Historical Data Review for the Sam Rayburn Reservoir, Texas

Prepared for:
Texas Commission on Environmental Quality

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1.0 Introduction

1.1 Project Overview and Objectives

Tetra Tech, Inc. (Tt) and its subcontractors (Tetra Tech-MFG, Angelina and Neches River Authority (ANRA), Lopez Garcia Group (LGG), and Diane Sheridan) are supporting the Texas Commission on Environmental Quality (TCEQ) in its effort to determine the Total Maximum Daily Loads (TMDLs) for the segments of Sam Rayburn Reservoir listed for aluminum, dissolved oxygen, and pH impairments. These listings are based on Texas's 2000 and 2002 Clean Water Act section 303(d) lists of impaired waters. The Tt team is also supporting investigations of other possible pollutants impacting the reservoir.

The objectives of the project are as follows:

1. Develop information necessary for the TCEQ to determine whether the segments are meeting applicable water quality standards.

2. Develop information necessary for the TCEQ to determine whether the existing designated uses and criteria are appropriate and, if not, develop information necessary for the TCEQ to change the designated use and/or applicable criteria.

3. Develop information necessary to support modeling and assessment activities for allocating pollutant loadings for all segments where water quality standards are not being met.

4. Perform the modeling and assessment activities necessary to allocate the loadings of the constituents of concern for all segments where water quality standards are not being met.

5. Provide technical assistance to the TCEQ in the evaluation of actions necessary to achieve the recommended loading allocations for all segments where water quality standards are not being met.

6. Document, compile, and summarize technical analyses in reports to the TCEQ.

7. Provide support to the TCEQ for public participation/education.

This report, the Historical Data Review, is a summary and evaluation of the existing data available to characterize the two 303(d)-listed segments in the Sam Rayburn Reservoir, as well as the contributing tributaries. The report satisfies the first objectives of the project. The Tt team has identified key information and data sources relevant to the Sam Rayburn Reservoir and its contributing watershed. All available data and information for the watershed have been compiled, including data related to water quality, point sources, land use and land cover, land characteristics, meteorology, flow, and reservoir water levels. The information compiled in this document assesses current levels and trends of dissolved oxygen, aluminum, and pH in the reservoir and supports the comparison of current stream conditions to the applicable water quality criteria. In addition to dissolved oxygen, aluminum, and pH, other potential pollutants are evaluated, namely, nutrients, bacteria, copper, lead, zinc, arsenic, selenium, and dioxin. These additional pollutants were identified by TCEQ for impairment potential.

The Historical Data Review includes in-depth review and analysis of available data, including statistical summaries of water quality data; comparisons of observed data to Texas Water Quality Standards; and maps of watershed characteristics and monitoring station locations. This report also discusses the model(s) that the Tt team recommends to study the fate and transport of constituents contributing to the dissolved oxygen, aluminum, and pH impairments.

1.2 Watershed and Impairment Overview

Sam Rayburn Reservoir (formerly McGee Reservoir) is in eastern Texas, on the Angelina River within the central portion of the Neches River Basin, approximately 10 miles northwest of Jasper, Texas. The reservoir covers portions of Angelina, Jasper, Nacogdoches, San Augustine, and Sabine Counties, and the Angelina River, Attoyac Bayou, and Ayish Bayou are its major tributaries (Figure 1-1). Sam Rayburn Reservoir includes TCEQ river segments 0610 (Sam Rayburn Reservoir) and 0615 (Angelina River/Sam Rayburn Reservoir) of the Sam Rayburn Reservoir watershed.

TCEQ river segments 0610 (Sam Rayburn Reservoir), 0611 (Angelina River above Sam Rayburn Reservoir), 0612 (Attoyac Bayou), 0613 (Lake Tyler/Lake Tyler East), and 0615 (Angelina River/Sam Rayburn Reservoir) are the major classified segments within the Sam Rayburn Reservoir watershed. Unclassified river segments 0611A (East Fork Angelina River), 0611B (La Nana Bayou), 0611C (Mud Creek), 0611D (West Mud Creek), 0611H (Ragsdale Creek), 0611Q (Lake Nacogdoches), 0615A (Paper Mill Creek), 0610A (Ayish Bayou), 0612B (Waffelow Creek), and 0612C (Pinkston Reservoir) are also within the watershed.

Both segments of the Sam Rayburn Reservoir (0610 and 0615) are on the 2000 Texas section 303(d) list. Several of the tributaries draining into the reservoir are also included on that list. Table 1-1 presents the listing information for the 2000 and Draft 2002 Texas section 303(d) lists for all of the waterbodies in the Sam Rayburn Reservoir watershed. Figure 1-2 presents the locations of the listed waterbodies in the watershed.

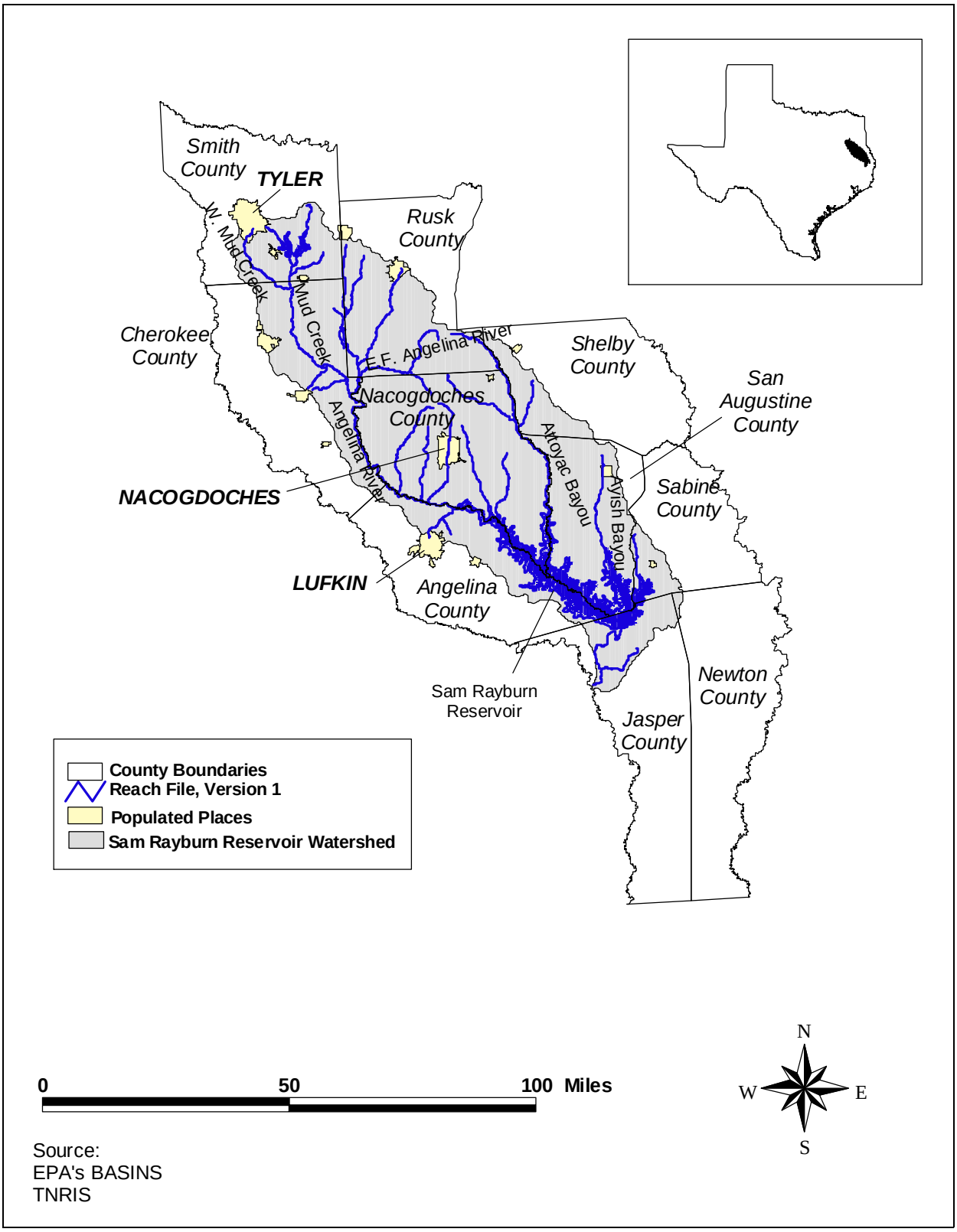

Figure 1-1. Location of the Sam Rayburn Reservoir Watershed

Table 1-1. 2000 and Draft 2002 Section 303(d) Listing Information for Sam Rayburn Reservoir Watershed

Waterbody	Segment ID	Waterbody Classification[a]	Designated Uses	Parameters of Concern on the 2000 303(d) List	Parameters of Concern on the Draft 2002 303(d) List
Sam Rayburn Reservoir	0610	Classified	• Aquatic Life • Contact Recreation • General Use • Fish Consumption • Public Water Supply	• Depressed dissolved oxygen • Aluminum (acute) • Low and high pH	• Depressed dissolved oxygen • Aluminum in water
Ayish Bayou	0610A	Unclassified	• Aquatic Life • Contact Recreation • Fish Consumption	• Bacteria	• Bacteria
Angelina River above Sam Rayburn Reservoir	0611	Classified	• Aquatic Life • Contact Recreation • General Use • Fish Consumption • Public Water Supply	• Bacteria	• Bacteria
East Fork Angelina River	0611A	Unclassified	• Aquatic Life • Contact Recreation • Fish Consumption	• Lead in water	• Bacteria
La Nana Bayou	0611B	Unclassified	• Aquatic Life • Contact Recreation • Fish Consumption	• Bacteria	• Bacteria
Mud Creek	0611C	Unclassified	• Aquatic Life • Contact Recreation • Fish Consumption	• Bacteria	• Bacteria
Attoyac Bayou	0612	Classified	• Aquatic Life • Contact Recreation • General Use • Fish Consumption • Public Water Supply	• Cadmium (chronic) • Lead (chronic)	-
Waffelow Creek	0612B	Unclassified	• Aquatic Life • Contact Recreation • Fish Consumption	• Bacteria	• Bacteria
Angelina River/Sam Rayburn Reservoir	0615	Classified	• Aquatic Life • Contact Recreation • General Use • Fish Consumption • Public Water Supply	-	• Depressed dissolved oxygen

[a]Classified waterbodies are all waterbodies listed in Appendix A or D of §307.10 of the Texas Administrative Code. Unclassified waterbodies are those not specifically listed.

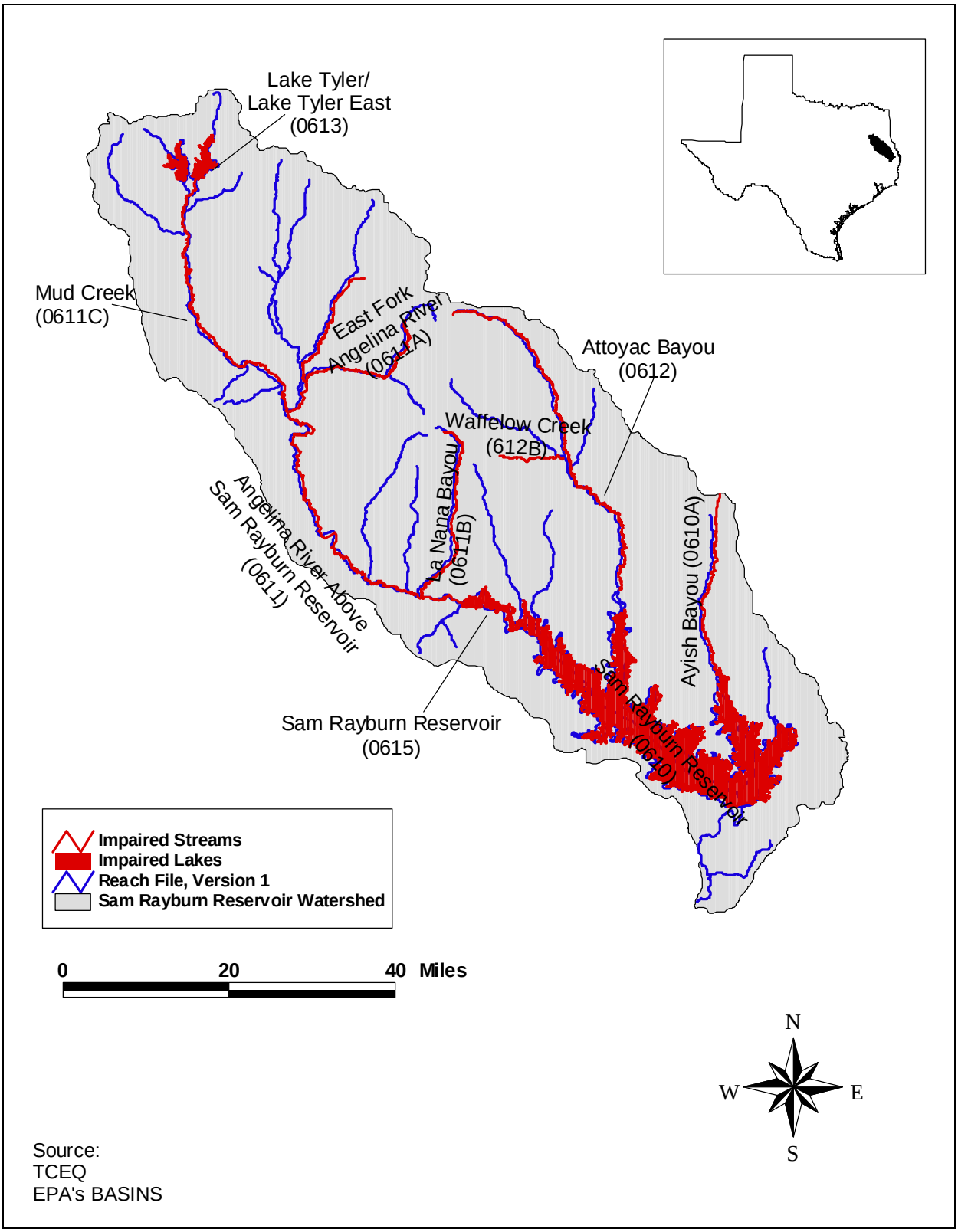

Figure 1-2. Location of the Impaired Waterbodies in the Sam Rayburn Reservoir Watershed

1.3 TCEQ Water Quality Standards

The TCEQ's Texas Surface Water Quality Standards establish numeric and narrative goals for water quality. They also provide a basis on which TCEQ regulatory programs can establish reasonable methods to implement and attain the state's goals for water quality (TCEQ 2003). These standards are codified in the Texas Administrative Code (TAC), Title 30, Chapter 307 (TCEQ 2000).

