduced by many sources of uncertainty and environmental variability.

There are many sources oxygen-demanding pollution in surface waters. In general, these sources can be classified as point and nonpoint sources. With the implementation of technology-based controls, pollution from continuous point sources, such as factories and wastewater treatment facilities, has been greatly reduced. The Clean Water Act requires these point sources to obtain a National Pollutant Discharge Elimination System (NPDES) permit. In South Carolina, NPDES permits require that dischargers of wastewater must meet the DO water quality standard at the point of discharge.

Municipal and private sanitary wastewater treatment facilities may occasionally be sources of oxygen-demanding substances. However, if these facilities are discharging wastewater that meets their permit limits, they are not causing impairment. If any of these facilities is not meeting its permit limits, enforcement actions/mechanisms are required.

Other non-continuous point sources required to obtain NPDES permits that may be a source of oxygen-demanding substances include municipal separate storm sewer systems (MS4s) and stormwater discharges from industrial or construction sites. MS4s might require NPDES discharge permits for industrial and construction activities under the NPDES Phase II Stormwater regulations. These sources are also required to comply with the state standard for the pollutant(s) of concern. If MS4s and discharges from construction sites meet the percentage reduction for BOD5 and ammonia, as prescribed in Section 5 of this TMDL document and required in their MS4 permit(s), they should not be causing or contributing to an in-stream DO impairment.

Richland County and the Gills Creek Watershed Association (GCWA) recently developed a watershed management plan for Gills Creek, prepared by Tetra Tech, Inc., and BP Barber and Associates, Inc. (Tetra Tech and BP Barber 2009). The plan contains a source assessment with detailed discussions and maps of potential pollutant sources, including sources that affect DO. A summary of the findings of that source assessment (referred to hereafter as "the WMP") follows.

3.1. Point Sources

3.1.1. Continuous Discharge Point Sources

Figure 3-1 and Table 3-1 show the locations of NPDES-permitted facilities with active or inactive permits. There are currently four active NPDES discharges to surface waters in the watershed. Two of these discharges are stormwater outlets from diked oil storage facilities within Fort Jackson, which have the following permit limits related to DO (monitored monthly):

- Total organic carbon: 110 mg/L daily maximum

- Oil and grease: 10 mg/L monthly average and 15 mg/L daily maximum
- pH: 6.0–8.5 instantaneous minimum and maximum.

The NPDES facility in the upper part of the watershed (SC0046264) is a groundwater remediation site, and it is not expected to contribute to the C-017 DO impairment. The active facility in the lower portion of the watershed (SCG250180, formerly SC0002101) is a minor industrial discharger of cooling water with the following permit limits relevant to DO (monitored quarterly):

- Water temperature: 90 degrees Fahrenheit daily max
- BOD5: 20 mg/L daily maximum
- pH: 6.0–8.5 instantaneous minimum and maximum
- Total suspended solids (TSS): 40 mg/L daily maximum

Some of the facilities are currently inactive. Table 3-1 presents the period of record of data used in modeling. Future NPDES discharges in the referenced watershed are required to comply with the assumptions and requirements of the TMDL.

Table 3-1. NPDES Permits Active at Some Time during Model Period in the Gills Creek Watershed

Name	NPDES ID	Waterbody	Current Status	Dates during Model Period for Which Data Are Available	Permit Limits
Amphenol Corporation	SC0046264	Ephemeral tributary to Jackson Creek	Active	01-31-97 through 12-31-04	Trichloroethene – 0.005 mg/L daily maximum 1,1-Dichloroethylene[1] – 0.007 mg/L daily maximum pH – within 6.0 to 8.5 daily Flow – monitor and report Must monitor and report 6 other organic chemicals.
Aramark Uniform Services	SC0046566	Tributary to Tributary G-1	Inactive	No data available.	BOD5 – 10.0 mg/L daily average and 20 mg/L daily maximum pH – within 6.0 to 8.5 daily Flow – monitor and report Limits for 7 organic chemicals
Central Products[2]	SCG250180	Gills Creek	Active	01-31-97 through 12-31-04	*Before 10-31-98:* The previous limits as stated below. TDS – 500 mg/L daily maximum (if boiler blowdown is discharged) Flow – 0.50 MGD daily maximum Total residual chlorine – calculated based on flow using equation in permit. *After 10-31-98:* Water temperature – 90 degree F daily max BOD5 – 20 mg/L daily maximum TSS – 40 mg/L daily maximum pH – within 6.0 to 8.5 daily Flow – monitor and report
Fort Jackson	SC0003786 – Pipe 002	Wildcat Creek	Inactive	01-31-97 through 03-31-98	Total organic carbon – 110 mg/L daily maximum Oil and grease – 10 mg/L monthly average and 15 mg/L daily maximum pH – within 6.0 to 8.5 daily Flow – monitor and report

Name	NPDES ID	Waterbody	Current Status	Dates during Model Period for Which Data Are Available	Permit Limits
Fort Jackson	SC0003786 – Pipe 004	Wildcat Creek	Inactive	03-31-97 through 03-31-98	Total Organic carbon – 110 mg/L daily maximum Oil and grease – 10 mg/L monthly average and 15 mg/L daily maximum pH – within 6.0 to 8.5 daily Flow – monitor and report
Fort Jackson[3]	SC0003786 – Pipe 006	Lake Katherine	Inactive	09-30-97 through 09-30-04	Total organic carbon – 110 mg/L daily maximum Oil and grease – 10 mg/L monthly average and 15 mg/L daily maximum pH – within 6.0 to 8.5 daily Flow – monitor and report
Fort Jackson[3]	S0003786 – Pipe 007	Gills Creek	Inactive	09-30-97 through 12-31-04	Total organic carbon – 110 mg/L daily maximum Oil and grease – 10 mg/L monthly average and 15 mg/L daily maximum pH – within 6.0 to 8.5 daily Flow – monitor and report
Fort Jackson	SC0003786 – Pipe 008	Wildcat Creek	Inactive	03-31-97 through 11-30-97	Total organic carbon – 110 mg/L daily maximum Oil and grease – 10 mg/L monthly average and 15 mg/L daily maximum pH – within 6.0 to 8.5 daily Flow – monitor and report
Fort Jackson	SC0003786 – Pipe 009	Gills Creek	Inactive	03-31-97 through 02-28-99	Total organic carbon – 110 mg/L daily maximum Oil and grease – 10 mg/L monthly average and 15 mg/L daily maximum pH – within 6.0 to 8.5 daily Flow – monitor and report
Furon Company/ Helico Components	SC0046418	Unnamed Tributary to Gills Creek	Inactive	01-31-97 through 06-30-97	12 chemical parameters including: BOD5 – 10 mg/L monthly average; 20 mg/L daily maximum TSS – 30 mg/L monthly average; 60 mg/L daily maximum pH – within 6.0 to 8.5 daily Flow – monitor and report

Name	NPDES ID	Waterbody	Current Status	Dates during Model Period for Which Data Are Available	Permit Limits
Tenneco Direct Service Station	SC0043770	Eight Mile Branch	Inactive	01-31-97 through 03-31-97	BOD5 – 10 mg/L monthly average and 20 mg/L daily maximum pH – within 6.0 to 8.5 daily Lead – 0.05 mg/L daily maximum Limits for 12 organic chemicals. Flow – monitor and report

[1] Parameter was Dichloroethene through 6-30-98.

[2] Formerly Intertape Polymer Group, SC0002101.

[3] On 10-27-08, NPDES permit SC0003786 was cancelled. Certification (#SCR001892) was issued by SCDHEC for these Fort Jackson outfalls 006 and 007 under the industrial stormwater general permit SCR000000. Therefore, after 10-27-08, these two outfalls were no longer classified as continuous point sources; they are non-continuous point sources.

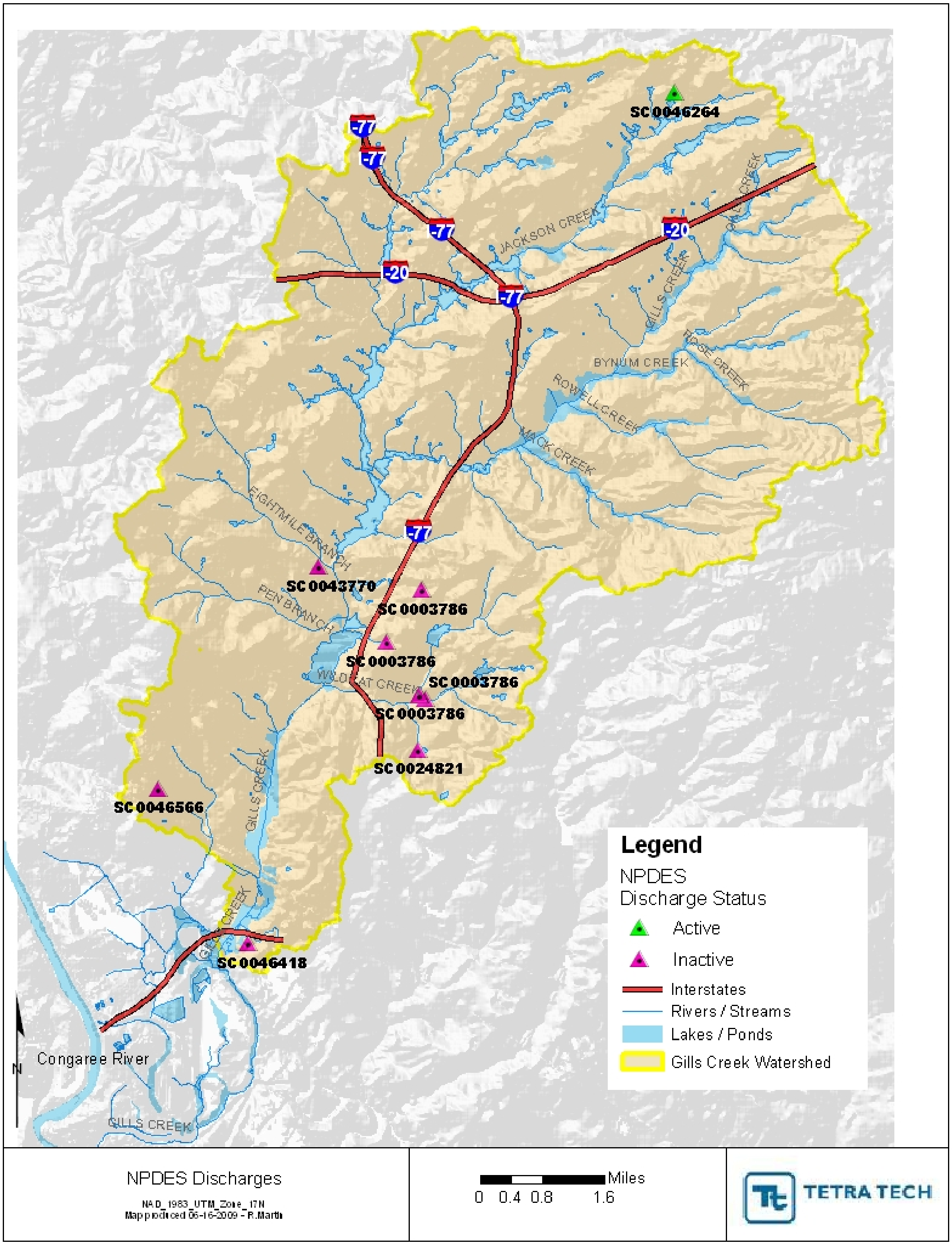

Figure 3-1. Gills Creek watershed NPDES point source discharges.

3.1.2. Point Sources from Non-continuous Discharges

Non-continuous point sources include all NPDES-permitted stormwater discharges, including current and future MS4s, construction, and industrial discharges covered under permits SCS and SCR and regulated under South Carolina Water Pollution Control Permits Regulation 122.26(b)(14) and (15); see Figure 3-1. All regulated MS4 entities have the potential to contribute pollutant loadings in the delineated drainage area used in the development of this TMDL.

The South Carolina Department of Transportation (SCDOT) is designated as an MS4 within the Gills Creek watershed. SCDOT operates under NPDES MS4 SCS040001 and owns and operates roads in the watershed (Figure 4). However, the Department recognizes that SCDOT is not a traditional MS4 in that it does not possess statutory taxing or enforcement powers. SCDOT does not regulate land use or zoning, issue building or development permits.

As previously mentioned, the following jurisdictions are regulated MS4 entities within the Gills Creek watersheds: Richland County, the City of Columbia, the Town of Arcadia Lakes, the City of Forest Acres, and the U.S. Army/Fort Jackson (Figure 3-3). Of these jurisdictions, Richland County and the City of Columbia are designated Phase I MS4s. The Town of Arcadia Lakes and the City of Forest Acres are Phase II MS4s currently covered under the jurisdiction of the Richland County Phase I MS4 permit and are not considered separate MS4 entities for the purposes of this TMDL document. If future MS4 permits are applicable to this watershed, those discharges will be subject to the assumptions and requirements of the wasteload allocation (WLA) portion of this TMDL.

The MS4 urbanized area in the watershed is shown in Figure 3-3. It encompasses a majority of the watershed, excluding the lower portion near the Congaree River and the upper, northeastern portion. This area is expected to be a major source of sediment and nutrients in stormwater runoff that can decrease DO concentrations. In addition to pollutants in runoff, increased stormwater flow from development may increase stream bank and channel erosion, which can introduce large quantities of sediment and phosphorus into surface water.

