Final

Total Maximum Daily Load (TMDL)
for
Town Creek
Waterbody ID # AL/06030002-0604-100
Organic Enrichment/Low Dissolved Oxygen (OE/DO)

Alabama Department of Environmental Management
Water Quality Branch
Water Division
December 2006

Town Creek Watershed within the Tennessee River Basin

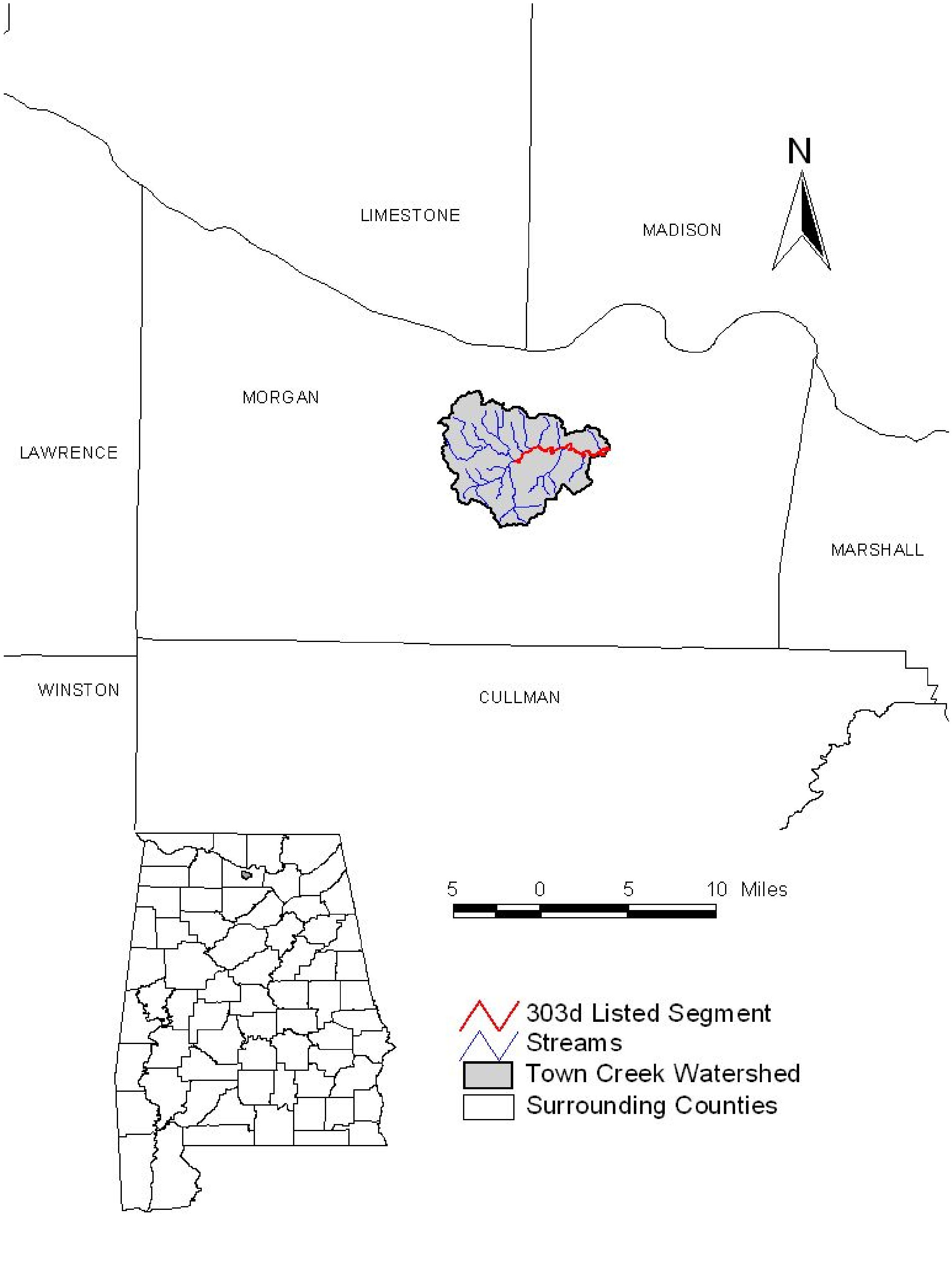


Table of Contents ***Page***

1.0 Executive Summary

Section 303(d) of the Clean Water Act (CWA) as amended by the Water Quality Act of 1987 and EPA's Water Quality Planning and Management Regulations [(Title 40 of the Code of Federal Regulations (CFR), Part 130)] requires states to identify waterbodies which fail to meet established water quality criteria for their designated stream use classifications. Identified waters are further prioritized according to severity of impairment with respect to stream use classification. Total Maximum Daily Loads (TMDLs) for all pollutants resulting in violations of related water quality standards are then determined for each identified stream segment. Loads are established at levels necessary to achieve applicable water quality standards when implemented, with consideration given to seasonal variations and the use of Margins of Safety (MOS). The TMDL process establishes allowable loadings of pollutants, as well as, other quantifiable parameters of a waterbody, in relation to pollution sources and desired instream water quality conditions. States are then able to implement appropriate water-quality based controls which will reduce pollution from point and/or non-point sources as needed in order to restore and maintain desired instream water quality conditions (USEPA, 1991).

Town Creek is a part of the Cotaco Creek watershed and greater Tennessee River basin. Town Creek is located entirely within Morgan County, Alabama, and retains a Fish & Wildlife (F&W) stream use classification. Town Creek was added to the State of Alabama's 1998 §303(d) use impairment list for organic enrichment/low dissolved oxygen (OE/DO), based upon 40% noncompliance of recorded monthly instream DO measurements obtained between June 25, 1997 and October 22, 1997 by the Tennessee Valley Authority (TVA) at Antioch Road (TVA Station #1150301). A poor to fair benthic macroinvertebrate [Ephemeroptera-Plecoptera-Trichoptera (EPT)] taxa richness assessment along with a poor fish [Index of Biotic Integrity (IBI)] assessment were also obtained by TVA on August 9, 1995 at the same sampling location.

Monthly water quality data collected by ADEM Field Operations Division (FOD) between March 25, 2003 and October 16, 2003 at Alabama Highway 67 (Station TWNM-25), and again at Antioch Road (Station TWNM-24) revealed 22% noncompliance of recorded monthly instream DO measurements at Station TWNM-25 and 30% noncompliance at Station TWNM-24. Additional water quality data collected by Alabama Water Watch (AWW) at Antioch Road (AWW Station #08033004) between January 15, 1999 and November 15, 2003 demonstrated even greater noncompliance at 36%. As expected, DO impairments typically occurred during summer sampling events when stream flows approached established $7Q_{10}$ (the minimum 7-day average flow over a 10-year recurrence interval) levels and stream temperatures were high. Based on the above findings, a steady state modeling approach was considered appropriate for TMDL development. Of available water quality data, measurements recorded on July 23, 1998, offered the best representation of critical stream conditions for TMDL development of Town Creek.

Since ADEM water quality standards require a minimum instream DO concentration of 5.0 mg/l for F&W stream use classification, load reductions necessary to achieve this standard were determined.

Available water quality data and resulting water quality modeling of Town Creek, indicate OE/DO impairment resulting from non-point source (NPS) pollutant loadings, for which needed reductions will be sought during TMDL implementation. Table 1-1 below, summarizes pollutant source reductions required to achieve a minimum 5.0 mg/l instream DO concentration in terms of Ultimate Carbonaceous Biochemical Oxygen Demand ($CBOD_u$) and Nitrogenous Biochemical Oxygen Demand (NBOD).

Table 1-1 Required TMDL Reductions for Town Creek Watershed HUC AL06030002-0604-100

Loading Parameter	Existing Loads		Allowable Loads		Reductions	
	WLA	LA	WLA	LA	% WLA	% LA
$CBOD_u$	0.063 lbs/day	7.137 lbs/day	0.063 lbs/day	3.710 lbs/day	0.0	48.0
NBOD	0.126 lbs/day	0.076 lbs/day	0.126 lbs/day	0.038 lbs/day	0.0	50.0

2.0 Basis for §303(d) Listing

2.1 Introduction

Section 303(d) of the Clean Water Act (CWA) as amended by the Water Quality Act of 1987 and EPA's Water Quality Planning and Management Regulations [Title 40 of the Code of Federal Regulations (CFR), Part 130] requires states to identify waterbodies which fail to meet established water quality criteria for their designated stream use classifications. Identified waters are further prioritized according to severity of impairment with respect to stream use classification. Total Maximum Daily Loads (TMDLs) for all pollutants resulting in violations of related water quality standards are then determined for each identified stream segment. Loads are established at levels necessary to achieve applicable water quality standards when implemented, with consideration given to seasonal variations and the use of Margins of Safety (MOS). The TMDL process establishes allowable loadings of pollutants, as well as, other quantifiable parameters of a waterbody, in relation to pollution sources and desired instream water quality conditions. States are then able to institute appropriate water-quality based controls which will reduce pollution from point and/or non-point sources as needed in order to restore and maintain desired instream water quality conditions (USEPA, 1991).

Town Creek is a part of the Cotaco Creek watershed and greater Tennessee River basin. Town Creek is located entirely within Morgan County, Alabama and retains a Fish & Wildlife (F&W) stream use classification. The State of Alabama originally identified Town Creek as being impaired for organic enrichment/low dissolved oxygen (OE/DO) in the State of Alabama's 1998 §303(d) list of impaired waters due to organic loading (i.e., $CBOD_u$ and NBOD) for a length of approximately 8.4 miles. Town Creek remained on the State's 2000, 2002, 2004, and 2006 §303(d) lists, receiving "high" priority ranking. Listing was based upon 40% noncompliance of recorded monthly instream DO measurements obtained between June 25, 1997 and October 22, 1997 from TVA Station #1150301 at Antioch Road by TVA. Poor to fair EPT taxa richness macroinvertebrate assessments along with poor IBI fish assessments were also obtained by TVA on August 9, 1995 at the same sampling location.

Development of the Town Creek OE/DO TMDL sets forth the process by which the existing impairment will be mitigated and desired water quality will be restored. This process consists of a multi-phased-approach in which needed pollutant load reductions are determined, load reduction controls [Best Management Practices (BMPs)] are implemented, and resulting water quality and remediation strategies are afterwards monitored and assessed. Re-evaluation of load reduction targets and control measures may be needed if follow-up monitoring indicates continuing water quality impairment or failure in attaining required water quality standards.

2.2 Problem Definition

Town Creek watershed encompasses a total drainage area of approximately 35 mi^2. Low instream DO concentrations in Town Creek have been recorded in association with lower flows and warmer temperatures. Water quality data collected in 1997 by TVA, between 1999 and 2003 by AWW, and in 2003 by ADEM FOD, document dissolved oxygen impairment to Town Creek during summer months (May through November). In general, depressed instream DO concentrations result from the decay of oxygen demanding waste derived from point and non-point sources, algal respiration, and/or sediment oxygen demand.

Waterbody Impaired:	Town Creek – from its source to Cotaco Creek for a length of 5.28 miles.
Water Quality Criteria Violation:	Dissolved Oxygen (DO) Levels Below 5 mg/l.
Pollutant of Concern:	Organic Enrichment ($CBOD_u$/NBOD)
Stream Use Classification:	Fish & Wildlife

The impaired stream segment of Town Creek, is classified as Fish & Wildlife. Use of waters within this classification is described in ADEM Administrative Code R. 335-6-10-.09(5)(a), (b), (c), and (d) and summarized below.

(a) Best usage of waters:

Fishing, propagation of fish, aquatic life, and wildlife, along with any other usage with the exception of swimming and water-contact sports or as a water supply source for drinking or food processing.

(b) Conditions related to best usage:

Waters shall be suitable for fish, aquatic life, and wildlife propagation. The quality of salt and estuarine waters to which this classification is assigned shall additionally be favorable for the propagation of shrimp and crabs.

(c) Other usage of waters:

Such waters may furthermore be used for incidental water contact and recreation during June through September. Water contact, however, is strongly discouraged in the vicinity of discharges or other conditions beyond the control of the Department or the Alabama Department of Public Health.

(d) Conditions related to other usage:

Waters, under proper sanitary supervision of controlling health authorities, shall satisfy accepted standards of water quality for outdoor swimming and other whole body water-contact sports.

3.0 Technical Basis for TMDL Development

3.1 Water Quality Target Identification

In accordance with ADEM's Water Quality Regulations [ADEM Administrative Code R. 335-6-10-.09-(5)(e)(4.)] the dissolved oxygen criteria for diversified warm water biota, including game fish, shall not be less than 5 mg/l at any given time; except under extreme naturally occurring conditions during which it may range between 5 and 4 mg/l, provided that all other water quality parameters remain favorable and both seasonal and daily fluctuations are maintained above such levels.

The goal of the Town Creek OE/DO TMDL is to establish and maintain the minimum instream DO concentration of 5 mg/l during critical stream flow conditions through the reduction of $CBOD_u$ and NBOD loadings.

3.2 Source Assessment

Point and non-point sources typically contribute $CBOD_u$ and NBOD (i.e., organic loading) to a given waterbody. One way in which dissolved oxygen depletion occurs is when oxygen consuming organisms metabolize organic material found either on or within stream sediments, referred to as Sediment Oxygen Demand (SOD). This SOD component is derived from point source discharges and runoff in combination with the additional organic material produced by existing aquatic plants. Potential sources of organic loading are numerous and often occur simultaneously. Storm or rain event runoff from row crops, livestock pastures, animal waste application sites, and feedlots has the potential of conveying significant organic loads to adjoining waterways. Inadequately treated municipal and industrial wastewater discharges contribute additional organic compounds which when hydrolyzed create additional loading. Urban storm water runoff and sanitary sewer overflows, as well as, combined sewer overflows similarly contribute additional organic loading.

Non-point source pollutant loading to surface water may be attributed to the natural erosion and weathering of soils, rocks, and uncultivated land; the erosion of pastureland where livestock are allowed direct access to streams which thereby hinders normal vegetative ground cover and results in streambank deterioration; the erosion of cleared or barren construction sites; wash-off of accumulated dust and litter from impervious roadways; and the erosion of unpaved dirt roads.

While non-point source pollutant loadings usually occur during rain events, the full extent and severity of their influence are not altogether immediate and are usually delayed until critical stream flow conditions develop. Critical stream conditions, in regards to DO levels, most often occur during summer months which are characterized by extended absences of rain, higher temperatures, and greater evaporation which invariably result in lower stream velocities and decreased stream depths.

Potential loading from non-point sources within the Town Creek watershed was identified and assessed according to principal land use activities and applied to the development of TMDL allocations. Assessment of organic loadings within the Town Creek watershed, however, focus primarily upon non-point sources since no industrial or municipal wastewater treatment facility discharge was identified as a significant contributor.

3.2.1. NPDES Permitted Facilities within the Town Creek Watershed

A search of ADEM's database of National Pollutant Discharge Elimination System (NPDES) permits and Geographical Information System (GIS) identified only two NPDES permitted facilities within the Town Creek watershed:

Crosscreek Subdivision (AL0042043)
Tina Renee Poultry Farm (A000405)

Crosscreek Subdivision (AL0042043)

Of these facilities, only Crosscreek Subdivision, a Semi Public/Private (SPP) wastewater treatment facility (WWTP), is permitted as a point source discharge to Town Creek, approximately 0.33 miles downstream of Town Creek's headwaters at a latitude of 34.459405^{o} N and longitude of 86.794539^{o} W. Permit parameter limits for Crosscreek Subdivision are presented in Table 3-1 below.