On July 26, 2000 the Texas Natural resource Conservation Commission (TNRCC), now TCEQ, adopted proposed amendments to the state's existing surface water quality standards, as codified by rule in the TAC, Title 30, Chapter 307. The U.S. Environmental Protection Agency (EPA) is reviewing the final rule in consultation with the U.S. Fish and Wildlife Service. Therefore, the water quality criteria used in this study have not yet been approved by EPA but are expected to be approved in the near future.

Table 1-2 presents the water quality criteria for segments 0610, 0611, 0612, 0613, and 0615 in the Sam Rayburn Reservoir watershed (TCEQ 2000).

Several of the Texas aquatic life water quality criteria for metals are based on total hardness as $CaCO_3$ in milligrams per liter. Individual segment values for hardness are used when there are sufficient data. The TCEQ has derived 15th percentile hardness values for many of the state's classified waterbodies for use in determining conservative metals criteria for a given stream segment. Table 1-3 presents the site-specific hardness values and equations for determining metals criteria for the segments in the Sam Rayburn reservoir watershed. Table 1-4 lists the values for the metals criteria calculated using the equations and hardness values presented in Table 1-3 for segments 0610, 0611, 0612, 0613, and 0615. The remaining applicable criteria for metals, including non-hardness-based criteria for metals and dioxin, are presented in Table 1-5.

Table 1-2. Site-specific Water Quality Criteria for the Sam Rayburn Reservoir Watershed

Parameter	Segment ID				
	0610	0611	0612	0613	0615
Cl^{-1} (mg/L) [a,b]	100	125	75	50	150
$SO4^{-2}$ (mg/L) [a,b]	100	50	50	50	100
TDS (mg/L) [a,b]	400	250	50	50	500
DO (mg/L) 24 hour average [c,d]	5.0	5.0	5.0	5.0	5.0
DO (mg/L) 24 hour minimum [c]	3.0	3.0	3.0	3.0	3.0
DO (mg/L) grab minimum [c]	3.0	3.0	3.0	3.0	3.0
pH range [c]	6.0—8.5	6.0—8.5	6.0—8.5	6.5—9.0	6.5—9.0
Fecal coliform bacteria #/100ml [a,e]	200/400	200/400	200/400	200/400	200/400
E. coli #/100ml [1,f]	126/394	126/394	126/394	126394	126/394
Temperature (°F; °C) [a]	93; 33.9	90; 32.2	90; 32.2	93; 33.9	93; 33.9

[a] Surface measurements typically collected at a depth of 1 foot from the water surface (TNRCC 2002).
[b] Chloride, sulfate, and total dissolved solids criteria represent annual averages of all values that were collected when streamflow equaled or exceeded the 7-day, 2-year low-flow value established for each segment. Because of infrequent monitoring and the absence of stream flow information for many sites, all of the chloride, sulfate, and TDS values measured during the 5-year period (10-sample minimum) are averaged for all sites within the waterbody and compared to the criterion for each parameter (TNRCC 2002).
[c] Dissolved oxygen and pH criteria apply to the entire mixed water column, or only to measurements made in the mixed surface layer if the water column is stratified. For reservoirs, the mixed surface layer is defined as the portion of the water column from the surface to the depth at which water temperature decreases by greater than 0.5°C (TNRCC 2002).

[d] The dissolved oxygen 24-hour average is based on a 4-sample minimum (TNRCC 2002).
[e] 200 counts/100mL is the geometric mean criterion for fecal coliform bacteria. The fecal coliform bacteria data in this study were compared to the instantaneous criterion of 400 counts/100mL.
[f] 126 counts/100mL is the geometric mean criterion for *E. coli* bacteria. The *E. Coli* bacteria data in this study were compared to the instantaneous criterion of 394 counts/100mL.

Table 1-3. Metals Criteria Equations and Hardness Values

Metals (µg/L)	Equations for Acute Criteria[a]	Equations for Chronic Criteria[a]	Total Hardness as $CaCO_3$ (mg/L)[2] for Each Segment				
			0610	0611	0612	0613	0615
Copper (diss)	$0.960we^{(0.9422(\ln(hardness))-1.3844)}$	$0.960we^{(0.8545(\ln(hardness))-1.386)}$	29.8	30.0	28.0	26.0	29.8
Lead (diss)	$0.889we^{(1.273(\ln(hardness))-1.460)}$	$0.792we^{(1.273(\ln(hardness))-4.705)}$					
Zinc (diss)	$0.978we^{(0.8473(\ln(hardness))+0.8604)}$	$0.986we^{(0.8473(\ln(hardness))+0.7614)}$					

[a]w in the equations indicates that a criterion is multiplied by a water-effects ratio to incorporate the effects of local water chemistry on toxicity. The water-effects ratio is equal to 1 except where sufficient data are available to establish a site-specific water-effects ratio. There are no site-specific water-effects ratios for the above metals in the Sam Rayburn Reservoir watershed. The number preceding the w in the freshwater criterion equation is an EPA conversion factor used to convert the total recoverable criterion to a dissolved criterion.
Source: TCEQ 2003.

Table 1-4. Site-specific Metals Criteria Based on Hardness as $CaCo_3$ (mg/L)

Metals	Segment ID	Freshwater Acute Criteria (mg/L)	Freshwater Chronic Criteria (mg/L)
Copper (dissolved)	0610	5.9	4.4
	0611	5.9	4.4
	0612	5.6	4.1
	0613	5.2	3.9
	0615	5.9	4.4
Lead (dissolved)	0610	15.5	0.5
	0611	15.7	0.5
	0612	14.4	0.5
	0613	13.1	0.5
	0615	15.5	0.5
Zinc (dissolved)	0610	41.0	37.5
	0611	41.2	37.7
	0612	38.9	35.5
	0613	36.5	33.4
	0615	41.0	37.5

Table 1-5. Texas Water Quality Criteria for Metals and Dioxins in Freshwater

Parameters[a]	Applicable to All Segments		
	Acute	**Chronic**	**Human Health[b]**
Aluminum (dissolved) (µg/L)	991(w)	—	—
Arsenic (dissolved) (µg/L)	360(w)	190(w)	50
Copper (dissolved) [a] (µg/L)	See Table 1-4	See Table 1-4	—
Lead (dissolved)[a] (µg/L)	See Table 1-4	See Table 1-4	4.98
Zinc (dissolved) [a] (µg/L)	See Table 1-4	See Table 1-4	—
Selenium (total) (µg/L)	20	5	50
Dioxins (µg/L)	-—	—	0.000000134

[a] For toxic substances in water, individual surface grab samples or surface-to-bottom composite samples are evaluated (TNRCC 2002).
[b]Human health protection criteria for water and fish ingestion.
(w) indicates that a criterion is multiplied by a water-effects ratio to incorporate the effects of local water chemistry on toxicity. The water-effects ratio is equal to 1 except where sufficient data are available to establish a site-specific water-effects ratio. A water effects ratio (WER) of 8.39 has been approved by the EPA for the mixing zone for the discharge from Abitibi Consolidated. The WER is being reviewed by the TPWD at this time. The Water Quality Standards group of TCEQ is determining if a WER for the reservoir is appropriate.

The state of Texas currently has no numerical criteria for nutrients in the Texas Surface Water Quality Standards. Nutrient controls, however, do exist in the form of narrative criteria, watershed rules, and antidegradation considerations. The TCEQ screens phosphorus, nitrogen, and chlorophyll a water quality monitoring data as a preliminary indication of areas of possible concern for the 303(d) listings of impaired waterbodies.

EPA has indicated that states must develop nutrient criteria and begin incorporating them into their water quality standards by the end of 2004. Therefore, the TCEQ staff are in the process of developing and evaluating criteria to address nutrients and eutrophication, as well as complementary approaches to control nutrients.

In the absence of numerical criteria, nutrient screening levels and reference conditions were used to compare to the water quality data available for the Sam Rayburn Reservoir watershed. Table 1-6 presents the nutrient screening levels provided in TCEQ's *Guidance for Assessing Texas Surface and Finished Drinking Water Quality Data* (2002) as well as EPA's reference conditions (USEPA 2000).

Table 1-6. Texas Nutrient Screening Levels and EPA Nutrient Reference Criteria

EPA Reference Criteria[a]			TCEQ Screening Levels	
Parameter	**Lake & Reservoir**	**Stream**	**Lake & Reservoir**	**Stream**
TKN (mg/L)	0.459	0.44	—	—
NO_2+NO_3 (mg/L)	0.033	0.067	0.32	2.76
TN calculated (mg/L)	0.492	0.507	—	—
TP (µg/L)	32.5	50	180	800
Secchi depth (meters)	1.1	—	—	—
Chlorophyll a (µg/L), spectrophotometric	2.834	0.566	21.4	11.6
Ammonia, Total (mg/L)	—	—	0.106	0.17
Ortho P (mg/L)	—	—	0.05	0.5

[a] For ecoregion IX, subregion 35 (Pineywoods of Texas)

EPA's recommended criteria for nutrients were developed to reduce and prevent eutrophocation on a national scale (USEPA 2002). Criteria are recommended for total phosphorus, total nitrogen, chlorophyll a, and some form of water clarity (e.g., Secchi depth). This information is intended to be used as a starting point for states to develop more refined, site-specific nutrient criteria. The EPA reference conditions for nutrients are the result of monitoring data from several reservoirs throughout Texas used to develop generic reservoir conditions considered to be representative of a healthy waterbody. The nutrient references are 25th percentile values for all seasons based on minimally affected surface waters for ecoregion IX, subregion 35 (Pineywoods of Texas). In general, the values EPA put forth are guideline values that the Agency believes (based on its data set) are protective of aquatic ecosystems, in that they are representative of minimally affected waters.

Note that the Texas nutrient screening levels and EPA's reference conditions are not adopted water quality standards; they are only benchmark criteria used to indicate potential pollutant concerns.

The remainder of this Historical Data Review presents a summary and analysis of all pertinent water quality data collected in the watershed since 1990, a source assessment of point and nonpoint sources of pollutants in the watershed, and the selection of a model and modeling approach potentially to be used in developing TMDLs for the Sam Rayburn Reservoir.

2.0 Data Inventory

2.1 Geographic and Monitoring Data

A wide range of data and information were reviewed for inclusion in the Historical Data Review for Sam Rayburn Reservoir. The Data Review summarizes existing data available to characterize the 303(d)-listed Sam Rayburn Reservoir and its contributing watershed and identifies recommended data sets to support potential TMDL development. Readily available data and information for the watershed were identified and in most situations compiled, including data related to water quality, point sources, land use and land cover, land characteristics, meteorology, and flow. All of these data were used to characterize the watershed and the potential pollutant sources. The information compiled in Table 2-1 was used to support the development of an Historical Data Review and comparison of current waterbody conditions to the applicable water quality criteria.

Table 2-1 is composed geographic or locational information, monitoring data, and land practices and activities.

Table 2-1. Inventory of data and information used for the source assessment of the watershed

Data Category	Description	Data Source(s)
Geographic or Locational Information	Land Use Coverage	• USGS Multi-Resolution Land Chracteristics
	Reservoir boundary and stream network	• EPA Better Assessment Science Integrating point and Nonpoint Sources (BASINS) Reach File coverages (RF1, RF3) • USGS National Hydrography Dataset (NHD)
	Weather Information	• National Climatic Data Center (NOAA)
	County boundaries, cities/towns, populated places	• EPA BASINS • Texas Natural Resources Information System (TNRIS)
	Soils	• County soil surveys for Smith, Cherokee, Rusk, Shelby, Nacogdoches, Angelina, San Augustine, Sabine, Newton, and Jasper Counties. • USGS STATSGO (entire state) • Physiographic Map of Texas
	Watershed boundaries	• Angelina and Neches River Authority (ANRA) • USGS Hydrologic Unit Boundaries (8-digit)
	Topographic relief and elevation data	• USGS 7.5 minute Topos • USGS Digital Elevation Models (DEM)

Data Category	Description	Data Source(s)
Geographic or Locational Information	Dam locations	• EPA BASINS
	Hazardous waste sites	• ANRA
	CAFOs	• ANRA
	Septic/Sewer spatial coverages	• ANRA
Monitoring Data	303(d) Listed Waters	• TCEQ
	Water Quality Monitoring Data	• TCEQ's TRACS • EPA's STORET • ANRA SWQM database
	Flow Monitoring Data	• USGS
	Biomonitoring and habitat data	• TCEQ's TRACS
	Reservoir physical data and water surface levels	• U.S. Army Corps of Engineers
	Stream channel data (for upstream tributaries)	• EPA BASINS Reach File coverages (RF1 & RF3) • USGS NHD
	Septic systems and illicit discharges (lake proper and upstream watershed)	• ANRA OSSF Database of permitted systems within 2,000 feet of Sam Rayburn Reservoir • U.S. Census
	TPDES permitted facilities	• TCEQ database • EPA STORET
Land Practices and Activities	Livestock	• USDA-NRCS Agricultural Census
	Major crops, rotation, management	• USDA-NRCS Agricultural Census
	Timber practices	• U.S. Forest Service • Texas State Soil and Water Conservation Board (TSSWCB)

2.2 Additional Reports and Information

This section contains a list of currently available reports with information pertaining to the Sam Rayburn Reservoir or the Angelina River watershed. These reports were used to help characterize the reservoir, its contributing watershed, and potential impairments to the waterbody.

Adler, P.M. 1972. A Study of Eutrophication in Upper Sam Rayburn Reservoir. M.S. Thesis, Stephen F. Austin State University, Nacogdoches, Texas.