At any time, industrial or construction activities that could produce stormwater runoff might be going on. Industrial facilities that have the potential to cause or contribute to a violation of a water quality standard are covered by the NPDES Storm Water Industrial General Permit (SCR000000). Construction activities are usually covered by the NPDES Storm Water Construction General Permit from SCDHEC (SCR100000). Where construction activities have the potential to affect water quality of a water body with a TMDL, the Storm Water Pollution Prevention Plan (SWPPP) for the site must address any pollutants of concern and adhere to any WLAs in the TMDL.

Locations of construction permits were not available prior to September 2006. Between 2006 and 2008, 17 construction permits were active in the watershed, with a total disturbed area of 374 acres. The sediment loading from construction sites might have contributed to low DO in the watershed by introducing sediment and nutrients into surface water through the erosion of bare soil. These sites are regulated under the NPDES General Permit for Storm Water Discharges from Large and Small Construction Activities in the State of South Carolina (SCR100000). Under the permit, developers must develop and implement a stormwater pollution prevention plan (SWPPP) that includes best management practices (BMPs) to minimize sediment in stormwater runoff.

Congaree Sand Pit, which is downstream of C-017 in subbasin m1_2, is the only active mining operation in the watershed for the entire modeling period; it is a sand mine. Cherokee Inc Highway #1 Plant (subbasin m1_6) was active 06-01-1999 through 12-06-2000. These operations are regulated under the NPDES General Permit for Nonmetal Mineral Mining Discharges, Groundwater, Storm Water, and Mine Process Wastewater in the State of South Carolina (SCG730000. In addition to meeting permitted numeric limits, operations must develop and implement SWPPPs and BMPs on their sites.

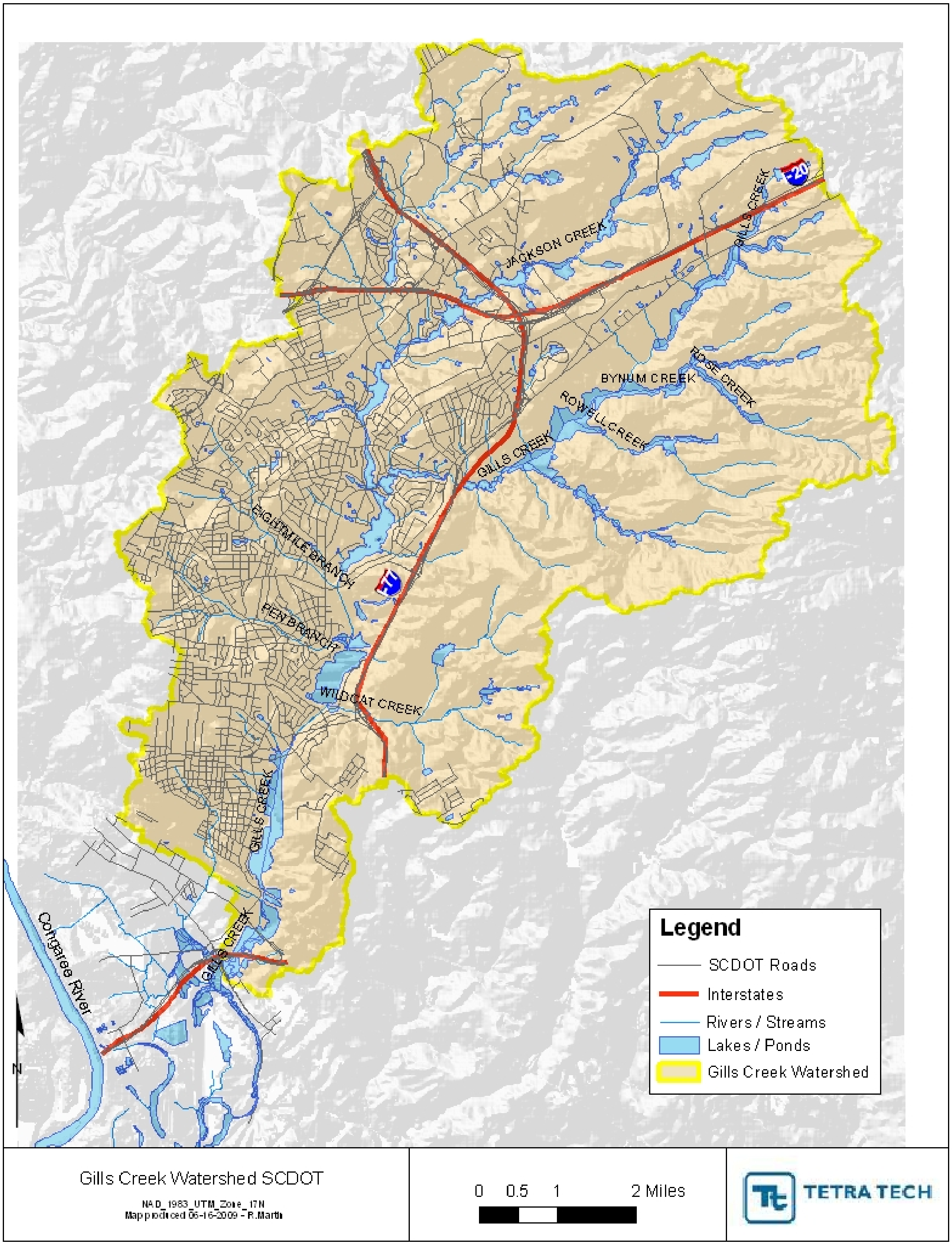

Figure 3-2. South Carolina Department of Transportation roads in Gills Creek watershed.

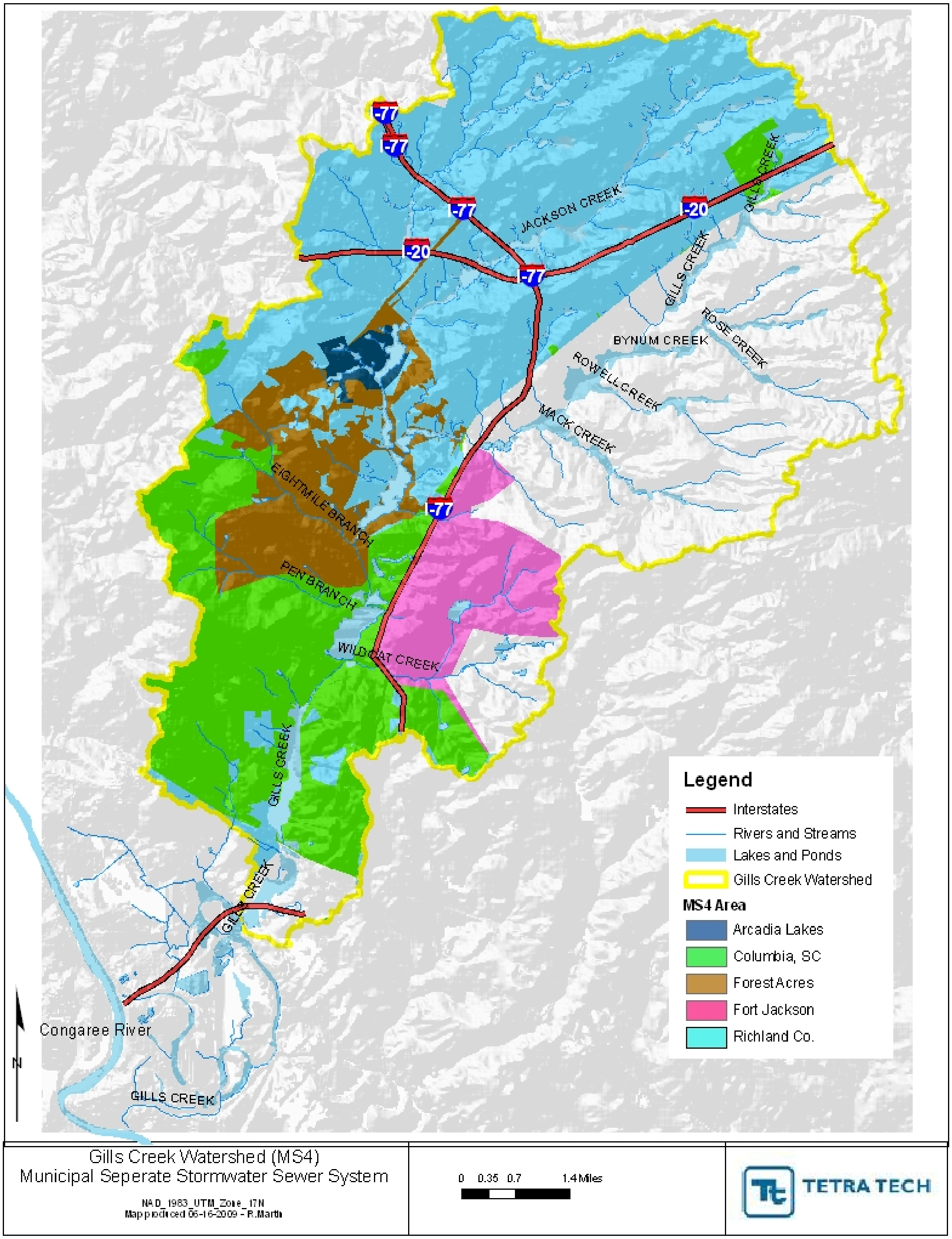

Figure 3-3. Regulated municipal separate storm sewer systems in Gills Creek watershed.

3.2. NONPOINT SOURCES

The Department recognizes that there may be agricultural activities, septic tanks, leaking sanitary sewers, wildlife, grazing animals, and/or other nonpoint source contributors located within unregulated areas (outside the permitted area) of the Gills Creek watershed. Nonpoint sources located in unregulated areas are subject to the load allocation (LA) portion and not the WLA portion of the TMDL document.

3.2.1. Agricultural Activities

Agricultural activities that involve livestock, animal wastes, or unstabilized surfaces are potential sources of BOD5 substances to surface waters. Owners/operators of most commercial animal growing operations are required by SC Regulation 61-43, Standards for the Permitting of Agricultural Animal Facilities, to obtain permits for the handling, storage, treatment (if necessary) and disposal of the manure, litter, and dead animals generated at their facilities (SCDHEC 2002). The requirements of R. 61-43 are designed to protect water quality; therefore, we have a reasonable assurance that facilities operating in compliance with this regulation should not contribute to downstream water quality impairments. South Carolina currently does not have any confined animal feeding operations (CAFOs) under NPDES coverage; however, the State does have permitted animal feeding operations (AFOs) covered under R. 61-43. These permitted operations are not allowed to discharge to waters of the State and are covered under ‘no discharge’ (ND) permits. Discharges from these operations to waters of the State are illegal and are subject to enforcement actions by SCDHEC.

No permitted AFOs, Manure Utilization Areas (MUAs), or Buried Dead Animal (BDA) sites exist in the Gills Creek Watershed at this time. Individual farmers can legally apply up to 12 tons of manure per year to land that they own or lease without being permitted; therefore, their application sites would not be recorded in the database. Manure application, in conjunction with a regulated animal facility, is regulated per R.61-43 100.100 and R.61-43 200.100.

Individually owned horse farms are present in the upper, northeastern portion of the watershed, and a few additional operations may exist throughout the less developed portions (H. Caldwell, Richland County Soil and Water Conservation District, personal communication to H. Fisher, September 2008). All of these operations are expected to be small farms with low densities of livestock. Livestock operations might contribute some nutrient and sediment loading to the watershed but are not expected to be a major source.

Cropland is likely to be a minor contributor to DO impairments. About 4 percent of the watershed is maintained as cropland, and about 2 percent is maintained for pasture or hay production, according to the USGS 2001 land use and land cover. The USGS provides 30 by 30 meter grid land use and land cover information generated though aerial photography for the entire United States (USGS 2009). Its data set is the most comprehensive land cover dataset for the entire Gills Creek watershed. Most of the agricultural land is located in the lower portion of the watershed near the Congaree River. The major crops grown are corn, soy and hay (H. Caldwell, Richland County Soil and Water Conservation District, personal communication to H. Fisher, September 2008).

3.2.2. Leaking Sanitary Sewers and Illicit Discharges

Leaking sewer pipes and illicit sewer connections represent direct inputs of BOD5 and nutrients to water bodies. Quantifying these sources is extremely speculative without direct monitoring of the source because the magnitude is directly proportional to the volume and the proximity of the source to the surface water.

At the time of TMDL development, data on the condition of sewer pipes were not available from the two major municipal sewer districts in the watershed, the City of Columbia and the East Richland County Public Service District (ERCPSD). Some pipes within ERCPSD date back to the 1940s, and the District continually repairs leaks in the infrastructure (Donny Way, ERCPSD, personal communication to H. Fisher, May 14, 2009). Portions of the City of Columbia system are likely to be of similar age and condition. In the future, comprehensive studies of infiltration and inflow within both districts would provide an estimate of impacts due to these sources.

Illicit discharges that might be occurring in the watershed include, but are not limited to:

- Sewer pipes wrongly connected to storm sewers, including restaurant sewer pipes (which can happen intentionally or unintentionally and can be identified through dye tests and infrared imaging)
- Septic systems emptying into storm drains (which a septic system owner might do after a drain field malfunctions).

Monitoring of storm drain outfalls during dry weather is needed to document the presence or absence of sewage in the drainage systems. Dye tests and infrared imaging, as noted above, would allow the identification of specific sources.