Table 3-1. NPDES Permit Requirements for Crosscreek Subdivision

Effluent Parameter	Daily Minimum	Monthly Average	Weekly Average	Minimum Percent Removal	Monthly Geometric Mean	Daily Maximum
Flow (Facility's Permitted Design Capacity)		0.009 mgd				
$CBOD_5$ (5-Day Carbonaceous Biochemical Oxygen Demand)		9.0 mg/l	13.5 mg/l	85%		
NH_3-N (Ammonia Nitrogen)		1.0 mg/l	1.5 mg/l			
TSS (Total Suspended Solids)		30 mg/l	45 mg/l	85%		
DO (Dissolved Oxygen)	6.5 mg/l					
pH (power [p] of hydrogen ion concentration [H]).	6 s.u.		8.5 s.u.			
FC (Fecal Coliform) Summer (Jun-Sep)					200 col./100 ml	2000 col./100 ml
FC (Fecal Coliform) Winter (Oct-May)					1000 col./100 ml	2000 col./100 ml

Water quality sampling data obtained from Town Creek on April 30, 2003, and March 25, 2003, by ADEM FOD were considered the most complete, comprehensive, and thorough data sets available and therefore used in model calibration and verification respectively. The data set obtained on July 23, 1998, by TVA was considered most representative of critical stream flow conditions and thus used in developing the actual OE/DO TMDL for Town Creek and in determining needed load reductions. Table 3-2 below provides a summary of monthly Discharge Monitoring Report (DMR) effluent values for Crosscreek Subdivision during each of the aforementioned sampling events. No permit violations or exceedances were reported for the facility during these months or during the 3 to 4 months which preceded each of the sampling events.

Table 3-2. Crosscreek Subdivision DMR Summary Results

	Flow Monthly Average (mgd)	**Flow Monthly Maximum (mgd)**	**$CBOD_5$ Monthly Average (mg/l)**	**$CBOD_5$ Monthly Maximum (mg/l)**	**NH_3-N Monthly Average (mg/l)**	**NH_3-N Monthly Maximum (mg/l)**	**DO Monthly Minimum (mg/l)**
Permit Limits	**0.0090**		**9.00**	**13.50**	**1.00**	**1.50**	**6.5**
July-98	0.0036	0.0043	1.40	2.00	0.46	0.54	6.6
March-03	0.0050	0.0072	8.15	12.40	0.74	0.86	6.9
April-03	0.0003	0.0003	4.95	6.20	0.29	0.30	8.1

The percentage of effluent waste flow (Q_w) from Crosscreek Subdivision WWTP in relation to the combined flows of both waste flow Q_w and stream flow (Q_s) in Town Creek at the point of discharge varied between 0.002 % and 0.68 % of the overall flow for each of the observed sampling events. Crosscreek Subdivision WWTP, as such, was not considered a significant contributor of pollutant loading to the impaired stream. While facility design waste flow (0.009 mgd or 0.014 cfs) during $7Q_{10}$ stream flow stream conditions (0.06 cfs) represents approximately 19 % of the overall flow, existing NPDES permit limits for Crosscreek Subdivision WWTP were developed for conditions in which stream flow is 0.00 cfs at the point of discharge. Three different critical condition models with corresponding load reduction models were, nonetheless, developed using the critical stream flow condition data set obtained from July 23, 1998, to further demonstrate that Crosscreek Subdivision WWTP is not a significant contributor of pollutant loading to the impaired stream. One scenario utilized the actual recorded effluent flow from July 23, 1998, of 0.0036 mgd; a second model artificially set effluent flow at the facility’s design flow of 0.009 mgd and maximum permitted parameter limits; while a third scenario completely omitted the point source altogether. A summary of resulting pollutant loadings and required load reductions from this comparison of different effluent flows is presented within Table 3-3. Figures 3-1 and 3-2 also provide comparison of DO projections for both critical and load reduction conditions of all three scenarios.

Table 3-3. Different Effluent Flows from Crosscreek Subdivision WWTP at Critical Stream Flow Conditions

Date	Model Run Description	WLA CBODu (ppd)	WLA NBOD (ppd)	LA CBODu (ppd)	LA NBOD (ppd)	SOD at Ambient Temperature (gm O_2/ft^2/day)
	(Headwater Flow = 0.34 cfs)					
7/23/98	Critical Conditions w/7-23-98 Qw	0.063	0.126	7.137	0.076	0.131
7/23/98	Load Reduction w/7-23-98 Qw	0.063	0.126	3.710	0.038	0.063
	Resulting Differences			3.427	0.038	0.068
	Percent Reductions			**48.02**	**50.00**	**51.91**
7/23/98	Critical Conditions w/Permit Limit Qw	1.013	0.686	7.137	0.076	0.132
7/23/98	Load Reduction w/Permit Limit Qw	1.013	0.686	3.710	0.038	0.064
	Resulting Differences			3.427	0.038	0.068
	Percent Reductions			**48.02**	**50.00**	**51.52**
7/23/98	Critical Conditions w/o WWTP Qw	0.000	0.000	7.137	0.076	0.131
7/23/98	Load Reduction w/o WWTP Qw	0.000	0.000	3.710	0.038	0.064
	Resulting Differences			3.427	0.038	0.067
	Percent Reductions			**48.02**	**50.00**	**51.15**

Figure 3-1. DO vs. Distance Comparison of Different Effluent Flows from Crosscreek Subdivision WWTP for Critical Stream Flow Conditions

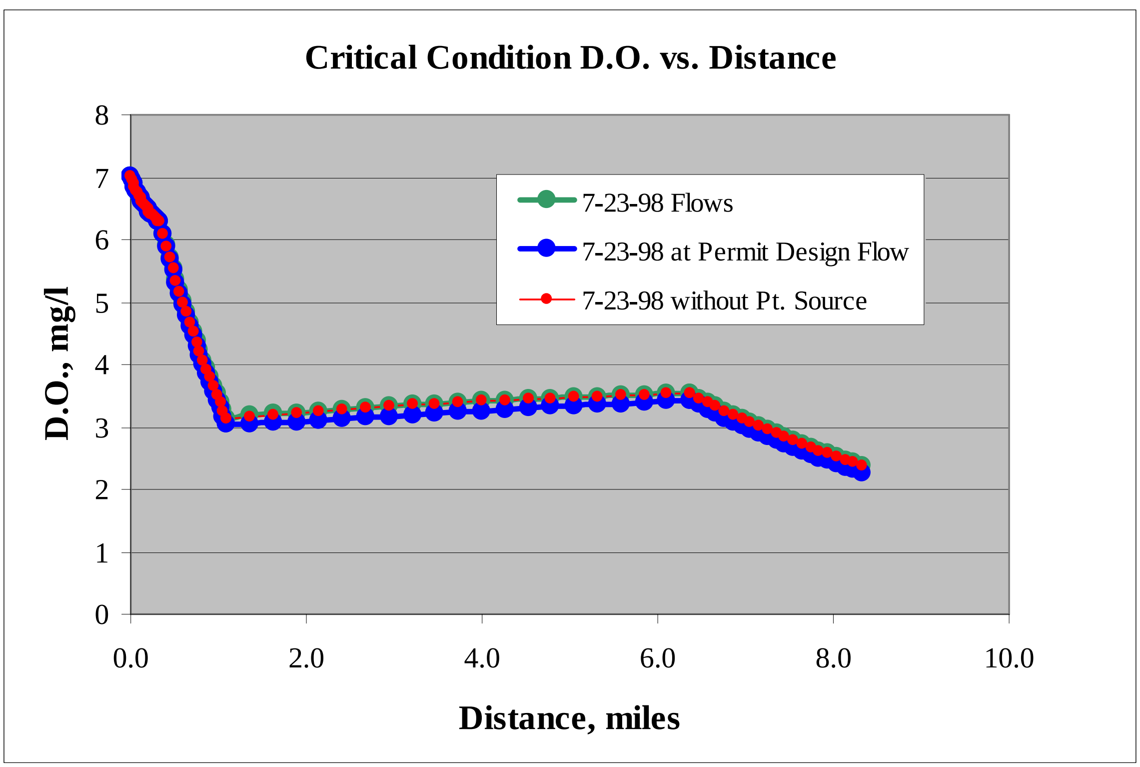
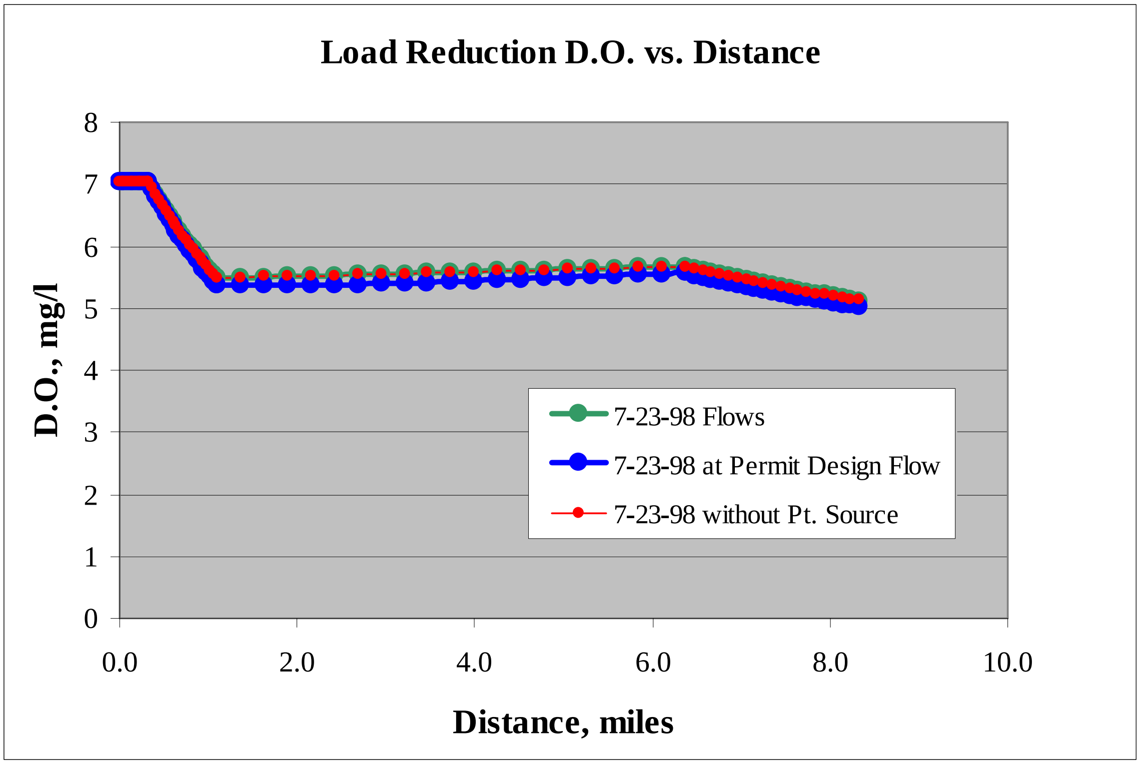


Figure 3-2. DO vs. Distance Comparison of Different Effluent Flows from Crosscreek Subdivision WWTP for Load Reduction at Critical Stream Flow Conditions



Tina Renee Poultry Farm (A000405)

The Tina Renee Poultry Farm is located approximately 2 ¾ miles upstream of Town Creek's headwaters at a latitude of 34.489450° N and longitude of 86.810175° W and adjacent to an unnamed tributary to England Creek. The Tina Renee Farm officially operated between April 2003 and December 2005 as a registered Confined Animal Feeding Operation (CAFO), which for poultry farming is defined in size as a facility raising 125,000 or more chickens at a given time. While the farm operated and continues to operate at a level of only 120,000 chickens at any given time, the farm's owner/operator, Tina Renee Allen, voluntarily registered the farm as a CAFO with ADEM in April 2003 to insure conformance with recommended pollution control measures. As a part of the registration process, the Natural Resources Conservation Service (NRCS) developed and submitted a waste management plan for the farm in accordance with ADEM's approved technical standards for pollution prevention. Having implemented the plan's recommended pollution control measures, the farm, however, elected not to continue its registration as a CAFO after December 2005.

The purpose of NPDES CAFO permits and the design of their pollution control measures are to completely prevent or eliminate potential pollutant discharges from entering neighboring streams. Any potential pollutant discharges which may have occurred during the sampling events would not have been directly measured as part of the collected water quality stream data. No monitoring or sampling stations were located on England Creek or any of its tributaries. Their effects, however, would ultimately be represented by the water quality data collected from Town Creek downstream.

3.2.2. NPDES Construction Activities and Municipal Separate Storm Sewer Systems

Construction activities disturbing 1 or more acres of land, and Municipal Separate Storm Sewer Systems (MS4s) serving municipalities with urban residential populations greater than 50,000 people and overall population densities of 1,000 people per square mile are currently regulated by the State's NPDES program.

Pollutant loadings from MS4s enter surface waters in response to storm events. MS4s discharge to waterbodies during storm events by way of road drainage systems, curb and gutter systems, ditches, and storm drains. Such systems convey urban runoff from barren surfaces, as well as, wash-off of accumulated street dust and litter from impervious roadway surfaces during rain events. The purpose of both construction and MS4 NPDES permits is to eliminate or minimize the extent to which these pollutants discharge to neighboring streams.

Town Creek originates approximately 1 mile south of Somerville, Alabama, and extends approximately 4½ miles east through an area that is primarily forested and agricultural before joining with Cotaco Creek. With a population of only 347 residents (2000 U.S. Census) the Town of Somerville would not be regulated under the MS4 NPDES Storm Water Program. A search of ADEM's NPDES and GIS database also failed to identify any permitted construction activities of 1 or more acres in size within the Town Creek watershed.

3.2.3. Non-Point Sources within the Town Creek Watershed

Table 3-3 details principal land usage within the Town Creek watershed. Land use activities were derived from the 2001 Multi-Resolution Land Characterization (MRLC) Consortium's 2001 National Land Cover Dataset (NLCD). Predominant land uses within the watershed consist of forest and pasture at 35.6% and 40.7%, respectively.

