Lower Satilla River Basin Watershed Improvement Plan

A TMDL Extended Revision for Dissolved Oxygen Impairments in the Satilla River Segment from Rose Creek to White Oak Creek

Developed by:

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Contents

Executive Summary

The following is a summary of the Nine Key Elements addressed in the Lower Satilla River Basin Watershed Improvement Plan.

1. **An identification of the sources or groups of similar sources contributing to nonpoint source pollution to be controlled to implement load allocations or achieve water quality standards.**

Forestry (silviculture) or timber operations, through alterations to natural hydrology and conversion of swamps and wetlands to forest plantation, are the most significant manmade activity within the segment of the Lower Satilla River Basin addressed in this watershed improvement plan. Other farming operations along with urban and suburban development are comparatively insignificant. The hydrology of the Satilla River watershed has been massively altered by the dominant land uses, those associated with forestry and timber harvesting practices. It is quite possible that most of the dissolved oxygen deficiency in the lower Satilla is caused from problems upstream of the impaired segment and stems from flow alterations. Manmade activities are indentified in Sections 1 and 6 through review of available studies and information on historic and current manmade activities within the watershed.

Natural sources are also identified as a significant contributing source to the dissolved oxygen water quality impairments contributing significant oxygen demanding organic materials from local wetlands and forested stream corridors. The Lower Satilla River Basin is influenced by tidal activity and variations in salinity as it nears the coast. Furthermore, this segment is located in a "zone" area where microorganisms that thrive in either fresh or salt water, but are intolerant of the other, build up and die, contributing to decay and increasing the biological oxygen demand. The information concerning the influence of the natural systems, identified through review of available studies, is found in Section 3.

In Section 6, Table 3 list and ranks potential nonpoint sources in order importance, with forestry activities and natural sources most significant sources. This list was developed by the Technical Advisory Committee based on the information available on both manmade and natural activities within the watershed.

2. **An estimate of the load reductions expected for the management measures described under paragraph (3) below;**

There is little information regarding the effectiveness of the proposed management measures to address the sources of dissolved oxygen impairment in general. There are limited financial resources available to stakeholders and local governments to address nonpoint sources. This is addressed in Section 9 and is based on the review of the information available and data collected during the planning process.

3. A description of the NPS management measures that will need to be implemented to achieve the load reductions established in the TMDL or to achieve water quality standards;

There is are a number of existing management measures in place along with proposed management measures available to be implemented within the impaired River Basin segment of the Lower Satilla River. The existing and proposed management measures are presented in tables identifying the measure, a description of what and how the measure seeks to address an issue, and the responsible authority(s) for implementing the measure. The existing management measures are found in Table 4, in Section 7. These existing management measures include structural BMPS, legislation and regulations, monitoring and enforcement of regulations already in place to be administered by the responsible federal, state and/or local authority. The proposed management measures are found in Table 5, in Section 8. The proposed management measures include implementation of regional and local plans, increase coordination between government authorities, education and support for proper and improved operation and management of manmade activities, additional monitoring and study of activities to determine level of influence activities are having in the watershed, enforcement of existing and new regulations

4. An estimate of the sources of funding needed, and/or authorities that will be relied upon, to implement the plan;

The responsible authorities for the existing and proposed management measures are listed with each measure in Tables 4, Section 7, and Table 5, Section 8, above. In Table 5 possible funding sources and resources are listed with each measure, though no estimate of funding needs is provided.

5. An information/education component that will be used to enhance public understanding of and participation in implementing the plan;

Public education and outreach recommendations are identified in Table 5, in Section 8, and are a primary measureable milestone of the implementation schedule found in Table 6, in Section 11.

6. A schedule for implementing the management measures that is reasonably expeditious;

The schedule for implementing the management measures through 2013 are found in Table 6, in Section 11. The schedule included establishing monitoring program for water quality and acquiring funding in the first year. Monitoring of water quality and implementation activities, along with education and outreach are to continue throughout the implementation period.

7. A description of interim, measurable milestones (e.g., amount of load reductions, improvement in biological or habitat parameters) for

determining whether management measures or other control actions are being implemented;

In Section 9 a number of goals and objectives are recommended as interim milestones proposed to implement the management measures of this watershed improvement plan. The goals address implementation of management practices, education activities, planning activities, and programs focusing on identified manmade agricultural and development related activities within the watershed

8. **A set of criteria that can be used to determined whether substantial progress is being made towards attaining water quality standards and, if not, the criteria for determining whether the plan needs to be revised; and;**

The Lower Satilla River is a complex environmental influenced by natural and manmade activities. Sufficient data is not available to determine the exact influence of the various natural and manmade activities are having on the impairment of the segment addressed in the watershed improvement plan. Further study is recommended to determine the influences of the various activities so that management measures can be implemented or modified to effectively address concerns. In the interim, continued monitoring of water quality and of the implementation of the existing and proposed management measures is necessary to determine if revisions are needed. Section 8 addresses the issue of criteria to measure progress.

9. **A monitoring component to evaluate the effectiveness of the implementation efforts, measured against the criteria established under item (8).**

In Section 10, the watershed improvement plan recommends that the Satilla Riverkeeper should continue to conduct sampling within the watershed as management measures are being implemented. The implementation measures in Table 6, Section 11, also calls for the various responsible agencies at all levels of government to continue to implement and enforce their regulations governing the various manmade activities within the watershed.

Section 1 Introduction

The purpose of this Total Maximum Daily Load (TMDL) Extended Revision is to further develop the processes to achieve nonpoint source pollutant load reductions in an impaired segment of the Satilla River Basin. Although the contracted party is limited by regional boundaries, the major goal to restore water quality should not be limited to the particular impaired segment, but for the entire Satilla River Basin. This goal will be difficult to achieve without a strong local or regional commitment and funding to support the necessary implementation measures and management practices. This plan attempts to counteract these constraints by exposing them forthright, while creating a vehicle that would ensure that funding for water quality improvements will be a non-issue in the future.

The major challenge is to develop measures that would potentially improve water quality for a particular segment of the Satilla River Basin that is at the receiving end from all other segments and their subwatersheds that are located upstream.

The Satilla River lies entirely within the Coastal Plain of Southeast Georgia. It is a typical 'black water' river, characterized as having a clear, yet tinted color to the water due to inputs of tannic, or humic, material from the extensive flood plain swamps of cypress and black gum trees bordering the river. The drainage area of the Satilla River is approximately 3,940 square miles, and occupies portions of thirteen counties. The main headwaters of the Satilla River Basin to the northwest are located within Ben Hill and Jeff Davis Counties.

The lower portions of the basin are within Camden and Glynn Counties. Thus it can be identified as the Lower Satilla River Basin. The 19-mile segment of Rose Creek to White Oak Creek is further classified by the U.S. Geologic Survey as being located in Hydrologic Unit Code #0307020112, the "HUC 10" watershed. The State-listed impaired segment of Rose Creek to White Oak Creek flows along the northern boundary of the City of Woodbine in Camden County and is approximately 19 miles long. The Satilla River Basin is dominated by forest and forested wetland. Agricultural use occurs mostly to the northwest. Forest plantations and limited residential use also exist within the basin.

The water use classification for the HUC 10 watershed, including the Satilla River's Rose Creek to White Oak Creek segment, is fishing. The Georgia Environmental Protection Division's (EPD) December 2001 report "Satilla River Basin Dissolved Oxygen TMDLs" specifies the major impairment of the river basin as low dissolved oxygen. The potential nonpoint source contributions are stated as being from urban, agriculture, and forested areas. Croplands, pasture, forest, urban areas, and wetlands were all identified in the basin. The TMDL Analysis states that in urban or suburban settings, significant sources of loading are surface stormwater runoff, failing septic systems, and leakage and overflows from sanitary sewer systems. In rural areas, sources of oxygen demanding substances may include diffuse runoff of agricultural fertilizer and animal wastes, erosion of sediments, and runoff from concentrated animal operations.

Potential nonpoint sources of oxygen demanding substances are contributed by both natural and human origins. Erosion of sediments and the transport of sediments by stormwater runoff are

natural occurrences, but are intensified by land disturbance associated with urban and suburban development, agriculture, and various elements of timber management operations.

The source loading analysis for the TMDL also accounted for point sources of oxygen demanding substances, including wastewater treatment plants, industrial facilities, combined sewer overflows, sanitary sewer overflows, and storm sewer outfalls. The TMDL lists the contributing point sources to be: Georgia Department of Corrections - Wayne County State Prison; Georgia Baptist Children's Home; Milliken-Alma Plant; Alma WPCP; Patterson Water Reclamation Center; Pearson WPCP; Brantley County High School; and Woodbine WPCP. The receiving subwatersheds and permitted flows are also provided in the TMDL Analysis.

Section 2 Plan Preparation and Implementation

The development of this TMDL Implementation Plan Extended Revision coincided with the development of new and revised TMDL Implementation Plans for impaired stream segments within the St. Marys River Basin, also located within Camden County. The Coastal Georgia Regional Development Center, now know as the Coastal Regional Commission (CRC), partnered with the Satilla Riverkeeper as they have an intimate knowledge of the Satilla River Basin as well as the St. Marys River Basin.

A stakeholder meeting was held on May 1, 2008, at Woodbine City Hall, within the local vicinity of the general study area for the St. Marys and Satilla River Basins. The meeting was advertised through several newspapers and was attended by 21 people. The TMDLs and the TMDL Implementation Plan preparation process were explained with the aid of a power-point presentation. In addition, the following occurred at this meeting:

- Stakeholder participation was solicited;
- Technical advisory committee participation was solicited; and
- The role of citizens and technical advisors in the process was explained.