3.2.3. Failing Septic Systems

Failing septic systems are potential sources of nutrients and BOD5 in surface water and groundwater. The entire watershed is serviced by municipal sewer systems, indicating that new or recent development is likely to be serviced by municipal sewer systems and not septic systems. Older development might be serviced by septic systems. U.S. Census data indicate that in 1990 the onsite wastewater system density in the watershed ranged from 3 to 1,100 systems per square mile. Since the 1990 census, it is likely that some septic systems in developing areas have been replaced with sanitary sewers. The Richland County Public Health Department is not aware of any septic systems within the watershed (Robert Deyo, Richland County Public Health Department, personal communication to H. Fisher, November 2008). The WMP stakeholder survey indicated that there is at least one remnant septic system in the lower portion of the watershed, between US-76 and SC-48 (Bluff Road). BP Barber estimated that about 1 percent of the ERCPSD is served by septic tanks (T. Thain, BP Barber, personal communication, July 2008).

To estimate the approximate loading from remnant septic systems, about 1 percent of the ERCPSD by area was assumed to be served by septic tanks. For areas within the watershed where no current estimate of septic density was available, it was assumed that half of the systems present in 1990 are still in use, which represents the midpoint within the range of potential values for this estimate. This is a gross estimate that could be refined if geospatial data on sanitary sewer lines are available in the future. It was also assumed that each system serves about three persons per household and that the average failure rate of the systems is 20 percent (Schueler 1999). Based on the 1990 census data and these assumptions, it was estimated that 1,071 septic systems are active in the watershed and that 214 of those systems are failing.

3.2.4. Sanitary Sewer Overflows

Sanitary sewer overflows (SSOs) contribute high concentrations of BOD5 and nutrients during short time intervals. About 71 overflows have been recorded at 60 locations in the watershed since 2000. These overflows represent 308,025 gallons released, and 93 percent of this volume was released to surface waters. Additional SSOs might have occurred in the watershed, but they could not be geolocated due to insufficient information. The overflows do not appear to be concentrated in a single portion of the watershed. The locations that contribute the nutrient and sediment loads to surface waters are likely those that occur directly adjacent to water bodies, such as the locations directly upstream of Lake Katherine. SCDHEC is not aware of any combined sewer overflows (CSOs) in the watershed and does not expect that any CSOs have occurred (G. Trofatter, SCDHEC Bureau of Water, personal communication to H. Fisher, September 2008).

The Department acknowledges that limited data are available to quantify the location of SSOs and the quantity of spills that reach surface waters. The assumptions of the TMDL are expected to be a fraction of the number of spills actually occurring in the watershed.

3.2.5. Urban/Suburban Runoff

A significant portion of the Gills Creek watershed has been developed into suburban and urban lands (~36.5 mi^2). This development is scattered throughout most of the watershed, with the exception of Fort Jackson lands (mostly forested) Impacts from urban/suburban land are likely to occur throughout the watershed due to the sprawling nature of this development (see Figure 1-2). The developed areas outside the MS4 jurisdictions are considered nonpoint pollutant sources, although runoff is a concern for nutrients and BOD5 substances both within and outside MS4 jurisdictions.

The application of fertilizer on residential lawns and recreational land (e.g., golf courses, soccer fields) can be a major source of nutrient loads to surface water and groundwater. Table 3-2 outlines the nitrogen application rates recommended for lawns in the watershed. Fertilizer applied to roughly half the lawns in the watershed likely contains phosphorus; most fertilizer applied probably contains potassium as well. Residents are likely applying fertilizer at higher than the recommended rates and might be using cool season grass fertilizer, which contains 30 percent nitrogen and 2 to 3 percent of potassium and phosphorus, during the summer (D. Mcinnes, Clemson University Cooperative Extension, personal communication to H. Fisher, May 15, 2009).

Table 3-2. Recommended Nitrogen Application Rates in the Gills Creek Watershed

Type of Grass	Approximate Percentage of Lawns in Watershed	Recommended Rate of Nitrogen Application
Centipede	60%	1 lb N per 1,000 ft^2 per year
Bermuda, St. Augustine, or Zoysia	40%	2-3 lbs N per 1,000 ft^2 per year

Source: D. McInnes, Clemson University Cooperative Extension, personal communication to H. Fisher, May 15, 2009.

3.2.6. Atmospheric Deposition

Atmospheric deposition can be a source of nutrients that originate from air emissions within and outside the watershed. This is important for nitrogen, but generally more significant for phosphorus, which does not have a common gaseous phase. Nutrients in the atmosphere can originate from automobiles, power plants, incinerators, factories, and a number of other sources. The sources of nutrients may be located many miles from the receiving watershed. Deposition can occur during rain events (wet deposition) and between rain events (dry deposition).

Data on the deposition of phosphorus were not available for the watershed. Estimated deposition rates are available for nitrogen from the EPA Clean Air Status and Trends Network (CASTNET). The closest CASTNET monitoring station is in Montgomery County, North Carolina, near the North Carolina–South Carolina border. Data from 1997 through 2007 are summarized in Table 3-3.

Table 3-3. Range and Average of CASTNET Annual Deposition Rates for Nitrogen 1997–2007, excluding 1998 and 2004, for Site NC36 in Montgomery County, North Carolina

	Nitrogen Deposition (kg N/ha/year)		
	Dry	Wet	Total
Minimum	1.8	3.1	5.4

	Nitrogen Deposition (kg N/ha/year)		
	Dry	Wet	Total
Average	2.2	4.5	6.6
Maximum	2.6	5.6	7.6

Wet deposition estimates are also available from the National Atmospheric Deposition Program (NADP). These data are interpolations of monitoring data, and the stations used are within closer proximity to the Gills Creek watershed than the CASTNET monitoring stations. Table 3-4 summarizes the NADP average annual nitrate concentration data for the years 1994 through 2006. These concentrations will be translated into loading rates and used with the CASTNET data to inform model input. It should be noted that these estimates measure only nitrate, whereas CASTNET measures total nitrogen.

Table 3-4. Range and Average of NADP Wet Deposition Annual Average Concentrations for Nitrate (as Nitrogen) 1994–2006 for the Gills Creek Watershed

	NO_3 as N (mg/L) in Precipitation
Minimum	0.15
Average	0.25
Maximum	0.83

4.0 Modeling Methodology

To develop TMDLs for the Gills Creek watershed, SCDHEC contracted Tetra Tech to update a watershed model developed by the Richland County Department of Public Works (Richland County). The Loading Simulation Program C++ (LSPC) was selected to address all the modeling needs in the Gills Creek watershed. LSPC is a version of the Hydrologic Simulation Program–FORTRAN (HSPF) model that has been ported to the C++ programming language to improve efficiency and flexibility.

LSPC was configured to simulate the Gills Creek watershed as a series of hydrologically connected subbasins. The delineated subbasins from Richland County's HSPF model were the basis for further delineation at the U.S. Geological Survey (USGS) flow gauge (USGS 02169570) and SCDHEC water quality assessment points. The subbasins were configured to model streams and lakes in the Gills Creek watershed. The simulation period, a 7-year period from January 1, 1998, through December 31, 2004, was chosen to correspond with Richland County's HSPF model.

The LSPC model is driven by precipitation and other climatological data (e.g., air temperature, evapotranspiration, dew point, cloud cover, wind speed, solar radiation). Of the four available stations, two stations that had been used for Richland County's HSPF model—the National Oceanic and Atmospheric Administration's (NOAA) Columbia Metropolitian Airport weather station (KCAE) located approximately 11 miles southwest from the centroid of the Gills Creek watershed and the Sandhill Research Elgin weather station located approximately 8.5 miles northeast from the centroid of the Gills Creek watershed—were selected as the rainfall stations for this modeling effort.

The basis for distributing hydrologic and pollutant loading parameters throughout the watershed is correlated to soil characteristics and land practices. The land use data used in watershed modeling for the Gills Creek watershed was compiled from two land use data sources: Richland County's HSPF modeled land use and the 2001 National Land Cover Database (NLCD) program (Homer et al. 2004). HSPF's modeled land use was used for most of the LSPC subbasins. However, the additional delineation for the new water quality assessment points and the USGS flow gauge location required redistribution and processing of the existing HSPF modeled land use. For the subbasins that required modification of the delineation line, a redistribution of the existing modeled land use was conducted. Modeled land use was reassigned to each new delineated subbasin using NLCD GIS data. NLCD land use categories were combined to match the current HPSF-modeled land use categories. The HSPF modeling land use areas were then redistributed using a ratio of the NLCD land use for the new smaller subbasins and the HSPF modeled land use for the original larger watershed.

Additional sources of pollutant loads were defined in the watershed model as point sources. Continuous point source discharges, SSOs, and failing septic systems were input to the model and quantified as described in Appendix B. Appendix B also includes additional details of the methods used to set up the watershed model. The resulting hydrologic calibration and water quality calibrations are presented in Figures 4-1 through 4-3.

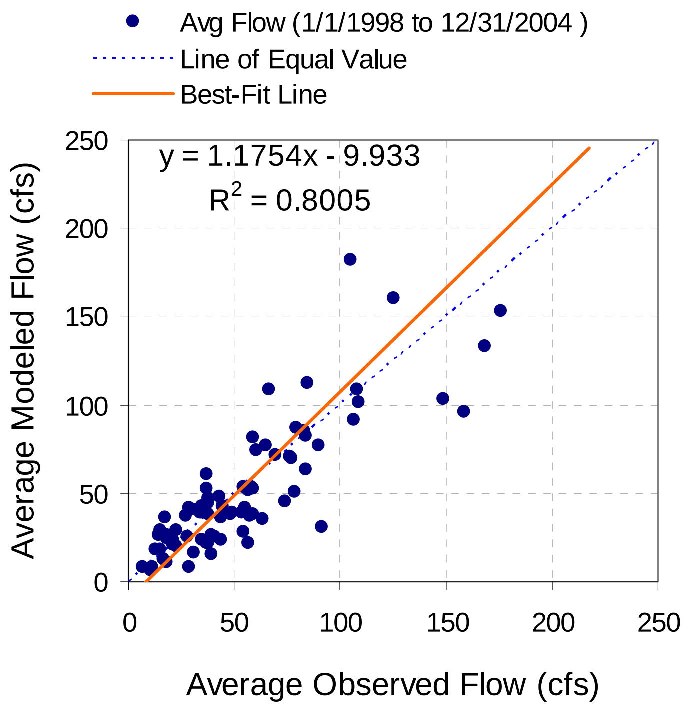

Figure 4-1. Comparison of monthly average observed and modeled flows at USGS 02169570.

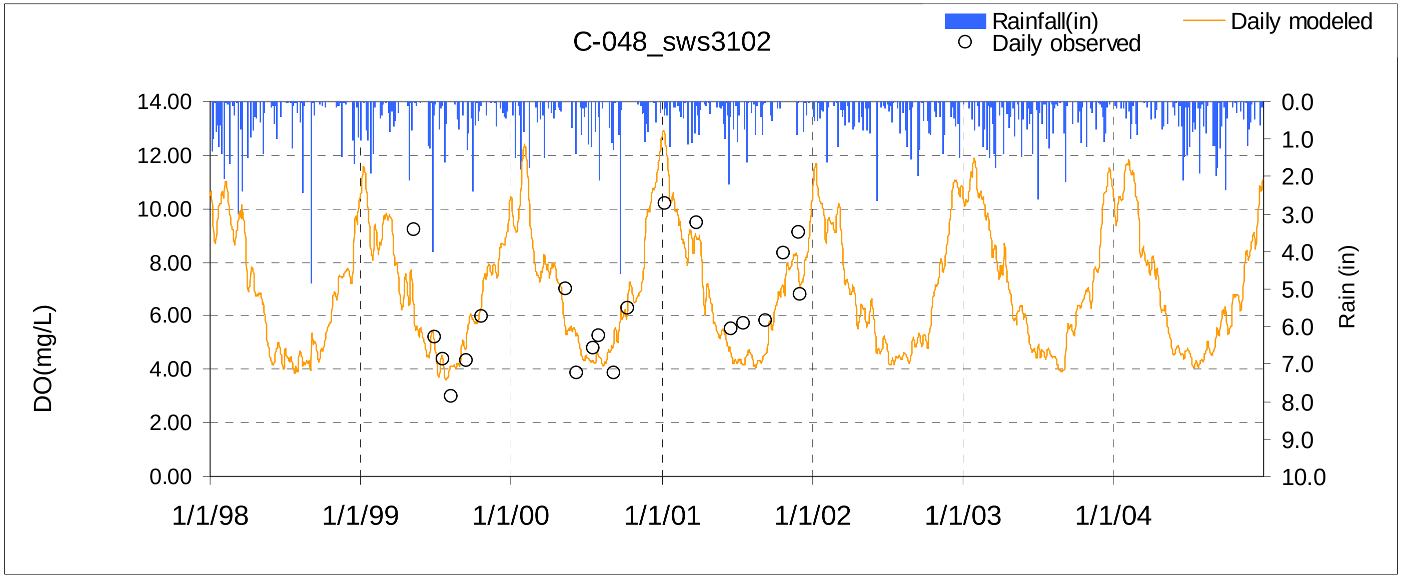

Figure 4-2. Dissolved oxygen comparison of observed and modeled results at C-048.