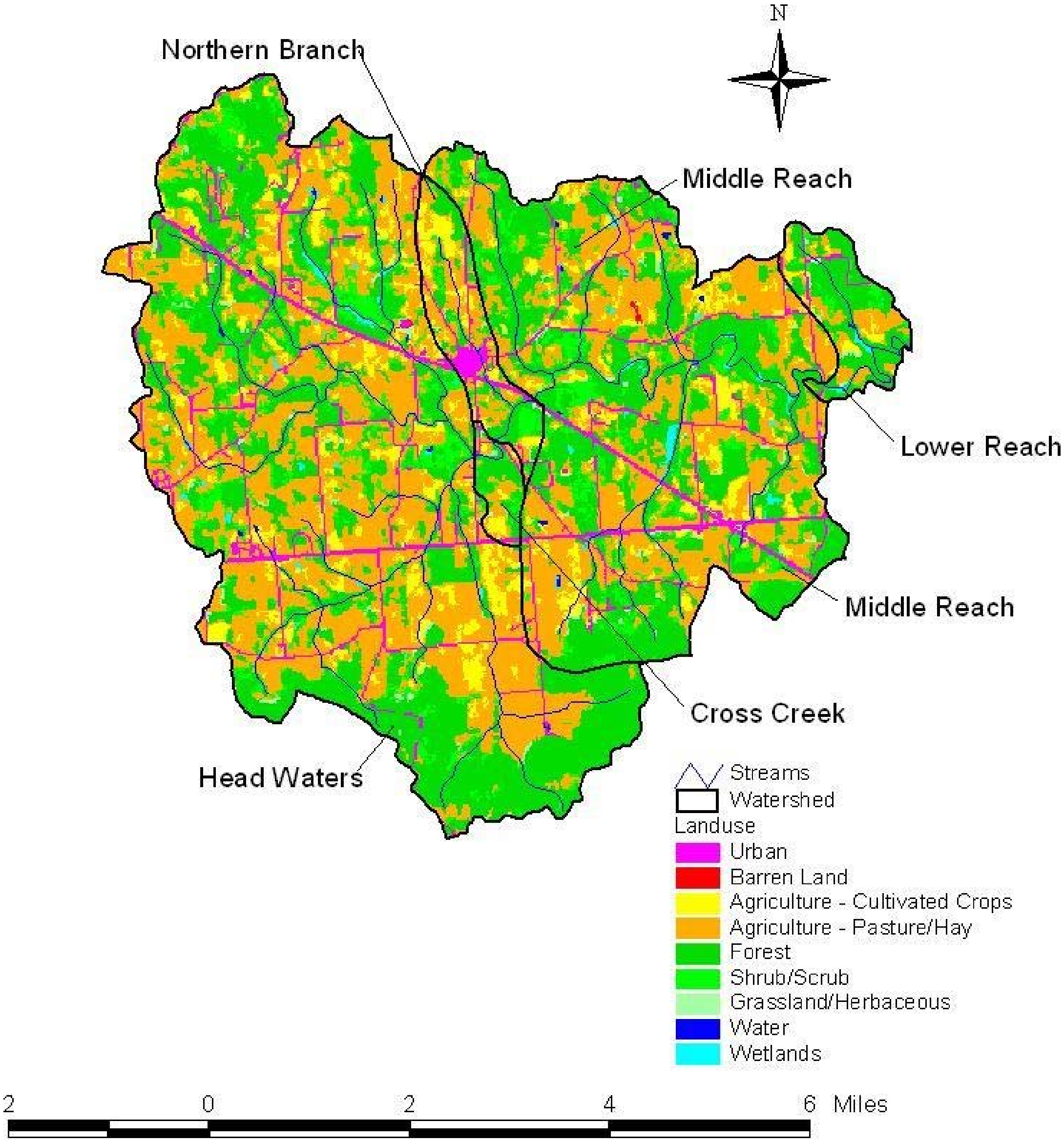
Table 3-3. Land Use in the Town Creek Watershed.

LAND USE	PERCENTAGE
Forest	35.6
Grassland	1.1
Shrub/Scrub	8.8
Wetland	0.6
Cropland	7.4
Pasture/Hay	40.7
Urban	5.6
Barren Land	0.0
Water	0.1
Total	100.0

Combined predominant land uses of forest and pasture accordingly represent 76.3 % of the watershed's overall characterization with remaining areas consisting primarily of shrub/scrub, cropland, and urban related activities. Each land use has the potential of contributing organic loading due to runoff/erosion of land surface organic material.

Major sources of organic enrichment from non-point sources within the Town Creek watershed were associated with forest, wetland, and pasture land use activities. Organic enrichment from forest land relative to other land uses is considered comparatively insignificant, given that forest lands tend to filter out any naturally occurring pollution. Some organic loading may, however, be derived from forested areas owing to the presence of wild animals such as deer, raccoons, turkeys, waterfowl, etc. Control of such sources would be limited to best management practices (BMPs) of land management which are commonly considered impractical. By contrast, agricultural lands represent major sources of potential organic loading. Runoff from pastures and animal operations, improper land application of animal wastes, and animals with direct access to streams, all illustrate mechanisms by which organic loadings can enter or be introduced into streams.

Figure 3-3. Land Use Map for Town Creek Watershed.



3.3 Loading Capacity – Linking Numeric Water Quality Targets and Pollutant Sources

EPA regulations define loading, or assimilative capacity, as the maximum loading that a waterbody can receive without violating water quality standards [40 CFR Part 130.2(f)].

According to ADEM's Water Quality Regulations [ADEM Admin. Code R. 335-6-10-.09-(5)(e)(4.)] the dissolved oxygen criteria for a diversified warm water biota, including game fish, shall not be less than 5 mg/l at any given time; except under extreme conditions resulting from natural causes during which it may range between 5 and 4 mg/l, provided that all other water quality parameters remain favorable and compliant. Normal seasonal and daily fluctuations must also be maintained above these levels.

In setting the DO water quality criterion of 5.0 mg/l as the numerical target, a TMDL was developed to determine Town Creek's total loading capacity during critical stream flow conditions. This was accomplished through multiple modeling simulations in which various source contribution loadings were adjusted in order to achieve the dissolved oxygen target. Additional model analyses were performed to access relative potential impacts from the municipal semi-public/private wastewater treatment facility (Crosscreek Subdivision). Results for the various models developed are provided in Appendix 9.3. The load reduction simulation developed using critical stream flow data from July 23, 1998 represents the actual TMDL or total loading capacity for Town Creek.

Initial pollutant concentrations for various land uses were derived from the following sources: *Catoma Creek Watershed Management Plan*, CH_2M HILL, October 1998; *Event Mean Concentration for Each land Use Classification*, Baird and Jennings, 1996; and *National Surface Water Quality Database (NSQD) ver. 1.1*, Dr. Pitt, University of Alabama. During model calibration, land use concentrations were reasonably adjusted to align model predicted instream pollutant concentrations with corresponding field data and laboratory values collected from Town Creek itself.

3.4 Data Availability and Analysis

3.4.1. Watershed Characteristics

A. General Description: Town Creek, located entirely in Morgan County, is a tributary to Cotaco Creek and therefore a part of the Tennessee River basin. Town Creek is designated on the State of Alabama's §303(d) list of impaired waters by the Waterbody ID (12-Digit HUC) of AL06030002-0604-100. Town Creek originates at the confluence of Gill Creek and Gum Spring Creek approximately 1 mile south of Somerville, Alabama, and about 50 yards west of County Road 49 at a latitude of 34.45923^{o} N and a longitude of 86.79942^{o} W. Town Creek covers a stream distance of roughly 8.4 miles, encompasses a drainage area of approximately 35.2 square miles, and retains an assigned stream use classification of Fish & Wildlife (F&W).

B. Geological Description: The Town Creek watershed consists largely of two Mississippian System formations: Pride Mountain Formation and Monteagle Limestone undifferentiated (Mpmm) immediately along stream drainage areas and Hartselle Sandstone (Mh) located outside those immediate areas and comprising the major portion of drainage area. Pride Mountain Formation and Monteagle Limestone undifferentiated consist of light-gray oolitic limestone, argillaceous and in part bioclastic with interbeds of medium to dark-gray shale. The Hartselle Sandstone consists of light-colored thick-bedded to massive quartzose sandstone, containing interbeds of dark-gray shale.

Two additional Mississippian System formations found along the watershed's northern and southern boundaries are Monteagle Limestone (Mm) and Bangor Limestone (Mb) respectively. The Monteagle Limestone formation consists of light-gray oolitic limestone containing interbedded argillaceous, bioclastic, or dolomitic limestone, dolomite, and medium-gray shale. The Bangor Limestone is comprised of medium-gray bioclastic and oolitic limestone, with interbeds of dusky-red and olive-green mudstone in upper portions.

C. Eco-region Description: Ecoregion designations are of significance to the biological assessment process. Ecoregions are areas which feature a high degree of similarity and homogeneity in reference to perceived patterns of land use, naturally occurring vegetation, and local soil types. All streams within the Town Creek watershed are classified as part of the Interior Plateau Ecoregion (71) which is a diverse ecoregion extending from southern Indiana and Ohio to northern Alabama. Rock types are distinctly different from the coastal plain sands of ecoregion 65, and elevations are lower than the Appalachian ecoregions (66, 67, 68) to the east. Mississippian to Ordovician-age limestone, chert, sandstone, siltstone, and shale comprise the landforms of open hills, irregular plains, and tablelands. The Interior Plateau Ecoregion (71) represents an important agricultural region within the state of Alabama. Natural vegetation consists primarily of oak-hickory forest, with some mixed mesophytic forest and areas of cedar glades. Springs, lime sinks, and caves contribute to this region's distinctive faunal distribution. The Town Creek watershed is further subdivided into the Eastern Highland Rim (71g) and Little Mountain (71j) ecoregions.

The main area along and nearest to Town Creek itself consists of the Little Mountain ecoregion which is a narrow, plateau-like ridge, five to ten miles wide, that parallels the Tennessee River. It is distinguished from the surrounding Eastern Highland Rim by its sandstone geology, its more dissected and hilly topography, and greater forest coverage. The Little Mountain ecoregion exhibits some similarities to the Southwestern Appalachians ecoregion (68), yet with lower elevations and Hartselle sandstone which is Mississippian and not Pennsylvanian age. The broader, flat uplands of the Little Mountain ecoregion contain well-drained loamy soils often found in pasture and cropland areas. The larger streams cut through the Little Mountain ecoregion and flow north from the Eastern Highland Rim ecoregion in Moulton Valley to the Tennessee River.

The remaining and surrounding portion of the drainage area, both to the north and south, consists of the Eastern Highland Rim ecoregion which is characterized by flatter terrain and weaker dissection than the Western Highland Rim (71f), with flat to gently rolling landforms. Mississippian-age limestone, chert, shale, and dolomite predominate, with springs, sinks, and caves formed by limestone solution. Cave and spring-associated fish fauna also typify the region. In the southern part of the region, streams flow down from the Pottsville Escarpment of Southwestern Appalachians ecoregion, and cut north across Moulton Valley through narrow valleys of Little Mountain to the impounded Tennessee River. Natural vegetation for the region transitions between oak-hickory in the west and mixed mesophytic forests of the Appalachian ecoregions in the east. Much of the original bottomland hardwood forests have been inundated by impoundments. The flatter areas to the east and on both sides of the Tennessee River contain deep, well-drained, reddish, productive soils that are intensively farmed.

D. Other Notable Characteristics: None

3.4.2 Available Biological, Chemical, and Physical Water Quality Data

Biological Data

Historically, the health of aquatic systems was monitored primarily through chemical monitoring which only provided a "snapshot" of conditions at the time of sampling and may have failed to detect acute pollution events (e.g. runoff from heavy rain, spills), non-chemical pollution (e.g. habitat alteration) and non-point source pollution. In order to address these shortcomings, chemical monitoring is supplemented with biological monitoring which more accurately reflects the long-term conditions and health of biological communities.

Taxa Richness (TR) is a measure or assessment of the health of a given aquatic community which considers habitat diversity, suitability, and water quality. Increased TR values equate with increased number of taxa found within the sample. The greater the total number of taxa found within a sample, the larger the TR value and the healthier the aquatic community. A determination of taxa richness through examining Ephemeroptera (Mayflies), Plecoptera (Stoneflies), and Trichoptera (Caddisflies) or EPT taxa richness, demonstrates the stability of the community. These species are considered very pollution sensitive to poor water quality conditions such that their presence and abundance are indicators of good water quality. The higher the populations of these organisms the more stable the site. Benthic macroinvertebrate assemblages, however, are generally only reflective of short-term, local impairment.

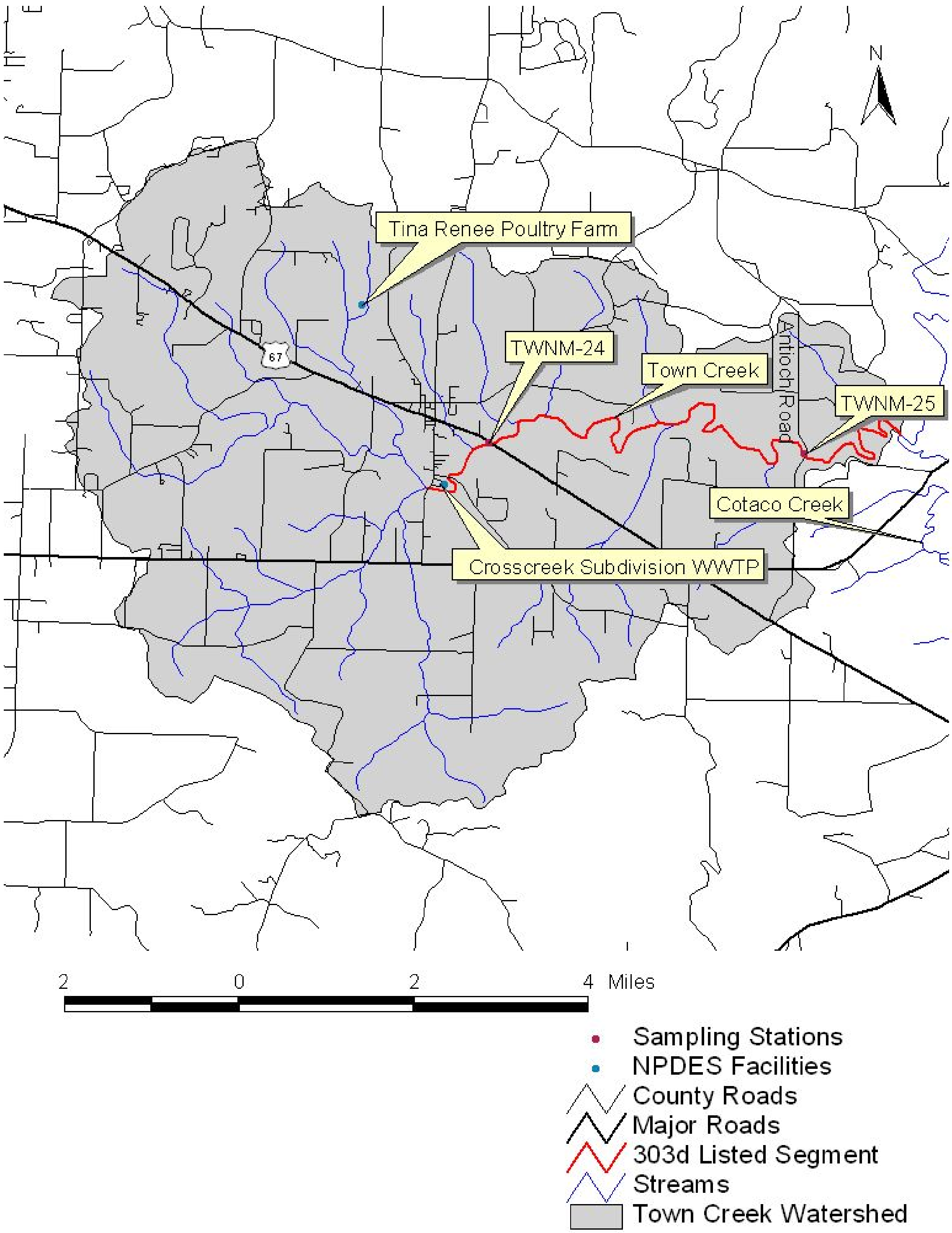
In order to assess environmental conditions on a larger spatial and temporal scale, ADEM supplements benthic macroinvertebrate monitoring with an Index of Biotic Integrity (IBI). The IBI is an index which measures the health of the stream based upon multiple attributes of the resident fish assemblage. The IBI looks at the fish community as a whole by determining fish abundance (total number of fish), their diversity (number of different species), and trophic (food chain) interactions. Each site sampled is scored based on its relative deviation from reference conditions (i.e. what would be found in an unimpacted stream) and classified as poor, fair, good, or excellent. IBI data provides a very reliable environmental indication of overall health and water quality integrity of the studied stream reach.