As a result of the initial meeting, a Technical Advisory Committee (TAC) was assembled. A list of all attendees was also compiled as those not directly serving on the TAC had obvious interest in the watershed and were therefore considered as stakeholders. The TAC is composed of a number of individuals whom represent a broad spectrum of expertise associated with surface water quality. Many of these were interested in management of the both the St. Marys and Satilla River Basins. Therefore, their involvement has been maintained to prepare and assist with the implementation of this Extended Revision and the local implementation plans for the St. Marys River Basin. The members of the TAC are included in Table 1. Stakeholders that have been identified and contributed throughout the plan's development process are listed in Table 2.

The TAC's key responsibilities were to:

- Advise on matters of concern to the community;
- Contribute to the education of the residents of the watershed on water quality issues;

- Help identify contributing pollution sources;
- Assist in arriving at equitable pollution reduction allocations among contributors;
- Recommend specific actions needed to effectively control sources of pollution; and
- Help develop and set in motion an extended plan.

Table 1: Satilla and St. Marys TMDL
Technical Advisory Committee (TAC)

Name/Org	Phone	E-mail
Dr. Clay Montague U. of Florida	352-375-7223; 352-538-5861	montague@ufl.edu
Mr. Joel Fleming GA DNR	912-264-7218	jfleming@dnr.state.ga.us
Dr. Liz Kramer U. of Georgia	706-542-3577	lkramer@uga.edu
Dr. Rob McDowell CVIOG (formerly GA DNR, EPD)	(706) 542-6271	mcdowell@cviog.uga.edu
Mr. John Day Jekyll Island Authority	912-635-4021	jday@jekyllisland.com
Mr. Don Harrison GA DNR	912-285-6094	don.harrison@dnr.state.ga.us
Mr. Robert Boland UGA Coop. Ext. Service	912-462-5724	bboland@uga.edu
Mr. John Feldt National Weather Service	770-486-0028, ext. 322	john.feldt@noaa.gov
Mr. Bill Alexander Soil and Water Conservation District	912-729-2458	wra@tds.net
Mr. Bill Sapp Southern Environmental Law Center	404-521-9900	bsapp@selcga.org
Ms. Jeannie Rhodes GA DNR, EPD	912-264-7284	jeannie.butler@dnr.state.ga.us
Mr. David Ferrell NRCS		david.ferrell@ga.usda.gov
Rob Hicks Plum Creek Timberlands	912-269-5981	rob.hicks@plumcreek.com
Brian Snow GA Forestry Commission Regional Forest Water Specialist	912-526-7909	bsnow@gfc.state.ga.us

Research on the part of Satilla Riverkeeper and CRC staff, resulted in a significant volume of technical literature being transmitted to the TAC. This information served as the major purpose to update the TAC on the latest relevant information on the TMDL process and on the dynamics of blackwater streams in Southeast Georgia. The TAC met for a full day on August 26, 2008,

resulting in findings and recommendations for improving the water quality within the St. Marys and Satilla River Basins.

A second public meeting was held at the Woodbine City Hall on Thursday, May 21, 2009. The meeting was advertised in the local paper of the host government and additional post cards were sent out to a list of previously identified stakeholders and the TAC. A third public stakeholder meeting will be held to present this plan upon approval by Georgia EPD.

Table 2: Lower Satilla River Basin Stakeholders

Name	Address	City	State	Zip	E-mail
Sandra Rayson	P.O. Box 26	Woodbine	GA	31569	cityofwoodbine@tds.net
Steve Howard	P.O. Box 99	Woodbine	GA	31659	showard@co.camden.ga.us
Hank Higginbotham	P.O. Box 416	Woodbine	GA	31569	seadawg@tds.net
Anne Blakely	P.O. Box 253	Woodbine	GA	31564	ablakely@tds.net
Rita Barrow	3661 Altama Ave	Brunswick	GA	31520	rita.barrow@ga.usda.gov
Emily Goodson	206 Osborne St	St. Marys	GA	31558	Emily@tribune-georgian.com
Bob Morgan	292 Cox Rd	Woodbine	GA	31569	Harley_rider@tds.net
Jill Andrews	One Conservation Way	Brunswick	GA	31520	Jill.Andrews@dnr.state.ga.us
John Carswell	P.O. Box 159	Waynesville	GA	31566	john@satillariverkeeper.org
Conn Cole	107 North Gross Road, Suite 4	Kingsland	GA	31548	ccole@co.camden.ga.us
Terry Ferrell	107 North Gross Road, Suite 4	Kingsland	GA	31548	tferrell1@dhr.state.ga.us
Arnettia Murphy	2 Martin Luther King Jr. Dr, Suite 1152, East Tower	Atlanta	GA	30334	Arnettia_Murphy@dnr.state.ga.us
Laurie Fowler	110 Riverbend Road, Rm 105	Athens	GA	30602	lfowler@uga.edu

Section 3 Segment and Watershed Description

For the most part, the Satilla watershed is located within a rural setting, and the conditions for this segment are similar. This segment of the Satilla River has its own contributing subwatersheds and is located downstream from all of the other segments and their contributing subwatersheds. The northern boundaries of the Rose Creek to White Oak Creek segment include wetlands and saltwater marshlands. Toward the central portion of the segment, it forms the northern boundary of the City of Woodbine. The TAC generally found that land use within the

entire Satilla River watershed is mostly timber plantation or other forms of agriculture, that nonpoint source dissolved oxygen water quality impairments resulting from urban or suburban development are comparatively insignificant, and that the hydrology of the Satilla River watershed has been massively altered by the dominant land uses – those associated with forestry and timber harvesting practices.

According to the 2001 Satilla River TMDL, streams in southern Georgia receive significant contributions of oxygen demanding organic materials from local wetlands and forested stream corridors. The following sources of naturally occurring organic materials have been identified in the Satilla River Basin:

- Adjacent wetland/swampy areas that have organically rich bottom sediments;
- Direct leaf litter fall onto the water surface from overhanging trees and vegetation;
- Lateral leaf litter fall that has fallen into the floodplains; and
- In the case of streams that have dry beds during dry weather, leaf litterfall and accumulation in stream beds during dry seasons.

That material which does not fall directly into the main channel is transported by wind or stormwater runoff. As a result, the low dissolved oxygen conditions of the basin may result from the naturally occurring process of decaying vegetation, which creates a chemical oxygen demand. A higher degree of fluctuation may especially occur during the summer months when the temperatures are higher and the flows are lower, or during conditions of drought.

Significant changes in the river basin due to human influence further augment the natural system. Hardwood swamps have been lost as a result of forestry practices that included the installation of channels or ditches designed to drain swamps for conversion to timber plantation. The filling of wetlands has led to decreased filtration capacity for natural processing of pollutants. The results are that headwaters drain more quickly – eight to ten days rather than two or three months – and would be pollutants are allowed to reach the main channel more rapidly and in higher concentrations. However, the correlation between such natural system conversion and the dissolved oxygen levels is difficult to quantify, especially from a historic perspective, since data for the Satilla River from before 1987 does not exist, and such activities occurred decades prior. These activities have been effective in altering flow rates of the headwaters and drainage areas of the subwatersheds, and consequently, the main river channel.

It is quite possible that most of the dissolved oxygen deficiency in the lower Satilla is caused from problems upstream of the impaired segment and stems from flow alterations. As stream flow decreases, so does dilution. Therefore local, urban (Woodbine area) inputs are more brightly spotlighted, meaning that local stormwater runoff and treated wastewater from the municipal WCPC issues become relatively more important.

Portions of the 19-mile segment of the Satilla River from Rose Creek to White Oak Creek are also subject to variation in salinity levels as this segment of the river is influenced by tidal patterns. In the tidal area of a river, the river volume does not build up or “puddle” but it does “pond” there during long periods of low flow (low river discharge), likely amplified twice a day during incoming tide, thus influencing the slowing of flow and resulting decrease in DO.

Furthermore, this segment is located in a "zone" area where microorganisms that thrive in either fresh or salt water, but are intolerant of the other, build up and die, contributing to decay and increasing the biological oxygen demand.

The tidal patterns also contribute to increased, localized sedimentation within the water column. Total suspended solids are identified in the 2001 TMDL as a parameter that either directly or indirectly constitutes a primary nonpoint source that contributes to dissolved oxygen depletion and/or replenishment. However, the effects of tidal patterns have not been discussed as a natural or even potential contributing factor to dissolved oxygen levels in past TMDL-related documentation for the Rose Creek to White Oak Creek segment.

Soils are considered to be a region's most basic and fragile natural resource, combined with such variable resources as air and water. Southeastern Georgia has been classified as the Atlantic Coast Flatwoods area due to soil type and climatic conditions. The majority of the terrain in Camden County and the Lower Satilla Watershed maintains an elevation of just above sea level and is characterized by poorly drained soils that are underlain by marine sands, loams, or clays and have a high water table that experiences seasonal changes depending on the amount of precipitation.

In addition, there is a significant area of marsh soils along the coastal areas that have a high content of silt and clay, are nearly continuously saturated, and have a high salt content. Due to high levels of saturation, the various soils in Camden County are not the most ideally suited to development, and most have moderate to severe development constraints in regards to on-site septic disposal systems (septic tanks and drain fields). Below is some general information on those soils in the County that are less suitable for any type of development.

Satilla - Areas of this classification are basically are found on the floodplain of the Satilla River. The Satilla soils have good open land and woodland wildlife habitat potential. It has poor potential for farming and urban uses.

Kingsland - Areas of this classification are generally flooded daily and are found on the floodplain of the Little Satilla River and the St. Marys River. It has good potential as habitat for wetland wildlife, but poor potential for most other uses. The daily flooding and wetness are the primary concerns for use and management.

Mandarin-Rutledge - Areas of this classification are generally found on marine terraces and cover about 24 percent of the County. This classification is used mainly for woodland and has poor potential for most other uses. Again, wetness, periods of the inundation, and flooding are concerns.