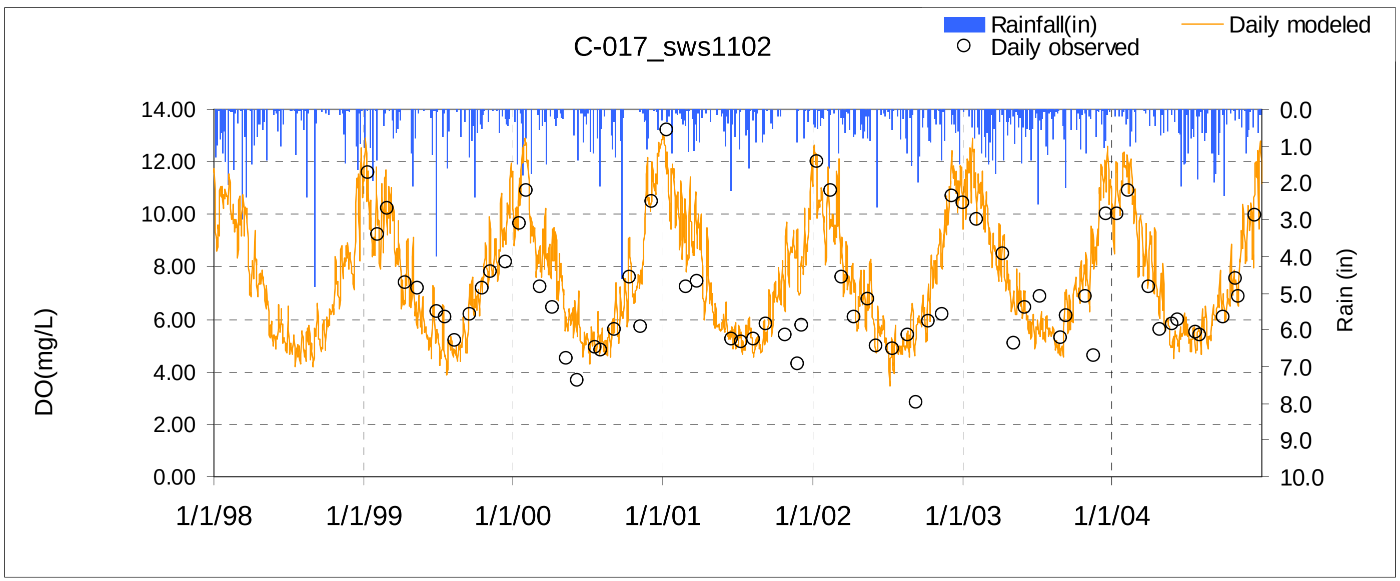

Figure 4-3. Dissolved oxygen comparison of observed and modeled results at C-017.

Sensitivity analysis of the modeled results for DO indicated that in addition to BOD5 and ammonia reductions, how these reductions influence sediment oxygen demand (SOD) must also be considered in order to meet the WQS for DO. A description of the allocation of load reductions is provided in Appendix B. SOD is the accumulated oxygen demanding materials, mainly particulate and dissolved organic matter from the upland loadings, that are deposited onto the streambed or lake bed. Reductions of BOD5 and ammonia are linked to SOD reductions.

To directly link the reductions in BOD5 and ammonia with the associated SOD reductions, a sediment flux model developed by Quantitative Environmental Analysis and Mississippi State University was used. The model was calibrated, and then the in-stream loadings at the assessment points (C-048 and C-017) based on all contributing sources were input to the model. The in-stream loadings were subsequently reduced in a stepwise manner (25 percent to 90 percent). This method quantified the relationship between BOD5 and ammonia loading reductions and calculated SOD at the assessment points C-017 and C-048.

As illustrated in Figure 4-4, varying the load of BOD5 and ammonia by making reductions varies the SOD. The relationship between SOD and BOD5 and ammonia reductions was fitted to a second-order polynomial line. This relationship was used to determine how reductions in BOD5 and ammonia would influence SOD, which influences DO.

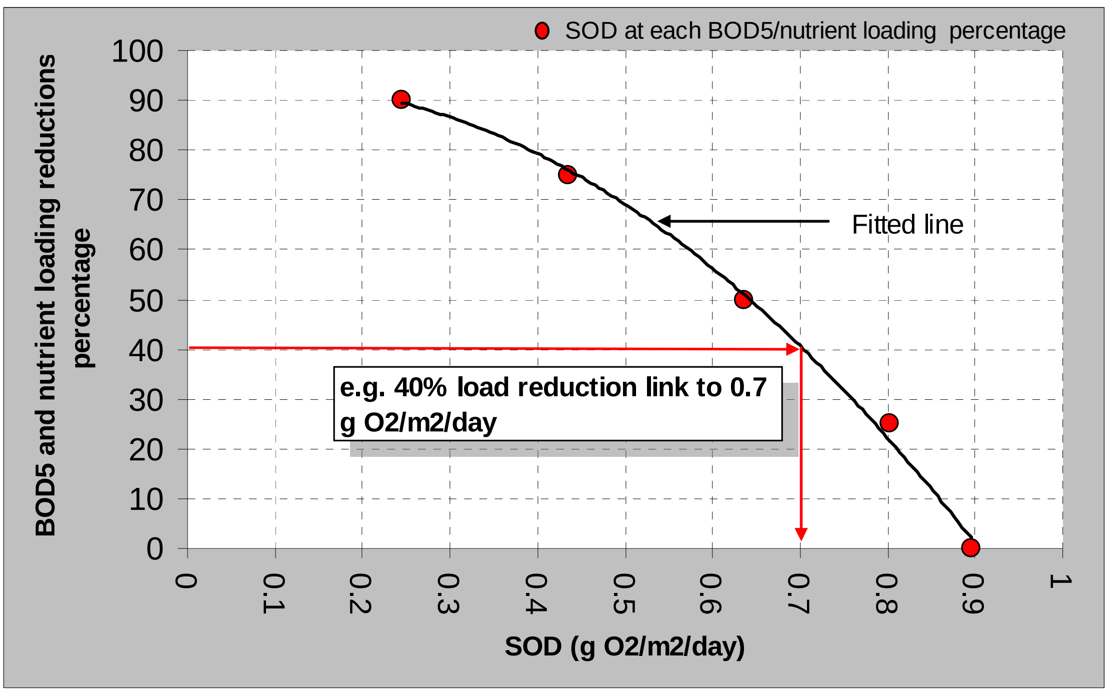

Figure 4-4. Reduced SOD estimated from reductions in BOD5 and ammonia.

5.0 Development of Total Maximum Daily Load

A total maximum daily load (TMDL) for a given pollutant and water body is composed 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), 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 following equation:

$$TMDL = \sum WLAs + \sum LAs + MOS \, .$$

The TMDL is the total amount of pollutant that can be assimilated by the receiving water body while still achieving compliance with the WQS. 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 most pollutants, TMDLs are expressed as a mass load (e.g., kilograms per day). For DO, however, TMDLs are expressed in terms of pollutants that influence DO, biochemical oxygen demand, and ammonia as a daily load (40 CFR 130.2(l)).

5.1. Critical Conditions

This TMDL is based on the greatest violations of the DO standard. The model outputs daily average concentrations over the simulation period, allowing distinguishing the most critical daily average DO from the existing conditions model. The critical conditions for DO in Gills Creek are illustrated in Figures 5-1 and 5-2.

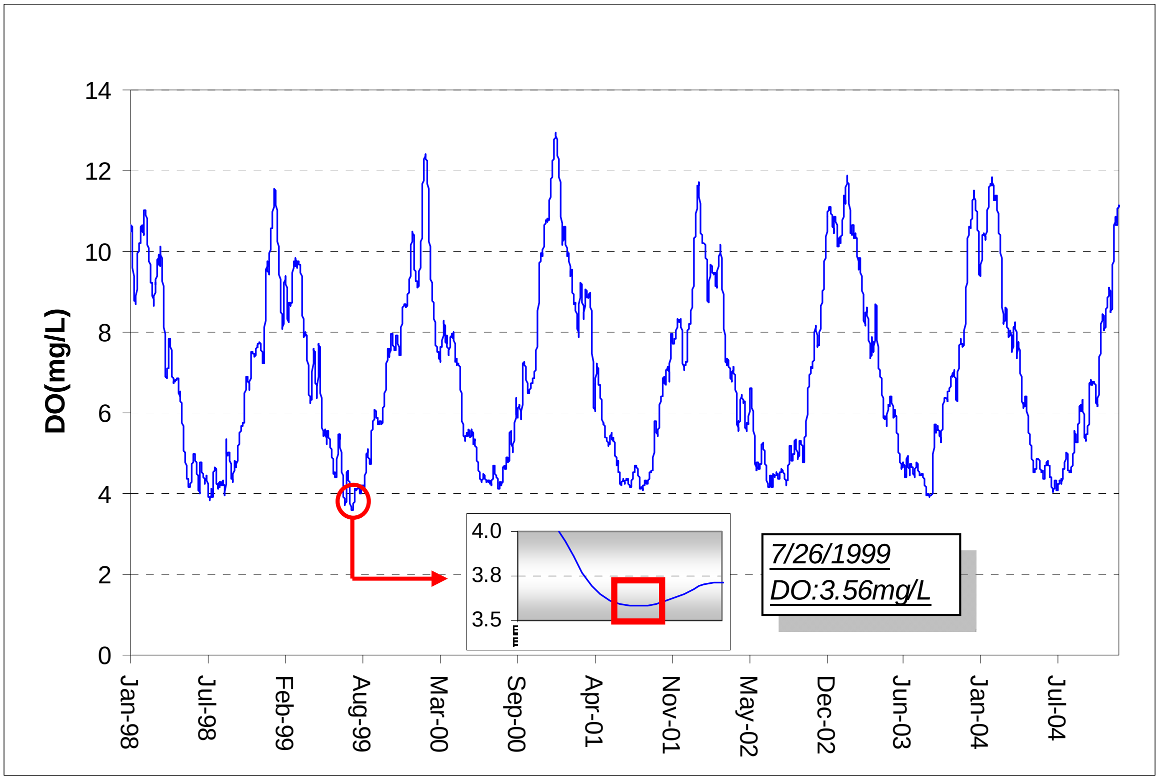

Figure 5-1. Critical conditions modeled at C-048.

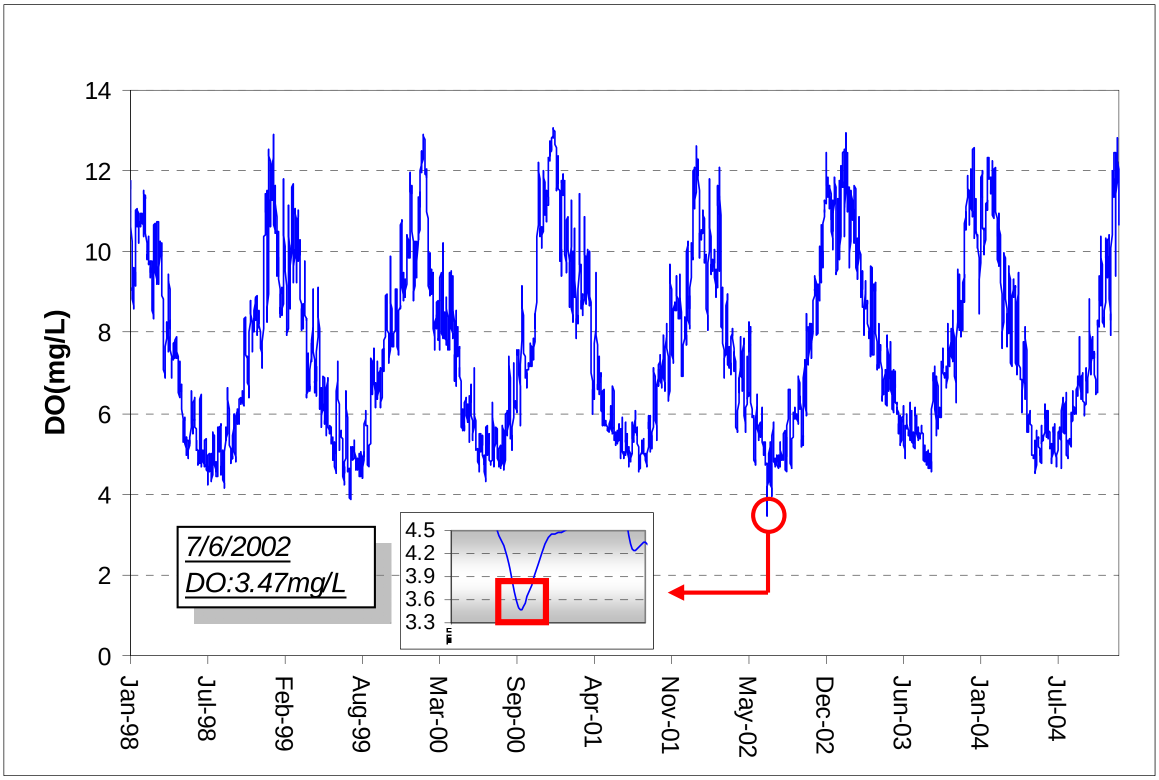

Figure 5-2. Critical conditions modeled at C-017.

5.2. Existing Load

An existing load was determined using the BOD5 and ammonia loads during the critical condition, described earlier in Section 5.1. Loadings from both urban and non-urban sources are included in this value.