A Poor to Fair EPT taxa richness assessment consisting of only 6 EPT families and a Poor IBI assessment with a score of 28 were obtained by TVA on August 9, 1995, from Town Creek at Antioch Road (TVA Station #1150301). On May 2, 2000, a Fair to Good EPT taxa richness assessment consisting of only 9 EPT families and a Poor to Fair IBI assessment with a score of 36 were again obtained by TVA at the same stream location.

Chemical Data

Water quality data for Town Creek watershed was collected by Alabama Water Watch (AWW), TVA, and by ADEM FOD. After careful evaluation of all available water quality data from the past 9 years, water quality measurements recorded on July 23, 1998, by TVA at TVA Station #1150301 at Antioch Road provided a data set which is considered the most representative of critical conditions for TMDL development. More recent data sets collected by ADEM FOD on April 30, 2003, and March 25, 2003, at both Antioch Road and Alabama Highway 67 were utilized in TMDL model calibration and verification respectively. A map displaying the locations of these sampling stations appears on the following page in Figure 3-2. A summary of related water chemistry data is provided in Appendix 9.2.

Figure 3-4. Map of Sampling Station Locations for Town Creek.



Physical Data

A $7Q_{10}$ flow represents the minimum 7-day flow which occurs, on average, over a 10-year recurrence interval, whereas, a $7Q_2$ flow represents the minimum 7-day flow that occurs, on average, over a 2-year recurrence interval. These flows are conventionally used in representing critical flow conditions for summer (May through November) and winter (December through April) seasons respectively.

Both $7Q_{10}$ and $7Q_2$ flows can be determined by using data collected from a nearby United States Geological Survey (USGS) stream flow gauge with similar flow characteristics or by using the Bingham Equation. The Bingham Equation is referenced from page 3 of the Geological Survey of Alabama's, *Low-Flow Characteristics of Alabama Streams, Bulletin 117*. Emphasis should be given that the Bingham Equation is only applicable to determining $7Q_{10}$ and $7Q_2$ flows and is not functional or appropriate in determining flows for other types of stream conditions.

Equations used in determining $7Q_{10}$ and $7Q_2$ flows for a given or particular drainage area (DA) or stream location using recorded $7Q_{10}$ and $7Q_2$ flow data from a USGS gauging station are as follows:

$$7Q_{10}\text{ (cfs)} = \frac{(7Q_{10}\text{ @ USGS Station (cfs))}}{(\text{DA @ USGS Station (mi}^2))} \times (\text{DA @ given stream location (mi}^2))$$

$$7Q_{2}\text{ (cfs)} = \frac{(7Q_{2}\text{ @ USGS Station (cfs))}}{(\text{DA @ USGS Station (mi}^2))} \times (\text{DA @ given stream location (mi}^2))$$

Low flow estimates employing the Bingham Equation are based upon a stream's recession index (G, no units), drainage area (A, mi^2), and mean annual precipitation (P, inches):

$$7Q_{10}\text{ (cfs)} = 0.15\text{x}10^{-5}(G-30)^{1.35}(A)^{1.05}(P-30)^{1.64}$$

$$7Q_{2}\text{ (cfs)} = 0.24\text{x}10^{-4}(G-30)^{1.07}(A)^{0.94}(P-30)^{1.51}$$

Whenever possible, $7Q_{10}$ and $7Q_2$ flows determined from USGS gauge station data are preferred over flows derived from the Bingham Equation and are considered to approximate or correlate more closely to actual critical flow conditions for a given or particular drainage area.

For purposes of this TMDL, water quality data collected on July 23, 1998, provides the most comprehensive representation of critical low flow (worst-case) conditions available for Town Creek. A winter TMDL was not attempted since no recorded DO violations occurred during winter sampling, thereby indicating that DO criterion is being met during winter months. Critical low flow or $7Q_{10}$ stream flow conditions for Town Creek at both its headwaters and confluence with Cotaco Creek (model reach end) were derived from USGS flow gauge #03576148, located adjacent to Pine Road on Cotaco Creek east of Florette, AL. No perennial streams or streams of significant size or volume with drainage areas equal to or greater than 5 mi^2, were identified as tributaries to Town Creek. All tributaries to Town Creek were determined to be less than 5 mi^2 and to contribute little if any flow during critical low flow conditions. Gauge derived $7Q_{10}$ flows for Town Creek's headwaters and model reach end were 0.06 cfs and 0.10 cfs accordingly. Flow measurements obtained on July 23, 1998, revealed slightly higher headwaters and model reach end flows at 0.34 cfs and 0.63 cfs respectively. Bingham Equation flow results for Town Creek, however, corresponded closely to July 23, 1998, flow conditions with a headwaters flow of 0.3 cfs and a model reach end flow of 0.57 cfs. While July 23, 1998, flows were slightly higher than their respective $7Q_{10}$ values, water quality data from that date still provided the best available representation of critical flow conditions. Differences between downstream and upstream flows within each stream segment were attributed to incremental flow (IF).

3.5 Critical Conditions

Lower dissolved oxygen concentrations typically occur as a result of critical stream flow conditions which develop during summer months (May – November). Reduced amounts of precipitation and higher temperatures routinely result in shallower stream depths, slower velocities, increased residence time, and decreased re-aeration. Increased residence time promotes additional decay which further depletes dissolved oxygen. Reaction rates for $CBOD_u$ and NBOD (i.e., organic loading) are temperature dependent and thereby increase with higher temperatures.

More frequent but less intense rain events occur during winter months which produce less land surface build-up of organic material and a more uniform load distribution. Higher flows in connection with lower temperatures effectively result in less residence time and lower decay rates that are capable of assimilating higher organic loads.

3.6 Margin of Safety (MOS)

Methods for integrating a MOS (USEPA, 1991) are usually either: 1) implicit, through input of conservative model assumptions, or 2) explicit by allocating a specified portion or percentage of the TMDL as the MOS itself.

The MOS chosen for the Town Creek critical conditions or TMDL model is implicit in that conservative model input parameters were selected and used. The higher temperatures, lower flows, and lower DO concentrations obtained by TVA on July 23, 1998, are considered representative of worse case or critical conditions for Town Creek. Three different models were developed using the data from July 23, 1998, to assess potential impacts from the municipal semi-public/private wastewater treatment facility (Crosscreek Subdivision) under differing conditions. One scenario utilized actual recorded effluent flow, a second model artificially set effluent flow at permit limits, while a third scenario completely omitted the point source altogether.

In the absence of SOD values from a specific reference site for Town Creek, an average mean SOD reaction rate value for all measured streams within the state of Alabama, both impaired as well as unimpaired, was derived from EPA, Region IV's *Sediment Oxygen Demand Data Insitu Chamber Measurements 1988-1997* database (representing mixed land uses and varying degrees of point source activity). This average mean SOD value of 0.103 O_2/ft^2/day was used to provide conservative yet realistic SOD rates for Town Creek during model development of critical conditions.

Stream depths were derived from stream depth measurements recorded by ADEM FOD during monthly sampling in 2003. The resulting shallow stream depths of 0.4 feet and 0.5 feet applied to the first two segments of the model reach and 1.6 feet and 2.0 feet assigned to the last two segments, effectively intensified SOD. In the absence of measured stream velocity values, default values of 0.10 feet/second were generated by the model for each segment, which resulted in further amplification of CBOD decay.

4.0 Water Quality Model Development

4.1 Water Quality Model Selection and Setup

Since recorded DO impairments occurred during periods of low flow, a steady-state modeling approach was adopted to represent all corresponding conditions of the impairment. A steady state TMDL Spreadsheet Water Quality Model (SWQM) developed by ADEM and subsequently approved by EPA Region IV, was selected in view of the following reasons:

- It represents a simplified approach devoid of unnecessary or undue complexity.
- It conforms to ADEM standards for development of wasteload allocations.
- It affords development with limited data.
- It allows for input and assessment of tributary, point, and non-point source load contributions.

The selected TMDL spreadsheet model furthermore provides a complete spatial view of stream variations throughout the entire modeled reach. Dissolved oxygen concentrations are derived from a modified Streeter-Phelps equation which considers oxygen demand from carbonaceous decay, as well as, from nitrification or ammonia decay. Each stream reach segment is divided into twenty-one computational elements, with each element functioning as the equivalent of a completely mixed reaction.

The following assumptions were made during TMDL model development:

- Headwater and incremental loadings were apportioned according to principal land use patterns.
- The $CBOD_u$/ $CBOD_5$ ratio was set at 1.5.
- NBOD loadings were set equal to 4.57 times the Total Kjeldahl Nitrogen (TKN) loadings.
- Forested land use concentrations were considered equivalent to background conditions.

4.1.1. SOD Representation

Sediment Oxygen Demand (SOD) in relation to the decomposition of organic materials can represent a significant portion of overall oxygen demand within shallow streams as a result of stream bed sediment accumulation and build up. This SOD component is ultimately derived from discharges and/or runoff in conjunction with the production of new organic material generated from existing stream plants. Measured SOD reaction rates for unimpaired streams are conventionally used in determining achievable SOD target values for assessed impaired stream segments which have the same or similar ecoregion characteristics. Unimpaired ecoregionally based reference streams of similar land use characteristics and stream conditions generally contain less pastures, cropland, and urban areas and more forested areas when compared to impaired watersheds. Unimpaired reference watersheds are considered the “least impacted” in a given ecoregion and, as such, the pollutant loading from these watersheds serve as appropriate targets in TMDL development.

In the absence of SOD values from a specific reference site for Town Creek, an average mean SOD reaction rate value for all measured streams within the state of Alabama, both impaired as well as unimpaired, was derived from EPA, Region IV’s *Sediment Oxygen Demand Data Insitu Chamber Measurements 1988-1997* database (representing mixed land uses and varying degrees of point source activity). This average mean SOD value of 0.103 O_2/ft^2/day was used to provide realistic SOD rates for Town Creek during the modeling process.

4.1.2. Calibration Model Data

Model calibration was performed using water quality data (ref: Appendix 9.2) collected by ADEM FOD on April 30, 2003, from Stations TWNM-24 and TWNM-25. Stream data, consisted of water temperature, DO, $CBOD_5$, and NH_3-N. Values for TON were determined by taking the differences between reported TKN and NH_3-N values since TKN is considered equal to TON and NH_3-N.

4.1.3. Verification Model Data

Model verification was performed using water quality data (ref: Appendix 9.2) from March 25, 2003, which was similarly collected by ADEM FOD from Stations TWNM-24 and TWNM-25, and which again consisted of water temperature, DO, CBOD, NH_3-N, and TON.

4.1.4. Critical Conditions or TMDL Model Data

As stated previously, the critical conditions or TMDL model was developed using water quality data (ref: Appendix 9.2) collected by TVA on July 23, 1998, from TVA Station #1150301 at Antioch Road (ADEM Station TWNM-24) to represent critical stream conditions associated with low flows and low DO values.

4.2 Water Quality Model Summary

Town Creek is listed on the State of Alabama's §303(d) use impairment list for organic enrichment and low dissolved oxygen concentration, from its headwaters at the confluence of Gill Creek and Gum Spring Creek to its confluence with Cotaco Creek for its entire length of 8.33 miles. A schematic flow diagram of the entire modeled reach is presented as Figure 4-1.

Definitions of various abbreviations used in the following model reach schematic are as follows:

D.A. = Drainage Area in square miles

Qs = Stream flow in cfs

Qw = Waste flow in cfs

cfs = cubic feet per second

Elev. = Elevation in feet at segment beginning or end

Avg. Ht. = Average segment height in feet

L = Length of segment in miles

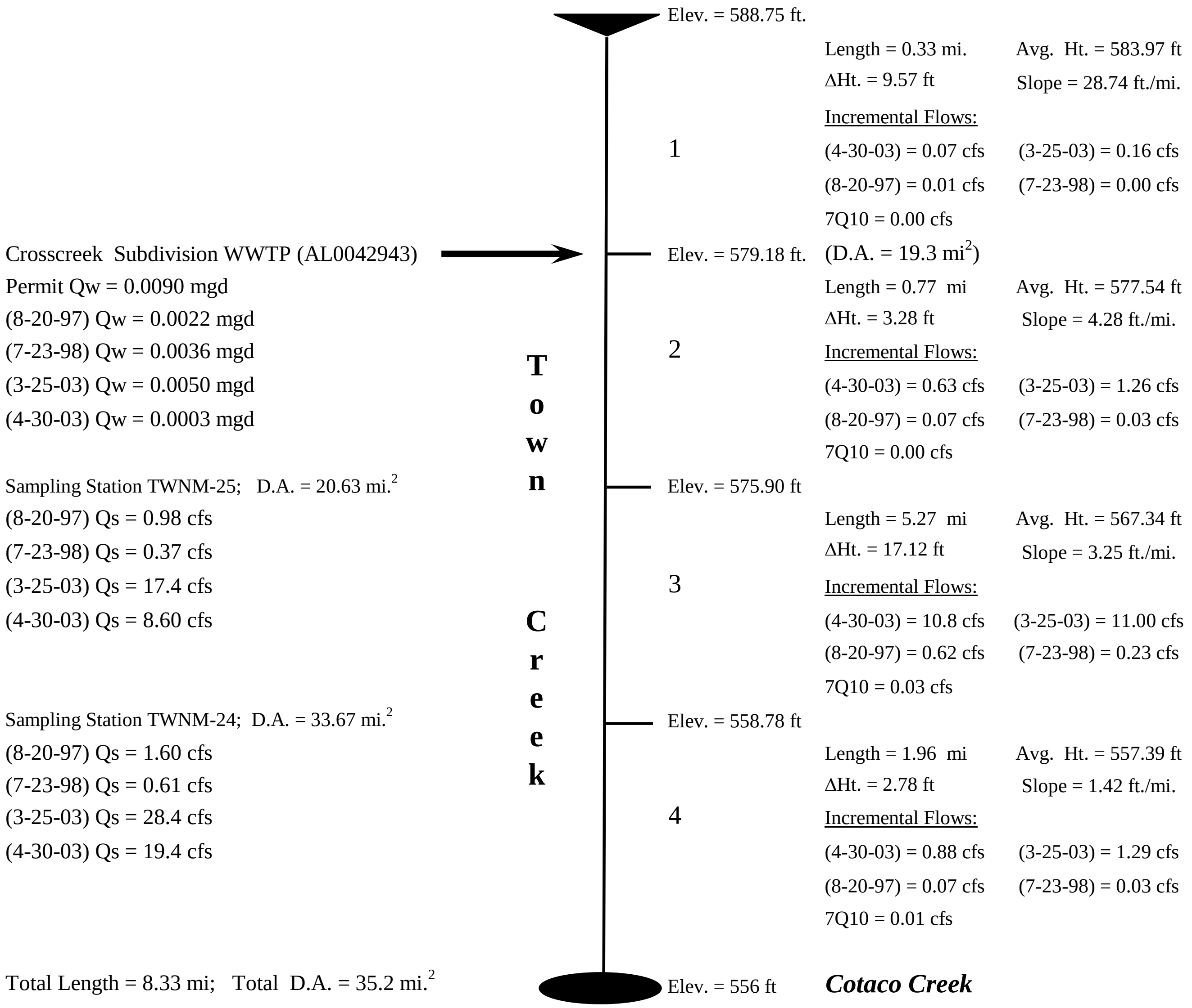
ΔHt. = Change in height from segment beginning to segment end in feet

Figure 4-1. Schematic Diagram of Modeled Reach.