Bladen-Brookman-Meggett - This classification covers about 22 percent of the County and consists of soils that are subject to flooding in the winter and spring. This classification is found in the western part of the County and is used mainly for woodland. It has good potential for locally grown pines and as habitat for wetland wildlife species; however, the potential for most other uses is poor.

Pelham-Sapelo - This classification covers about 21 percent of the County in the west-central areas. It is used mainly for woodland. It also has fair potential as habitat for most kinds of wildlife; however, the potential for most other uses is poor. Wetness is a primary concern with flooding in the depressions and drainage ways.

Fripp-Duckston-Beaches - This classification is found on Cumberland Island. It mainly supports live oak, brush, and grasses. While some areas have been developed for dwellings and recreation, the overall development potential is poor because of wetness and flooding. Furthermore, the soils are too sandy for many recreation and wildlife uses.

Bohicket-Capters - This classification is generally found in tidal marshes and generally border the Atlantic Ocean and can extend several miles inland along Cumberland Sound and the tributaries of the Satilla River. It is mainly in its natural state with smooth cordgrass near the ocean and black rush along the creeks and rivers. It has good potential for wetland wildlife habitat. Potential is poor for other uses, particularly as the natural sulfur in these soils causes an unpleasant odor if exposed to air.

In terms of the soils in Camden County, it would appear that virtually all development must take into consideration the wet nature of all of the soils in the County, and the propensity of many of the soils for inundation or flooding during the year.

Section 4 Water Quality Impairments and Total Maximum Daily Loads (TMDLs)

In 1996, the Georgia EPD established water quality monitoring stations for the Ochlockonee, Suwannee, Satilla, and St. Mary's River Basins as part of the Georgia River Basin Planning Program. A five-year water quality monitoring cycle was developed and was set to begin in 1998. Currently, the Rose Creek to White Oak Creek segment of the Satilla River violates the State of Georgia's water quality standards for dissolved oxygen for the water use classification of fishing. Georgia's water quality standards for measurements of dissolved oxygen for this use are a daily average of 5.0 mg/L and no less than 4.0 mg/L at all times for waters supporting warm water species of fish. According to Georgia EPD, water bodies in the Satilla River Basin are assumed to contain warm water species of fish.

This impaired stream segment was placed on the State of Georgia's 305(b)/303(d) list as "partially supporting" the use of fishing as a result of 1998 monitoring assessment. The violations of dissolved oxygen water quality standards resulted in a TMDL being developed for the river basin in 2001. There were 22 measurements for this segment from the USGS2228070 monitoring station located at U.S. Highway 17 in Woodbine, which resulted in the following dissolved oxygen conditions:

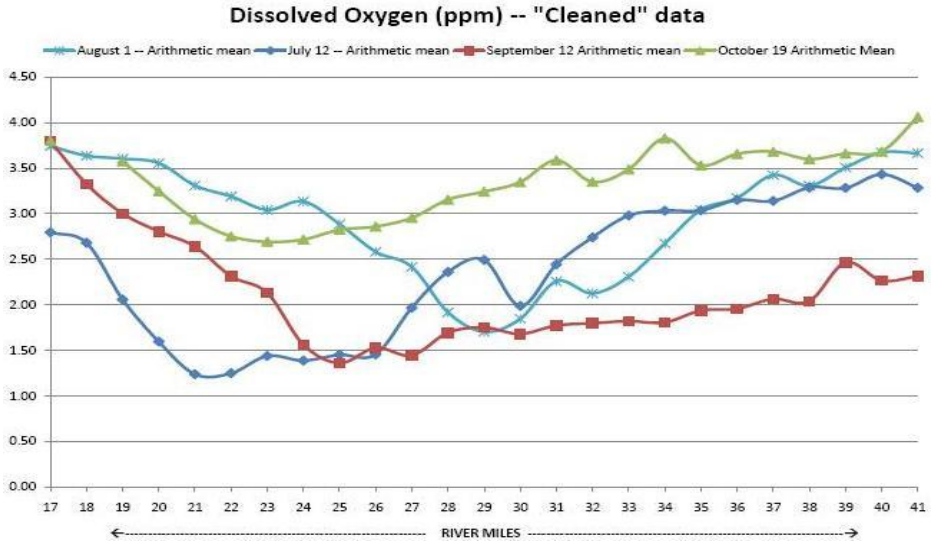
- Minimum level of 2.2 mg/L
- Maximum level of 7.8 mg/L
- Mean of 4.8 mg/L

In 2003, the State conducted another water quality monitoring assessment for the impaired segment. The results show the segment had a minimum dissolved oxygen level of 2.44 mg/L, a maximum dissolved oxygen level of 12.7 mg/L, and a DO mean of 5.54 mg/L. The numbers indicate that there was some improvement in the minimum, maximum, and mean dissolved oxygen levels between the 1998 and 2003 monitoring assessment. However, that data included samples that were out of compliance with state standards more than 25 percent of the time. As a result, the 305(b)/303(d) list published in 2006 assessed the segment as "not supporting" the use of fishing. This demotion has led to increased focus on the Satilla River Basin.

In order to meet the State's water quality standards for dissolved oxygen, the 2001 TMDL recommended that the following load reduction percentages be obtained in the Rose Creek to White Oak Creek section of the Satilla River: 18 percent reduction in Total Organic Carbon (lb/yr) loading; 18 percent reduction in Total Nitrogen (lb/yr) loading; and 19 percent reduction in Total Phosphorus (lb/yr) loading.

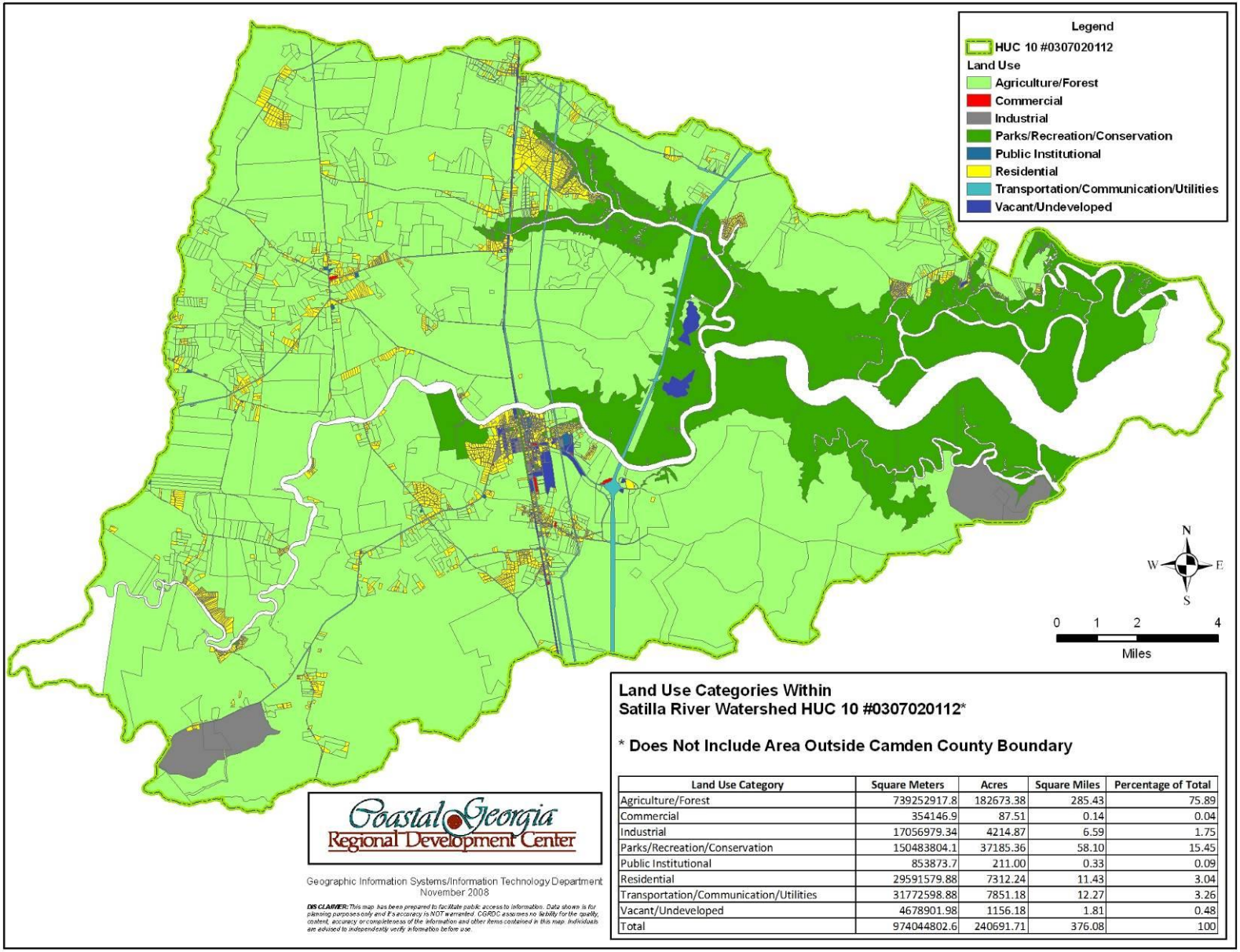
Section 5 Watershed Surveys and Targeted Monitoring

Where watershed–wide monitoring had not been conducted, a targeted monitoring plan (Appendix A) was developed with the intent to geographically isolate any major or potential sources of the dissolved oxygen impairment within the 19-mile segment. Targeting monitoring of the impaired segment occurred on select locations of the main channel of the impaired segment as well as one mile upstream and downstream between August and October 2008. CRC and Satilla Riverkeeper staff, as well as members of the Riverkeeper volunteer network traveled by boat while taking the samples. The results of the samples are included in the figure below. The samples were taken during times when the segment was least likely to be influenced by incoming high tide flows. The dissolved oxygen levels at just about every sampling site were below the State's water quality standards.