5.3. Wasteload Allocation

The WLA is the portion of the TMDL allocated to NPDES-permitted point sources (USEPA 1991). The WLA summation is determined by subtracting the MOS and the sum of the LA from the TMDL. Note that all illicit dischargers, including SSOs, are illegal and are not covered under the WLA of this TMDL.

5.3.1. Continuous Point Sources

Central Products does not have a WLA reduction at this time. Of the two active continuous point source discharges, Central Products (SCG250180) is permitted for contributing BOD5 to the Gills Creek watershed. The other active continuous point source discharge, Amphenol Corporation (SC0046264), does not contribute BOD5 or ammonia to the Gills Creek watershed and is not permitted for either pollutant. Both of the continuous point sources in the watershed discharge upstream of C-017, and neither are permitted for flow. Therefore, Table 5-1 presents Central Products' existing permitted concentration contributing BOD5 in the C-017 watershed. The two continuous point sources do not require a WLA percent reduction. Future or relocated discharges may be modeled before they receive a permitted loading that meets the updated prescribed loading for the pollutants of concern.

Table 5-1. Average Monthly Permitted Pollutants and WLAs for the continuous NPDES Discharges in the Gills Creek Watershed.

Station	Facility Name	Permit #	Permitted Pollutant
C-048 & C-017	Amphenol Corporation	SC0046264	BOD5 – NA* Ammonia – NA*
C-017	Central Products	SCG250180	BOD5 – 20 mg/L daily maximum Ammonia –**

* NA = This active discharge is composed of treated groundwater and does not have permit limits for BOD5 and ammonia.
** This discharge is not permitted for ammonia but the model input was calculated based on reported TKN.

5.3.2. Non-Continuous Point Sources

Non-continuous point sources include all NPDES-permitted stormwater discharges, including current and future MS4, construction, and industrial discharges covered under permits SCS and SCR and regulated under South Carolina Water Pollution Control Permits Regulation 122.26(b)(14) and (15). Illicit discharges, including SSOs, are not covered under any NPDES permit and are subject to enforcement mechanisms. All areas defined as "Urbanized Area" by the U.S. Census are required under the NPDES Stormwater Regulations to obtain a permit for the discharge of stormwater. Other non-urbanized areas may be required under the NPDES Phase II Stormwater Regulations to obtain a permit for the discharge of stormwater.

Based on the available information at this time, the portion of the watershed that drains directly to a regulated MS4 and that which drains through the unregulated MS4 has not been clearly defined within the MS4 jurisdictional area. Loading from both types of sources (regulated and unregulated) typically occurs in response to rainfall events, and discharge volumes as well as recurrence intervals are largely unknown. Therefore, the regulated MS4 is assigned the same percent reduction as the unregulated sources in the watershed. The regulated MS4 entity is only responsible for implementing the TMDL WLA in accordance with their MS4 permit requirements.

As appropriate information is made available to further define the pollutant contributions for the permitted MS4, an effort can be made to revise these TMDLs. This effort will be initiated as resources permit and if deemed appropriate by the Department. For the Department to revise these TMDLs the following information should be provided, but not limited to:

1. An inventory of service boundaries of the MS4 covered in the MS4 permit, provided as ARCGIS compatible shape files.
2. An inventory of all existing and planned stormwater discharge points, conveyances, and drainage areas for the discharge points, provided as ARCGIS compatible shape files. If drainage areas are not known, any information that would help estimate the drainage areas should be provided. The percentage of impervious surface within the MS4 area should also be provided.
3. Appropriate and relevant data should be provided to calculate individual pollutant contributions for the MS4 permitted entities. At a minimum, this information should include precipitation, water quality, and flow data for stormwater discharge points.

WLAs for stormwater discharges are expressed as a percentage reduction instead of a numeric loading because of the uncertain nature of stormwater discharge volumes and recurrence intervals. Regulated stormwater discharges are required to meet the percentage reduction for the pollutants of concern. The percent reduction is based on the maximum percent reduction (critical condition) within any hydrologic category necessary to achieve target conditions. Table 5-2 and Figure 5-3 present the reductions for ammonia and BOD5 needed at each of the impaired stations. The reduction percentages in this TMDL also apply to the BOD5 and ammonia waste load attributable to those areas of the watershed which are covered or will be covered under NPDES MS4 permits. Compliance by an entity with responsibility for the MS4 with the terms of its individual MS4 permit may fulfill any obligations it has toward implementing this TMDL.

Table 5-2. Regulated MS4 Entity(ies) Responsible for Meeting the Allowable Load or Percentage Reduction by Monitoring Station.

Station	BOD5 WLA % Reduction	NH_3 WLA % Reduction	Existing Regulated MS4 Entity(ies) in Watershed
C-048	62	55	Richland County SCS400001
	62	55	SC DOT SCS040001
C-017	61	22	City of Arcadia Lakes SCS400001
	61	22	City of Columbia
	61	22	City of Forest Acres SCS400001
	61	22	Fort Jackson SCR037901
	61	22	Richland County SCS400001
	61	22	SC DOT SCS040001

It should be noted that in order to meet the allowable loads for BOD5 and ammonia, prescribed load reductions must be targeted from all NPDES permitted stormwater sources and nonpoint sources.

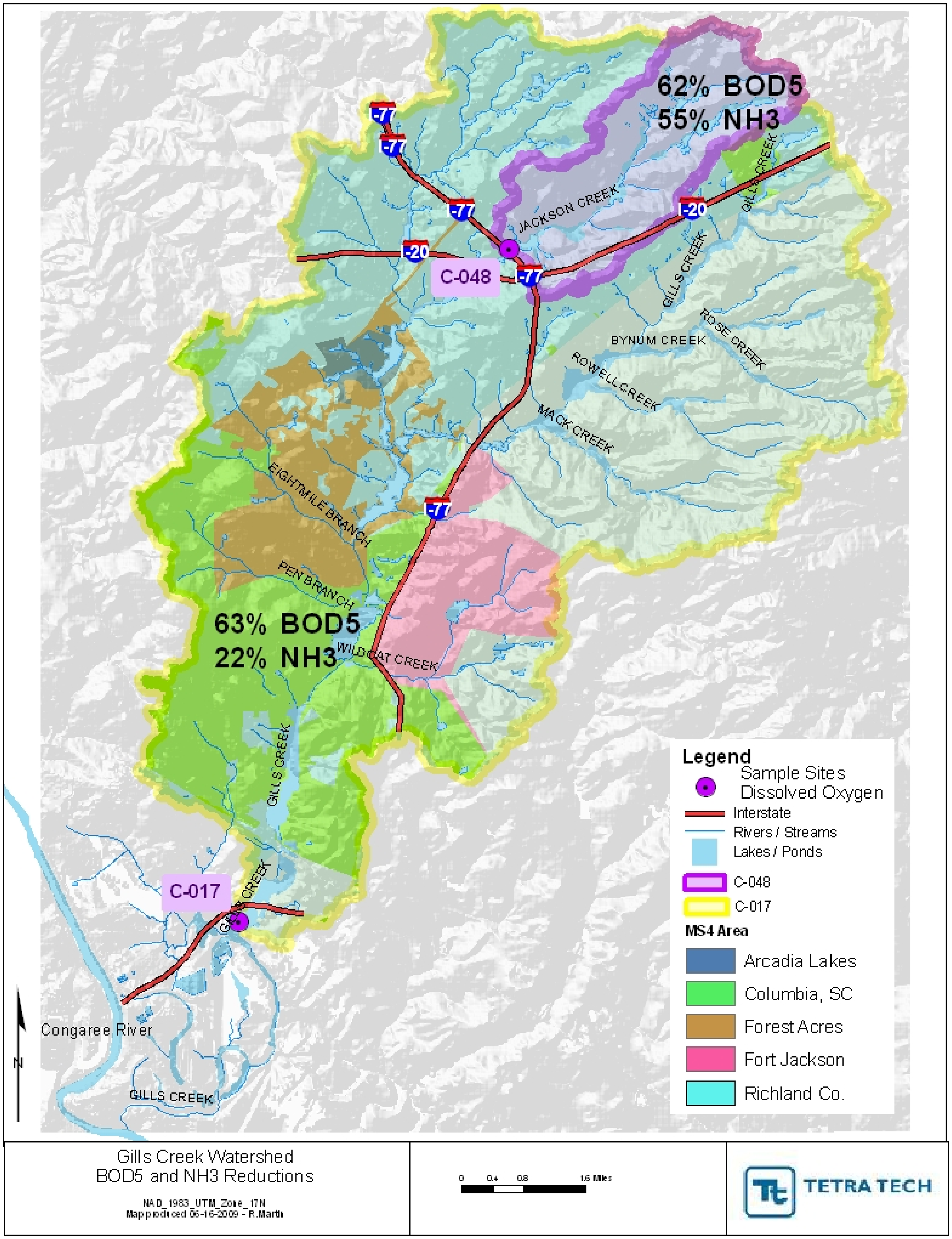

Figure 5-3. Gills Creek Percent Reductions

5.4. LOAD ALLOCATION

The LA applies to the nonpoint sources of BOD5 and ammonia. In watersheds covered under an MS4 permit, it is assumed that some contribution of the total load is not being conveyed through stormwater sewers. This contribution is considered as the LA, and it is expressed as a percent reduction equal to the percent reduction for the non-continuous WLA. There may be unregulated MS4s located in the watershed that are subject to the LA component of this TMDL. At such time that the referenced entities, or other future unregulated entities become regulated NPDES MS4 entities and subject to applicable provisions of SC Regulation 61-68D, they will be required to meet load reductions prescribed in the WLA component of the TMDL. This also applies to future discharges associated with industrial and construction activities that will be subject to SC R. 122.26(b)(14)(15) (SCDHEC 2003).

Table 5-3. Percentage Reductions Necessary to Achieve Target Loads for BOD5 and Ammonia.

Station	BOD5 LA % Reduction	NH_3 LA % Reduction
C-048	62	55
C-017	61	22

5.5. SEASONAL VARIABILITY

Federal regulations require that TMDLs take into account the seasonal variability in watershed loading. Seasonal variability in this TMDL is accounted for by using a 7-year simulation period and a 12-month water quality sampling data set, which includes data collected from all seasons.

5.6. MARGIN OF SAFETY

The MOS may be explicit, implicit, or both. This TMDL considers an explicit margin of safety at 5 percent. The MOS will be applied to the allowable load for BOD5 and ammonia.

5.7. TOTAL MAXIMUM DAILY LOAD

TMDLs are expressed in terms of pounds per day (or resulting concentration), in accordance with 40 CFR 130.2(l). The target load is defined as the load (from point and nonpoint sources), minus the MOS, that a stream segment can receive while meeting the WQS. The TMDL value is the target load within the critical condition. Values for each component of the TMDL for the impaired segments of the Gills Creek watershed are provided in Table 5-1.

Figures 5-4 and 5-5 illustrate modeled results that confirm reductions to meet the DO WQS. Terms and conditions of NPDES permits for continuous discharges require facilities to demonstrate compliance in treated effluent. The MS4 entity(ies) are responsible for meeting the allowable load or percentage reductionby individual water quality monitoring station. Note that all future regulated NPDES-permitted stormwater discharges will also be required to meet the percentage reduction. It should be noted that in order to meet the WQS for DO, prescribed load reductions must be targeted from all sources, including non-continuous NPDES permitted and nonpoint sources.

Table 5-4. Total Maximum Daily Loads for the Gills Creek Watershed.

Station	Pollutant	Existing Load (lb/day)	TMDL (lb/day)	Margin of Safety (MOS) (lb/day)	Wasteload Allocation (WLA)		Load Allocation (LA)	
					Continuous Sources[1] (lb/day)	Non-Continuous Sources[2] (% Re duction)	Load Allocation (lb/day)	% Reductio n to Meet LA[3]
C-048	BOD5	26.6	10.6	0.5	See Note Below	62%	10.1	62%
C-048	Ammonia	0.7	0.34	0.02	See Note Below	55%	0.32	55%
C-017	BOD5	511.6	210.1	10.5	1.0	63%	191.9	63%
C-017	Ammonia	22.2	18.4	0.92	0.13	22%	17.3	22%

Table Notes:

1. WLAs are expressed as a daily maximum. Existing continuous discharges are required to meet the prescribed loading for the pollutants of concern. Future or relocated discharges may be modeled before they receive a permitted loading that meets the updated prescribed loading for the pollutants of concern.
2. Percent reduction applies to all NPDES-permitted stormwater discharges, including current and future MS4, construction and industrial discharges covered under permits numbered SCS & SCR. Stormwater discharges are expressed as a percentage reduction due to the uncertain nature of non-continuous discharge volumes and recurrence intervals. Stormwater discharges are required to meet the percentage reduction or the existing instream standard for the pollutant of concern in accordance with their NPDES Permit.
3. Percent reduction applies to existing instream load; where Percentage Reduction = (Existing Load - Load Allocation) / Existing Load
4. By implementing the best management practices that are prescribed in either the SCDOT annual SWMP or the SCDOT MS4 Permit to address dissolved oxygen, the SCDOT will comply with this TMDL and its applicable WLA to the maximum extent practicable (MEP) as required by its MS4 permit.