Angelina & Neches River Authority, USGS, and University of Texas at Austin. (No date). Water Quality Assessment Protocol for Texas River Basins: A Case Study on the Upper Neches River

Basin Study Area for the Clean Rivers Program-Book I Report.

Angelina & Neches River Authority, USGS, and University of Texas at Austin. (No date). Water Quality Assessment Protocol for Texas River Basins: A Case Study on the Upper Neches River Basin Study Area for the Clean Rivers Program-Book II Appendices.

Angelina & Neches River Authority, Upper Neches River Municipal Water Authority, Lower Neches Valley Authority. 1992. Consolidated Executive Summary: Regional Assessment of Water Quality Neches River Basin.

Angelina & Neches River Authority. 1994. Regional Assessment of Water Quality, Neches River Basin, Volume I, Upper Neches River Basin Study Area.

ANRA Regional Assessment of Water Quality, 1996

ANRA and SFASU. 1996. Poultry Litter Land Application Rate Study (PLLARS). (copies at ANRA)

ANRA Upper Neches Basin Summary Report, 1999

Dion, E.O. 1988. A comparison of the benthic macroinvertebrate communities of the main tributaries of Sam Rayburn Reservoir; the Angelina and Attoyac Rivers, Texas. M.S. Thesis, Stephen F.Austin State University, Nacogdoches, Texas.

EA Engineering, Science, and Technology. 1996. Site Specific Dissolved Oxygen Criteria Development for the Riverine Reach of Segment 0610. Prepared for Champion International Corporation Lufkin Mill, Lufkin Texas.

El-Hage, A. and D.W. Moulton. 1998. Evaluation of Selected Natural Resources in Angelina, Cherokee, Gregg, Nacogdoches, Rusk, and Smith Counties, Texas.

Texas Parks and Wildlife Department. 2000. 1999 Report of Sam Rayburn Task Force.

TNRCC Region 10 staff. Sediment Contaminants Study. Available from TNRCC SWQM in Austin.

TNRCC Region 10 Staff. 1998-2000. Aquatic Life Use Determinations conducted by TNRCC Region 10 staff.

TNRCC. 1998. 1998 State of Texas Reservoir Water Quality Assessment.

Tischler and Kocurek. 1996. Development of a site-specific water quality standard for Aluminum. Prepared for Champion International Paper, Lufkin, Texas.

U.S. Army Corps of Engineers. 1998. Report on Water Quality - Sam Rayburn Reservoir, Angelina River, Neches River Basin, Texas.

U.S. Army Corps of Engineers, Ft. Worth District. 1998. Report on Water Quality, Sam Rayburn Reservoir.

U.S. EPA. Review of Use Attainability Analysis for Segment 0615

U.S. EPA, Texas Water Quality Board, and Texas National Guard. 1977. National Eutrophication Survey - Report on Sam Rayburn Reservoir, Angelina, Jasper, Nacogdoches, Sabine, and San Augustine Counties, Texas, Region VI, Working Paper # 657. 1977

Correspondence letters between Region 6 and TNRCC Regarding review of reclassification of Angelina River Segment 615

3.0 Watershed Characteristics

3.1 General Information

Sam Rayburn Reservoir (formerly McGee Reservoir) is in eastern Texas, on the Angelina River within the central portion of the Neches River Basin. The reservoir covers portions of Angelina, Jasper, Nacogdoches, San Augustine, and Sabine Counties, and the Angelina River, Attoyac Bayou, and Ayish Bayou are its major tributaries. The U. S. Army Corps of Engineers built the reservoir and continues to own and operate it. The primary goals of the reservoir are control of floodwaters, generation of hydroelectric power, as well as water for municipal, industrial, agricultural, and recreational uses. Construction of the reservoir began in September 1956. Impoundment began on March 29, 1965, creating a conservation pool of 164.4 feet above mean sea level (msl), impounding approximately 114,500 surface acres, and creating 750 miles of shoreline. Sam Rayburn Reservoir is 43 miles long. It has a mean depth of 20 feet and a maximum depth of approximately 90 feet, with annual average water level fluctuations of 8 feet. The reservoir is almost entirely surrounded by the Angelina National Forest and to a lesser extent by the Sabine National Forest, with only a small portion of the northwestern Angelina River arm, eastern Ayish Bayou arm, and southeastern basin shorelines outside National Forest lands. Sam Rayburn Reservoir lies within TCEQ river segments 0610 (Sam Rayburn Reservoir) and 0615 (Angelina River/Sam Rayburn Reservoir) of the Angelina River watershed.

The upper portion of the Sam Rayburn Reservoir watershed lies entirely within Smith, Cherokee, Rusk, Nacogdoches, Shelby, San Augustine, Angelina, Jasper, Sabine and Newton Counties. The watershed drains approximately 886,400 acres (1,385 square miles). Cities in the Sam Rayburn Reservoir watershed with populations greater than 10,000 are Lufkin, Nacogdoches, Jacksonville, Henderson, and Tyler. Numerous less-populated cities and townships are also part of the watershed. TCEQ river segments 0610 (Sam Rayburn Reservoir), 0611 (Angelina River above Sam Rayburn Reservoir), 0612 (Attoyac Bayou), 0613 (Lake Tyler/Lake Tyler East), and 0615 (Angelina River/Sam Rayburn Reservoir) are the major classified segments within the Sam Rayburn Reservoir watershed (refer to Figure 1-1). Unclassified river segments 0611A (East Fork Angelina River), 0611B (La Nana Bayou), 0611C (Mud Creek), 0611D (West Mud Creek), 0611H (Ragsdale Creek), 0611Q (Lake Nacogdoches), 0615A (Paper Mill Creek), 0610A (Ayish Bayou), 0612B (Waffelow Creek) and 0612C (Pinkston Reservoir) are located within the watershed. Each river segment is discussed further below, beginning at the top of the watershed.

> *River Segment 0613: Lake Tyler/Lake Tyler East*, from Whitehouse Dam and Mud Creek Dam in Smith County up to the normal pool elevation of 375.38 feet, impounding portions of Prairie Creek and Mud Creek. Segment 0613 watershed lies entirely within Smith County. The City of Tyler has owned Lake Tyler since its deliberate impoundment in 1949 (by Whitehouse Dam) as a water supply for municipal, domestic, and industrial use. The lake has a capacity of 43,400 acre-feet and a surface area of 2,450 acres at 375.5 feet above msl. In 1967 Mud Creek Dam was completed, impounding Mud Creek and forming Lake Tyler East, with a surface area of 2,530 acres at 375.4 feet above msl. In 1968 the two lakes were joined by a canal, and they have since been regarded as Lake Tyler.

River Segment 0611: Angelina River above Sam Rayburn Reservoir, from the aqueduct crossing 0.6 mile upstream of the confluence of Paper Mill Creek in Angelina/Nacogdoches County to the confluence of Barnhardt Creek and Mill Creek at FM 225 in Rusk County. Unclassified river segments 0611A (East Fork Angelina River), 0611B (La Nana Bayou), 0611C (Mud Creek), 0611D (West Mud Creek), 0611H (Ragsdale Creek), and 0611Q (Lake Nacogdoches) are within the segment 0611 watershed. The Angelina River is formed by the junction of Barnhardt and Shawnee Creeks 3 miles northwest of Laneville in Rusk County. The river flows southeast for around 110 miles, forming the boundaries between Cherokee and Nacogdoches Counties, Angelina and Nacogdoches Counties, and Angelina and San Augustine Counties. The headwaters of the East Fork of the Angelina River at at the junction of Ham Creek, Double Tree Branch, and several other small streams, about 3 miles northwest of Mount Enterprise in southern Rusk County. It runs southwest for 19 miles to its mouth on the Angelina River, near the Nacogdoches county line 2 miles southeast of Reklaw.

The Mud Creek headwaters are just west of Douglas, northeast of the Chapel Hill oilfield, and northeast of Hope Pond in eastern Smith County, flowing southeast for 37 miles to its mouth on the Angelina River, 3 miles southwest of Sacul at the Cherokee/Nacogdoches county line. In Smith County impoundment of Mud Creek forms the eastern half of Lake Tyler (a.k.a. East Lake Tyler). West Mud Creek headwaters are in southeastern Tyler just west of Farm Road 2964 in central Smith County and runs southeast for 21 miles to its mouth on Mud Creek, 4 miles northeast of Mixon in Cherokee County. Lake Nacogdoches is on Bayou Loco, a tributary of the Angelina River, 10 miles west of Nacogdoches in western Nacogdoches County. Impoundment of Bayou Loco (by the Bayou Loco Dam) was completed in 1977. It created Lake Nacogdoches which has an average surface area of 42,318 acre-feet. La Nana Bayou originates approximately 8 miles north of Nacogdoches in central Nacogdoches County and flows south, through the city of Nacogdoches, for approximately 25 miles to its mouth at the Angelina River south of Climax.

River Segment 0615 Angelina River/Sam Rayburn Reservoir, originally part of Segment 0610; the riverine portion of Sam Rayburn Reservoir from a point 3.5 miles upstream of Marion's Ferry to the aqueduct crossing 0.6 mile upstream of the confluence of Paper Mill Creek. Unclassified segment 0615A, Paper Mill Creek flows, northeast from the city of Lufkin to its mouth on the Angelina River.

River Segment 0610: Sam Rayburn Reservoir, from Sam Rayburn Dam in Jasper County to a point 3.5 miles upstream of Marion's Ferry on the Angelina River Arm in Angelina/Nacogdoches County and to a point 2.4 miles downstream of Curry Creek on the Attoyac Bayou Arm in Nacogdoches/San Augustine County, up to normal pool elevation of 164 feet at msl. Unclassified segment 0610A (Ayish Bayou) is within the segment 0610 watershed. The headwaters of Ayish Bayou are about 7 miles north of San Augustine in northern San Augustine County, near the Shelby county line. Before the impoundment of the Angelina River and formation of Sam Rayburn Reservoir, Ayish Bayou flowed southeast for approximately 47 miles.

River Segment 0612: Attoyac Bayou, from a point 2.4 miles downstream of Curry Creek in Nacogdoches and San Augustine Counties to FM 95 in Rusk County. The Attoyac Bayou watershed also includes unclassified segments 0612B (Waffelow Creek) and 0612C (Pinkston Reservoir), and it lies within Rusk, Shelby, Nacogdoches, and San Augustine Counties. The headwaters of Attoyac Bayou are one mile south of Minden School in southeastern Rusk County and flows southeast for sixty miles to its mouth at the Sam Rayburn Reservoir in Nacogdoches County forming county boundaries between Rusk and Shelby, Nacogdoches and Shelby, and Nacogdoches and San Augustine Counties. Waffelow Creek originates about 3 miles east of Appleby in central Nacogdoches County, and flows east for approximately 14 miles until its confluence with Attoyac Bayou. Pinkston Reservoir is located in southwestern Shelby County, less than one mile north of Aiken on Hwy 7.

3.2 Geology

The Sam Rayburn Reservoir watershed is wholly located within the Interior Coastal Plains physiographic subprovince of the Gulf Coastal Plains province according to the Physiographic Map of Texas (Bureau of Economic Geology 1996). The Interior Coastal Plains comprise alternating belts of resistant uncemented sand among weaker shales that erode into long, sandy ridges. At least two major down-to-the coast fault systems trend nearly parallel to the coastline. Clusters of faults also concentrate over salt domes in this region. Much of the watershed is underlain by the Eocene age Claiborne Group, including the Yegua Formation, with the exception of the southern boundaries of the watershed adjacent to Sam Rayburn Dam, which is underlain by the Oligocene-age Catahoula Formation.

3.3 Soils

The soils adjacent to the Sam Rayburn Reservoir are predominantly sand, clay and sandy clays. Alluvial soils in the reservoir area occur in narrow strips along numerous streams. Predominant upland soils are the Lufkin fine sandy loam and Susquehanna group. Bottom lands are characterized by Bibb fine sandy loam, Bibb clay, and Bibb clay loam. Soils have been developed mostly from beds of non-calcareous clay, sandy clay, clay shale, or sand. The developed soil characteristics reflect the influences of a warm moist climate.

3.4 Climate

Climate over the entire watershed is generally mild with moderate temperatures. Temperatures at or below freezing and frozen precipitation are very rare in the southern parts of the watershed, but occur occasionally in the northwestern parts. A low of -4 °F (-20 °C) and a high of 110 °F (43 °C) were recorded in Nacogdoches in 1930 and 1954, respectively. The average annual temperature recorded at Sam Rayburn Dam from 1966 to 1996 is 65.4 °F (18.5 °C). Winds prevail from the south during the spring, summer, and early fall months, with northerly winds prevailing during winter months. The observed average annual rainfall at Sam Rayburn Dam was 47.58 inches from 1968 to 2000. Average annual rainfall observed at new Summerfield from 1962 to 1996 was 37.58 inches, whereas annual rainfall at Swan was 39.33 inches for 1957 to 1996.

Several meteorological stations in and around the Sam Rayburn Reservoir watershed have the potential to be used to represent weather conditions in the area for any future modeling efforts. There are three stations in the watershed itself and four nearby stations outside the watershed's boundaries. The Nacogdoches (TX6177), New Summerfield 2W (TX6335), and Sam Rayburn Dam (TX7936) precipitation stations are inside the watershed in Nacogdoches, Cherokee, and Jasper Counties, respectively. These stations and the four stations outside the watershed boundaries contain hourly precipitation data. The four nearby stations outside the watershed are Longview 11 SE (TX5348), Lufkin Angelina County Airport (TX5424), Palestine 2 NE (TX6757), and Swan 4NW (TX8778). Three Surface Airways stations just outside the watershed contain additional meteorological data, including temperature and evapotransipiration observations. These stations are Longview WSMO (03951), Tyler Pounds Field (13972), and Lufkin Angelina County Airport (93987). Table 3-1 presents all of the stations in and near the Sam Rayburn Reservoir watershed, as well as the percent coverage for each station. The percent coverage is the percentage of days that each station has precipitation data for the period of record at the station. All of the hourly precipitation stations have data through December 2000. Figure 3-1 shows the locations of each of the meteorological stations.