Concurrent with the sampling sessions, the party was also able to observe the conditions of the corridor for the entire 19-mile stream segment. For the most part, development within or adjacent to the segment corridor is rather nonexistent. The integrity has been maintained with the exception of historical development that has occurred along the waterfront within the City of Woodbine. The visual surveys by and large verify the sources and causes of impairments initially identified in the 2001 TMDL, which generalized that nonpoint source contribution from urban, agriculture, and forested areas are all likely in the Satilla River Basin, as well as the segment.

The State's 305(b)/303(d) lists "Urban Runoff/Urban Effects" as the potential causes for the dissolved oxygen impairments specifically for this segment. It is recommended that the "Potential Cause Code" on future 305(b)/303(d) is changed to "Nonpoint Source/Unknown Source." Currently, urban influences in the entire Lower Satilla Basin within Camden County, and the segment watershed, are very limited. Further reference may be obtained from the land use map that follows.



Land Use Categories Within
Satilla River Watershed HUC 10 #0307020112*

* **Does Not Include Area Outside Camden County Boundary**

Land Use Category	Square Meters	Acres	Square Miles	Percentage of Total
Agriculture/Forest	739252917.8	182673.38	285.43	75.89
Commercial	354146.9	87.51	0.14	0.04
Industrial	17056979.34	4214.87	6.59	1.75
Parks/Recreation/Conservation	150483804.1	37185.36	58.10	15.45
Public Institutional	853873.7	211.00	0.33	0.09
Residential	29591579.88	7312.24	11.43	3.04
Transportation/Communication/Utilities	31772598.88	7851.18	12.27	3.26
Vacant/Undeveloped	4678901.98	1156.18	1.81	0.48
Total	974044802.6	240691.71	376.08	100

Section 6 Identification and Ranking Significant Sources and Causes of Impairments

Table 2 ranks the potential nonpoint sources of water quality impairments in order of importance as determined through this development process of this plan. A five point scale is used with "5" being the most significant. The information in this table relies heavily on the guidance of the Technical Advisory Committee and involvement of stakeholders through the public involvement process. The nonpoint sources of low dissolved oxygen in the impaired segment may or may not occur directly within the Lower Satilla River Basin; however, and must be considered as sources that occur either upstream or downstream, and within and outside the boundaries of Camden County, Georgia.

Table 3: Source Contribution of Dissolved Oxygen Impairments in the Lower Satilla River Basin

Source	Estimated Contribution (Rank 1 – 5)	TAC & Stakeholder Opinion (1 – 5)	Comments
Organic loading of fertilizers, herbicides, pesticides, septic effluent from failing systems, and dead vegetation from farming and silvicultural operations	5	5	Farming operations are a minor source contributor. Silviculture or timber operations occur on a more wide scale basis throughout the watershed and are a major source contributor.
Decreased capacity for natural processing of organic loading, resulting from decreased base flow caused by silvicultural activity, suburban development, filling of wetlands and overall hardening of the landscape (impervious surface)	Unknown	5	The relationships between loadings and changes in base flow should be investigated to determine potential effectiveness of measures altering base flow to natural flows as part of the solution to impairment.
Natural sources including adjacent wetlands with organically rich bottom sediments; direct and lateral leaf litter fall onto water surfaces and adjacent floodplains	4	4	Impacted by wind and rainfall (stormwater runoff) events.
Erosion and stormwater runoff of sediments from areas of land disturbance	3	3	Land disturbance could occur from natural or human origins. For example, exposed mud flats as a result of marsh die back.
Urban Point and Nonpoint Sources	1	1	Includes the Eight point sources identified in the 2001 TMDL: four municipal wastewater treatment facilities (one occurs in the impaired segment – Woodbine); one state prison facility; one industrial facility; one high school; and one faith-based residential use

Section 7 Identification of Applicable Existing Management Measures

According to the U.S. Environmental Protection Agency (EPA) management measures are defined as "economically achievable measures for the control of the addition of pollutants from existing and new categories and classes of nonpoint and stormwater sources of pollution, which reflect the greatest degree of pollutant reduction achievable through the application of the best available nonpoint and stormwater source pollution control practices, technologies, processes, citing criteria, operating methods, or other alternatives."

Descriptions of existing management measures for the Lower Satilla River Basin are summarized below in Table 3. These measures are effective, practical, structural or nonstructural methods which have the potential to prevent or reduce the movement of sediment, nutrients, pesticides and other pollutants from the land to surface or ground water, or which otherwise protect water quality from potential adverse effects. These practices are developed to achieve water quality protection within natural and economic limitations.

Table 4: Identification of Existing Management Measures

Management Measure	Responsibility	Description
Structural Best Management Practices from Georgia's Best Management Practices for Forestry – January 1999	Georgia Forestry Commission (GFC) (matters involving enforcement are generally referred to GA EPD)	Document emphasizes protection of water resources when conducting forestry operations, through BMPs to control soil erosion and stream sedimentation. GFC program to inform landowners, foresters, timber buyers, loggers, site preparation and reforestation contractors and others involved with silvicultural operations about commonsense, economical practices to minimize nonpoint source and thermal pollution. GFC encourages and monitors compliance and conducts a complaint resolution program.
Structural Best Management Practices from Best Management Practices for Georgia Agriculture – Conservation Practices to Protect Surface Water Quality – March 2007	Georgia Department of Agriculture / Georgia Environmental Protection Division for enforcement action.	Provides the agricultural community with knowledge of the BMPs that work to protect surface water quality, as well as to help agency personnel educate farmers about BMPs and their usefulness.
1985 Farm Bill, Sect. 1221	USDA	Denies eligibility for commodity program payments and other USDA programs to those agricultural operators who convert wetlands for agriculture.
1996 Farm Bill, Sections 321 to 326	USDA	Prohibits USDA delegation of compliance decisions to a private entity.
Professional Forestry Standards of Practice (OCGA 43-1-19)	Georgia State Board of Registration of Foresters, Foresters	Failure to practice professional forestry in accordance with generally accepted standards of practice (including BMPs) shall constitute unprofessional conduct and shall be grounds for disciplinary action.
Georgia Water Quality Control Act (OCGA 12-5-20)	Georgia DNR and EPD	Prohibits discharge of excessive pollutants, including sediments, nutrients, pesticides and animal waste, etc., into waters of the State in amounts harmful to public health, safety or welfare, or to animals, birds, or aquatic life or the physical destruction of stream habitats.

Management Measure	Responsibility	Description
Land Development Review Process	Camden County Planning and Development	Ensures compliance with land use, engineering, and environmental policies and regulations; and guides development toward preferred land use.
Camden County Soil Erosion and Sedimentation Control Ordinance, those of counties upstream	Camden County Planning and Development, and similar departments of upstream counties	County Unified Development Code requiring permits, inspections, monitoring, and enforcement for land disturbing activities, by County Erosion and Sediment Control (ESC) Investigator ; Sediment and erosion control measures are required, including BMPs consistent with the Manual for Erosion and Sedimentation Control in Georgia; A 25-foot buffer from the banks of any state waters is required; Camden County is a state-designated Local Issuing Authority (LIA), requiring inspections of permitted land disturbing activities.
Greenprint Plan	Camden County / Trust for Public Land	Promotes water quality protection
Enforce Part V Environmental Protection Ordinance	Camden County Planning and Development	Groundwater, watershed, river corridor, wetlands protection
Apply/Enforce Septic Tank Installation and Design Standards; Educate Property Owners	Camden County Environmental Health	Rules and Regulations promulgated by On-site Sewage Management Systems, Chapter 290-5-26, Georgia DHR, Division of Public Health, Environmental Health and Injury Control
Camden County Water Well and Septic Survey	Camden County Environmental Health, Coastal RC&D Council	Provides locations where high numbers of potentially failing on-site septic systems occur. Among the findings, approximately six percent of the systems surveyed experienced some level of maintenance-related problems. Public outreach and education is focused to address maintenance and repair; A training session was held on August 20, 2004 to discuss findings with stakeholders.

Section 8 Recommendations for Additional Management Measures

Development of effective management measures depends on accurate source assessment. The accuracy of previous source assessments and even those involved in the development of this plan are questionable. Low dissolved oxygen levels have been shown herein to be contributed to the environment from a number of sources, activities, or practices that include a complex natural system that is further impacted by the human influence. Each potential "cause" of low dissolved levels may or may not respond to one or more additional management measures listed below, but they have been designed to assist in reducing the sources of dissolved oxygen impairments. Each management strategy has one or more entities that can take lead responsibility to effect the strategy. Furthermore, this plan should be amended based on the success or failure of any of the management measures, or with the availability of additional information or technological advancements.

Some of these management measures may possibly involve years of extensive research to further determine pollutant source assessments and ultimately restore water quality. Therefore, it is imperative that funding is available for all activities involved to ensure the implementation of this plan, or assist with water quality protection and/or improvement within the entire Satilla River Basin.