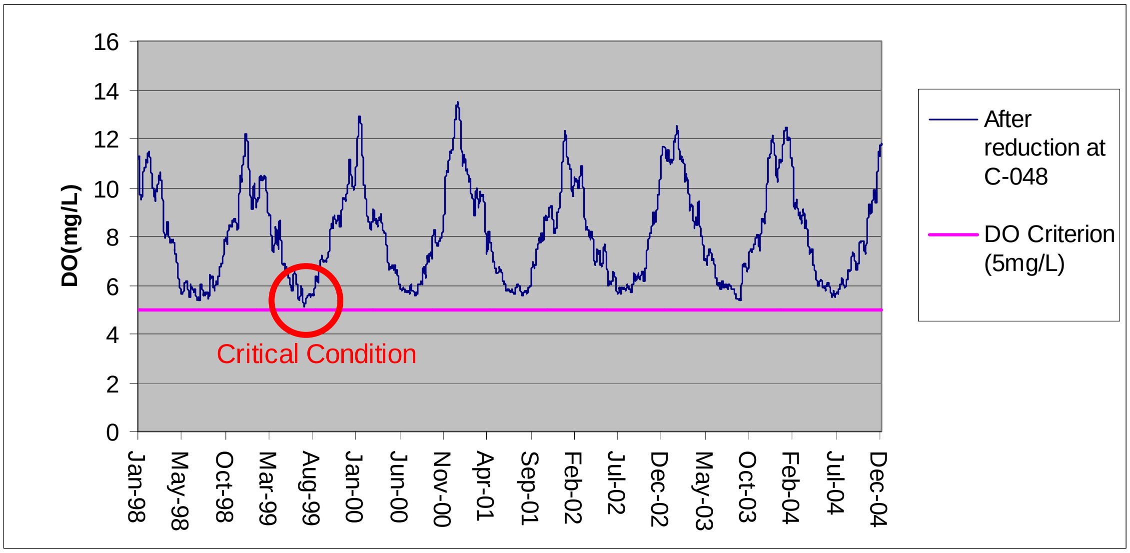

Figure 5-4. Confirmation of BOD5 and ammonia reductions to meet dissolved oxygen criteria at C-048.

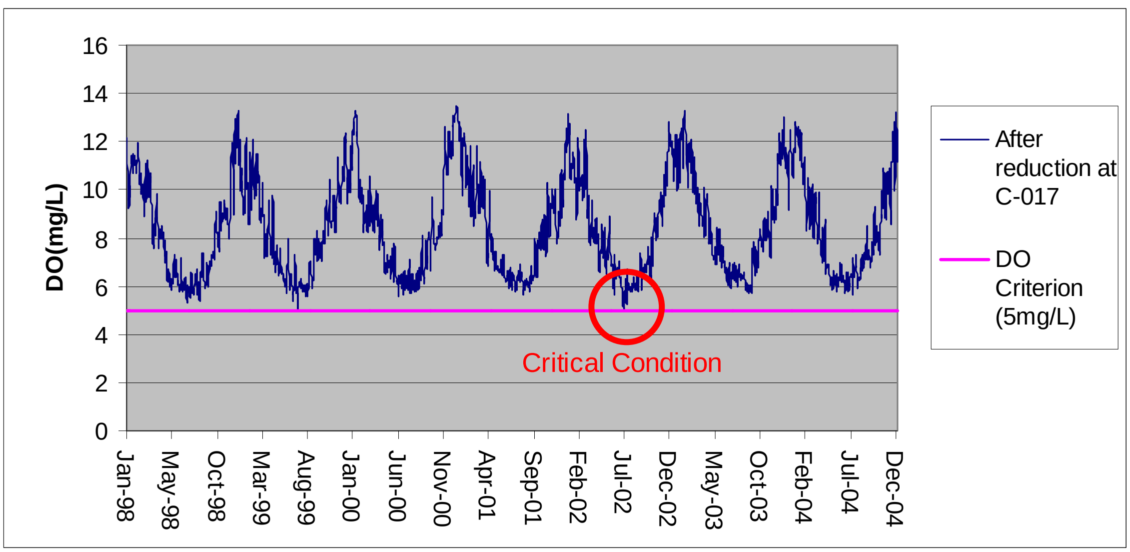

Figure 5-5. Confirmation of BOD5 and ammonia reductions to meet dissolved oxygen criteria at C-017.

6.0 Implementation

The implementation of both point (WLA) and non-point (LA) source components of the TMDL are necessary to bring about the required reductions in BOD5 and ammonia to meet water quality standards for dissolved oxygen in Gills Creek and its tributaries in order to achieve the water quality standards. Using existing authorities and mechanisms, an implementation plan providing information on how point and non-point sources of pollution are being abated or may be abated in order to meet water quality standards is provided. Sections 6.1.1-6.1.7 presented below correspond with sections 3.1.1-3.2.6 of the source assessment presented in the TMDL document. As the implementation strategy progresses, SCDHEC may continue to monitor the effectiveness of implementation measures and evaluate water quality where deemed appropriate.

Point sources are discernible, confined, and discrete conveyances of pollutants to a water body including but not limited to pipes, outfalls, channels, tunnels, conduits, man-made ditches, etc. The Clean Water Act's primary point source control program is the National Pollutant Discharge Elimination System (NPDES). Point sources can be broken down into continuous and non-continuous point sources. Some examples of a continuous point source are wastewater treatment facilities (WWTF) and industrial facilities. Non-continuous point sources are related to stormwater and include municipal separate storm sewer systems (MS4), construction activities, etc. Current and future NPDES discharges in the referenced watershed are required to comply with the load reductions prescribed in the wasteload allocation (WLA).

Nonpoint source pollution originates from multiple sources over a relatively large area. It is diffuse in nature and indistinct from other sources of pollution. It is generally caused by the pickup and transport of pollutants from rainfall moving over and through the ground. Nonpoint sources of pollution may include, but are not limited to: wildlife, agricultural activities, illicit discharges, failing septic systems, and urban runoff. Nonpoint sources located in unregulated portions of the watershed are subject to the load allocation (LA) and not the WLA portion of the TMDL document.

South Carolina has several tools available for implementing the non-point source component of this TMDL. The *Implementation Plan for Achieving Total Maximum Daily Load Reductions From Nonpoint Sources for the State of South Carolina* (SCDHEC 1998) document is one example. Another key component for interested parties to control pollution and prevent water quality degradation in the watershed would be the establishment and administration of a program of Best Management Practices (BMPs). Best management practices may be defined as a practice or a combination of practices that have been determined to be the most effective, practical means used in the prevention and/or reduction of pollution.

Congress amended the Clean Water Act (CWA) in 1987 to establish the Section 319 Nonpoint Source Management Program. Under Section 319, States receive grant money to support a wide variety of activities including the restoration of impaired waters. TMDL implementation projects are given highest priority for 319 funding. CWA §319 grants are not available for implementation of the WLA component of this TMDL nor within any permitted jurisdictional MS4 area. Additional resources are provided in Section 7.0 of this TMDL document.

SCDHEC will also work with the existing agencies in the area to provide nonpoint source education in the Gills Creek watershed. Local sources of nonpoint source education and assistance include the Natural Resource Conservation Service (NRCS), the Richland County Soil and Water Conservation Services, the Clemson University Cooperative Extension Service, and the South Carolina Department of Natural Resources.

The Department recognizes that **adaptive management/implementation** of this TMDL might be needed to achieve the water quality standard and we are committed towards targeting the load reductions to improve water quality in the Gills Creek Watershed. As additional data and/or information becomes available, it may become necessary to revise and/or modify the TMDL target accordingly.

6.1. IMPLEMENTATION STRATEGIES

The strategies presented in this document for implementation of the referenced TMDL are not inclusive and are to be used only as guidance. The strategies are informational suggestions which may lead to the required load reductions being met for the referenced watershed while demonstrating consistency with the assumptions and requirements of the TMDL. Application of certain strategies provided within may be voluntary and are not a substitute for actual NPDES permit conditions.

6.1.1. Continuous Point Sources

There are no Continuous point source WLA reductions at this time. Existing and future continuous discharges are required to meet the prescribed loading for the pollutants of concern and demonstrate consistency with the assumptions and requirements of the TMDL. Loadings are developed based upon permitted flow and the assimilative capacity of the creek.

6.1.2. Non-Continuous Point Sources

An iterative BMP approach as defined in the general stormwater NPDES MS4 permit is expected to provide significant implementation of the WLA. Permit requirements for implementing WLAs in approved TMDLs will vary across waterbodies, discharges, and pollutant(s) of concern. The allocations within a TMDL can take many different forms – narrative, numeric, specific BMPs – and may be complimented by other special requirements such as monitoring.

The level of monitoring necessary, deployment of structural and non-structural BMPs, evaluation of BMP performance, and optimization or revisions to the existing pollutant reduction goals of the SWMP or any other plan is TMDL and watershed specific. Hence, it is expected that NPDES permit holders evaluate their existing SWMP or other plans in a manner that would effectively address implementation of this TMDL with an acceptable schedule and activities for their permit compliance. The Department staff (permit writers, TMDL project managers, and compliance staff) is willing to assist in developing or updating the referenced plan as deemed necessary. Please see Appendix C, which provides additional information as it relates to evaluating the effectiveness of an MS4 Permit as it related to compliance with approved TMDLs. For SCDOT and existing and future NPDES MS4 permittees, compliance with terms and conditions of its NPDES MS4 permit is effective implementation of the WLA to the MEP. For existing and future NPDES construction and Industrial stormwater permittees, compliance with terms and conditions of its permit is effective implementation of the WLA.

The Department acknowledges that progress with the assumptions and requirements of the TMDL by MS4s is expected to take one or more permit iteration. Achieving the WLA reduction for the TMDL may constitute MS4 compliance with its SWMP, provided the maximum extent practicable definition is met, even where the numeric percent reduction may not be achieved in the interim.

Regulated MS4 entities are required to develop a SWMP that includes the following: public education, public involvement, illicit discharge detection & elimination, construction site runoff control, post construction runoff control, and pollution prevention/good housekeeping. These measures are not exhaustive and may include additional criterion depending on the type of NPDES MS4 permit that applies. The following examples are recognized as acceptable stormwater practices and may be applied to unregulated MS4 entities or other interested parties in the development of a stormwater management plan.

An informed and knowledgeable community is crucial to the success of a stormwater management plan (USEPA 2005). MS4 entities may implement a public education program to distribute educational materials to the community, or conduct equivalent outreach activities about the impacts of stormwater discharges on local waterbodies and the steps that can be taken to reduce stormwater pollution. Some appropriate BMPs may be brochures, educational programs, storm drain stenciling, stormwater hotlines, tributary signage, and alternative information sources such as web sites, bumper stickers, etc (USEPA 2005).

The public can provide valuable input and assistance to a stormwater management program and they may have the potential to play an active role in both the development and implementation of the stormwater program where deemed appropriate by the entity. There are a variety of practices that can involve public participation such as public meetings/citizens panels, volunteer water quality monitoring, volunteer educators, community clean-ups, citizen watch groups, and "Adopt a Storm Drain" programs which encourage individuals or groups to keep storm drains free of debris and monitor what is entering local waterways through storm drains (USEPA 2005).

Illicit discharge detection and elimination efforts are also necessary. Discharges from MS4s often include wastes and wastewater from non-stormwater sources. These discharges enter the system through either direct connections or indirect connections. The result is untreated discharges that contribute high levels of pollutants, including heavy metals, toxics, oil and grease, solvents, nutrients, viruses, and bacteria to receiving waterbodies (USEPA 2005). Pollutant levels from these illicit discharges have been shown in EPA studies to be high enough to significantly degrade receiving water quality and threaten aquatic, wildlife, and human health. MS4 entities may have a storm sewer system map which shows the location of all outfalls and to which waters of the US they discharge for instance. If not already in place, an ordinance prohibiting non-stormwater discharges into a MS4 with appropriate enforcement procedures may also be developed. Entities may also have a plan for detecting and addressing non-stormwater discharges. The plan may include locating problem areas through infrared photography, finding the sources through dye testing, removal/correction of illicit connections, and documenting the actions taken to illustrate that progress is being made to eliminate illicit connections and discharges.

A program might also be developed to reduce pollutants in stormwater runoff to the MS4 area from construction activities. An ordinance or other regulatory mechanism may exist requiring the implementation of proper erosion and sediment controls on applicable construction sites. Site plans should be reviewed for projects that consider potential water quality impacts. It is recommended that site inspections should be conducted and control measures enforced where applicable. A procedure might also exist for considering information submitted by the public (USEPA 2005). For information on specific BMPs please refer to the SCDHEC Stormwater Management BMP Handbook online at: http://www.scdhec.com/environment/ocrm/pubs/docs/SW/BMP_Handbook/Erosion_prevention.pdf

Post-construction stormwater management in areas undergoing new development or redevelopment is recommended because runoff from these areas has been shown to significantly affect receiving waterbodies. Many studies indicate that prior planning and design for the minimization of pollutants in post-construction stormwater discharges is the most cost-effective approach to stormwater quality management (USEPA 2005). Strategies might be developed to include a combination of structural and/or non-structural BMPs. An ordinance or other regulatory mechanism may also exist requiring the implementation of post-construction runoff controls and ensuring their long term-operation and maintenance. Examples of non-structural BMPs are planning procedures and site-based BMPs (minimization of imperviousness and maximization of open space). Structural BMPs may include but are not limited to stormwater retention/detention BMPs, infiltration BMPs (dry wells, porous pavement, etc.), and vegetative BMPs (grassy swales, filter strips, rain gardens, artificial wetlands, etc.).