Table 3-1. Meteorological Stations in or near the Sam Rayburn Reservoir Watershed

Station ID	Station Name	County	Percent Coverage
Hourly Precipitation Stations			
TX6177	Nacogdoches	Nacogdoches	90%
TX6335	New Summerfield 2W	Cherokee	92%
TX7936	Sam Rayburn Dam	Jasper	91%
TX5348	Longview 11 SE	Rusk	91%
TX5424	Lufkin Angelina County Airport	Angelina	100%
TX6757	Palestine 2 NE	Anderson	94%
TX8778	Swann 4NW	Smith	91%
Surface Airways Stations			
03951	Longview WSMO	Rusk	N/A
13972	Tyler Pounds Field	Smith	N/A
93987	Lufkin Angelina County Airport	Angelina	N/A

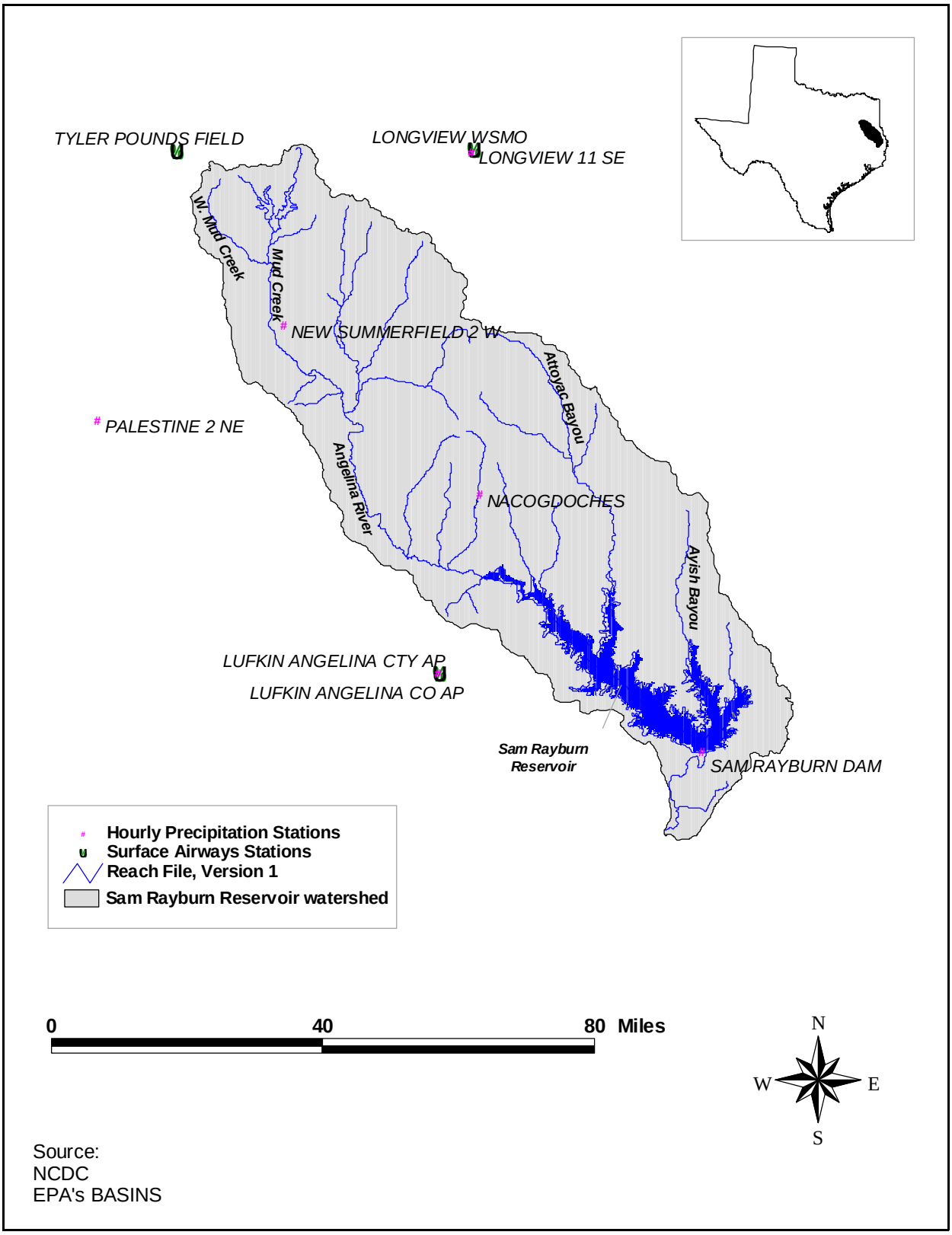

Figure 3-1. Weather Stations in and near the Sam Rayburn Reservoir Watershed.

Figures 3-2 and 3-3 show the annual and monthly precipitation at the Sam Rayburn Dam (TX7936) precipitation station. As seen from figure 3-2 the average annual rainfall for the last 33 years was 47.58 inches. The mean monthly rainfall for the last 10 years was 4.2 inches (Figure 3-3). In general, wet springs, dry summers, and wet falls and winters are typical.

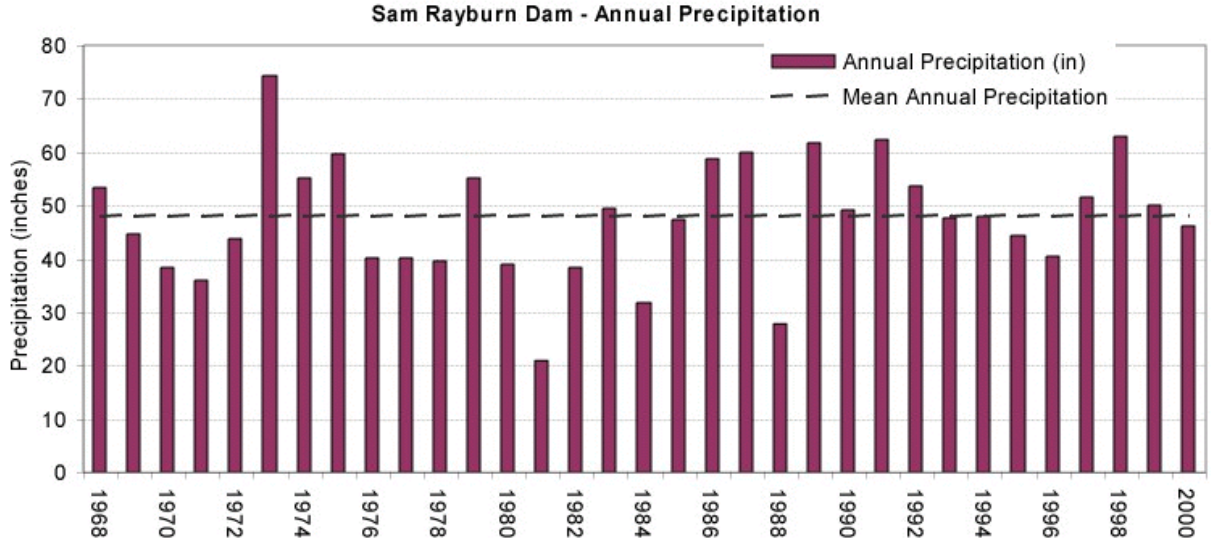

Figure 3-2. Annual Precipitation at Sam Rayburn Dam (TX7936)

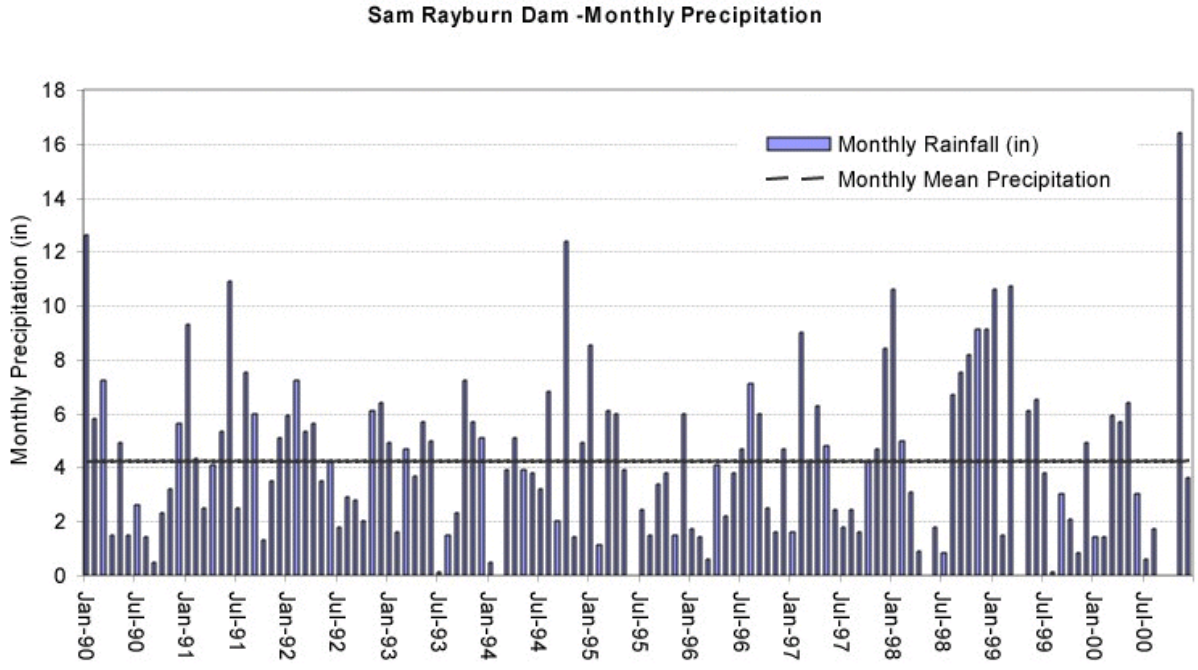

Figure 3-3. Monthly Precipitation Averages at Sam Rayburn Dam (TX7936)

3.5 Landuse

Multi Resolution Land Characteristics (MRLC 1993) data were used to assess the variety of landuse/land cover in the Angelina River watershed which contains Sam Rayburn Reservoir. These data were segregated by county to identify any major differences in land use types in the nine-county region that makes up the watershed. Table 3-2 describes the land use coverages within the watershed. Similar land use types were grouped for analysis purposes. For example, mixed forest, deciduous forest, and conifer forest all have similar physical properties such as infiltration and runoff rates so they were included in one "forest" group. Table A-1 in the Appendix at the end of Section 3.0 describes the landuse coverages segregated by county. Following are some of the highlights from these data as they potentially relate to the overall watershed characteristics and effects on water quality in Sam Rayburn Reservoir.

Table 3-2. Landuse as Determined by MRLC (1992) for the Sam Rayburn Reservoir Watershed

			Grouped Landuses			
Landuse Type	**Areac (acres)**	**Area (mi^2)**	**Landuse**	**Area (acres)**	**Area (mi^2)**	**Percent of Total Area (%)**
Open water	122,521	191	Open water	122,521	191	5
Low-intensity residential	15,869	25	Low-intensity residential	15,869	25	1
High-intensity residential	4,772	8	High-intensity residential	4,772	8	0
Commercial/industrial	19,198	30	Industrial/mining/transitional	80,585	126	4
Bare rock/sand/clay	2,187	3				
Quarries/strip mining	382	1				
Transitional	58,818	92				
Deciduous forest	496,927	777	Forest	1,354,089	2,116	59
Evergreen forest	339,680	531				
Mixed forest	517,483	809				
Grasslands	16	0	Grasslands/recreation	2,012	3	0
Urban recreation	1,996	3				
Pasture/hay	516,420	807	Pasture/hay	516,420	807	23
Row crops	31,616	49	Cropland	31,616	49	1
Woody wetlands	128,323	201	Wetlands	153,248	240	7
Emergent wetlands	24,924	39				
TOTAL AREA	2,281,131	3,564	TOTAL AREA	2,281,131	3,564	100

Nearly 60 percent of the watershed is forested, represented by approximately 1,354,000 acres, followed by pasture and hay production lands, represented by approximately 516,420 acres. Within the watershed as a whole, the various types of forested lands are similar in size with mixed forest making up the largest coverage (809 mi^2), followed by deciduous (777 mi^2) and evergreen (531 mi^2) forest. However, the Counties of Angelina, Jasper, Sabine, and San Augustine, which make up the southern and southeastern region of the watershed surrounding Sam Rayburn Reservoir, are dominated by forestlands (65%-71%), principally made up of evergreen forest followed by mixed forest. The northern and northwestern regions of the watershed represented by Cherokee, Rusk and Smith Counties have far greater acreages of pasture/hay production lands and croplands (33%-39%), with forested lands (45%-55%) dominated by deciduous forests. Similar distributions of cropland/pasture lands were found in the 1997 Census data, from the National Agricultural Statistics Service (NASS), and they are shown in Section 6. Forest

Inventory statistics (discussed in Section 6) indicate a larger amount of forested lands; however, these statistics are for the entire county and not limited by the watershed boundaries, which could account for the discrepancies in the numbers.

Approximately 122,520 acres are open waters within the watershed, representing 5 percent of the total coverage. Due in large part to Sam Rayburn Reservoir, Angelina (33,217 acres), Sabine (57,395 acres), and San Augustine (40,788 acres) Counties have the largest percentage of open water.

Wetlands account for 7 percent of the total land coverage within the watershed, comprising of 128,323 acres of woody wetlands and 24,924 acres of emergent wetlands. Among Counties the percentage of land coverage as wetlands is relatively even with as few as 14,808 acres (3.9%) in Sabine County and as much as 57,819 acres (9.4%) in Jasper County.

Both low-intensity and high-intensity residential make up a very small percentage (approximately 1%) of the total land coverage in the watershed. Smith and Angelina Counties are the only Counties with any appreciable acreage in residential use, 16,894 and 6,690 acres. Figure 3-2 presents the landuse coverage for the Sam Rayburn Reservoir watershed.