Table 5: Recommended Management Measures for Dissolved Oxygen Water Quality Improvements

Management Measure	Responsibility	Description	Sources of Funding &Resources
Coastal Georgia Regional Plan Implementation	CRC, Camden County, City of Woodbine	Regional Auditing Process – Assess how local governments incorporate quality growth principles into their Comp Plans, ordinances, or land use regulations. Evaluate local compliance with the Regional Plan and other plans of the region.	EPD 319 Grant, DNR Coastal Incentive Grants, Camden County, City of Woodbine, DCA, NOAA, NRCS Conservation Innovation Grant
Local Comp Plan and ordinance amendment, adoption, and enforcement	Camden County, City of Woodbine, CRC	Local comprehensive plan amendments or ordinance adoption may be recommended or even needed from time to time to ensure that local needs are being met, or to obtain compliance with the Regional Plan. Incentives for local governments that exceed minimum quality growth standards will likely be developed on the regional and State levels. Quality development tools such as model ordinances are being developed as part of the Regional Plan; some are currently available through DCA.	EPD 319 Grant, DNR Coastal Incentive Grants, Camden County, City of Woodbine, DCA, NOAA, NRCS Conservation Innovation Grant
Camden County (Local Issuing Authority) and State monitoring and enforcement review	Camden County, Developers	Review for potential improvements Local Issuing Authority (LIA) and any State monitoring and enforcement of erosion and sediment control, associated with any locally jurisdictional land disturbing activities, including NPDES sediment and erosion control for construction-related disturbance, BMPs associated with county-maintained dirt roads, and BMPs associated with farming.	Developers through permit conditions, EPD 319 Grant, DNR Coastal Incentive Grants, Camden County
Shorter sampling intervals	DNR/EPD	Decrease the standard 5-year sampling interval to	EPD funds

Management Measure	Responsibility	Description	Sources of Funding &Resources
		account for year by year rainfall change, and require shorter intervals for TMDL implementation monitoring.	
On-site Septic-related Funding Source Development	Georgia DPH, Camden County Environmental Health	Develop Funding Source for on-site septic repairs/replacements for low income residents.	State Revolving Fund, USDA Rural Development Fund, HUD, Economic Development Administration, EPD 319 Grant, DNR Coastal Incentive Grants
On-site septic system inspections	Camden County, Camden County Environmental Health, Property owners	Recommend state-mandated inspections of existing on-site septic systems. Model ordinances for septic system maintenance and/or inspection are being developed as part of the Coastal Regional Plan.	Fees to property owners
Education	CRC, TAC, Camden County Environmental Health, UGA Extension, Local Developers	Continue and increase education of property owners on septic maintenance and associated environmental benefits.	Georgia DPH, Camden County Environmental Health, EPD 319 Grant, DNR Coastal Incentive Grants
Woodbine Water Treatment Plant outfalls	DNR/EPD, City of Woodbine	Research current and projected standards, effluent constituents and volumes associated with water treatment plant outfall. (See Appendix B– Comments of Dr. Montague)	DNR/EPD funds, Woodbine
Point/Nonpoint sources relative	DNR/EPD	Determine the relative point/nonpoint impairment	EPD 319 Grant, DNR

Management Measure	Responsibility	Description	Sources of Funding &Resources
contributions and reduction feasibilities and costs		contributions, and relative feasibilities and costs of implementing point and nonpoint source reductions specific to the impaired segment. (See Appendix B – Comments of Dr. Montague)	Coastal Incentive Grants, NOAA, NRCS Conservation Innovation Grant
Nutrient trading	DNR/EPD, CRC, Satilla Riverkeeper	Explore and evaluate the value of nutrient trading as an offset in proposed increases in the base flow of water treatment plants.	EPD 319 Grant, DNR Coastal Incentive Grants, NOAA, NRCS Conservation Innovation Grant
Local government collaboration	DNR/EPD, CRC, Camden County, City of Woodbine	Collaborate with all watershed local governments on the development of measures and activities to decrease impairment.	EPD 319 Grant, DNR Coastal Incentive Grants, Camden County, Woodbine
RC to RC coordination	CRC	Recommend coordination between Regional Commissions (RCs) where respective RC jurisdictions share watersheds.	EPD 319 Grant, DNR Coastal Incentive Grants
Mitigation banking	DNR/EPD, CRC, Satilla Riverkeeper	Explore, evaluate, and market value of mitigation banking upstream of impairment sources, as an alternative to conventional timber plantations, targeting base flow offsets and restoration credits.	EPD 319 Grant, DNR Coastal Incentive Grants, NOAA, NRCS Conservation Innovation Grant
Enforce Clean Water Act, Section 404 permits and associated mandated BMPs; EPA/Corps 1995 MOU	EPA, EPD, Army Corps of Engineers, Georgia Forestry Commission (GFC) and Property Owners	For wet hardwood forests at least ten acres in area, and swamp forests at least five acres in area, with seasonally flooding or saturation by high water tables: 404 permit required for conversion to pine plantation; Federally mandated BMPs include maintenance of natural contour and ensuring that activities do not immediately or gradually convert	EPA, Army Corps of Engineers, Georgia EPD

Management Measure	Responsibility	Description	Sources of Funding &Resources
		the wetland to non-wetland; provisions for forest road construction/maintenance in and across waters of the U.S., in order to qualify for the silvicultural exemption from the permit process.	
Review GFC Forest Management monitoring	CRC and GFC	Review GFC monitoring of forest management operations for potential improvements and elimination of non-permitted forest conversion to other uses.	EPD 319 Grant, DNR Coastal Incentive Grants, GFC
Local government and GFC coordination	CRC, GFC, Camden County, EPD	Explore opportunities for improved coordination between LIA and GFC representatives, to facilitate common monitoring objectives.	EPD 319 Grant, DNR Coastal Incentive Grants, Camden County, EPD, GFC
State/Federal enforcement and permitting review	CRC, EPD, GFC, Army Corps of Engineers, EPA, Camden County	Review enforcement and any associated permitting by EPD, the Corps of Engineers and EPA, for improved control against forest management violations and non-permitted forest conversion to other uses	EPD 319 Grant, DNR Coastal Incentive Grants, GFC
DO conditions assessment and DO dynamics research – Impairment Sourcing Study	DNR/EPD	Conduct a current assessment of DO conditions in the segment; research DO dynamics in the system, including using BOD work to explore the details of dynamics beyond mere measurement. Gain a complete understanding of the hydrologic changes in the watershed, including opportunities for restoration of lost functions/flows; understand the sourcing of nonpoint pollutants, the nutrient budgets, BOD dynamics, and the relationship of hydrology to all. (See Appendix B – Comments of Dr. Montague)	DNR/EPD, EPD 319 Grant, DNR Coastal Incentive Grants

Section 9 Interim Milestones

The ultimate goal of this implementation plan extended revision is to bring the Rose Creek to White Oak Creek segment of the Satilla River into compliance with water quality standards, which will result in its being listed as supporting the use of fishing in accordance with the State's 305(b)/303(d) list of impaired waters. This goal will be measured by the concentration of dissolved oxygen levels in samples, but milestones along the way will include both water quality measurements and implementation of various management measures and BMPs. The construction of BMPs may be dependent as opportunities, especially funding, are presented. Even more so, it is important that the installation of management measures or BMPs are not limited to only areas adjacent to the river corridor or within the boundaries of Camden County.

In order to achieve the TMDL it was recommended that there be an 18 percent reduction in Total Organic Carbon (lb/yr) loading; 18 percent reduction in Total Nitrogen (lb/yr) loading; and 19 percent reduction in Total Phosphorus (lb/yr) loading. These are a combined average of all the recommended load reductions within the segment's contributing subwatersheds. There is very limited data available on the effectiveness of existing and/or potential management measures available to address the sources or the dissolved oxygen impairment in general. Furthermore, there are also limited financial resources available to stakeholders and local governments to address nonpoint sources.

In order to bring this segment of the Lower Satilla River Basin in compliance with State water quality standards, additional goals and objectives are listed below. These address the segment watershed issues outlined in the previous sections of this report; however, they must be considered as applicable on a basin-wide scale as many of these are more applicable in areas within the upper portions of the river basin:

GOAL #1: Implement cost-shared BMPs to achieve targeted agricultural reductions.

- Objective: Educate targeted landowners about funding available and procedures for implementing BMPs on their properties.
- Objective: Install appropriate BMPs such as, but not limited to, exclusion fencing to prevent livestock access to streams, riparian buffers, and cover crops.

GOAL #2: Reduce inputs in urban and residential areas through education.

- Objective: Encourage installation of urban streamside forest buffers, where possible.
- Objective: Encourage installation of homeowner Low Impact Development (LID) measures such as those included in the Coastal Resources Division's *Green Growth Guidelines* Program.

- Objective: Educate homeowners in funding available for forested buffers.
- Objective: Use media to increase awareness of water quality issues and good stewardship practices.
- Objective: Include education about water quality and stewardship in local school curricula.
- Objective: Offer educational programs and literature through homeowners' associations and other neighborhood or civic organizations.
- Objective: Ensure Adopt-a-Stream program in the watershed is effective and expand as necessary.

GOAL #3: Implement stormwater management practices to reduce inputs from municipal community infrastructure.

- Objective: Install and monitor demonstration LID sites.
- Objective: Improve enforcement of Erosion and Sediment Control regulations.
- Objective: Improve efficiency of street sweeping practices if available locally.
- Objective: Seek opportunities for remediation and increased stormwater infiltration with redevelopment and new construction.
- Objective: Reduce sanitary sewer overflows.
- Objective: Prevent infiltration/exfiltration from sanitary sewers.

GOAL #4: Through planning activities, identify and prioritize opportunities for stream protection and restoration, and ensure that codes and design standards are "water quality friendly."

- Objective: Revise as necessary master plans and action lists for watershed.
- Objective: Review and adopt codes and design standards as needed.
- Objective: Encourage future development to use smart development guidelines or LID strategies.
- Objective: Encourage stream buffer restoration and other suitable infiltration practices in areas of redevelopment.

GOAL #5: Reduce inputs from failing septic systems by performing inspection, monitoring and maintenance on septic tanks and drain fields in order to ensure proper performance and prevent pollution.

- Objective: Update Service Delivery Strategies to extend municipal wastewater treatment services to areas where services are currently unavailable. Keep current maps of service delivery areas.
- Objective: Ensure that property owners are connected to municipal wastewater treatment systems in areas where such services are available, or in accordance with State law or local ordinance.