Town Creek OE/DO TMDL Schematic Diagram

Headwaters: Town Creek; S 1/2, SEC 1, T7S, R3W, 212 NE (Somerville); Lat.: 34.459234° N; Long.: 86.799418° W

Drainage Area (D.A.) = 18.94 mi.^{2}; $7Q_{10}$ = 0.06 cfs; $7Q_2$ = 0.23 cfs; Average Flow = 37.18 cfs; (4-30-03) Calibration Flow = 7.9 cfs; (3-25-03) Verification Flow = 15.98 cfs; (8-20-97) Critical Flow = 0.90 cfs; (7-23-98) Critical Flow = 0.34 cfs.



Total Length = 8.33 mi; Total D.A. = 35.2 mi.^{2}

$7Q_{10}$ = 0.10 cfs; 7Q2 = 0.44 cfs

SE 1/4, SEC 34, T6S, R2W, 211 NW (Center Grove); Lat.: 34.467921° N; Long.: 86.720904° W

$7Q_{10}$ and $7Q_2$ flows were ratioed from USGS Gauge #03576148 at Pine Road on Cotaco Creek east of Florette, AL, where D.A. = 136 mi^2; $7Q_{10}$ = 0.4 cfs; and $7Q_2$ = 1.7 cfs.

4.3 Load Reduction Analysis

4.3.1. Calibrated Model

Water quality data collected on April 30, 2003, by ADEM FOD was used in calibrating the Town Creek spreadsheet water quality model. During model calibration, reaction rates for CBOD, NH_3-N, TON, and SOD, and non-point source loadings from different landuses (CBOD, NH_3-N, and TON concentrations) were adjusted to align model projected parameter values as closely as possible to observed field measured parameter values while preserving a reasonable representation of stream water quality conditions for the recorded sampling event. Figure 4-2, below plots calibrated model predicted DO against field measured DO.

Figure 4-2. Calibrated Model DO Predictions vs. DO Field Data.

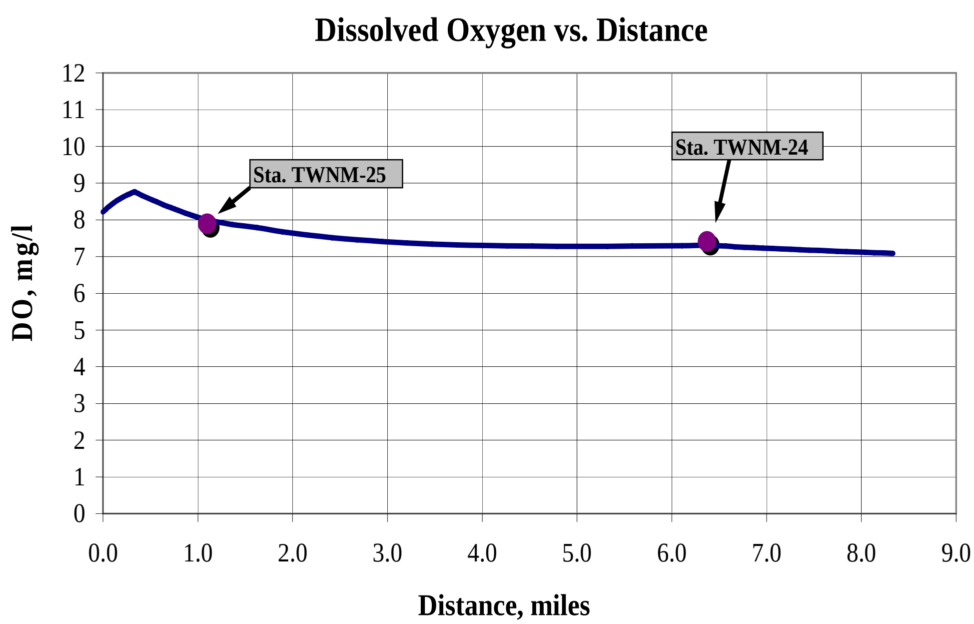


Table 4-1 provides a summary of parameter values at Town Creek's headwaters and calibrated model projected values for locations of lowest predicted DO and model's end.

Table 4-1. Calibrated Model Headwaters, Lowest Projected DO, and End Model Parameters

Description	$CBOD_u$ (mg/l)	NH_3-N (mg/l)	TON (mg/l)	DO (mg/l)	Flow (cfs)	Temp (°C)
Headwaters	2.18	0.021	0.127	8.22	7.90	17.0
Lowest Projected DO (@ 8.33 mi.)	1.63	0.022	0.122	7.09	20.28	17.6
Model End	1.63	0.022	0.122	7.09	20.28	17.6

Table 4-2 provides a summary of incremental flow parameter values which were used in model calibration.

Table 4-2. Calibrated Model Incremental Flow Parameters

Segments	$CBOD_u$ (mg/l)	NH_3-N (mg/l)	TON (mg/l)	DO (mg/l)	Flow (cfs)	Temp. (°C)
1	2.38	0.025	0.141	6.77	0.07	17.0
2	2.79	0.028	0.176	6.77	0.63	17.0
3	2.21	0.022	0.128	6.63	10.80	18.0
4	1.96	0.022	0.112	6.63	0.88	18.0

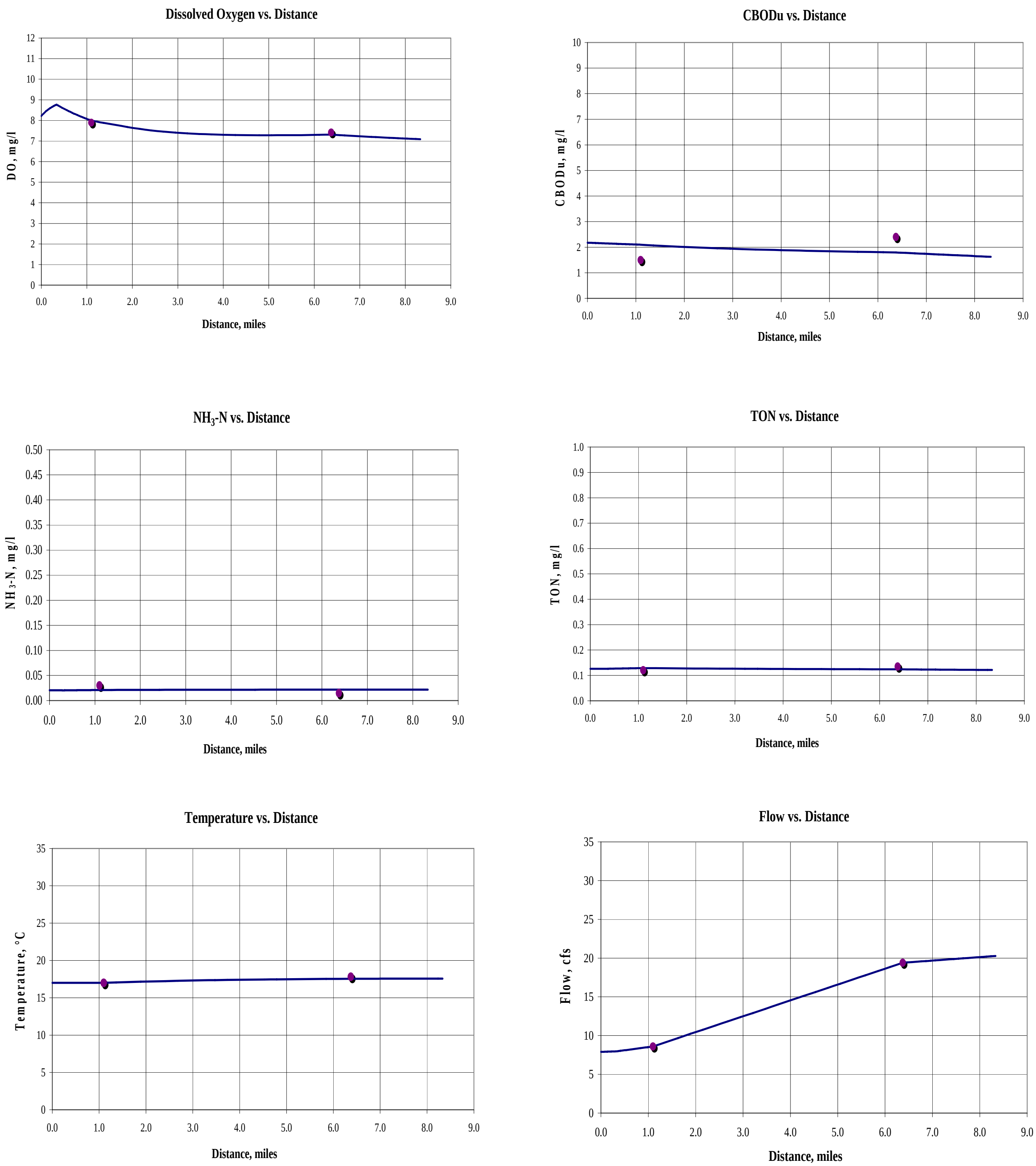
Table 4-3 provides a comparison between calibrated model projected parameter values and field measured parameter values collected at sampling station locations during the sampling event.

Table 4-3. Comparison of Projected Calibrated Model Parameters to Field Data

Description	$CBOD_u$ (mg/l)	NH_3-N (mg/l)	TON (mg/l)	DO (mg/l)	Flow (cfs)	Temp (°C)
Actual Conditions @ 1.1 miles	1.50	0.030	0.120	7.89	8.6	17.0
Projected Conditions @ 1.1 miles	2.10	0.021	0.129	7.99	8.6	17.0
Actual Conditions @ 6.37 miles	2.40	< 0.015	0.135	7.41	19.4	17.8
Projected Conditions @ 6.37 miles	1.79	0.022	0.124	7.31	19.4	17.6

Graphs showing calibrated model predicted parameter values and field measured parameter values for each parameter are presented in Figure 4-3.

Figure 4-3. Calibrated Model Predictions.



4.3.2. Verified Model

Water quality data collected on March 25, 2003, by ADEM FOD was used to verify the Town Creek spreadsheet water quality model. During model verification, SOD reaction rates and non-point source loadings were again adjusted to align model projected parameter values with observed field measured parameter values from the recorded sampling event. CBOD, NH_3-N, and TON reaction rates obtained during calibration were held constant. Figure 4-4, below plots verified model predicted DO against field measured DO.

Figure 4-4. Verified Model DO Predictions vs. DO Field Data.

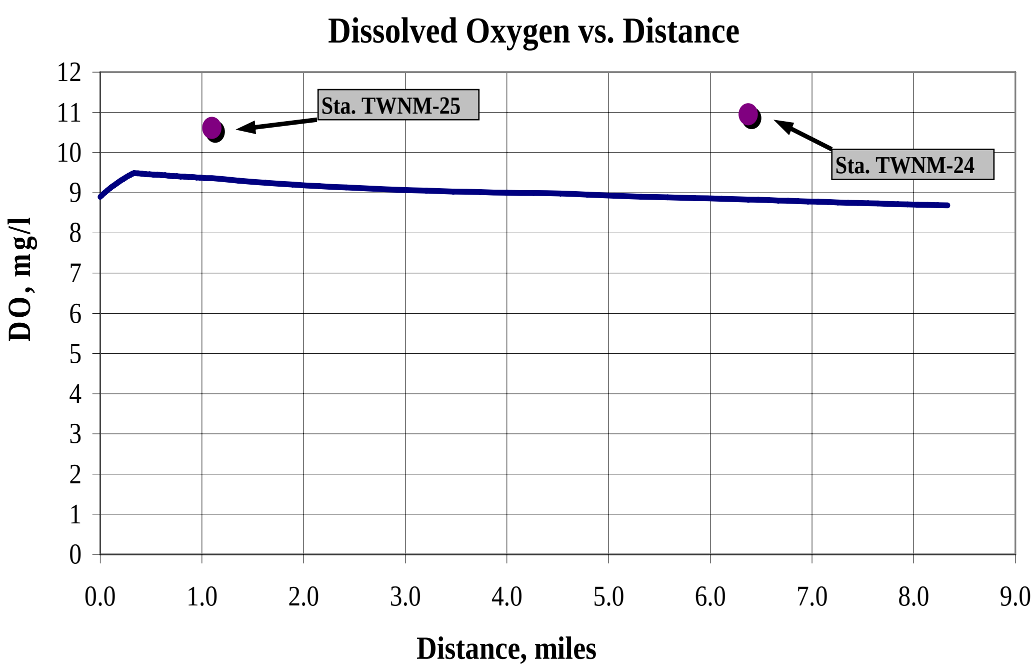


Table 4-4 provides a summary of parameter values at Town Creek's headwaters and verified model projected values for locations of lowest predicted DO and model's end.

Table 4-4. Verified Model Headwaters, Lowest Projected DO, and End Model Parameters

Description	$CBOD_u$ (mg/l)	NH_3-N (mg/l)	TON (mg/l)	DO (mg/l)	Flow (cfs)	Temp (^oC)
Headwaters	3.50	0.013	0.136	8.90	15.98	13.3
Lowest Projected DO (@ 8.33 mi.)	2.87	0.016	0.134	8.68	29.70	14.3
Model End	2.87	0.016	0.134	8.68	29.70	14.3

Table 4-5 provides a summary of incremental flow parameter values which were used in the verified model.