Pollution prevention/good housekeeping is also a key element of stormwater management programs. Generally this requires the MS4 entity to examine and alter their programs or activities to ensure reductions in pollution are occurring. It is recommended that a plan be developed to prevent or reduce pollutant runoff from municipal operations into the storm sewer system and it is encouraged to include employee training on how to incorporate and document pollution prevention/good housekeeping techniques. To minimize duplication of effort and conserve resources, the MS4 operator can use training materials that are available from EPA or relevant organizations (USEPA 2005).

MS4 communities are encouraged to utilize partnerships when developing and implementing a stormwater management program. Watershed associations, educational organizations, and state, county, and city governments are all examples of possible partners with resources that can be shared. For additional information on partnerships contact the SCDHEC Watershed Manager for the waterbody of concern online at: http://www.scdhec.gov/environment/water/shed/contact.htm For additional information on stormwater discharges associated with MS4 entities please see SCDHEC's NPDES web page online at http://www.scdhec.gov/environment/water/swnpdes.htm as well as the USEPA NPDES website online at http://cfpub.epa.gov/npdes/home.cfm?program_id=6 for information pertaining to the National Menu of BMPs, Urban BMP Performance Tool, Outreach Documents, etc.

6.1.3. Agricultural Activities

Suggested forms of implementation for agricultural activities will vary based on the activity of concern. Agricultural BMPs can be vegetative, structural or management oriented. When selecting BMPs, it is important to keep in mind that nonpoint source pollution occurs when a pollutant becomes available, is detached and then transported to nearby receiving waters. Therefore, for BMPs to be effective, the transport mechanism of the pollutant needs to be identified. For livestock in the referenced watershed, installing fencing along the streams within the watershed and providing an alternative water source where livestock are present would eliminate direct contact with the streams. Very few livestock are present in the watershed at the time of this study. If fencing is not feasible, it has been shown that installing water troughs within a pasture area reduced the amount of time livestock spent drinking directly from streams by 92% (ASABE 1997). An indirect result of this was a 77% reduction in stream bank erosion by providing an alternative to accessing the stream directly for water supply.

For row crop farms in the referenced watershed, many common practices exist to reduce nutrient contributions. Unstable soil directly adjacent to surface waters can contribute to nutrient and sediment loading during periods of runoff after rain events. Agricultural field borders and filter strips (vegetative buffers) can provide erosion control around the border of planted crop fields. These borders can provide food for wildlife, may possibly be harvested (grass and legume), and also provide an area where farmers can turn around their equipment (SCDNR 1997). A study conducted in 1998 by the American Society of Agricultural and Biological Engineers (ASABE 1998) has shown that a vegetative buffer measuring 6.1 meters in width can reduce phosphorous and nitrogen concentrations by 75%.

The agricultural BMPs listed above are a sample of the many accepted practices that are currently available. Many other techniques such as conservation tillage, responsible pest management, and precision agriculture also exist and may contribute to an improvement in overall water quality in the watershed. Education should be provided to local farmers on these methods as well as acceptable manure spreading and holding (stacking sheds) practices.

For additional information on accepted agricultural BMPs, you can obtain a copy of the *Farming for Clean Water in South Carolina* handbook by contacting Clemson University Cooperative Extension Service at (864) 656-1550. In addition, 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. You can access *Farm-A-Syst* by going onto the Clemson Extension Service website: http://www.clemson.edu/waterquality/FARM.HTM.

NRCS provides financial and technical assistance to help South Carolina landowners address natural resource concerns, promote environmental quality, and protect wildlife habitat on property they own or control. The cost-share funds are available through the Environmental Quality Incentives Program (EQIP). EQIP helps farmers improve production while protecting environmental quality by addressing such concerns as soil erosion and productivity, grazing management, water quality, animal waste, and forestry concerns. EQIP also assists eligible small-scale farmers who have historically not participated in or ranked high enough to be funded in previous sign ups. Please visit www.sc.nrcs.usda.gov/programs/ for more information, including eligibility requirements.

Also available through NRCS, the Grassland Reserve Program (GRP) is a voluntary program offering landowners the opportunity to protect, restore and enhance grasslands on their property. NRCS and the Farm Service Agency (FSA) coordinate implementation of the GRP, which helps landowners restore and protect grassland, rangeland, pastureland, shrubland and certain other lands and provides assistance for rehabilitating grasslands. The program will conserve vulnerable grasslands from conversion to cropland or other uses and conserve valuable grasslands by helping maintain viable grazing operations. A grazing management plan is required for participants. NRCS has further information on their website for the GRP as well as additional programs such as the Conservation Reserve Program, Conservation Security Program, Farm and Ranch Lands Protection Program, etc. You can visit the NRCS website by going to: www.sc.nrcs.usda.gov/programs/.

6.1.4. Leaking Sanitary Sewers and Illicit Discharges

Leaking sanitary sewers and illicit discharges, although illegal and subject to enforcement, may be occurring in regulated or unregulated portions of the watershed at any time. Due to the high concentration of pollutant loading that is generally associated with these discharges, their detection may provide a substantial improvement in overall water quality in the Gills Creek watershed. Detection methods may include, but are not limited to: dye testing, air pressure testing, static pressure testing, and infrared photography.

SCDHEC recognizes illicit discharge detection and elimination activities are conducted by regulated MS4 entities as pursuant to compliance with existing MS4 permits. Note that these activities are designed to detect and eliminate illicit discharges that may contain nutrients. It is the intent of SCDHEC to work with the MS4 entities to recognize nutrient load reductions as they are achieved. SCDHEC acknowledges that these efforts to reduce illicit discharges and SSOs are ongoing and some reduction may already be accountable (i.e., load reductions occurring during TMDL development process). Thus, the implementation process is an iterative and adaptive process. Regular communication between all implementation stakeholders will result in successful remediation of controllable sources over time. As designated uses are restored, SCDHEC will recognize efforts of implementers where their efforts can be directly linked to restoration.

6.1.5. Failing Septic Systems

A septic system, also known as an onsite wastewater system, is defined as failing when it is not treating or disposing of sewage in an effective manner. The most common reason for failure is improper maintenance by homeowners. Untreated sewage water contains disease-causing bacteria and viruses, as well as BOD5 and nutrients. Failed septic systems can allow untreated sewage to seep into wells, groundwater, and surface water bodies, where people get their drinking water and recreate. Pumping a septic tank is probably the single most important thing that can be done to protect the system. If the buildup of solids in the tanks becomes too high and solids move to the drainfield, this could clog and strain the system to the point where a new drainfield will be needed.

SCDHEC's Office of Coastal Resource Management (OCRM) has created a toolkit for homeowners and local governments which includes tips for maintaining septic systems. These septic system Do's and Don't's are as follows:

Do's:

- Conserve water to reduce the amount of wastewater that must be treated and disposed of by your system. Doing laundry over several days will put less stress on your system.
- Repair any leaking faucets or toilets. To detect toilet leaks, add several drops of food dye to the toilet tank and see if dye ends up in the bowl.
- Divert down spouts and other surface water away from your drainfield. Excessive water keeps the soil from adequately cleansing the wastewater.
- Have your septic tank inspected yearly and pumped regularly by a licensed septic tank contractor.

Don'ts:

- Don't drive over your drainfield or compact the soil in any way.
- Don't dig in your drainfield or build anything over it, and don't cover it with a hard surface such as concrete or asphalt.
- Don't plant anything over or near the drainfield except grass. Roots from nearby trees an shrubs may clog and damage the drain lines.
- Don't use your toilet as a trash can or poison your system and the groundwater by pouring harmful chemicals and cleansers down the drain. Harsh chemicals can kill the bacteria that help purify your wastewater.

For additional information on how septic systems work, how to properly plan and maintain a septic system, or to link to the OCRM toolkit mentioned above, please visit the SCDHEC Environmental Health Onsite Wastewater page at the following link:
http://www.scdhec.gov/health/envhlth/onsite_wastewater/septic_tank.htm

6.1.6. Urban Runoff

Urban runoff is surface runoff of rainwater created by urbanization outside of regulated areas which may pick up and carry pollutants to receiving waters. Pavement, compacted areas, roofs, reduced tree canopy and open space increase runoff volumes that rapidly flow into receiving waters. This increase in volume and velocity of runoff often causes stream bank erosion, channel incision and sediment deposition in stream channels. In addition, runoff from these developed areas can increase stream temperatures that along with the increase in flow rate and pollutant loads negatively affect water quality and aquatic life (USEPA 2005). This runoff can pick up nutrients along the way. Many strategies currently exist to reduce nutrient loading from urban runoff and the USEPA nonpoint source pollution website provides extensive resources on this subject which can be accessed online at: http://www.epa.gov/nps/urban.html.

Some examples of urban nonpoint source BMPs are street sweeping, stormwater wetlands, pet waste receptacles (equipped with waste bags), educating stakeholders about fertilizer application, and educational signs which can be installed adjacent to receiving waters in the watershed such as parks, common areas, apartment complexes, trails, etc. Low impact development (LID) may also be effective. LID is an approach to land development (or re-development) that works with nature to manage stormwater as close to its source as possible. LID employs principles such as preserving and recreating natural landscape features, minimizing effective imperviousness to create functional and appealing site drainage that treats stormwater as a resource rather than a waste product. There are many practices that have been used to adhere to these principles such as bioretention facilities, rain gardens, vegetated rooftops, rain barrels, and permeable pavements (USEPA 2009).

Clemson Extension's *Home-A-Syst* handbook can also help homeowners reduce sources of non-point source pollution on their property. This document guides homeowners through a self-assessment of their property and can be accessed online at: http://www.clemson.edu/waterquality/HOMASYS.HTM

7.0 Resources for Pollutant Management

This section provides a list of available resources to aid in the mitigation and control of pollutants. There are examples from across the nation, most of which are easily accessible on the Internet.

7.1. General for Urban and Suburban Stormwater Mitigation

- *National Management Measures to Control Nonpoint Source Pollution from Urban Area*. Draft. 2002. EPA842-B-02-003. Available at http://www.epa.gov/owow/nps/urbanmm/index.html
- *Stormwater Management Volume Two: Stormwater Technical Manual*. 1997. Massachusetts Department of Environmental Management. Available at http://www.mass.gov/dep/brp/stormwtr/stormpub.htm
- Fact Sheets for the six minimum control measures for storm sewers regulated under Phase I or Phase II. Available at http://cfpub1.epa.gov/npdes/stormwater/swfinal.cfm?program_id=6
- *A Current Assessment of Urban Best Management Practices*. 1992. Metropolitan Washington Council of Governments. Washington, DC
- *Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs*. 1987. Metropolitan Washington Council of Governments. Washington, DC
- *2004 Stormwater Quality Manual*. Connecticut Department of Environmental Protection 2004. Available at http://dep.state.ct.us/wtr/stormwater/strmwtrman.htm
- *Stormwater Treatment BMP New Technology Report*. 2004. California Department of Transportation. SW-04-069-.04.02 Available at http://www.dot.ca.gov/hq/env/stormwater/special/newsetup/_pdfs/new_technology/CTSW-RT-04-069.pdf
- Moonlight Beach Urban Runoff Treatment Facility: Using Ultraviolet Disinfection to Reduce Bacteria Counts. J. Rasmus and K. Weldon. 2003. *StormWater*, May/June 2003. Available at http://www.forester.net/sw_0305_moonlight.html
- *Operation, Maintenance, and Management of Stormwater Management Systems*. Livingston, Shaver, Skupien, and Horner. August 1997. Watershed Management Institute. Call (850) 926-5310.
- Model Ordinances to Protect Local Resources – Stormwater Control Operation and Maintenance. USEPA Web page: http://www.epa.gov/owow/nps/ordinance/stormwater.htm
- Stormwater O & M Fact Sheet: Preventive Maintenance. 1999. U.S. Environmental Protection Agency. EPA 832-F-99-004. Available at http://www.epa.gov/owm/mtb/prevmain.pdf
- *The MassHighway Stormwater Handbook*. 2004. Massachusetts Highway Department. 2004. Available at http://166.90.180.162/mhd/downloads/projDev/swbook.pdf

- University of New Hampshire Stormwater Center Web site: http://www.unh.edu/erg/cstev/index.htm#
- U.S. Environmental Protection Agency's Stormwater Web site: http://www.epa.gov/region1/topics/water/stormwater.html

7.2. Illicit Discharges

- *Illicit Discharge Detection and Elimination Manual—A Handbook for Municipalities*. 2003. New England Interstate Water Pollution Control Commission. Available at http://www.neiwpcc.org/PDF_Docs/iddmanual.pdf
- Model Ordinances to Protect Local Resources – Illicit Discharges. U.S. Environmental Protection Agency Web page: http://www.epa.gov/owow/nps/ordinance/discharges.htm

7.3. Septic Systems

- *National Management Measures to Control Nonpoint Source Pollution from Urban Areas.* Draft. Chapter 6. New and Existing Onsite Wastewater Treatment Systems. 2002. U.S. Environmental Protection Agency. EPA842-B-02-003. Available at http://www.epa.gov/owow/nps/urbanmm/index.html
- Septic Systems. U.S. Environmental Protection Agency Web page: http://cfpub.epa.gov/owm/septic/home.cfm