- Objective: Develop and adopt local ordinances that set up a requirement and schedule for septic system maintenance and inspection for all property owners not served by municipal or community wastewater treatment systems.

Section 10 Recommendations for Monitoring and Evaluating Measures of Success

Perhaps the largest constraint for the Lower Satilla River Basin is a lack of monitoring data, specifically data used for 305(b)/303(d) listing purposes. The Satilla Riverkeeper conducts sampling for multiple parameters throughout the entire basin to determine trends in water quality impacts. The Satilla Riverkeeper should continue to conduct sampling within this watershed for dissolved oxygen as management measures are being implemented. They have an extensive volunteer network with sampling experience that has the capability to get out in the field and on the water. Data should be maintained on their website and submitted to Georgia EPD as necessary. If needed, a Sampling Quality Assurance Plan (SQAP) should be developed that would be applicable for the entire river basin (upper and lower portions). Georgia EPD is available for assistance with setting up, designing, and implementing monitoring programs. Funding for such activities and data should be considered for utmost importance on applications submitted to implement this plan. This information could help verify which management measures or BMP projects are most beneficial. This information will also be useful in determining how to proceed and/or revise this management plan.

Section 11 Plan Implementation

The objective of TMDL implementation is to restore impaired water quality to meet water quality standards. From a broader perspective, Georgia's water quality management strategy addresses three things:

1. Protection: Prevent the degradation of healthy waters.
2. Restoration: Develop and execute plans to eliminate impairments.
3. Maintaining Restored Waters: Institutionalize technical and administrative procedures to prevent or offset new pollutants.

A list of management measures and other general actions to be implemented during the first 3 years is shown in Table 5.

Table 6: Implementation Schedule

2009	
Measurable Milestone	**Party Responsible**
Complete final TMDL Extended Revision Plan	CRC
Contact Stakeholder and Advisory Groups to present and discuss funding options and future goals	CRC
2010	
Milestone or Management Measure to Accomplish	**Party Responsible**
Develop SQAP (if needed) for annual water quality monitoring program and submit to EPD	CRC, TAC, Satilla Riverkeeper, EPD
Apply for funding for multi-year water quality monitoring program	CRC, TAC (specifically Satilla Riverkeeper), EPD
Education, coordination and collaboration with watershed citizens, stakeholders, and TAC	CRC, TAC, Satilla Riverkeeper, Camden County, City of Woodbine
Present a community educational workshop	CRC, TAC, Camden County, City of Woodbine
Implement BMPs (existing or recommended)	CRC, GFC, Developers, TAC, Stakeholders, EPD, Landowners
Complete Regional Plan	CRC
2011	
Milestone or Management Measure to Accomplish	**Party Responsible**
Education, coordination and collaboration with watershed citizens, stakeholders, and TAC	CRC, TAC, Satilla Riverkeeper, Camden County, City of Woodbine
Initiate water quality monitoring program (as identified in SQAP)	CRC, Satilla Riverkeeper, TAC, EPD
Present a community educational workshop	CRC, TAC, Camden County, City of Woodbine
Implement BMPs (existing or recommended)	CRC, GFC, Developers, TAC, Stakeholders, EPD, Landowners, Camden County, City of Woodbine
Quality Growth Audits as part of Regional Plan Implementation; recommend amendments to local plans or ordinances as needed	CRC, Camden County, City of Woodbine
Local Comp Plan and ordinance amendment, adoption, and enforcement as needed to achieve Regional Plan compliance, promote quality growth principles, and promote water quality protection	CRC, Camden County, City of Woodbine
Complete Regionally Important Resources (RIR) Plan	CRC
2012	
Milestone or Management Measure to Accomplish	**Party Responsible**
Continuation of Water Quality Monitoring Program	CRC, Satilla Riverkeeper, TAC, EPD
Education, coordination and collaboration with watershed citizens, stakeholders, and TAC	CRC, TAC, Satilla Riverkeeper, Camden County, City of Woodbine
Implement BMPs (existing or recommended)	CRC, GFC, Developers, TAC, Stakeholders, EPD,

	Landowners, Camden County, City of Woodbine
2013	
Measurable Milestone	**Party Responsible**
Continuation of Water Quality Monitoring Program	CRC, Satilla Riverkeeper, TAC, EPD
Coordination and collaboration with watershed Citizens, stakeholders, and TAC	CRC, TAC, Satilla Riverkeeper, Camden County, City of Woodbine
Implement BMPs (existing or recommended)	CRC, GFC, Developers, TAC, Stakeholders, EPD, Landowners, Camden County, City of Woodbine
Perform Success Rate Analysis: Determine if the plan is working or needs to be amended. Will be based on level of known BMP activity and results from water quality monitoring.	CRC, TAC, Satilla Riverkeeper, EPD, Camden County, City of Woodbine
Measures Recommended to Occur Annually	
Measurable Milestone	**Party Responsible**
Update Service Delivery Strategy as applicable to allow provision of municipal wastewater treatment service to underserved areas; keep service area maps current	Camden County, City of Woodbine, CRC, DCA
Encourage and install appropriate BMPs. – may include those not specifically identified in the plan.	CRC, GFC, Developers, TAC, Stakeholders, EPD, Landowners, Camden County, City of Woodbine
Keep record of BMP Activities in the Watershed	CRC, TAC, EPD, GFC, Camden County, City of Woodbine, Stakeholders, Landowners
Improve enforcement of Erosion and Sediment Control regulations.	Camden County, City of Woodbine, EPD
Review and revise local plans and ordinances (comp plans, master plans, etc)	CRC, Camden County, City of Woodbine

APPENDIX A: TARGETED MONITORING PLAN

TARGETED MONITORING PLAN
EXTENDED REVISION
SATILLA RIVER TMDL, ROSE CREEK TO WHITE OAK CREEK

Coastal Georgia Regional Development Center and
The Satilla Riverkeeper®
May 14, 2008

Parameterization

In the field, the following parameters will be observed or measured (as appropriate) and recorded. Data will be stored in an Excel database or otherwise equally transferable format.

The parameters are:

- latitude and longitude
- river mile or fraction thereof (to the nearest tenth) as measured from the sound/beach boundary
- tide state
- depth
- water temperature (degrees, centigrade, nearest tenth)
- oxygen saturation (percent, nearest tenth)
- oxygen concentration (mg/l, nearest tenth)
- salinity (parts per thousand, nearest tenth)
- conductivity (for salinities less than 2 ppt, to nearest whole digit)
- wind direction and velocity at beginning of expedition (nearest compass eighth, nearest knot)
- river stage at Atkinson (nearest tenth of foot)
- weather (qualitative; e.g. rain, overcast, partly cloudy, clear)

Water resistant field data sheets will be used; parameters will be recorded in pencil; corrections will be strike-through only with no erasures. Electronic devices will be calibrated prior to field expedition. For water quality readings, two such electronic devices will be used for cross-checking purposes. Water-quality measuring devices will be YSI-85 instruments, or comparable equipment.

Geographic and Depth Coverage

Sampling will be conducted from outside the area slated for monitoring under the extended revision, from the downstream end, through the listed area, to outside the area on the upstream end. Specifically, parameters will be recorded on either dead high or dead low tide during the sampling day (logistics-dependent). A "mixture" of dead high and dead low will be ensured over

the sampling time span (see below). Stations will be established starting one mile below the listed segment, and extend thereafter upstream every one mile extending through the segment to one mile upstream of the upstream boundary of the segment. This will establish 21 stations bracketing and including the listed segment, based upon currently published delineation of the segment.

At each of the 21 stations, water quality parameters will be recorded at the surface (a few inches in depth), one meter below the surface, at mid-depth, and one meter above the bottom. All readings will be measured mid-channel of the river.

Temporal Coverage

The first field session (day) will be during the last two weeks of May 2008, completed by June 1, 2008. The second field session (day) will be during July of 2008, completed by July 31, 2008. The third field session will be during August of 2008, completed by August 31, 2008. The fourth and final field session will likely be during the last two weeks of September 2008, likely completed by September 30, 2008, but will be timed to occur after the "first cool front" or other temperature-changing event (e.g. tropical disturbance and associated heavy rains) of the late-summer season. This timing is critical, as is the late-May session, so that sampling is conducted "outside" of the standard "summertime condition" state. This sampling plan targets the sampling area before, during, and after the establishment of oxygen-minima and temperature-maxima. This sampling plan is based upon knowledge of oxygen dynamics in the system from earlier field work by DNR and private interests.

APPENDIX B: NOTES FROM TAC/STAKEHOLDER MEETINGS

NOTES FROM THE AUGUST 26, 2008, MEETING OF THE TMDL TECHNICAL ADVISORY COMMITTEE

Findings:

- Land use within the Satilla River watershed is mostly timber plantation and other forms of agriculture, and water quality impairments resulting from suburban development are comparatively insignificant.
- The hydrology of the Satilla River watershed has been massively altered, and the impairments in fresh tidewater and the oligohaline portion of the estuary may be flow-related (i.e. decreased baseflow-related) as well as due to non-point pollution sourcing. Concomitantly, assimilative capacity in tidewater may have been reduced over time.
- Historical oxygen data from the impaired segment indicate that the condition was already in place by the late 1980s. Earlier data have not been located. No data are available from the segment (from what the TMDL team can garner) since the late 1990s (1998), with the exception that limited data are being collected under the current contract (4 cruises).
- Additional data on D. O. dynamics are needed.
- Based on the complexity of the estuarine system of the main stem, as well as impacting variables such as tide, wind and flow, data on Biological Oxygen Demand (BOD) is needed to better understand the nature of D. O. deficits on an areal and seasonal basis, and to better determine water quality impairment relative to the designated use of fish habitat.
- Five-year sampling intervals are not reliable. Sampling should be done at shorter intervals.
- An understanding of hydrology for the entire watershed of the segment is lacking.
- Research is needed on the current and any future location, standards, effluent constituent, and volume of water treatment plant outfalls serving Woodbine.
- All watershed local governments need to be involved in the TMDL implementation process.
- Coordination between RDC's (now RC's) should occur where respective RDC jurisdictions share watersheds.
- Mitigation banks or hydrologic offsets (e.g. hydrologic volume and/or nutrient loading) may be an economically viable alternative for owners and developers of large properties, with "banks" located upstream of the impaired segment(s) at or near headwaters to achieve maximum benefit.
- Nutrient trading may be effective to offset proposed increases in the base flow of water treatment plants. An example of an offset is installation of retainment structures to impede flow within drainage ditches.