Table 4-5. Verified Model Incremental Flow Parameters

Segments	$CBOD_u$ (mg/l)	NH_3-N (mg/l)	TON (mg/l)	DO (mg/l)	Flow (cfs)	Temp. (°C)
1	3.83	0.016	0.152	7.07	0.16	14.9
2	4.49	0.018	0.190	7.06	1.26	15.0
3	3.56	0.014	0.137	7.00	11.00	15.4
4	3.15	0.014	0.120	6.95	1.29	15.7

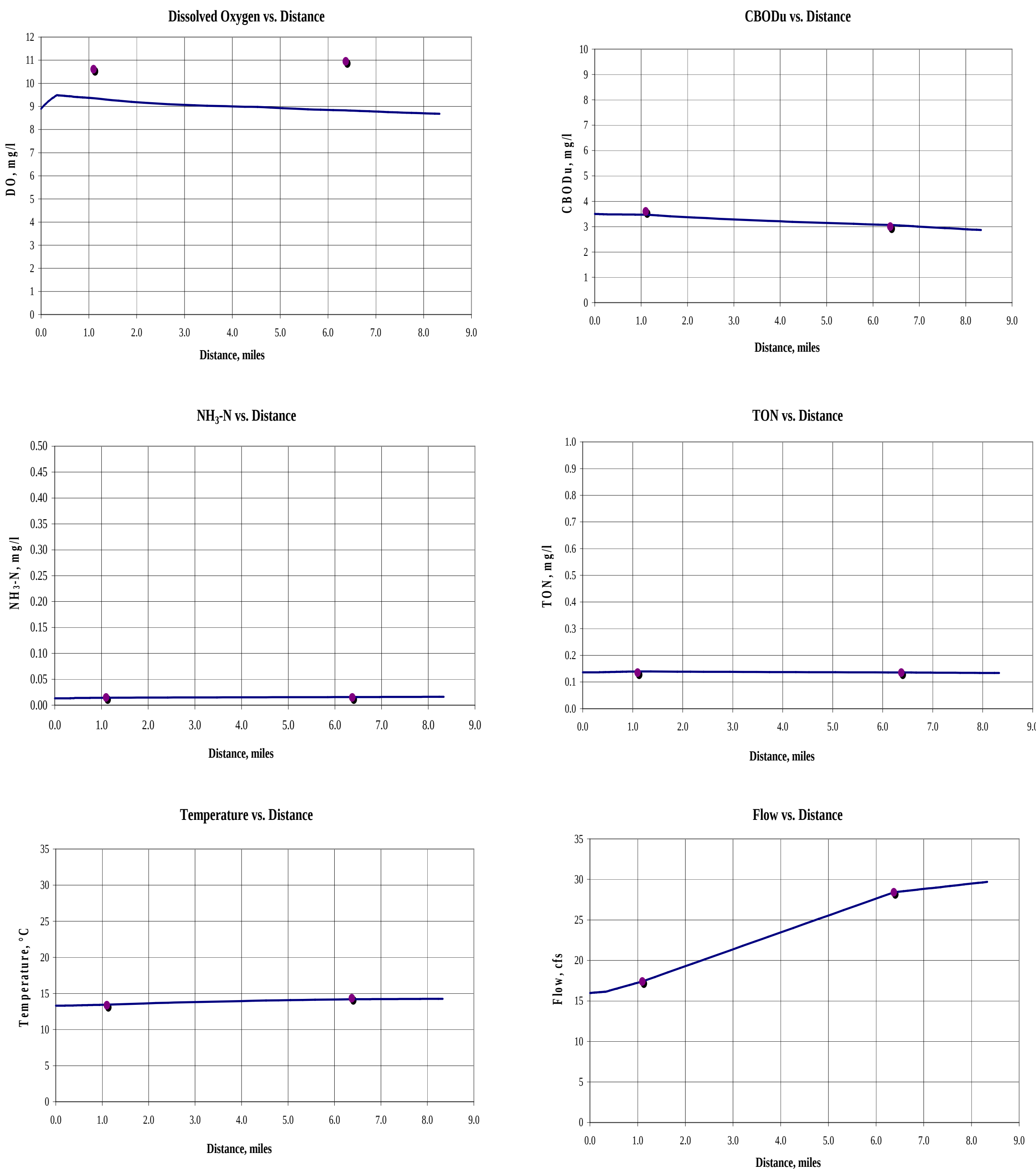
Table 4-6 provides a comparison between verified model projected values and field measured parameter values which were collected at sampling station locations during the sampling event

Table 4-6. Comparison of Projected Verified Model Parameters to Field Data

Description	$CBOD_u$ (mg/l)	NH_3-N (mg/l)	TON (mg/l)	DO (mg/l)	Flow (cfs)	Temp (°C)
Actual Conditions @ 1.1 miles	3.60	< 0.015	0.135	10.61	17.4	13.4
Projected Conditions @ 1.1 miles	3.47	0.014	0.140	9.36	17.4	13.4
Actual Conditions @ 6.37 miles	3.00	< 0.015	0.135	10.95	28.4	14.3
Projected Conditions @ 6.37 miles	3.07	0.016	0.136	8.83	28.4	14.2

Graphs showing verified model predicted parameter values and field measured parameter values for each parameter are presented in Figure 4-5.

Figure 4-5. Verified Model Predictions.



4.3.3. Critical Conditions Model

Water quality data collected on July 23, 1998, by TVA from TVA Station #1150301 at Antioch Road, provided the best representation of critical low flow stream conditions available and was therefore used to develop the critical conditions or TMDL water quality model for Town Creek. Instream DO at TVA Station #1150301, located 6.37 miles downstream from Town Creek's headwaters, was measured at 3.5 mg/l. Sediment oxygen demand reaction rates and non-point source loadings were again adjusted to align model projected parameter values with observed field measured parameter values from the recorded sampling event. CBOD, NH_3-N, and TON reaction rates obtained during calibration were again held constant. Figure 4-6, below plots critical conditions model predicted DO against field measured DO. Predicted DO values less than 5 mg/l are shown beginning at 0.64 miles downstream of Town Creek's headwaters and extending to Cotaco Creek.

Figure 4-6. Critical Conditions Model DO Predictions vs. DO Field Data.

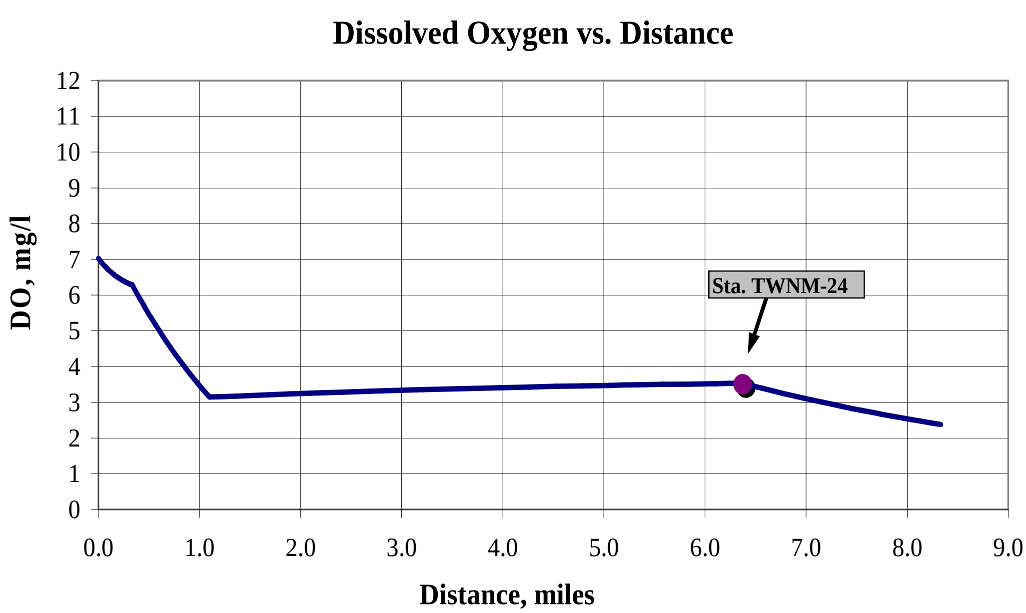


Table 4-7 provides a summary of parameter values at Town Creek's headwaters and critical conditions model projected values for locations of lowest predicted DO and model's end.

Table 4-7. Critical Conditions Model Headwaters, Lowest Projected DO, and End Model Parameters

Description	$CBOD_u$ (mg/l)	NH_3-N (mg/l)	TON (mg/l)	DO (mg/l)	Flow (cfs)	Temp (°C)
Headwaters	2.08	0.000	0.005	7.02	0.34	25.0
Lowest Projected DO (@ 8.33 mi.)	0.53	0.002	0.007	2.38	0.63	25.0
Model End	0.53	0.002	0.007	2.38	0.63	25.0

Table 4-8 provides a summary of incremental flow parameter values used in the critical conditions model.

Table 4-8. Critical Conditions Model Incremental Flow Parameters

Segments	$CBOD_u$ (mg/l)	NH_3-N (mg/l)	TON (mg/l)	DO (mg/l)	Flow (cfs)	Temp. (°C)
1	2.28	0.000	0.005	5.78	0.00	25.0
2	2.67	0.000	0.007	5.78	0.03	25.0
3	2.11	0.000	0.005	5.78	0.23	25.0
4	1.87	0.000	0.004	5.78	0.03	25.0

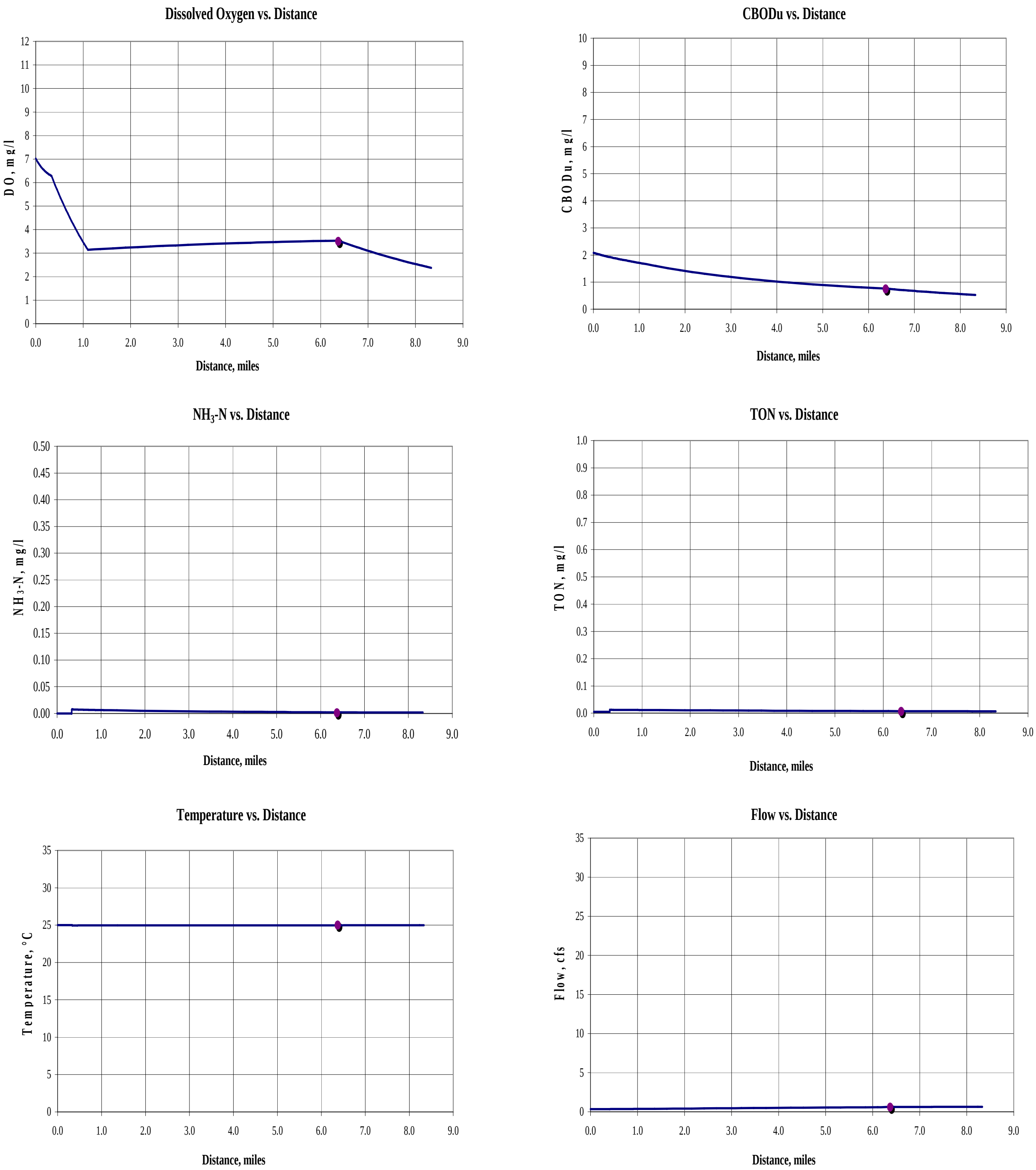
Table 4-9 provides a comparison between critical conditions model projected values and field measured parameter values which were collected at sampling station locations during the sampling event

Table 4-9. Comparison of Projected Critical Conditions Model Parameters to Field Data

Description	$CBOD_u$ (mg/l)	NH_3-N (mg/l)	TON (mg/l)	DO (mg/l)	Flow (cfs)	Temp (°C)
Actual Conditions @ 6.37 miles	0.75	0.001	0.006	3.50	0.60	25.0
Projected Conditions @ 6.37 miles	0.76	0.002	0.007	3.53	0.60	25.0

Graphs showing critical model predicted parameter values and field measured parameter values for each parameter are presented in Figure 4-7.

Figure 4-7. Critical Model Predictions.



4.3.4. Load Reduction Model

In the fourth and final simulation, hereafter referred to as the “load reduction model”, non-point source loadings and SOD reaction rates from the critical conditions or TMDL model were adjusted in order to achieve projected instream DO concentrations of 5 mg/l or greater throughout Town Creek. The critical conditions/calibrated TMDL for this waterbody revealed strong connections between CBOD levels and SOD reaction rates (resulting from stream sediment accumulation) and resulting Organic Enrichment/Low Dissolved Oxygen (OE/DO) impairment. Table 4-10 provides a summary of parameter values at Town Creek’s headwaters and load reduction model projected values for locations of lowest predicted DO and model’s end.

Table 4-10. Load Reduction Model Headwaters, Lowest Projected DO, and End Model Parameters

Description	$CBOD_u$ (mg/l)	NH_3-N (mg/l)	TON (mg/l)	DO (mg/l)	Flow (cfs)	Temp (^oC)
Headwaters	1.10	0.000	0.003	7.02	0.34	25.0
Lowest Projected DO (@ 8.33 mi.)	0.28	0.001	0.005	5.12	0.63	25.0
Model End	0.28	0.001	0.005	5.12	0.63	25.0

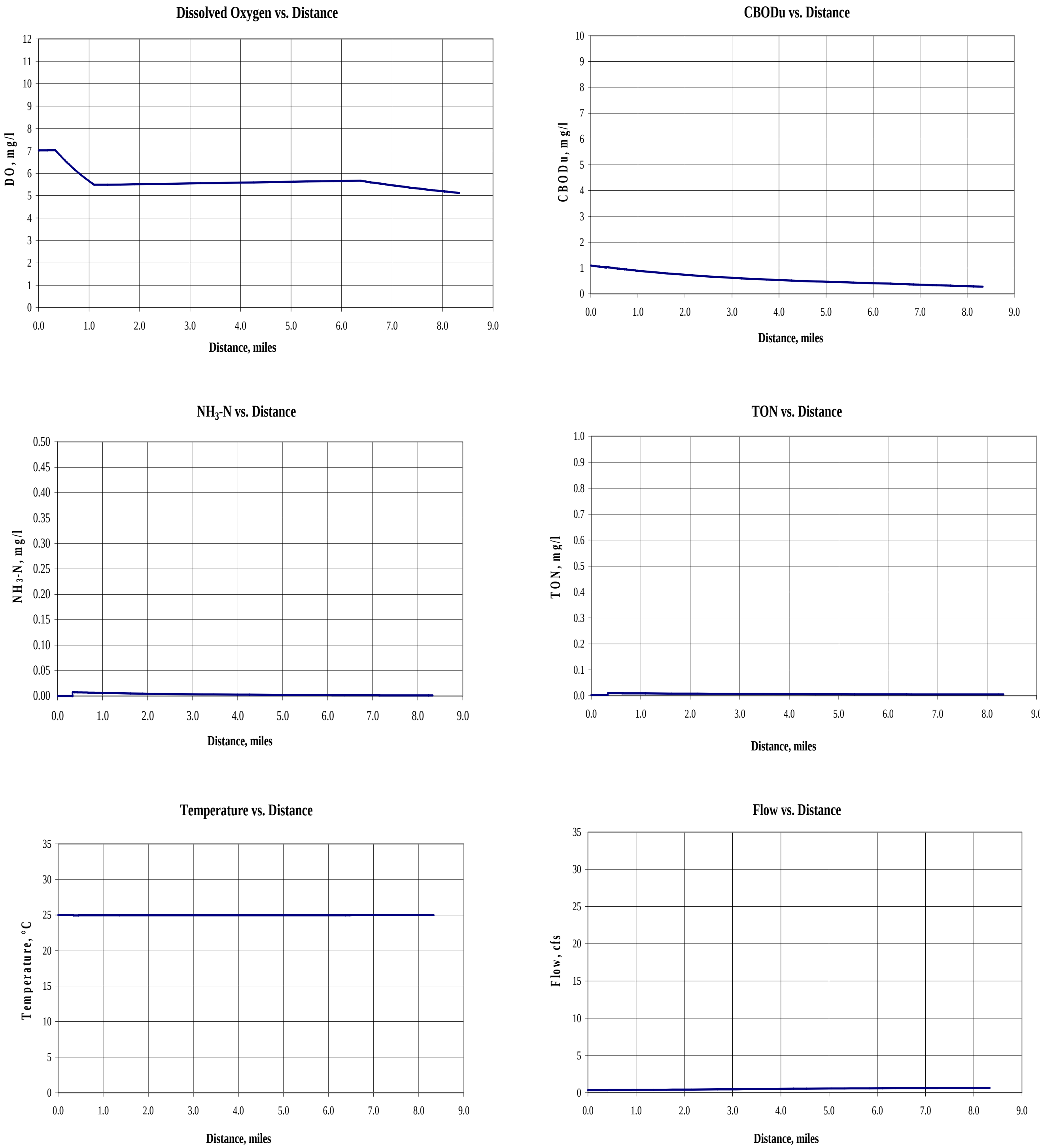
Table 4-11 provides a summary of incremental flow parameter values used in the load reduction model.