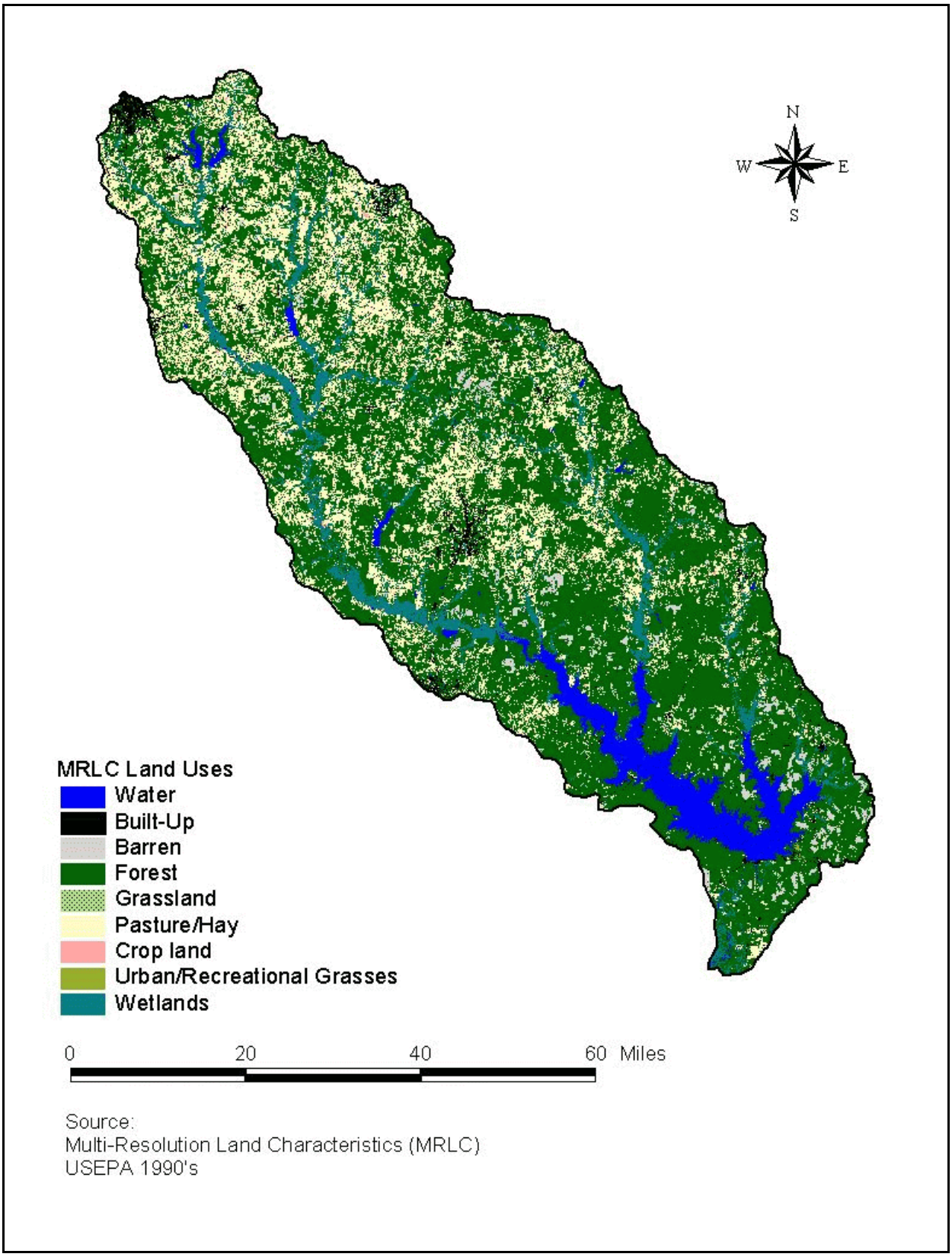

Figure 3-4. MRLC Landuse Coverage for the Sam Rayburn Reservoir Watershed.

3.6 Ecological Characterization

The Sam Rayburn Reservoir watershed lies entirely within the Austroriparian Biotic Province (Dice 1943; Blair 1950). In Texas the province comprises two vegetational regions, the long-leaf pine and the pine-oak forest regions (Tharp 1939). Longleaf pine (*Pinus palutris*) and loblolly pine (*Pinus taeda*) were dominant in much of the watershed, however, logging, silvicultural, and agricultural practices have led to a more monocultural distribution of loblolly pine with scattered young pine forest islands and emergent prairies. The pine-oak forest vegetational regions typical of the northern parts of the watershed are dominated by longleaf pine, loblolly pine, yellow pine, post oak (*Quercus stellata*), blackjack oak (*Quercus marilandica*), and red oak (*Quercus rubra*). Bottomland areas adjacent to perennial streams are dominated by complexes of sweetgum (*Liquidambar styraciflua*), water oak (*Quercus nigra*), magnolia (*Magnolia grandiflora*), tupelo (*Nyssa sylvatica*), and various other species of oaks, elms, and ashes. The construction of dams resulting in upstream flooding and the clearing of bottomlands for agricultural production have led to the loss of thousands of acres of historical bottomland hardwood forests.

El Hage and Moulton of the Texas Parks and Wildlife Department conducted an in-depth assessment of the ecological resources of a six-county region, which includes several of the Counties in the Angelina River watershed. Their findings compiled in *Evaluation of Selected Natural Resources in Angelina, Cherokee, Gregg, Nacogdoches, Rusk , and Smith Counties, Texas(El Hage and Moulton 1998)*. An excerpt from the Executive Summary of that document notes the following:

The study area contains three major types of bottomland hardwood forests. The most extensive type is the water oak-willow oak-blackgum association. Forested wetlands are the most threatened wetland type in the United States. These losses would require substantial mitigation. These wetlands, in conjunction with the large reservoirs in the study area, support a diverse fauna and flora consisting of wetland dependent, aquatic, semi-aquatic, and riparian species.

The study area rivers and streams have a variety of fish species. Two of those fish species are listed as state threatened species, the paddlefish and the creek chubsucker. Many species of migrating birds, waterfowl, wintering shorebirds, and neotropical stopover in the study area to rest and to feed along the river banks and creek bottoms. Of the 1,100 vertebrate species in Texas, at least 64 species of mammals, amphibians, and reptiles, that are either aquatic, semi-aquatic, or in some way wetland-dependent, are present in the study area.

Substantial amounts of surface water are available from the reservoirs of the area. The development of these reservoirs has caused substantial loss of habitat for wildlife and some native river fishes.

Texas Parks and Wildlife has defined several areas within the Angelina River Watershed as Unique habitats. Angelina River segment 0611 is listed by Texas Parks and Wildlife as an ecologically unique river and stream segment for its biological function as priority bottomland hardwood habitat, and habitat for the threatened (state-listed) paddlefish (*Polyodon spathula*). Alazan Bayou, a tributary of the Angelina River in Nacogdoches County, is listed by Texas Parks and Wildlife as an ecological unique river and stream segment for biological function as priority bottomland hardwood habitat.

A portion of Attoyac Bayou segment 0612 is the only known remaining population of the endemic triangle pigtoe freshwater mussel. Mud Creek in Cherokee County is listed by Texas Parks and Wildlife as an ecologically unique river and stream segments for its biological function as priority bottomland hardwood habitat and habitat for the perennial herb Neches River rose-mallow a candidate for federal endangered species listing.

Candidate, threatened, and endangered species of concern are found in Counties of the Angelina River Watershed. Table 3-3 presents relative data for habitat, known county distributions, and likely presence or absence of those species, considered as of this writing, to be state or federally listed/federal candidate threatened or endangered species for the Counties included in the Sam Rayburn Reservoir watershed. No species are specifically listed for the Reservoir, although the paddlefish is listed for Segment 0611 immediately adjacent to reservoir segment 0610.

Table 3-3. Potential Threatened and Endangered Species in the Sam Rayburn Reservoir Watershed[a]

Scientific Name	Common Name	Federal Status	State Status	County	Habitat	Presence Likely
Birds						
Falco peregrinus anatum	American peregrine falcon	DL	E	Cherokee, Jasper, Newton, Rusk, Sabine, and Smith	Meadows, mudflats, beaches, marshes, and lakes where birds are abundant[b]	No
Falco peregrinus tundrius	Arctic peregrine falcon	DL	T	Angelina, Cherokee, Jasper, Nacogdoches, Newton, Rusk, Sabine, San Augustine, Shelby, and Smith	Meadows, mudflats, beaches, marshes, and lakes where birds are abundant[b]	No
Haliaeetus leucocephalus	Bald eagle	LT-PDL	T	Angelina, Cherokee, Jasper, Nacogdoches, Newton, Rusk, Sabine, San Augustine, Shelby, and Smith	Quiet coastal areas, rivers or lakeshores with large trees[c]	Yes
Aimophila aestivalis	Bachman's sparrow		T	Angelina, Cherokee, Jasper, Nacogdoches, Newton, Rusk, Sabine, San Augustine, Shelby, and Smith	Open pine woods with scattered brushes or understory[a]	Yes
Mycteria americana	Wood storck		T	Angelina, Cherokee, Jasper, Nacogdoches, Newton, Rusk, Sabine, San Augustine, Shelby, and Smith	Mudflats and other wetlands, even those associated with forest[a]	Yes
Piccoides borealis	Red-cockaded woodpecker	LE	E	Angelina, Cherokee, Jasper, Nacogdoches, Newton, Rusk, Sabine, San Augustine, and Shelby	Old growth pine forest; prefers longleaf, shortleaf, and loblolly.	Yes
Elanoides forticatus	Swallow-tailed kite		T	Angelina, Cherokee, Jasper, Nacogdoches, Newton, Sabine, San Augustine, and Shelby	Lowland forest areas, especially swampy areas; marshes, along rivers, lakes, and ponds	Yes
Plegadis chihi	White-faced ibis		T	Jasper, Newton,and Sabine	Freshwater marshes, sloughs, and irrigated rice fields	Yes
Fishes						
Erimyzon oblongus	Creek chubsucker		T	Angelina, Cherokee, Jasper, Nacogdoches, Newton, Rusk, Sabine, San Augustine, Shelby, and Smith	Small rivers and creeks of various types; seldom impoundments; prefers headwaters, but seldom occurs in springs[a]	Yes
Cycleptus elongatus	Blue sucker		T	Jasper, Newton and Sabine	Channels and flowing pools with a moderate current	Yes

Polyodon spathula	Paddlefish		T	Angelina, Cherokee, Jasper, Nacogdoches, Newton, Rusk, Sabine, San Augustine, Shelby, and Smith	Large, free -flowing rivers with swiftly flowing waters; will frequent impoundments with access to spawning areas[d]	Yes
Mammals						
Ursus Americanus	Black bear	T/SA	T	Angelina, Cherokee, Jasper, Nacogdoches, Newton, Rusk, Sabine, San Augustine, Shelby, and Smith	Remote, less-accessible mountainous areas or nearly impenetrable thickets along watercourses.[f]	No
Ursus americanus luteolus	Lousiana black bear	LT	T	Angelina, Cherokee, Jasper, Nacogdoches, Newton, Rusk, Sabine, San Augustine, Shelby, and Smith	Remote bottomlands, floodplains and upland hardwoods. [e]	No
Corynorhinus rafinesquii	Rafinesque's big-eared bat		T	Angelina, Cherokee, Jasper, Nacogdoches, Newton, Rusk, Sabine, San Augustine, and Shelby.	Roosts in cavity trees of bottomland hardwoods, concrete culverts, and abandoned man-made structures	Yes
Canis rufus	Red wolf	LE	E	Extirpated	Extirpated	No
Reptiles						
Macroclemys temminckii	Alligator snapping turtle		T	Angelina, Cherokee, Jasper, Nacogdoches, Newton, Rusk, Sabine, San Augustine, Shelby, and Smith	Deep-water rivers, canals, lakes, and oxbows; also swamps, bayous, and ponds near deep running water; occasionally enters brackish waters.[a]	No
Crotalus horridus	Timber/canebrake rattlesnake		T	Angelina, Cherokee, Jasper, Nacogdoches, Newton, Rusk, Sabine, San Augustine, Shelby, and Smith	Swamps, floodplains, upland pine and deciduos woodlands, riparian zones, abandoned farmland; prefers dense ground cover.[a]	No
Pituophis ruthveni	Louisiana pine snake	C1	T	Angelina, Cherokee, Jasper, Nacogdoches, Newton, Rusk, Sabine, San Augustine, Shelby, and Smith	Mixed deciduous-longleaf pine woodlands	Yes
Cemophora coccinea copei	Northern scarlet snake		T	Jasper, Newton, and Sabine	Mixed hardwood scrub on sandy soils	Yes
Cemophora coccinea	Scarlet snake		T	Newton	Mixed hardwood scrub on sandy soils	No

Phrynosoma cornutum	Texas horned lizard		T	Angelina, Cherokee, Jasper, Nacogdoches, Newton, Rusk, Sabine, San Augustine, Shelby, and Smith	Arid to semiarid open country with sparse plant growth; must have some loose soil to bury themselves [g]	No
Plants						
Siprathes parskii	Navasota ladies'-tresses	LE	E	Jasper	Endemic; margins of and openings within post oak woodlands in sandy loams along intermittent tributaries of rivers	Yes
Leavenworthia texana	Texas golden glade cress		C1	Sabine, San Augustine	Vernal wet glades on Weches Formation ironstone outcrops	No
Hibiscus dasycalyx	Neches River rose-mallow		C1	Cherokee	Endemic; wet alluvial solis in swamps or open riparian woodlands	Yes
Lesquerella pallida	White bladderpod	LE	E	San Augustine	Seasonally wet, comparatively high pH sandy soils in natural openings or glades within pine/oak forests over Weches Formation ironside/glauconite	No

DL, PDL: Delisted, Proposed Delisted

LE, LT: Federally listed as Endangered/threatened

T/SA: Federally Threatened by Similarity of Appearance

C1: Federal Candidate, Category 1

E, T: State listed as Endangered/Threatened

[a] Based on the Texas Parks and Wildlife Department, Endangered Resources Branch, Special Species List, for Angelina, Cherokee, Jasper, Nacogdoches, Newton, Rusk, Sabine, San Augustine, Shelby, and Smith Counties.