Recommendations:

- Continue the current assessment of Dissolved Oxygen (DO) conditions in the segment; research DO dynamics in the system, including using Biological Oxygen Demand (BOD) work to explore the details of dynamics beyond mere measurement.
- Gain a complete understanding of the hydrologic changes in the watershed, including opportunities for restoration of lost functions; understand the sourcing of nonpoint pollutants, the nutrient budgets, BOD dynamics, and the relationship of hydrology to all.
- Review Camden County's and Woodbine's ordinances for amendment opportunities to promote techniques and measures associated with Limited Impact Development, with emphasis on progressive storm water management designed to retain or restore natural hydrology, and to enhance water quality. Extend this analysis across RC boundaries.
- Review the Coastal Georgia Comprehensive Plan against the Camden County Joint Comprehensive Plan, to determine potential amendments guiding regulations and development toward more effective control of adverse impacts to water quantity and quality.
- Propose comprehensive plan and ordinance amendments to achieve effective control of adverse impacts to water quantity and quality, including techniques and measures associated with Limited Impact Development, with emphasis on progressive storm water management designed to retain or restore natural hydrology, and to enhance water quality.
- Acquire data on BOD to improve determination of water quality impairment, and to monitor success of BMPs, regulations and other activities.
- Recommend to EPD, sampling intervals shorter than the standard five days, and use shorter intervals for TMDL implementation monitoring.
- Collaborate with all watershed local governments on the development of measures and activities to decrease impairment.
- Recommend coordination between RDC's where respective RDC jurisdictions share watersheds.
- Explore, evaluate, and market the value of mitigation banking upstream of impairment sources, as an alternative to conventional timber plantations, targeting baseflow offsets and restoration credits.
- Explore and evaluate nutrient trading as an offset in proposed increases in the base flow of water treatment plants.

TMDL TECHNICAL ADVISORY COMMITTEE (TAC)/STAKEHOLDERS' PUBLIC MEETING HELD MAY 21, 2009 - SAMPLE POSTCARD

A public meeting concerning water quality in the lower Satilla River will be held at Woodbine City Hall, at 6:30 pm, Thursday, May 21, 2009.

Draft Best Management Practices, Measures and Activities for a water quality management plan (Total Maximum Daily Load (TMDL) Implementation Plan) affecting the Satilla River Basin in Camden County are being developed for eventual plan completion in December of 2009. All stakeholders and interested citizens are invited to attend this meeting for the purpose of discussing strategies to improve water quality within the lower Satilla River, the Rose Creek to White Oak Creek segment.

Public involvement is important, and a Technical Advisory Committee (TAC) was organized pursuant to the initial meeting in May, 2008. Some of the TAC members will attend this upcoming meeting to help in the discussion regarding water quality management strategies. The draft best management practices, measures and activities the TAC has been instrumental in developing will be shared for discussion.

This meeting is being organized by the Coastal Georgia Regional Development Center (CGRDC), in partnership with the Satilla RIVERKEEPER®. Any questions can be referred to Kevin Vienneau, Senior Planner with CGRDC, at 912-262-2872.

TMDL TECHNICAL ADVISORY COMMITTEE (TAC)/STAKEHOLDERS' MAY 21, 2009 PUBLIC MEETING DISCUSSION ITEMS

- By approving the 2009 TMDL Implementation Plans for the impaired stream segments of Horsepen Creek and the St. Marys River, EPD has accepted quantity related causes as a contributing factor to Dissolved Oxygen (DO) impairment.
- Significantly altered flows were discussed.
- Four (4) milligrams per liter (mg/l) DO is the EPD threshold standard for streams throughout Georgia, notwithstanding the broad geographic variation in natural levels of DO.
- A DO level of 2.8 mg/l at any time of year and in any stream is considered widely as being inadequate to sustain fish species.
- Blackwater streams like the Satilla River are naturally lower in DO than in higher-slope & alluvial rivers during any temperature regime and can become problematic if altered in the water conditions of summer; the DO conditions are lowest in the estuarine & fresh tidal environment where saline conditions exist and/or where metabolism (community respiration) is peaking.
- The most important question that must be answered is … How low should the DO get, while sustaining native fish species, during summer, under natural conditions, without non-natural causes of impairment?

- The Satilla Riverkeeper suggests that the more likely threshold in Southeast Georgia is somewhere around 3.2 mg/l DO rather than 4.0 (current EPD threshold). *(Note: after the meeting, feedback from CRD/DNR staff indicated that previous EPD modeling has pegged the 'Satilla tidal segment' natural level at 3.66 . . . . from a 2006 modeling exercise . . . . reported by Kelly O'Rourke from Susan Shipman)*.
- Biochemical Oxygen Demand (BOD) was discussed as a potentially more reliable measure of a stream's health or impairment, as opposed to DO.
- NPDES permits could be based on the natural BOD capacity of a river given the time of year.
- The EPA/EPD standard of 4.0 mg/l DO specific to SE Georgia is unrealistic. The standard needs to be evaluated, appropriately adjusted based on science; and then it has to be determined whether the river is consistently above or below the realistic standard.
- Every river within a region has characteristics different enough to warrant different baseline standards. Georgia is extremely diverse in terms of river types.
- No detailed study of oxygen dynamics has ever been done for the tidewater area of SE Georgia.

QUESTION AND ANSWER PERIOD (ANSWERS DISPLAYED)

- On the question over what various fish can tolerate in term of oxygen content:
    - A DO level below 3 mg/l is lethal to juvenile shad out migrating to the ocean in late August into September.
    - Shortnose Sturgeon die at circa 2.8 mg/l DO with water temperature in the mid-20c centigrade, likely at higher DO levels under higher temperature conditions and/or slightly elevated levels of salinity.
    - Sea Trout are severely stressed at 3.5 to 3.8 mg/l DO.
    - Redfish can live in conditions of DO down to 3.1 mg/l.

- The important question again is what is natural and tolerable to fish in terms of decreased DO.
- The question over success of other advisory groups in causing change to EPA standards was discussed. While there are TMDL success stories, there has also been arbitrary weakening of standards in response to industry or development pressure, without adequate scientific basis. A current example of law suits resulting from such arbitrary changes to standards is one against Florida with respect to the St. Johns River; environmental advocates generally are trying to achieve better water quality without resorting to law suits.
- Water Councils, including the Coastal Georgia Water Council, are established by state law, and have no authority to regulate water supply or quality; they are advisory in nature only, and can advise only within existing state law.
- The problems throughout the Satilla River Basin are all inter-related. For example, the increased rate of flow and decreased duration of flow after rain events changes the habitat and fishing for Red Breast, and those who lobby for Red Breast fishing are concerned. Thus 'their' concerns are parallel to those of downstream stakeholders concerned with the DO problem in the vicinity of Woodbine.

- Regarding remedies to the inter-related DO deficiency and flow problems, TMDL implementation would not necessarily cause extra steps in the regulatory structure; remedies might be market-based, incentivized, or quasi-regulatory in that they blend market opportunities with a regulatory structure; but, they COULD be purely regulatory and in many ways it is up to the citizenry.
- There is no current indication that new funding is getting allocated to the problem.
- When it is time to install best management measures, a citizen's group will get results if the basis is adequate research.
- More research is needed to fully understand cause and affect relationships.
- Data for the Satilla River from before 1987 does not exist.
- What has significantly changed in the river basin?
    - Hardwood swamps have been lost as a result of channels designed to drain swamps for conversion to timber plantation.
    - Headwaters drain more quickly, 8 to 10 days rather than 2 or 3 months.
- Request was made for the RDC to post the draft TMDL Implementation Plan on the RDC public website.
- Empirical evidence indicates that the DO concentration of 4 mg/l of water as a Federal/state standard is exceedingly high, and likely unrealistic for a blackwater river in Southeast Georgia.
- Questions should be answered before lobbying for large expenditures to remedy the DO problem, and for decreasing the Federal/state standard for DO.
    - What is the relationship between Biochemical Oxygen Demand (BOD) and DO?
    - What are the effects of human-induced changes in flow with respect to decreased dilution?
    - What is the relationship between alterations in flow and DO?
- Who petitions the state to change the standard? The answer to this is unclear, but may result directly from this TMDL planning process, followed by science, followed by a request; Changes in standards are typically brought about by strong business/industrial lobbying, and if standards are changed arbitrarily without adequate scientific basis, law suits can result as is the current case with Florida and the St. Johns River.
- The alternative to the regulatory based rubric to remedy the DO impairment is the incentive based rubric.
- The incentive based remedies are expensive, and are therefore demanding in terms of better and more complete technical information; Lobbying for big money (e.g. via farm bill, or GLCP) to fix the problem is pre-mature.
- Which agency has the final word on the water quality impairment solution?
    - Georgia EPD is delegated by the EPA the authority to enforce the Clean Water Act. EPD decisions can be appealed to the Federal level.
- Is the low DO in the lower Satilla River caused from problems upstream?
    - In the Satilla Riverkeeper's opinion, most of the DO deficiency in the lower Satilla is caused from problems upstream of the impaired segment, and is flow-alteration related; however, the science must be tightened up, and it is also important to recognize that as flow decreases, so does dilution; and therefore LOCAL (Woodbine area) inputs are more brightly spotlighted, meaning that local stormwater and treated wastewater issues become relatively more important.