Table 4-11. Load Reduction Model Incremental Flow Parameters

Segments	$CBOD_u$ (mg/l)	NH_3-N (mg/l)	TON (mg/l)	DO (mg/l)	Flow (cfs)	Temp. (^oC)
1	1.10	0.000	0.003	5.78	0.00	25.0
2	1.10	0.000	0.003	5.78	0.03	25.0
3	1.10	0.000	0.003	5.78	0.23	25.0
4	1.09	0.000	0.003	5.78	0.03	25.0

Graphs showing load reduction model predicted parameter values and field measured parameter values for each parameter are presented in Figure 4-8.

Figure 4-8. Load Reduction Model Predictions.



4.3.5. Required Reductions

In the load reduction model, non-point source loadings from the critical conditions or TMDL model were adjusted in order to achieve projected instream DO concentrations of 5 mg/l or greater throughout Town Creek. All land uses, with the exception of open water and wetlands, were given the same background concentrations as forested land use. While this adjustment effectively lowered instream loadings, it fell short of achieving the minimum instream DO concentration of 5 mg/l. The critical conditions or TMDL model for Town creek, however, revealed strong connections between CBOD levels and SOD reaction rates (resulting from stream sediment build-up) and resulting OE/DO impairment. Low flow, high temperatures, and low reaeration combined during critical conditions result in considerable impact from SOD. Given that sediment accumulation is the result of erosion and run off, reasonably achievable reductions in SOD (consistent with the average minimum SOD value of 0.065 $gmO_2/ft^2/day$ for the state of Alabama as determined from EPA, Region IV's *Sediment Oxygen Demand Data Insitu Chamber Measurements 1988-1997* database) were performed until an instream DO of 5 mg/l was attained. Resulting SOD reaction rates for the load reduction model were 0.063 and 0.064 $gmO_2/ft^2/day$ at ambient temperature. This represented a 51.9% needed reduction in SOD in order to achieve an instream DO concentration of 5 mg/l which resulted in approximately the same recommended or needed percent reductions for $CBOD_u$ and NBOD. Achieving recommended reductions in $CBOD_u$ and NBOD loadings, will thereby result in the same needed reductions in SOD.

Combined total organic loadings for $CBOD_u$ and NBOD were determined for both the critical conditions or TMDL model and load reduction model. The resulting difference between loadings for the critical conditions model and load reduction model would require a 48.0 % reduction in total non-point source pollutant loadings in order to bring Town Creek into compliance with the ADEM's dissolved oxygen criterion of 5.0 mg/l. Table 4-12 summarizes the pollutant source reductions required to achieve an instream dissolved oxygen concentration of 5.0 mg/l. All loads are represented by their $CBOD_u$ and NBOD components.

Table 4-12 Required TMDL Reductions for Town Creek Watershed HUC AL06030002-0604-100

Loading Parameter	Existing Loads		Allowable Loads		Reductions	
	WLA	LA	WLA	LA	% WLA	% LA
$CBOD_u$	0.063 lbs/day	7.137 lbs/day	0.063 lbs/day	3.710 lbs/day	0.0	48.0
NBOD	0.126 lbs/day	0.076 lbs/day	0.126 lbs/day	0.038 lbs/day	0.0	50.0

Required reductions are to be accomplished through TMDL implementation of BMPs with follow up monitoring to determine their resulting effectiveness. Appropriately designed and adequately established BMPs are expected to provide the necessary load reduction from all sources. Follow up monitoring as discussed further in this document will be performed on rotational basis.

4.4 Seasonal Variation

Regulations require that TMDLs be established with consideration of seasonal variations. Since recorded DO violations only occurred during summer months, development of a winter TMDL was not attempted. Reductions necessary to achieve the 5 mg/l dissolved oxygen criterion during summer would also be protective of stream conditions during winter.

5.0 Conclusions

The State of Alabama originally identified Town Creek as impaired for organic enrichment/low dissolved oxygen (OE/DO) in the State of Alabama's 1998 §303(d) list of impaired waters due to organic loading (i.e., $CBOD_u$ and NBOD). Listing was based upon 40% noncompliance of recorded monthly instream DO measurements obtained between June 25, 1997 and October 22, 1997 from TVA Station #1150301 at Antioch Road by TVA. Poor to fair EPT taxa richness macroinvertebrate assessments along with poor IBI fish assessments were also obtained by TVA on August 9, 1995 at the same sampling location.

In accordance with ADEM's water quality standards, the minimum required instream dissolved oxygen concentration for waters classified as Fish and Wildlife is 5.0 mg/l. This DO criterion of 5.0 mg/l was used as the target for determining the required pollutant reductions needed to bring Town Creek into compliance with applicable water quality standards.

Additional monthly water quality data collected by ADEM FOD between March 25, 2003 and October 16, 2003 at Alabama Highway 67 (Station TWNM-25) and at Antioch Road (Station TWNM-24) revealed 22% noncompliance of recorded monthly instream DO measurements at Station TWNM-25 and 30% noncompliance at Station TWNM-24. Additional water quality data collected by Alabama Water Watch (AWW) at Antioch Road (AWW Station #08033004) between January 15, 1999 and November 15, 2003 demonstrated even greater noncompliance at 36%. This additional water quality data further revealed that DO impairments typically occurred during the summer months (May through November). Dissolved oxygen impairments in Town Creek were attributable to low flows and high temperatures as evidenced during summer sampling events. Based on ADEM's data analysis, a steady state modeling approach was determined appropriate for TMDL development.

In the absence of SOD values from a specific reference site for Town Creek, an average mean SOD reaction rate value for all measured streams within the state of Alabama, both impaired as well as unimpaired, was derived from EPA, Region IV's *Sediment Oxygen Demand Data Insitu Chamber Measurements 1988-1997* database (representing mixed land uses and varying degrees of point source activity). This average mean SOD value of 0.103 O_2/ft^2/day was used to provide realistic SOD rates for Town Creek during model development.

Water quality data collected on April 30, 2003, by ADEM FOD was used in calibrating the Town Creek spreadsheet water quality model. During model calibration, reaction rates for CBOD, NH_3-N, TON, and SOD, and non-point source loadings from different landuses (CBOD, NH_3-N, and TON concentrations) were adjusted to align model projected parameter values as closely as possible to observed field measured parameter values while preserving a reasonable representation of stream water quality conditions for the recorded sampling event.

Water quality data collected on March 25, 2003, by ADEM FOD was used to verify the Town Creek spreadsheet water quality model. During model verification, SOD reaction rates and non-point source loadings were again adjusted to align model projected parameter values with observed field measured parameter values from the recorded sampling event. CBOD, NH_3-N, and TON reaction rates obtained during calibration were held constant.

Water quality data collected on July 23, 1998, by TVA from TVA Station #1150301 at Antioch Road, provided the best representation of critical low flow stream conditions available and was therefore used to develop the critical conditions or TMDL water quality model for Town Creek. Sediment oxygen demand reaction rates and non-point source loadings were again adjusted to align model projected parameter values with observed field measured parameter values from the recorded sampling event. CBOD, NH_3-N, and TON reaction rates obtained during calibration were again held constant.

In the load reduction model, non-point source loadings from the critical conditions or TMDL model were adjusted in order to achieve projected instream DO concentrations of 5 mg/l or greater throughout Town Creek. All land uses, with the exception of open water and wetlands, were given the same background concentrations as forested land use. While this adjustment effectively lowered instream loadings, it fell short of achieving the minimum instream DO concentration of 5 mg/l. The critical conditions or TMDL model, however, revealed strong connections between CBOD levels and SOD reaction rates (resulting from stream sediment accumulation) and resulting OE/DO impairment. Given that sediment accumulation is the result of erosion and run off, reasonably achievable reductions in SOD (consistent with the average minimum SOD value of 0.065 gmO_2/ft^2/day for the state of Alabama as determined from EPA, Region IV's *Sediment Oxygen Demand Data Insitu Chamber Measurements 1988-1997* database) were performed until an instream DO of 5 mg/l was attained. Resulting SOD reaction rates for the load reduction model were 0.064 and 0.065 gmO_2/ft^2/day at ambient temperature. This represented a 51.9% needed reduction in SOD in order to achieve an instream DO concentration of 5 mg/l which resulted in approximately the same recommended or needed percent reductions for $CBOD_u$ and NBOD. Achieving recommended reductions in $CBOD_u$ and NBOD loadings, will thereby result in the same needed reductions in SOD.

Combined total organic loadings for $CBOD_u$ and NBOD were determined for both the critical conditions or TMDL model and load reduction model. The resulting difference between loadings for the critical conditions model and load reduction model would require a 48.0 % reduction in non-point source pollutant loadings in order to bring Town Creek into compliance with the ADEM's dissolved oxygen criterion of 5.0 mg/l.

Impairment to Town Creek was derived exclusively from non-point source (NPS) pollutant loadings, for which needed reductions will be sought during TMDL implementation. Table 5-1 summarizes the pollutant source reductions required to achieve an instream dissolved oxygen concentration of 5.0 mg/l. All loads are represented by their $CBOD_u$ and NBOD components.

Table 5-1. Required TMDL Reductions for Town Creek Watershed HUC AL06030002-0604-100

Loading Parameter	Existing Loads		Allowable Loads		Reductions	
	WLA	LA	WLA	LA	% WLA	% LA
$CBOD_u$	0.063 lbs/day	7.137 lbs/day	0.063 lbs/day	3.710 lbs/day	0.0	48.0
NBOD	0.126 lbs/day	0.076 lbs/day	0.126 lbs/day	0.038 lbs/day	0.0	50.0

6.0 TMDL Implementation

6.1 Non-Point Source Approach

Impairment to Town Creek is derived exclusively from non-point source (NPS) pollutant loads, for which needed reductions will be sought under TMDL implementation. Reductions in pollutant loading from non-point sources will be achieved through a phased approach. Voluntary, incentive-based mechanisms will be used in implementing NPS management measures and in achieving measurable reductions in pollutant loading. Cooperation and active participation by the general public, as well as, various industrial, commercial, and environmental groups are vital to successful TMDL implementation. Local citizen-led management measures offer the most effective and comprehensive opportunity for reducing non-point source pollutant loadings. TMDL implementation activities will be coordinated through interaction with local entities in conjunction with Clean Water Partnership efforts.

Government agencies and concerned stakeholders should, at minimum, be directed toward the implementation and maintenance of more conservation minded farming practices. Consideration should be given to conservation tillage, the use of contour strips, and to no till farming; to the installation of grass buffer zones along existing streams; to the reduction or elimination of potentially destructive activities within riparian areas; and to the minimization of construction related impacts to streams.

Primary implementation should concurrently employ education and outreach, training, technology transfer, and technical assistance with incentive-based pollutant management measures. The ADEM Office of Education and Outreach (OEO) provides needed assistance to both public and private stakeholders. Planning and oversight are available from ADEM's Section 319 non-point source grant program. The Clean Water Act (CWA) Section 319 grant program was created to fund further NPS pollutant source identification, pollutant reduction, educational outreach, pollution prevention, and needed management measures for restoring impaired waters.

Resources for corrective actions are also provided through the Alabama Cooperative Extension System (education and outreach); the USDA-Natural Resources Conservation Service (NRCS) (technical assistance); the Farm Services Agency (FSA) (federal cost-share funding); the Alabama Soil and Water Conservation Committee (state agricultural cost share funding and management measure implementation assistance); local Soil and Water Conservation Districts; and through Resource Conservation and Development Councils (funding, project implementation, and coordination). Additional assistance is also available from the Alabama Department of Public Health (septic systems); the Alabama Department of Agriculture and Industries (pesticides); the Alabama Department of Industrial Relations and Department of Interior - Office of Surface Mining (abandoned mines); and from both the Natural Heritage Program and US Fish and Wildlife Service (threatened and endangered species). Land use and population related issues can be addressed through the Non-point Source for Municipal Officials (NEMO) education and outreach program. Memorandums of Agreements (MOAs) may also be used to formally define the roles and responsibilities of various involved parties.

Additional public/private assistance is available through the Alabama Clean Water Partnership (CWP) Program, which provides a local citizen-based environmental protection approach to coordinating water shed restoration and protection efforts. Interaction between state and basin specific CWPs allows and promotes the exchange of much needed information between the effected communities, government, industries, special interest groups, and other concerned individuals. Clean Water Partnerships have been designed and developed to assist in the planning, development, and execution of stream restoration projects, eliminate duplication of efforts, and to allow for the most effective and efficient use of available resources in restoring impaired waters.

Local regulations or ordinances related to zoning, land use, or storm water control may be required. Funding through general revenues, bond issuance, special taxes, utility fees, or impact fees may also be needed. The Alabama Water Pollution Control Act enables ADEM to monitor streams and to inspect various related activities and conditions which may threaten their quality. The NPDES permit program is authorized to regulate animal feeding operations and land application of animal wastes. The State Clean Water Revolving Fund (SRF) additionally offers low interest loans to local qualifying governments which seek needed water quality improvements.

Long-term water quality improvements will determine the effectiveness of TMDL implementation. Follow-up evaluation of water quality may necessitate revision of initial TMDL results. ADEM will continue in its monitoring of impaired streams in keeping with its rotational river basin schedule. Assessments may also include local citizen-volunteer monitoring through the Alabama Water Watch Program and/or data collected by agencies, universities, or others trained in the use of approved standardized monitoring and assessment methods. Core management measures include water quality improvements, designated use support, the preservation and enhancement of public health and ecology, pollution prevention, load reductions, implementation of NPS controls, and outreach efforts toward changing public perception, awareness, attitudes, and behavior concerning water quality.