[b] http://www.tpwd.state.tx.us/nature/endang/birds/peregrin.htm

[c] http://www.tpwd.state.tx.us/nature/birds/baldeagl.htm

[d] http://www.tpwd.state.tx.us/expltx/eft/nasa/species/paddlefish.htm

[e] http://www.tpwd.state.tx.us/nature/endang/animals/blakbear.htm

[f] http://www.nsrl.ttu.edu/tmot1/ursuamer.htm

[g] http://sevilleta.unm.edu/data/species/reptile/socorro/profile/texas-horned-lizard.html

APPENDIX 3A
MRLC Landuse Areas and Oercent Covsergae by County for the Sam Rayburn Reservoir Watershed

Table A-1. MRLC (1992) Landuse areas and percent coverages for the Sam Rayburn Reservoir watershed counties

	Area (acres) by County																	
County	**SMITH**	**%**	**RUSK**	**%**	**CHEROKEE**	**%**	**SHELBY**	**%**	**NACOGDOCHES**	**%**	**SAN AUGUSTINE**	**%**	**SABINE**	**%**	**ANGELINA**	**%**	**JASPER**	**%**
Open Water	11,782.2	2.5	8,105.4	1.4	7,299.9	1.1	23,463.9	4.4	20,929.3	3.3	40,788.4	10.7	57,395.7	15.3	33,217.0	6.1	19,629.4	3.2
Low-intensity residential	16,894.6	3.6	2,705.9	0.5	2,187.5	0.3	1,444.9	0.3	3,934.1	0.6	639.4	0.2	1,037.7	0.3	6,690.1	1.2	3,982.9	0.6
High-intensity residential	3,518.5	0.8	699.0	0.1	635.2	0.1	314.2	0.1	1,389.1	0.2	112.5	0.0	216.2	0.1	1,755.8	0.3	2,177.0	0.4
Commercial	9,899.9	2.1	6,309.8	1.1	5,077.5	0.8	2,844.0	0.5	4,651.6	0.7	1,954.2	0.5	1,757.6	0.5	4,626.5	0.8	6,427.9	1.0
Bare rock	1,823.6	0.4	1,104.2	0.2	667.0	0.1	300.7	0.1	371.8	0.1	51.2	0.0	31.8	0.0	166.6	0.0	788.2	0.1
Quarries	160.3	0.0	2,709.9	0.5	492.2	0.1	7.6	0.0	12.5	0.0	19.3	0.0	1.1	0.0	149.9	0.0	278.0	0.0
Transitional	1,845.2	0.4	5,978.4	1.0	16,434.9	2.4	9,489.1	1.8	16,592.1	2.6	12,238.6	3.2	15,853.6	4.2	13,394.3	2.5	31,117.1	5.0
Deciduous Forest	131,159.5	28.3	149,975.4	25.1	179,870.5	26.7	126,152.8	23.7	148,767.8	23.3	71,898.0	18.9	56,947.5	15.1	97,373.6	17.8	57,633.6	9.3
Evergreen Forest	17,767.1	3.8	40,007.8	6.7	39,176.3	5.8	74,512.0	14.0	77,483.8	12.1	99,618.3	26.2	117,550.6	31.2	137,773.9	25.2	178,551.0	28.9
Mixed Forest	61,418.5	13.3	122,293.3	20.5	150,617.0	22.3	160,086.3	30.0	161,803.4	25.3	94,281.7	24.8	91,305.2	24.3	119,575.5	21.9	196,721.9	31.9
Grasslands	129.2	0.0	1,650.2	0.3	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	9.6	0.0
Urban Recreation	1,008.1	0.2	226.6	0.0	366.1	0.1	146.6	0.0	808.8	0.1	157.5	0.0	36.5	0.0	661.6	0.1	996.1	0.2
Pasture/hay	163,327.5	35.2	199,102.2	33.4	209,789.3	31.1	96,834.3	18.2	147,837.7	23.1	36,123.0	9.5	16,955.8	4.5	84,796.4	15.5	60,255.4	9.8
Row crops	17,012.0	3.7	13,479.1	2.3	12,621.3	1.9	5,303.7	1.0	7,409.5	1.2	2,381.2	0.6	2,442.3	0.6	4,556.6	0.8	842.9	0.1
Small grains	0.0	0.0	21.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Woody wetlands	19,361.6	4.2	33,727.8	5.7	41,789.6	6.2	27,330.2	5.1	39,077.5	6.1	17,002.2	4.5	13,661.0	3.6	36,426.4	6.7	51,155.3	8.3
Emergent wetlands	6,364.2	1.4	8,601.8	1.4	7,738.4	1.1	4,825.5	0.9	8,006.2	1.3	2,259.3	0.6	1,147.8	0.3	5,075.7	0.9	6,664.0	1.1
Total	463,472.1	100	596,697.7	100	674,762.4	100	533,055.6	100	639,075.3	100	379,526.6	100	376,340.2	100	546,239.8	100	617,230.2	100
Grouped Land Use Categories																		
Open water	11,782.2	2.5	8,105.4	1.4	7,299.9	1.1	23,463.9	4.4	20,929.3	3.3	40,788.4	10.7	57,395.7	15.3	33,217.0	6.1	19,629.4	3.2
Low-intensity residential	16,894.6	3.6	2,705.9	0.5	2,187.5	0.3	1,444.9	0.3	3,934.1	0.6	639.4	0.2	1,037.7	0.3	6,690.1	1.2	3,982.9	0.6
High-intensity residential	3,518.5	0.8	699.0	0.1	635.2	0.1	314.2	0.1	1,389.1	0.2	112.5	0.0	216.2	0.1	1,755.8	0.3	2,177.0	0.4
Industrial/ mining/ transitional	13,729.0	3.0	16,102.2	2.7	22,671.5	3.4	12,641.3	2.4	21,628.0	3.4	14,263.2	3.8	17,644.1	4.7	18,337.3	3.4	38,611.1	6.3
Forest	210,345.1	45.4	312,276.5	52.3	369,663.7	54.8	360,751.0	67.7	388,055.0	60.7	265,797.9	70.0	265,803.3	70.6	354,723.0	64.9	432,906.5	70.1
Grasslands/ recreation	1,137.3	0.2	1,876.8	0.3	366.1	0.1	146.6	0.0	808.8	0.1	159.5	0.0	36.5	0.0	661.6	0.1	1,005.7	0.2
Pature/hay	163,327.5	35.2	199,102.2	33.4	209,789.3	31.1	96,834.3	18.2	147,837.7	23.1	36,123.0	9.5	16,955.8	4.5	84,796.4	15.5	60,255.4	9.8
Cropland	17,012.0	3.7	13,500.2	2.3	12,621.3	1.9	5,303.7	1.0	7,409.5	1.2	2,381.2	0.6	2,442.3	0.6	4,556.6	0.8	842.9	0.1
Wetlands	25,725.9	5.6	42,329.6	7.1	49,528.0	7.3	32,155.7	6.0	47,083.7	7.4	19,261.5	5.1	14,808.8	3.9	41,502.0	7.6	57,819.3	9.4

Total	463,472.1	100.0	596,697.7	100.0	674,762.4	100.0	533,055.6	100.0	639,075.3	100.0	379,526.6	100.0	376,340.2	100.0	546,239.8	100.0	617,230.2	100

4.0 Reservoir Characteristics

This section discusses the history of Sam Rayburn Reservoir; some of the physical data available for the reservoir, including capacity, surface area, shoreline, average depth, maximum depth, and annual water level fluctuation; and the water quality data available for the reservoir. Water quality monitoring data were downloaded from the Texas Review and Comment System (TRACS) and EPA's STORET databases and analyzed. Analysis of the TRACS data is presented in Section 4.2 and the analysis of the STORET data is presented in Section 4.3.

4.1 Hydraulics

4.1.1 Reservoir Operations

Sam Rayburn Reservoir was constructed by the U.S. Army Corps of Engineers, Fort Worth District, and continues to be owned and operated by the Corps. Primary operation goals for the reservoir include control of flood waters, generation of hydroelectric power, and maintenance of an operating pool to sustain municipal, industrial, agricultural, and recreational uses. Construction of the reservoir began in September 1956. Impoundment began on March 29, 1965, creating a conservation pool of 164.4 feet above mean sea level (msl). The reservoir is an earthfill dam and has a spillway crest elevation of 176 feet and a top flood-control pool capacity of 3,997,600 acre-feet (Texas State Historical Association 2002). The reservoir impounds approximately 114,500 surface acres, creating 750 miles of shoreline and an overall length of 43 miles. It is the largest body of water in the state of Texas (USACE 2003). Sam Rayburn Reservoir has a mean depth of 20 feet and maximum depth of approximately 90 feet; the annual average water level fluctuation is 8 feet.

The dam is an earth embankment approximately 17,230 feet long, with concrete combined power intake and flood control outlet works located near the west abutment. The initial design resulted in excess water release, which was accommodated by a 2,300-foot concrete weir uncontrolled spillway approximately 7,000 feet west of the main embankment. Between 1994 and 1996, however, the spillway was updated. A 640-foot labyrinth weir spillway (with stilling basin) was constructed at the same location and with the same crest elevation (176 feet, msl) as the original spillway to prevent erosion in the event of water release (USACE 2003)

According to the Corps of Engineers (USACE 2003),

> Sam Rayburn Power House is one of only three hydroelectric generating facilities operated by the U.S. Army Corps of Engineers in Texas within the Fort Worth District. All three power plants are operated from the control room of the Sam Rayburn Power House, which is staffed 24 hours a day. The Sam Rayburn Power House contains two generators, each capable of generating 26,000 kilowatt-hours. Release of water is accomplished through two 18 foot x 26 foot power conduits and two 10 foot x 20 foot gated flood control conduits.

4.1.2 Water Surface Elevation

Elevation and evaporation data were obtained from U.S. Geological Survey (USGS) monitoring stations on the reservoir. Elevation data were provided for Sam Rayburn Reservoir for the time period of 1969 through 2002. Figure 4-1 presents the elevation levels of the reservoir during this time period.

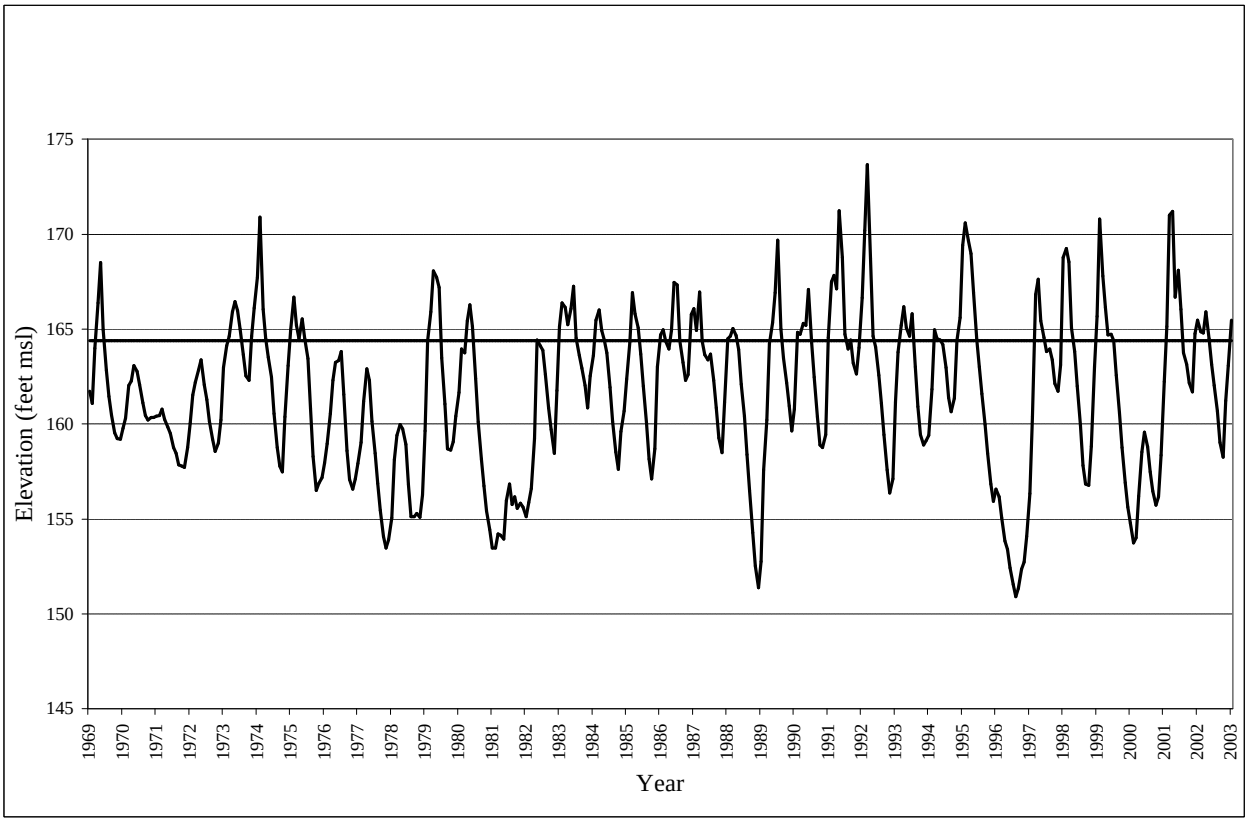

Figure 4-1. Average Water Surface Elevation of Sam Rayburn Reservoir (1969-2002)

Note that during the time period of 1990 through 2003 (the period used for water quality data analysis for this study), the lowest water surface elevation was during 1996. This elevation represents the effects of a severe drought in Texas during that time period.

USGS evaporation data show seasonal and annual trends in the evaporation of Sam Rayburn Reservoir. Monthly evaporation data were provided for the time period 1993 through 2002. Based on total monthly average evaporation, August tends to have the largest amount of evaporation, with an average of 7.6 inches (Figure 4-2).