7.4. Federal Agriculture Resources: Program Overviews, Technical Assistance, and Funding

- The U.S. Department of Agriculture's National Resources Conservation Service (USDA-NRCS) assists landowners with planning for the conservation of soil, water and natural resources. Local, state and federal agencies and policymakers also rely on NRCS expertise. Cost sharing and financial incentives are available in some cases. Most work is done with local partners. The NRCS is the largest funding source for agricultural improvements. To find out about potential funding, see http://www.ma.nrcs.usda.gov/programs. To pursue obtaining funding, contact a local NRCS coordinator. Contact information is available at http://www.ma.nrcs.usda.gov/contact/employee_directory.html
- CORE4 Conservation Practices. The common sense approach to natural resource conservation. 1999. USDA-NRCS. This manual is intended to help USDA-NRCS personnel and other conservation and nonpoint source management professionals implement effective programs using core conservation practices: nutrient management, pest management, and conservation buffers. Available at http://www.nrcs.usda.gov/technical/ECS/agronomy/core4.pdf
- County soil survey maps are available from NRCS at http://soils.usda.gov

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Appendix A. Dissolved Oxygen Data Analysis

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Table A-1. Dissolved Oxygen measured data at C-048

Sample Date	DO (mg/L)
5/12/1999	9.2
6/30/1999	5.2
7/19/1999	4.4
8/10/1999	3
9/16/1999	4.3
10/20/1999	5.95
5/11/2000	7
6/7/2000	3.85
7/19/2000	4.8
8/2/2000	5.25
9/6/2000	3.85
10/10/2000	6.3
1/10/2001	10.2
3/26/2001	9.48
6/19/2001	5.53
7/17/2001	5.69
9/10/2001	5.8
10/24/2001	8.34
11/28/2001	9.13
12/4/2001	6.79
1/26/2006	8.46
2/28/2006	10.08
3/15/2006	6.7
4/25/2006	6.71
5/8/2006	5.35
6/6/2006	6.58
7/12/2006	8.14
8/28/2006	4.68
9/9/2006	4.99
10/18/2006	6.39
11/8/2006	6.9
12/5/2006	6.96

Table A-2. Dissolved Oxygen measured data at C-017

Sample Date	DO (mg/L)
1/12/1999	11.6
2/3/1999	9.25
3/1/1999	10.2
4/13/1999	7.4
5/11/1999	7.2
6/30/1999	6.3
7/20/1999	6.1
8/11/1999	5.2
9/16/1999	6.2
10/19/1999	7.2
11/8/1999	7.8
12/15/1999	8.2
1/17/2000	9.65
2/1/2000	10.9
3/8/2000	7.25
4/5/2000	6.45
5/11/2000	4.5
6/5/2000	3.65
7/18/2000	4.95
8/2/2000	4.85
9/5/2000	5.6
10/10/2000	7.6
11/8/2000	5.7
12/5/2000	10.5
1/10/2001	13.2
2/26/2001	7.23
3/26/2001	7.43
6/18/2001	5.24
7/10/2001	5.12
8/8/2001	5.26
9/10/2001	5.8
10/24/2001	5.41
11/26/2001	4.28
12/4/2001	5.75
1/9/2002	12
2/13/2002	10.9
3/12/2002	7.6
4/10/2002	6.1
5/15/2002	6.75
6/4/2002	5
7/16/2002	4.88
8/20/2002	5.38
9/11/2002	2.84
10/9/2002	5.92
11/12/2002	6.19
12/5/2002	10.72
1/2/2003	10.46
2/4/2003	9.78
4/9/2003	8.5
5/6/2003	5.1
6/3/2003	6.46
7/8/2003	6.89
8/28/2003	5.3
9/10/2003	6.13
10/28/2003	6.88

Sample Date	DO (mg/L)
11/18/2003	4.6
12/17/2003	10
1/14/2004	10
2/10/2004	10.91
3/30/2004	7.24
4/27/2004	5.6
5/26/2004	5.8
6/8/2004	5.99
7/21/2004	5.5
8/3/2004	5.41
9/29/2004	6.07
10/27/2004	7.56
11/2/2004	6.89
12/14/2004	9.95
1/18/2005	10.6
2/8/2005	10.48
3/2/2005	10.68
4/13/2005	7.12
5/18/2005	6.03
6/22/2005	6.91
7/19/2005	7.13
8/24/2005	6.6
9/14/2005	5.45
10/11/2005	5.85
11/7/2005	5.9
12/12/2005	4
1/30/2006	7.94
2/15/2006	9.3
3/6/2006	8.32
4/18/2006	4.29
5/16/2006	5.5
6/5/2006	4.75
7/25/2006	5.64
8/9/2006	4.78
9/13/2006	6.07
10/18/2006	6.66
11/6/2006	8.88
12/4/2006	8.97

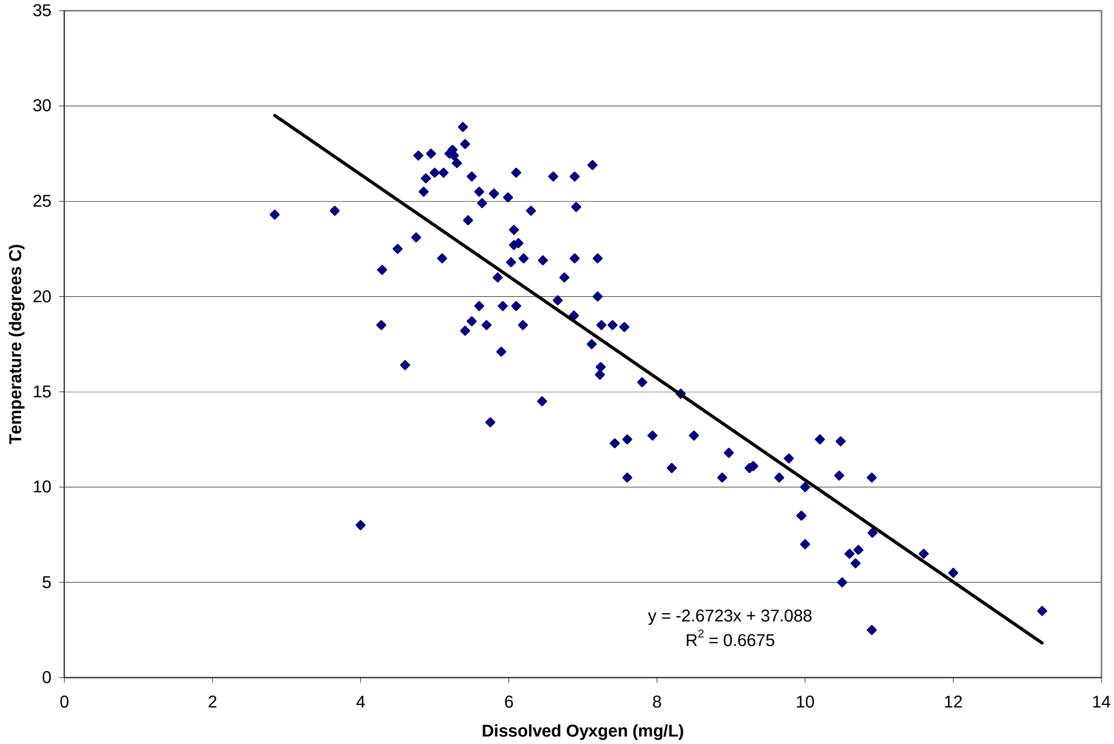

Figure A-1. C-017 relationship between dissolved oxygen and temperature.

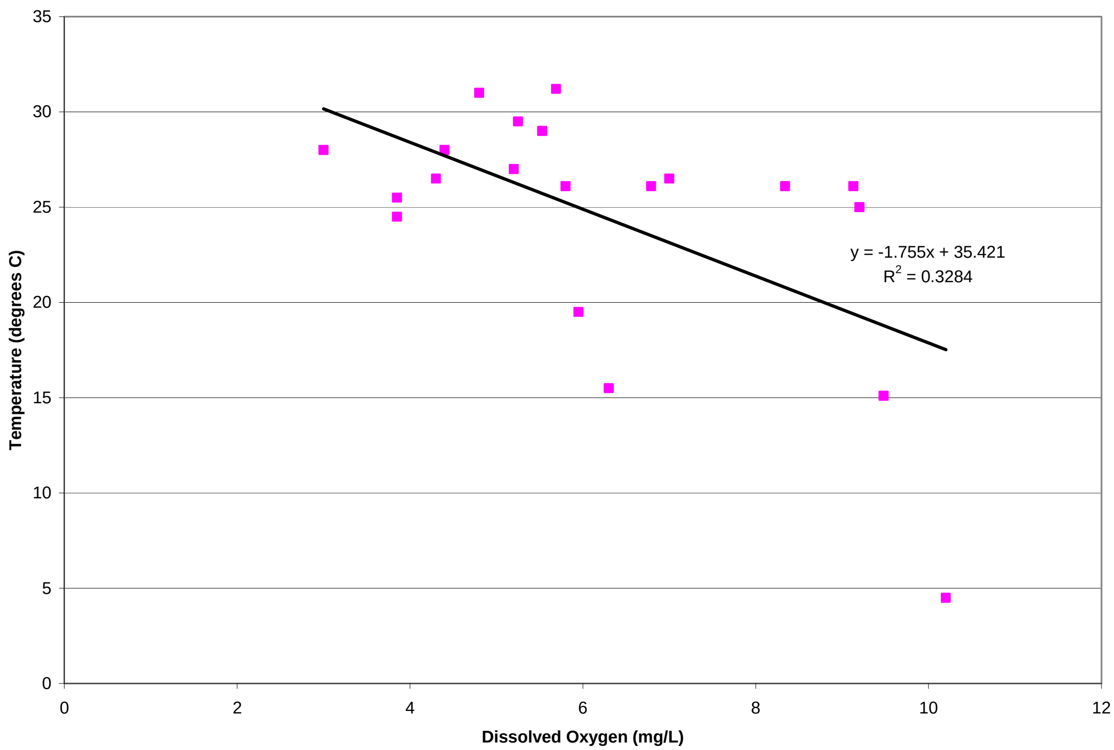

Figure A-2. C-048 relationship between dissolved oxygen and temperature.

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Appendix B. Evaluating the Progress of MS4 Programs

Evaluating the Progress of MS4 Programs:
Meeting the Goals of TMDLs and Attaining Water Quality Standards

Bureau of Water

August 2008

Described below are potential approaches that may be used by MS4 permit holders. These are recommendations and examples only, as SCDHEC-BOW recognizes that other approaches may be utilized or employed to meet compliance goals.

1. Calculate pollutant load reduction for each best management practice (BMP) deployed:
   - Retrofitting stormwater outlets
   - Creation of green space
   - LID activities (e.g., creation of porous pavements)
   - Creations of riparian buffers
   - Stream bank restoration
   - Scoop the poop program (how many pounds of poop were scooped/collected)
   - Street sweeping program (amount of materials collected etc.)
   - Construction & post-construction site runoff controls
2. Description & documentation of programs directed towards reducing pollutant loading
   - Document tangible efforts made to reduce impacts to urban runoff
   - Track type and number of structural BMPs installed
   - Parking lot maintenance program for pollutant load reduction
   - Identification and elimination of illicit discharges
   - Zoning changes and ordinances designed to reduce pollutant loading
   - Modeling of activities & programs for reducing pollutant reductions
3. Description & documentation of social indicators, outreach, and education programs
   - Number/Type of training & education activities conducted and survey results
   - Activities conducted to increase awareness and knowledge – residents, business owners. What changes have been made based on these efforts? Any measured behavior or knowledge changes?
   - Participation in stream and/or lake clean-up events or activities
   - Number of environmental action pledges
4. Water quality monitoring: A direct and effective way to evaluate the effectiveness of stormwater management plan activities.
   - Use of data collected from existing monitoring activities (e.g., SCDHEC data for ambient monitoring program available through STORET; water supply intake testing; voluntary watershed group's monitoring, etc)

- Establish a monitoring program for permitted outfalls and/or waterbodies within MS4 areas as deemed necessary– use a certified lab

- Monitoring should focus on water quality parameters and locations that would both link pollutant sources and BMPs being implemented

5. Links:

- Evaluating the Effectiveness of Municipal Stormwater Programs. September 2007. EPA 833-F-07-010

- The BMP database - http://www.bmpdatabase.org/BMPPerformance.htm (this link is specifically to the BMP performance page, and lot more)

- EPA's STORET data warehouse - http://www.epa.gov/storet/dw_home.html

- EPARegion 5: STEPL – Spreadsheet tool for estimating pollutant loads http://it.tetratech-ffx.com/stepl/

- Measurable goals guidance for Phase II Small MS4 - http://cfpub.epa.gov/npdes/stormwater/measurablegoals/index.cfm

- Environmental indicators for sotrmwater program- http://cfpub.epa.gov/npdes/stormwater/measurablegoals/part5.cfm

- National menu of stormwater best management practices (BMPs) - http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm

- SCDHEC – BOW: 319 grant program has attempted to calculate the load reductions for the following BMPs:

  - Septic tank repair or replacement
  - Removing livestock from streams (cattle, horses, mules)
  - Livestock fencing
  - Waste Storage Facilities (aka stacking sheds)
  - Strip cropping
  - Prescribed grazing
  - Critical Area Planting
  - Runoff Management System
  - Waste Management System
  - Solids Separation Basin
  - Riparian Buffers

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Appendix C. Watershed Hydrology and Water Quality Modeling Report