Potential controls may include streambank stabilization and restoration, development of stormwater retention ponds and livestock watering ponds, vegetated riparian buffer zones, limiting livestock access to streams, septic tank inspection and maintenance, and watershed awareness education and outreach activities.

6.2 Point Source Approach

No current load reduction is being proposed for the Crosscreek Subdivision SP&P municipal wastewater treatment facility given that their contribution and impact to Town Creek were not determined to be significant. It should also be noted that the facility's current NPDES permit limits are protective of water quality standards even when the receiving stream experiences little or no flow at the point of discharge.

7.0 Follow Up Monitoring

ADEM has adopted a basin-by-basin approach to water quality management which classifies Alabama's fourteen major river basins into five key groups. This watershed approach is based on a five-year rotational cycle which incorporates planning, monitoring, assessment, TMDLs, WLAs/LAs, and NPDES permit issuance within each group. ADEM water quality resources are allocated toward the annual study of each scheduled basin group. The effectiveness of TMDL implementation will be assessed within this rotating watershed management approach. Watershed monitoring and assessments are to provide the necessary information by which load reduction measures can be evaluated. Follow-up monitoring and pollutant source identification will also assist in prioritizing efforts to implement BMPs where needed within the each watershed. Continued monitoring of §303(d) listed waters will adhere to the following projected schedule:

River Basin Group	Schedule
Escatawpa / Upper Tombigbee / Lower Tombigbee / Mobile	2006
Cahaba / Black Warrior	2007
Tennessee	2008
Choctawhatchee / Chipola / Perdido-Escambia / Chattahoochee	2009
Tallapoosa / Alabama / Coosa	2010

Follow-up monitoring will also aid in the ongoing assessment and evaluation of corrective measures already implemented. As such, the Town Creek TMDL will be reevaluated and revised as needed to assure continued attainment of applicable water quality standards.

8.0 Public Participation

As part of the public participation process, this TMDL was placed on public notice and made available for review and comment. The public notice was prepared and published in the four major daily newspapers in Montgomery, Huntsville, Birmingham, and Mobile, as well as submitted to persons who have requested to be on ADEM's postal and electronic mailing distributions. In addition, the public notice and subject TMDL was made available on ADEM's Website: www.adem.state.al.us. The public can also request paper or electronic copies of the TMDL by contacting Mr. Chris Johnson at 334-271-7827 or clj@adem.state.al.us. The public was given an opportunity to review the TMDL and submit comments to the Department in writing. At the end of the public review period, all written comments received during the public notice period became part of the administrative record. ADEM considered all comments received by the public prior to finalization of this TMDL and subsequent submission to EPA Region 4 for final review and approval.

Appendix 9.1
References

References

Adkins, J.B., Pearman, J.L.. 1994. Low-Flow and Flow-Duration Characteristics of Alabama Streams. Water-Resources Investigations Report 93-4186.

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

ADEM. May 2000. Surface Water Quality Screening Assessment of the Tennessee River Basin - 1998.

United States Environmental Protection Agency , Region IV. 1988-1997. Sediment Oxygen Demand Data Insitu Chamber Measurements.

United States Environmental Protection Agency. June 1985. Rates, Constants, and Kinetics Formulations in Surface Water Quality Modeling, EPA /600/3-85/040.

ADEM. December 2005. Alabama's Water Quality Assessment and Listing Methodology,

Appendix 9.2
Water Quality Data

1995 TVA Habitat & Invertebrate Assessments of Town Creek at TVA Station #1150301

TVA Station #	ADEM Station #	Stream Name	Habitat			Benthic - EPT Family			Drainage Area (mi^2)
			Date	Score	Percent	Date	Score	Class	
11503-1	TWNM-24	Town Creek	08/09/95	22	55	08/09/95	6	poor/fair	36

1997 & 1998 TVA Monitoring Data from Town Creek TVA Station #1150301 at Antioch Road

Date	Time	Flow (cfs)	Air Temp. (ºC)	Water Temp. (ºC)	Depth (ft)	Turbidity (NTU)	Conductivity (mmhos/cm)	D.O. (mg/L)	pH (s.u.)	BOD_5 (mg/L)	TSS (mg/L)	NH_3-N (mg/L)	NO_2+NO_3-N (mg/L)	TKN (mg/L)	PO_4-P (mg/L)	Total P (mg/L)	Fecal Coliform (#/100mL)
06/25/97	9:00		21.9	20.5	5.0	8.2	210	7.1	7.2	<2.0	8	0.02	0.40	0.260	0.020	0.020	INT
07/16/97	9:30	9.4	24.5	23.1	2.0	5.5	276	7.4	7.6	2.0	5	0.05	0.40	0.220	0.009	0.020	330
08/20/97	9:30	1.6	24.0	24.1	1.6	7.5	262	3.9	7.3	<2.0	7	0.03	<0.01	0.370	0.009	0.060	1940
09/17/97	8:40	0.0	17.1	19.6	1.9	2.5	293	3.2	7.3	<2.0	3	0.02	<0.01	0.280	0.006	0.020	480
10/22/97	8:00	30.9	6.3	12.4	2.4	10.3	275	8.9	7.5	<2.0	6	<0.01	0.34	0.280	0.020	0.040	6200
Maximum		**30.9**	**24.5**	**24.1**	**5.0**	**10.3**	**293**	**8.9**	**7.6**	**2.0**	**8**	**0.05**	**0.40**	**0.370**	**0.020**	**0.060**	**6200**
Minimum		**0.0**	**6.3**	**12.4**	**1.6**	**2.5**	**210**	**3.2**	**7.2**	**2.0**	**3**	**0.01**	**0.01**	**0.220**	**0.006**	**0.020**	**330**
Mean		**10.5**	**18.8**	**19.9**	**2.6**	**6.8**	**263**	**6.1**	**7.4**	**2.0**	**6**	**0.03**	**0.23**	**0.282**	**0.013**	**0.032**	**2238**

Date	Time	Flow (cfs)	Air Temp. (ºC)	Water Temp. (ºC)	Depth (ft)	Turbidity (NTU)	Conductivity (mmhos/cm)	D.O. (mg/L)	pH (s.u.)	BOD_5 (mg/L)	TSS (mg/L)	NH_3-N (mg/L)	NO_2+NO_3-N (mg/L)	TKN (mg/L)	PO_4-P (mg/L)	Total P (mg/L)	Fecal Coliform (#/100mL)
07/23/98	7:30	0.6		25.0		4.9	288	3.5	7.2	0.5	3		0.11	0.007		<0.005	132

Alabama Water Watch Data for Town Creek
from AWW Station #08033004 at Antioch Road of Somerville, AL

Date	Alkalinity (mg/l)	Hardness (mg/l)	Air Temperature (°C)	Water Temperature (°C)	pH (su)	DO (ppm)	DO Saturation (% of Max.)	Turbidity (JTU)
01/15/99	70.0	70	19.0	11.0	7.5	7.000	62.90	5
08/15/00	170.0	150	27.5	25.0	7.5	4.600	56.30	2
01/15/01	90.0	90	14.5	9.0	7.5	10.000	85.80	2
05/15/01	115.0	90	15.0	17.0	7.5	6.100	62.90	5
05/15/02	40.0	50	20.0	17.0	6.5	5.900	60.90	
06/15/02	90.0	70	22.0	23.0	7.0	4.050	47.60	5
09/15/02	150.0	110	25.0	22.5	7.5	1.000		5
11/15/02	85.0	80	17.0	15.0	7.3	7.575	74.70	5
02/15/03	90.0	80	10.0	8.0	7.5	10.150	85.00	2
09/15/03	127.5	100	23.5	24.5	7.5	3.900	48.15	5
11/15/03	130.0	90	16.0	14.0	7.5	6.550	63.10	5

2003 ADEM Field Operations Division Field Parameters for Town Creek

Station ID	Date	Time (24hr)	Reach Description	Weather last 24 hrs	Rain previous 7 days	Flow Stage	Stream Velocity	Reason No Flow
TWNM-24	03/25/03	950	Samples taken 15 feet upstream from bridge	Clear/Cloudless	FALSE	Normal	Slow	
TWNM-24	04/30/03	800		Clear/Cloudless	FALSE	Normal	Slow	
TWNM-24	05/22/03	1100		Cloudy	FALSE	Normal	Moderate	not wadeable (too deep)
TWNM-24	06/11/03	900		Partly Cloudy	FALSE	Normal	Slow	extremely slow flow
TWNM-24	06/30/03	1130		Cloudy/Overcast	TRUE	Low	No Flow	no visible flow
TWNM-24	07/29/03	1130	Forest and agriculture along reach	Clear/Cloudless	TRUE	Low	No Flow	no visible flow
TWNM-24	08/13/03	1130	Forest and agriculture along reach	Rain	TRUE	Low	No Flow	no visible flow
TWNM-24	09/17/03	1015		Partly Cloudy	FALSE	Low	Slow	visible but not detectable
TWNM-24	10/16/03	1110	Forest and agriculture along reach	Partly Cloudy	FALSE	Low	Slow	no visible flow
TWNM-25	03/25/03	855	Samples taken 10 feet upstream from bridge	Clear/Cloudless	FALSE	Normal	Moderate	
TWNM-25	04/30/03	900		Clear/Cloudless	FALSE	Normal	Moderate	
TWNM-25	05/22/03	1030		Cloudy	FALSE	Normal	Moderate	not wadeable (too deep)
TWNM-25	06/11/03	845		Partly Cloudy	FALSE	Normal	Moderate	
TWNM-25	06/30/03	1200		Cloudy/Overcast	TRUE	Low	No Flow	no visible flow
TWNM-25	07/29/03	1200	Forest and agriculture along reach	Clear/Cloudless	TRUE	Low	No Flow	no visible flow
TWNM-25	08/13/03	1200	Forest and agriculture along reach	Rain	TRUE	Low	No Flow	no visible flow
TWNM-25	09/17/03	1030		Partly Cloudy	FALSE	Low	No Flow	no visible flow
TWNM-25	10/16/03	1130	Forest and agriculture along reach	Partly Cloudy	FALSE	Low	Slow	visible but not detectable

2003 ADEM Field Operations Division Field Parameters for Town Creek (Contd.)

Station ID	Date	Time (24hr)	Biological Indicators	Air Temp. (°C)	Water Temp. (°C)	pH (su)	Conductivity (υmhos @ 25°C)	DO (mg/l)	Field Turbidity (NTU)	Stream Flow (cfs)	Mid Channel Depth (ft)	Sample Depth (ft)
TWNM-24	03/25/03	950		26.0	14.34	7.28	228.0	10.95	7.8	28.4	4.0	2.00
TWNM-24	04/30/03	800	fish	20.0	17.81	7.75	251.0	7.41	9.0	19.4	4.0	2.00
TWNM-24	05/22/03	1100		23.0	17.90	6.09	179.8	11.96	14.0		6.0	3.00
TWNM-24	06/11/03	900		29.0	21.70	7.49	210.0	9.97	14.0		2.0	1.00
TWNM-24	06/30/03	1130		27.0	22.80	7.44	187.2	4.35	19.4		2.0	1.00
TWNM-24	07/29/03	1130		31.0	23.50	7.43	263.0	9.95	8.2		2.0	1.00
TWNM-24	08/13/03	1130		30.0	23.60	7.08	232.1	7.46	9.0		2.0	1.00
TWNM-24	09/17/03	1015		25.0	18.40	6.38	336.8	4.80	1.8		0.5	0.25
TWNM-24	10/16/03	1110		14.0	13.50	7.03	308.3	2.87	3.3		1.0	0.50
TWNM-25	03/25/03	855	fish & macroinvertebrates	25.0	13.38	6.48	225.0	10.61	4.4	30.4	1.0	0.50
TWNM-25	04/30/03	900		24.0	17.00	4.62	214.0	7.89	7.0	8.6	1.0	0.50
TWNM-25	05/22/03	1030		23.0	17.90	6.09	179.8	11.96	14.0		5.0	2.50
TWNM-25	06/11/03	845		30.0	21.30	7.67	205.0	10.71	6.0	7.1	0.7	0.35
TWNM-25	06/30/03	1200		28.0	22.10	7.45	184.6	8.64	9.0		1.0	0.50
TWNM-25	07/29/03	1200		29.0	22.40	7.52	267.0	9.41	3.9		1.0	0.50
TWNM-25	08/13/03	1200		28.0	22.90	7.58	271.2	7.45	4.0		1.0	0.50
TWNM-25	09/17/03	1030		24.0	19.50	6.85	301.9	2.81	3.2		2.0	1.00
TWNM-25	10/16/03	1130		16.0	15.00	7.19	330.3	4.98	3.4		2.0	1.00

2003 ADEM Field Operations Division Laboratory Data for Town Creek

Station ID	Date	Time (24hr)	Fecal Coliform (col/100ml)	Total Alkalinity (mg/l)	Hardness (Ca&Mg) (mg/l)	$CBOD_5$ (mg/l)	TSS (mg/l)	TDS (mg/l)	Total-P (mg/l)	NO2+NO3-N (mg/l)	NH3-N (mg/l)	TKN (mg/l)	DRP (mg/l)
TWNM-24	03/25/03	950	128	94	108	2.0	5	130	<0.004	0.261	<0.015	<0.150	<0.004
TWNM-24	04/30/03	800	144	109	120	1.6	5	154	<0.004	0.349	<0.015	<0.150	<0.004
TWNM-24	05/22/03	1100	900	78	88	<0.1	18	120	0.052	0.301	<0.015	0.399	<0.004
TWNM-24	06/30/03	1130	224	84	98	1.0	18	137	0.184	0.305	<0.015	0.654	0.018
TWNM-24	07/29/03	1130	63	123	132	0.6	11	169	<0.020	0.247	<0.015	0.352	<0.004
TWNM-24	08/13/03	1130	530	107	120	0.7	5	141	0.044	0.400	<0.015	0.680	0.012
TWNM-24	09/17/03	1015	62	150	168	0.3	2	201	0.059	1.075	<0.015	0.416	0.008
TWNM-24	10/16/03	1110	54	152	158	2.2	5	187	<0.020	0.015	0.043	0.460	0.008
TWNM-25	03/25/03	830	53	90	104	2.4	4	124	<0.004	0.343	<0.015	<0.150	<0.004
TWNM-25	04/30/03	900	172	114	126	1.0	3	156	<0.004	0.466	0.030	<0.150	<0.004
TWNM-25	05/22/03	1030	260	82	88	<0.1	10	122	0.046	0.315	<0.015	0.210	<0.004
TWNM-25	06/30/03	1200	192	101	104	0.7	7	155	0.026	0.466	<0.015	0.506	0.012
TWNM-25	07/29/03	1200	184	126	138	0.2	1	162	<0.020	0.585	<0.015	0.268	0.003
TWNM-25	08/13/03	1200	>620	133	146	0.8	3	184	<0.050	0.386	<0.015	0.513	0.034
TWNM-25	09/17/03	1030	40	7	152	0.9	7	67	0.034	0.018	<0.015	0.729	0.006
TWNM-25	10/16/03	1130	62	160	176	2.1	4	201	0.026	0.534	<0.015	0.458	0.007

Appendix 9.3
Water Quality Model
Input and Output Files

CALIBRATED MODEL

VERIFICATION MODEL

CRITICAL CONDITIONS/TMDL MODEL

LOAD REDUCTION MODEL