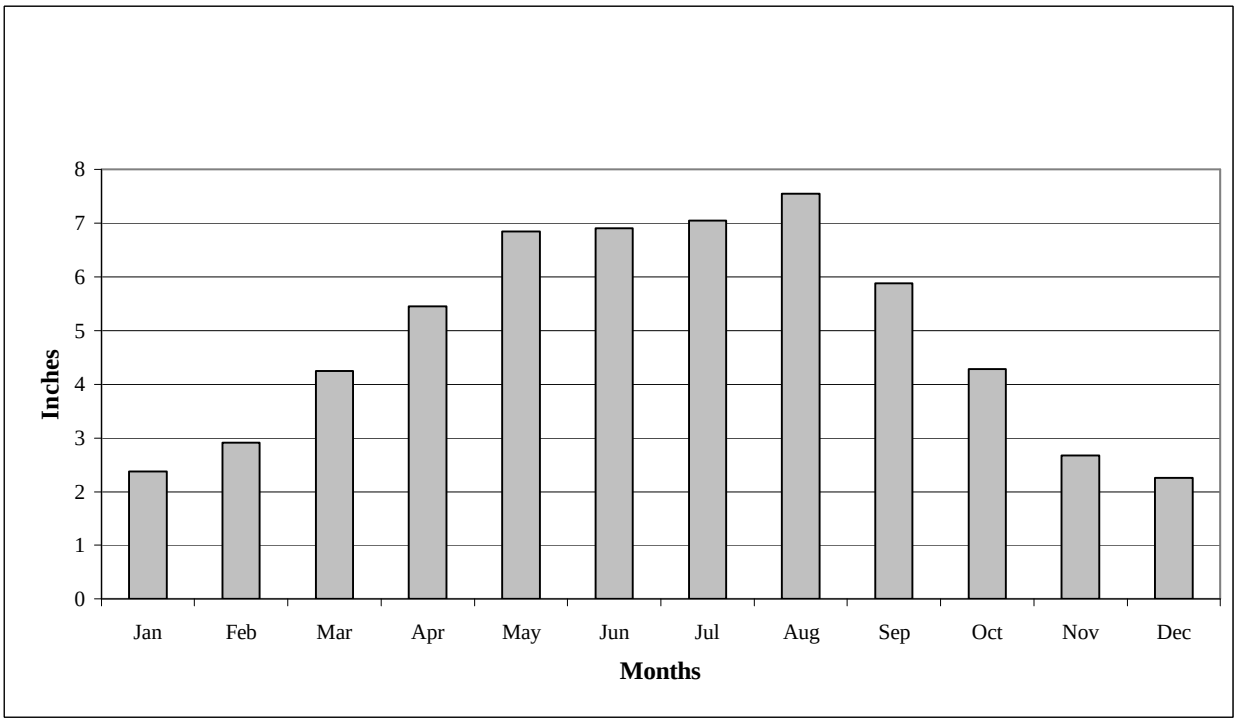

Figure 4-2. Average Monthly Total Evaporation at Sam Rayburn Reservoir from 1993 Through 2002.

Over the past 10 years (1993 through 2002), the greatest amount of evaporation in the reservoir occurred in 2000 (68.2 inches), 1998 (65.08 inches), 1999 (63.04 inches), and 1996 (61.13 inches). These were the years with annual evaporation levels greater than 60 inches during the period of record (Figure 4-3).

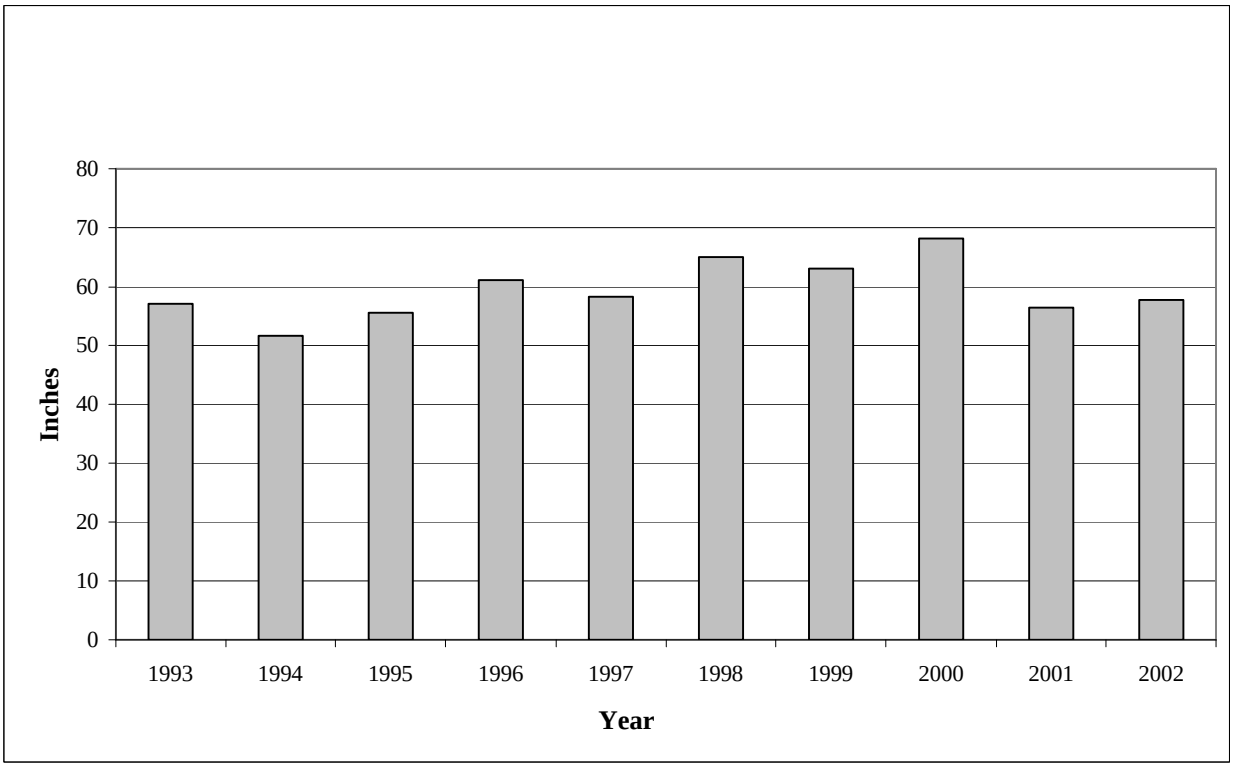

Figure 4-3. Total Annual Evaporation at Sam Rayburn Reservoir for the Period 1993 Through 2002.

4.2 Sam Rayburn Reservoir TRACS Water Quality Data

Water quality monitoring data were drawn from TCEQ's Texas Review and Comment System (TRACS) database for the two segments composing the Sam Rayburn Reservoir, 0610 and 0615 (segment 0610 includes subsegment 0610a). It is important to note that not all sample stations fall within the boundaries of the reservoir. Some stations, although within the segment being evaluated, are located in tributary streams to the reservoir. Where clear distinctions between lotic (moving waters) and lentic (still waters) waters are necessary to understand the dynamics of the parameter in question, sites that might fall outside the reservoir boundary are identified. Because this assessment is evaluating water quality for the entire segment, however, summary statistics for all sites within the defined boundaries of the segment are included by segment and station. In some cases this approach might indicate that an exceedance of criteria has occurred in the reservoir, when in fact the exceedance occurred in a tributary within the defined segment. This is important to understand because impacts that occur in tributary streams can easily translate to impacts in the reservoir.

Data in TRACS span a considerable time period, from about 1974 to the present. This assessment focuses on data from 1990 to the present because these are the most relevant data with respect to evaluating the current conditions of the reservoir and the relatively recent past. These data include at least one major drought period in 1996 and 1997, as well as periods when the reservoir was operating at or near full pool.

Some records in TRACS provided by TCEQ were not included in the data analysis because of various data qualifiers. Records with the following remarks were eliminated from the data set:

- D: Did not pass all quality control (QC) criteria
- E: Lab error
- ME: Analytical method not consistent with data quality objectives (DQOs)
- NO: Data not collected under approved agency quality assurance project plan (QAPP)

For most parameters, surface measurements were available from several locations within a segment. TCEQ's (2002) *Guidance for Assessing Texas Surface and Finished Drinking Water Quality Data, 2002* indicates that surface measurement data, typically collected at a depth of 1 foot from the water surface, are generally used for assessing water, temperature, chloride, sulfate, total dissolved solids, nutrients, chlorophyll a, fecal coliform bacteria, *E. coli*, and enterococci. Although depth-integrated data are available for certain parameters measured using direct reading instruments, this assessment examines depth-integrated data for only dissolved oxygen (DO) and pH because dissolved oxygen and pH criteria apply to the entire mixed water column, or only to measurements made in the mixed surface layer if the water column is stratified.

The following water quality parameters were reviewed to assess the water quality within the reservoir:

- Water temperature
- Transparency
- Conductivity
- Dissolved oxygen
- Biolochemical oxygen demand
- pH
- Total alkalinity
- Total solids
- Dissolved solids
- Ammonia
- Nitrate and nitrite
- Total Kjeldahl nitrogen
- Total nitrogen
- Phosphorus
- Total organic carbon
- Chlorophyll a
- Fecal coliform bacteria
- Chloride
- Sulfate
- Dissolved arsenic
- Dissolved aluminum
- Dissolved copper
- Dissolved lead
- Total selenium
- Dissolved zinc
- Dioxin

Texas Surface Water Quality Standards (TSWQS) used for this assessment are based on the August 17, 2000 edition of Chapter 307: TSWQS §§307.1-307.10, pending approval from EPA Region 6. Nutrients that have no criteria identified in Texas's Surface Water Quality Standards were compared to one or both of two values: EPA (2000) ecoregional reference values for Region IX reservoirs or TCEQ's (2000) screening level values found in *Guidance for Assessing Texas Surface and Finished Drinking Water Quality Data, 2002*.

See Section 1.3 for a detailed discussion of the applicable water quality criteria and other targets.

4.2.1 TRACS Monitoring Stations at Sam Rayburn Reservoir (Segments 0610 and 0615)

Monitoring stations identified in the TRACS database are listed in Table 4-1. Figure 4-4 presents the locations of the stations.

Table 4-1. Water Quality Monitoring Stations in Segments 0610 and 0615

Station	Station location
Segment 0610	
10483	Ayish Bayou at US 96 west of San Augustine
10503	Paper Mill Creek immediately Upstream from Angelina River Confluence
10611	Sam Rayburn Reservoir in powerhouse intake structure of dam
10612	Sam Rayburn Reservoir at SH 147 bridge SW of Broaddus and NE of Zavalla
10613	Sam Rayburn Reservoir at SH 103, 2.3 mi. west of Etoile
10614	Sam Rayburn Reservoir at SH 103, 6.5 mi. east of Etoile
10615	Sam Rayburn Reservoir at Marion's Ferry
14906	Sam Rayburn Reservoir at Main Pool
14907	Sam Rayburn Reservoir at FM 83 bridge
15357	Turkey Creek at FM 705, 0.4 km upstream of Ayish Bayou Confluence
15358	Sandy Creek at FM 705, 2.0 km north of Fm 83
15359	Chiamon Bayou at FM 1751, 6.0 km south of Chinquapin
15360	Chinquapin Creek at FM 1751, 1.8 km south of Chinquapin
15361	Ayish Bayou at SH 103, 0.8 km east of FM 705
15362	Caney Creek at SH 147, 1.0 km upstream of Ayish Bayou Confluence
15363	Venado Creek at SH 147, 2.0 km upstream of Ayish Bayou Confluence
15364	Ayish Bayou at SH 147, 0.2 km south of San Augustine
15365	Ayish Bayou at FM 3230, 3.0 km north of San Augustine
15366	Carrizo Creek at FM 2213, 2.4 km south of San Augustine
15522	Sam Rayburn Reservoir near Veach Basin
15523	Sam Rayburn Reservoir adjacent to Alligator Cove
15524	Sam Rayburn Reservoir near Shirley Creek
15525	Sam Rayburn Reservoir at Kingtown
15526	Sam Rayburn Reservoir between Needmore Point and Powell Park in the Ayish Bayou
15527	Sam Rayburn Reservoir near Mill Creek Park in the Bear Creek
15666	Sam Rayburn Reservoir USGS Site NC
15667	Sam Rayburn Reservoir USGS Site IC
15668	Sam Rayburn Reservoir USGS Site KC
15669	Sam Rayburn Reservoir USGS Site JC
15670	Sam Rayburn Reservoir USGS Site GC
15671	Sam Rayburn Reservoir USGS Site FC
15672	Sam Rayburn Reservoir USGS Site CC
15673	Sam Rayburn Reservoir USGS Site AC
15674	Sam Rayburn Reservoir USGS Site IC
15675	Sam Rayburn Reservoir USGS Site MC
16784	Sam Rayburn Reservoir at San Augustine Park Swimming Area
16785	Sam Rayburn Reservoir at East End Swimming Area

16786	Sam Rayburn Reservoir at Ebenezer Park Swimming Area
16787	Sam Rayburn Reservoir at Mill Creek Park Swimming Area
16788	Sam Rayburn Reservoir at Etoile Park Boat Ramp
16789	Sam Rayburn Reservoir at Marion Ferry Boat Ramp
16790	Sam Rayburn Reservoir at Cassel-Boykin Park Boat Ramp
16791	Sam Rayburn Reservoir at Jackson Hill Marina Swimming Area
16792	Sam Rayburn Reservoir at Hanks Creek Park Boat Ramp
16793	Sam Rayburn Reservoir at Shirley Creek Marina Boat Ramp
Segment 0615	
10496	Mill Creek at US 59 north of Lufkin
10497	Mill Creek at FM 2251 north of Lufkin
10498	Unnamed tributary of Mill Creek below Ellen Trout Dam north of Lufkin
10502	Paper Mill Creek Upper Bifurcation Channel, just upstream of Angelina River Confluence
10504	Paper Mill Creek at unnamed creek south of River Crest Estates
10505	Paper Mill Creek at FM 842 northeast of Lufkin
10506	Unnamed tributary of Paper Mill Creek at intersection of Moffett Rd and SH 287 in Lufkin
10507	Unnamed west tributary to Ellen Trout Lake at FM 2251 in Lufkin
10508	Unnamed east tributary to Ellen Trout Lake at SH 287
10616	Sam Rayburn Reservoir at Pipeline 7.67 km upstream of Marion's Ferry
10617	Sam Rayburn Reservoir at Moran's 11.67 km upstream of Marion's Ferry
10618	Sam Rayburn Reservoir Downstream, 3.5 km from Paper Mill Cr Confluence
10619	Sam Rayburn Reservoir Downstream, 2.0 km from Paper Mill Creek Confl.
10620	Sam Rayburn Reservoir 1.0 km downstream from Paper Mill Creek Confluence
10621	Sam Rayburn Reservoir 0.7 km downstream of Confluence with Paper Mill Creek
10622	Sam Rayburn Reservoir, 0.2 km downstream from Paper Mill Creek Confl.
10623	Sam Rayburn Reservoir at Confl of Angelina River, 0.75km NW of Paper Mill Creek