  - The lower Satilla River is a "barometer" for the health of the whole system, and the water quality problem is a general indicator of system wide problems in the river, an indicator of an unhealthy river; similarly, the impaired nature of many of the tributary creeks (likewise starved for flow, relatively overloaded with pollutants) is not a SEPARATE problem, rather is interrelated with the 'Woodbine area' problem.
  - Best management measures applied specifically within the impaired segment of the lower Satilla River will likely not alone effectively correct the problem.
- The Woodbine WPCP is properly permitted, though perhaps under unaltered flow conditions; re-permitting may be a step, but does not address the flow problems.
- Let's look at another City's WWTP situation: during recent (2006, 2007) periods of low flow at Waycross, 60% of the flow has been WPCP effluent, 40% of the flow has been river water, demonstrative of flow alterations in the headwaters of the basin, highlighting the extreme importance of properly permitting such a plant given the altered-flow regime. More specifically, the Waycross plant is operating, legally, discharging total Nitrogen levels greater than 10mg/litre on most days, approaching 20 mg/litre on many days. Yet, natural background levels of total N for blackwater in the Satilla, and in the SE US in general, are on the order of .02 to .2 mg/litre. Thus, the effluent is not only 60% of the flow under low-flow (remember, altered in this case) conditions … they are running 50 to 1,000 times the natural level of total N. This flow-altered system with resulting dilution, combined with input of nutrients, greatly contribute to increase the DO deficiency throughout the system. It is very likely that the City of Woodbine plant is interacting with the river in a similar way, but the analytical framework is problematic (tidal, salt-marsh, fresh water marsh, floodplain swamp-fringed system).
- A TMDL Implementation Plan for the whole system must be completed before going to the next step of basin wide data collection . . . . the TMDLIP is the necessary first step to be able to get the funding to do the work, to eventually lead to the cure, healing, restoration, the 'remedy'.
- How long would the data collection take?
  - Starting with existing GIS data, field data collection and analysis would likely take at least eight months (2 to 3 years with graduate students).
- The Technical Advisory Committee should meet to discuss:
  - the need for a study of an alternate criterion to the standard of 4 mg/l dissolved oxygen;
  - comprehensive TMDL work for the whole system.

**COMMENTS ON TIER 2 TMDL IMPLEMENTATION PLANS BY
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Ecological setting-specific recommendations for a rigorous and appropriate scientific approach:

1) Importance of properly apportioning the causes of low DO or fecal coliforms.

In the St Marys document, the listing as "unknown" for the impact rating of municipal wastewater treatment facilities, together with the statement in Part III that wasteload allocations are not part of the TMDL planning process is disturbing to me. Impacted zones include both point and non-point sources. Both types provide materials that exert biochemical oxygen demand (BOD) and both can account for increased fecal coliforms.

Some means is needed to separate point and non-point impacts in the TMDL planning process. It would seem appropriate to spread any cleanup in proportion to the cause. For example, if 30% of the problem is caused by sewage, then 30% of the cleanup should occur through additional sewage treatment, such as can be achieved through use of constructed wetlands. If 40% is caused by agricultural and silvicultural management practices, then their target can be set accordingly. Likewise, if septic tanks are contributing 25%, then they should be proportionately responsible. I am not referring to an apportionment of cleanup costs, but rather to the demonstrable removal of an appropriate portion of the BOD and fecal coliform according to their sources.

If insufficient effort is put into separating the sources, then agricultural and silvicultural interests may think they are being asked to overclean their industry in order to allow greater urban development (the source of the sewage). Could such a perception derail the sense of cooperation needed to implement a clean up?

On the other hand, superior treatment of urban sewage does not offset all environmental damage caused by nonpoint sources. Low dissolved oxygen (DO) and high fecal coliforms are convenient measures of environmental degradation, but they accompany other impacts. Activities vary in their causes of low DO or high coliform counts. Extensive regional ditching for silviculture, for example, has broad effects on the hydrodynamics of entire watersheds. As pointed out in the Horsepen plan, ditching may increase BOD and fecal coliform transmission from the landscape to streams and rivers, but it also alters hydroperiods. Ditches can impact flood control, fish nesting, downstream water availability, and perhaps the duration and intensity of periods of regional drought. To remove sufficient BOD and fecal sources from the watershed by doing excellent sewage treatment, puts a band-aid over a broader environmental problem caused by ditches.

The TMDL process can address low DO and high coliform counts as more general indicators of degradation. Accurately apportioning management responses to the separate causes should yield a lasting and overall improvement in the environment. And it would seem to me to better foster cooperation in taking care of the environment.

Imagine a scenario: Suppose through active management, the DO and fecal coliform counts return to healthful levels for fish, but in later years a new violation occurs in the same reach of river. Once again fish health is threatened. People will likely look for what has changed and will argue over it. Point sources will likely have increased, so it will be easy to blame those, but non-point sources will still contribute to the problem, even if they have not increased. It seems to me that the TMDL process could begin again in the same way: determine percentage contributions from each source and apportion expectations for clean up likewise. This approach seems fair and palatable. In this way everyone is in the environment together, which to me seems natural. Once healthful water is restored, the entire community will have reason to keep it healthy knowing that if one part creates a violation, all parts will have to shoulder their share of the cleanup (except those parts that have completely restored their portion and hence no longer contribute anything to the problem). I envision representatives of agricultural interests getting involved in residential sewage treatment decisions, for example.

To me, then, the success of the TMDL process seems to hinge on a reasonable effort to estimate the portion of the problem that should be attributed to each major cause: both wasteload allocations and non-point sources. Non-point sources can be attributed by general type, such as: septic tank density, silvicultural practices (e.g., ditching, clearcuts), agricultural practices, hard landscape runoff (pavement, rooftops, & lawns), and other categories. It will take some effort to do an acceptable allocation, but it seems to me to be fundamentally important to the success of the TMDL process.

2) Importance of measuring BOD.

Low dissolved oxygen (DO) occurs in water because the rate of oxygen use exceeds the rate of oxygen replenishment. Accounting for fluctuations in DO is very involved because it requires assessment of rates of photosynthesis, respiration, groundwater seepage and runoff, re-aeration with the atmosphere, and advective transport. However, a most convenient and standardized method of assessing the potential for oxygen use is biochemical oxygen demand (BOD). When DO is chronically low, the cause is almost always organic matter decomposing in the water, which creates a demand for oxygen. The decomposition of organic matter creates the oxygen demand. BOD measures that demand. BOD is a more valuable measure than the field measure of low DO itself mainly because it is the proximate cause of low DO, it is a more stable measure (it doesn't change for as many reasons), it can be better traced back to sources, and it is not affected during measurement by photosynthesis or changes in temperature (because samples are incubated in constant temperature in the dark).

Although BOD is caused by decomposition of organic matter, it is more immediately involved with accounting for low DO than would be a direct measure of organic matter. BOD measures the decomposability potential of the matter in the water. Not all forms of organic matter decompose at the same rate. A larger quantity of relatively refractory organic matter (say Styrofoam cups) might have the same BOD as a smaller quantity of more easily decomposed substances (say the entrails of a dead fish). Because the important characteristic of interest is the potential to lower DO, BOD is a preferred measure over organic matter. Moreover, BOD is very easy to measure and requires a very small investment in equipment and supplies.

Even more removed from DO in the causality chain is the measurement of inorganic nutrient levels (nitrate, nitrite, ammonium, and orthophosphate). Nutrients can stimulate both photosynthesis and microbial degradation, which in turn affect BOD and DO, but several links of the chain are involved. Like DO, levels of inorganic nutrients can change very quickly and measures are subject to greater variation by unknown factors. Although knowledge of inorganic nutrients is certainly useful if enough measurements are made, compared to BOD, inorganic nutrients are expensive to measure and more difficult to interpret. Though nutrient and organic matter measurements can be useful, I think BOD measurements are fundamental and essential.

Unlike BOD, DO and inorganic nutrients are rather volatile measures influenced by a variety of rapidly changing factors. It is a fascinating problem to try to account for the details in a record of DO dynamics, for example. Photosynthesis adds oxygen during the day and respiration uses it at night. Oxygen in water without living organisms reaches equilibrium with air, producing the so-called oxygen saturation level. Because the rate of equilibrium is relatively slow compared to photosynthesis and respiration, dissolved oxygen regularly exceeds the saturation level by day and falls below it at night. The degree to which it does this swing is a good measure of the overall ecological productivity of the water (though very high productivity is not always desirable).

The problem of decoding the oxygen pattern involves several considerations. Some of the animals and plants in water are microscopic, others are large. Some are fixed to the bottom and others flow along with the water, while still others move in and out of the water or swim along. Some of the water will typically have a lot of suspended algae, while other portions have little. In tidal regions, water flows both ways; in lakes water is exchanged very slowly; and in streams it rushes by quickly. Each of these differences affects DO dynamics and challenges one to account for them. Much can be learned from trying to explain DO fluctuations that occur over just one day.

Because DO typically changes considerably between day and night (because of photosynthesis), the most useful DO measurements are ones that are taken around the clock (preferably every 5 to 15 minutes). These are best taken within the same water mass, or simultaneously upstream and downstream, with spacing far enough to detect a difference as water travels from one point to another.

In spite of the complexity of DO dynamics, the simple assessment of BOD provides the main information needed to account for low DO. A network and regimen of BOD measurements will provide much useful information in the management of low DO in the context of the TMDL process.