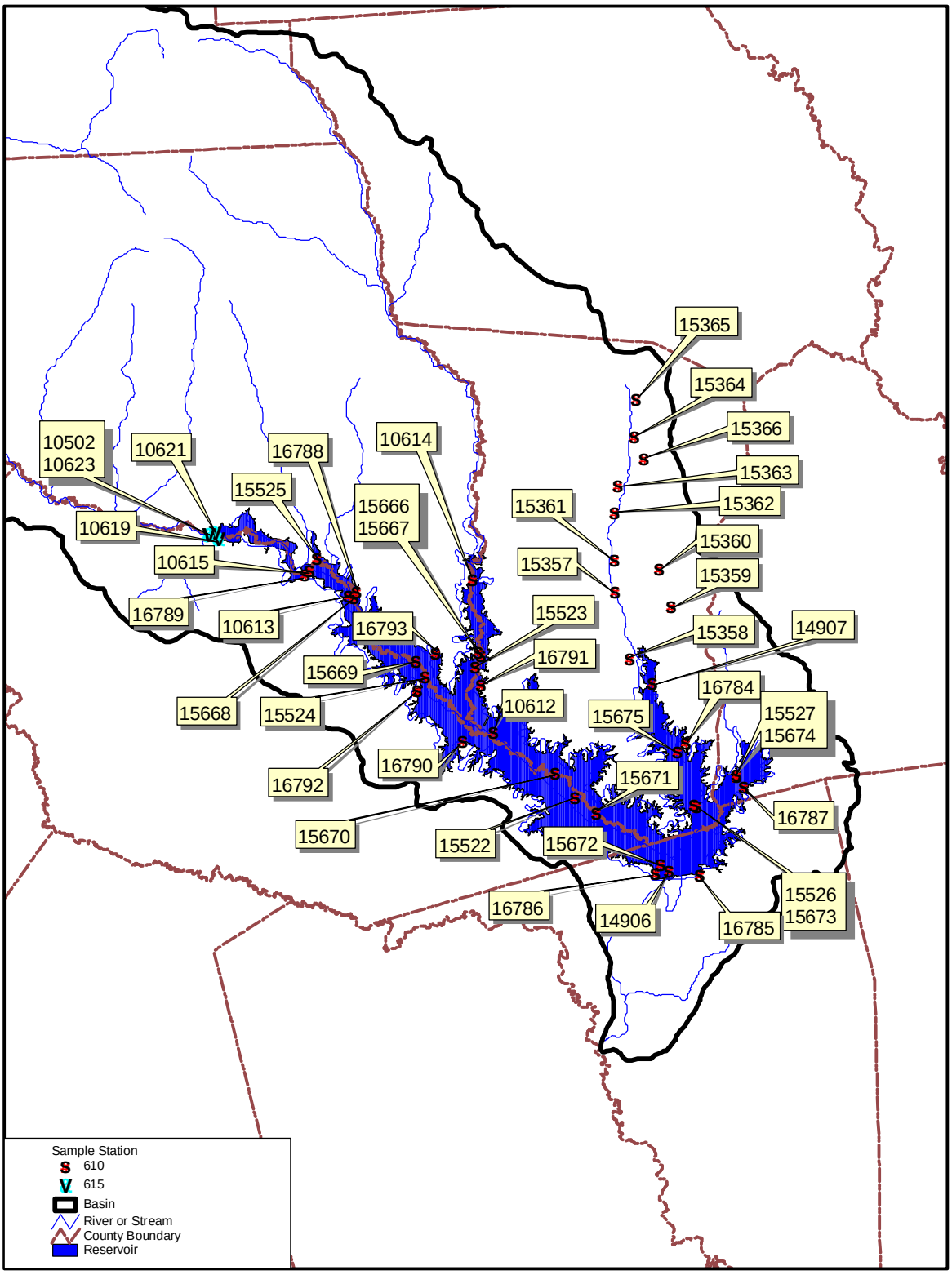

Figure 4-4. TRACS Water Quality Monitoring Stations in Sam Rayburn Reservoir

4.2.2 Water Quality Data Analysis

The following sections provide summaries of available water quality data at stations in segments 0610 and 0615, including number of samples, minimum, average, maximum, and the number of samples exceeding water quality criteria or targets. Sam Rayburn Reservoir was placed on Texas's 2000 and 2002 section 303(d) lists of impaired waterbodies for dissolved oxygen, pH, and aluminum impairments, therefore, these three parameters were analyzed for the reservoir. Any parameters that affect dissolved oxygen (i.e., nutrients and chlorophyll a) were also included in the analysis. Additional parameters were included in the analysis at the request of TCEQ to determine whether there are any other potential impairments of the reservoir. For parameters that have water quality criteria or screening levels, the number of exceedances was determined for each of the stations. Section 1.3 discusses the appropriate water quality criteria and screening levels.

4.2.2.1 Dissolved Oxygen and Nutrients

Dissolved Oxygen

Dissolved oxygen is one of the primary water quality measurement parameters by which TCEQ assesses use support of a waterbody. Each classified waterbody in the TSWQS is assigned one of the following aquatic life uses, based on physical, chemical, and biological characteristics: exceptional, high, intermediate, limited, or no significant aquatic life use. Dissolved oxygen criteria (24-hour averages) to protect these aquatic life uses for freshwater are 6.0, 5.0, 4.0, 3.0, and 2.0 mg/L, respectively (TNRCC 2002). These criteria are applied within the mixed surface layer. For reservoirs, the mixed surface layer is defined as the portion of the water column from the surface to the depth at which water temperature decreases by greater than 0.5 °C. Dissolved oxygen and pH criteria apply to the entire mixed water column or to only measurements made in the mixed surface layer if the water column is stratified (TNRCC 2002).

Segment 0610: Dissolved Oxygen

Dissolved oxygen data collected as surficial samples (0.3 meter below the water surface) were evaluated for the period from 1990 to present. Substantially more dissolved oxygen data are available in TRACs, measured at various times and locations. These data are discussed later in this section relative to five specific sites in the reservoir with several years of records displaying dissolved oxygen at depth. For the surficial records, summary statistics were generated, as well as a count of exceedances (Table 4A-1 in Appendix 4A). Tables 4A-1 through 4A-39 are presented in Appendix 4A at the end of Section 4.0 due to their large size.

Segment 0610, which represents the largest spatial extent of the reservoir, had the largest number of records and stations. Thirty-nine sampling stations in segment 0610 representing almost 500 surficial records over a period of more than 10 years showed relatively good mean dissolved oxygen values. The lowest mean dissolved oxygen was calculated as 5.33 mg/L at station 15357. There were few criterion exceedances for these surficial samples (e.g., <3.0 mg/L); only two samples were measured as less than 3.0 mg/L. These exceedances were recorded at sites 15357

and 15358 in Ayish Bayou tributary streams (unclassified segment 0610a). Based on these data, no exceedances of the criteria were observed from sites within the reservoir portion of segment 0610.

Twenty-four-hour minimum dissolved oxygen data are summarized in Table 4A-2 for segment 0610, for which relatively few measurement data were available. Unlike the surficial grab sample data that could be compiled for a single depth measurement, 24-hour minimum dissolved oxygen data were available from a variety of depths; however, judging from the sample depths, all measurements were within the mixed surface layer. Two exceedances of the minimum criterion (3.0 mg/L) were recorded from this data set at stations 10614 (2.7 mg/L) in the Attoyac Bayou arm of the reservoir and 14907 (0.7 mg/L) in the Ayish Bayou arm of the reservoir. Both exceedances occurred in 2001.

Twenty-four-hour average dissolved oxygen data are summarized in Table 4A-3 for segment 0610, where relatively few measurement data were available. These data had a depth distribution similar to that for the 24-hour minimum dissolved oxygen because these values were derived from the same measurement data sets. Two 24-hour average dissolved oxygen values exceeded the criterion (5.0 mg/L) at sites 14907 and 15361 in the Ayish Bayou arm of the reservoir. Only station 14907 is located within the reservoir. At station 14907 the 24-hour mean dissolved oxygen was 2.3 mg/L, while at station 15361 the 24-hour mean dissolved oxygen was 4.63 mg/L.

Dissolved oxygen at depth was assessed using a graphical approach to illustrate dissolved oxygen dynamics at several locations within the reservoir across depths and seasonal changes. These data were grouped into two primary seasonal categories: (1) late spring, summer and fall and (2) winter and early spring. These groupings facilitate evaluation of the depth level at which the reservoir stratifies based on the time of year and the location within the reservoir. Appendix 4B at the end of Section 4.0 presents the dissolved oxygen graphs as well as a detailed discussion of the results.

Overall, the depth profile data indicate that dissolved oxygen stratification occurs during the summer months, resulting in hypolimnetic oxygen deficits. Mixed surface layers differ widely depending upon the time of year, but dissolved oxygen concentrations in this layer do not exceed the minimum criterion of 3.0 mg/L. Station 10613 is much less similar in profile to the other stations evaluated during the summer months; during the winter months, however, dissolved oxygen at all sites suggests the reservoir is well mixed and unstratified.

Segment 0615: Dissolved Oxygen

Only three locations in segment 0615 where dissolved oxygen grab samples had been collected were found in the database. Data from these three sites were collected between 1990 and 2002 (Table 4A-1). Measurement data were available for 152 samples with mean dissolved oxygen concentrations ranging from 4.1 to 6.9 mg/L. Lower dissolved oxygen minima were found at these sites, with the lowest surficial grab sample recording a dissolved oxygen concentration of 1.9 mg/L. Over the period evaluated, a total of 19 sample measurements fell below the dissolved oxygen minimum criterion of 3.0 mg/L. This is a sharp contrast to segment 0610, which had only

two dissolved oxygen concentrations below the minimum criterion.

Table 4A-2 shows the 24-hour dissolved oxygen minimum values recorded for segment 0615. These data ranged in time from 1998 to 2001, representing 21 separate monitoring events at the three locations. Of the 21 events, 6 dissolved oxygen minima fell below the minimum dissolved oxygen criterion of 3.0 mg/L. Table 4A-3 shows the corresponding 24-hour dissolved oxygen averages monitored during this time frame. Similarly, six of the 24-hour dissolved oxygen average concentration fell below the 24-hour mean dissolved oxygen criterion of 5.0 mg/L. Stations 10621 and 10623 are on the Angelina River near Papermill Creek; station 10502 is in Papermill Creek.

Chlorophyll a and Secchi Depth

Chlorophyll a is a measure of the photosynthetic capacity of algae and algal biomass. The more chlorophyll a in the water, the higher the algal biomass and the higher the photosynthetic capacity. Chlorophyll a is an important variable in understanding the eutrophication potential of reservoirs because it provides a direct link with the nutrient concentrations, algal biomass, and photosynthetic activity that affect dissolved oxygen concentrations. No criteria are promulgated for chlorophyll a, but both TCEQ and EPA have developed screening criteria for this parameter. The EPA (2000) ecoregional screening value for reservoirs in ecoregion IX is 2.834 µg/L, while TCEQ's screening value is 21.4 µg/L.

Similarly, Secchi depth is a companion measure by which limnologists assess eutrophication. The measure evaluates water transparency. The deeper the transparency, the greater the photic zone and the less light penetration is diminished by light-scattering or -absorbing factors such as algae. The EPA (2000) ecoregional screening value for reservoirs in ecoregion IX is 1.1 meters.

Segment 0610: Chlorophyll a

In segment 0610 of Sam Rayburn Reservoir, chlorophyll a was measured at nine stations from 1990 to 2002 for a total 118 measurements (Table 4A-4). Concentrations averaged from 1.8 to 28 µg/L. Of the measurement data for segment 0610, 70 samples had concentrations of chlorophyll a that exceeded the ecoregional values from EPA, while only 5 samples exceeded TCEQ's screening value. Except for the highest value observed, mean chlorophyll a concentrations are similar to those observed in an EPA eutrophication study conducted for the reservoir (USEPA, 1974), which found at the time that Sam Rayburn Reservoir was a eutrophic reservoir. A 1998 Reservoir Assessment conducted by TCEQ found that based on chlorophyll a concentrations, Sam Rayburn Reservoir falls in the mesotrophic range. Based on the mid-range mean value, Carlon's Trophic Index for chlorophyll a is 54.95, which is considered to be on the low end of the eutrophic category.

Segment 0615: Chlorophyll a

In segment 0615, chlorophyll a was measured at four stations from 1991 to 2002 for a total 119 measurements (Table 4A-4). On average, mean chlorophyll a concentrations were generally lower in segment 0615 than in segment 0610. Mean chlorophyll a in segment 0615 ranged from 3.4 to 7.6 µg/L. Of the 119 values, 63 exceeded the EPA ecoregional reference value, whereas only 4 values exceeded TCEQ's screening value. Based on the mid-range mean value, Carlson's Trophic Index for chlorophyll a is 42.9, which is considered to fall within the mesotrophic range.

Segment 0610: Secchi Depth

In segment 0610 Secchi depth was determined at 21 locations from 1991 to 2002 for a total of 401 measurements (Table 4A-5). Average Secchi depths at stations ranged from 0.45 meter to 2.18 meters. Of the 401 samples, 158 were less than the ecoregional screening levels. Depth values less than the screening levels suggest lower transparency, which might be due to excessive algal production or other factors that reduce water clarity. The mean Secchi depth for segment 0610 is 1.31 meters, which is consistent with the mean Secchi depth reported by TCEQ in its Reservoir Assessment (1998). EPA's eutrophication assessment in 1974 showed Secchi depth measurements that averaged 1.63 meters. Overall, historical depths are not substantially different from present-day depths.

Segment 0615: Secchi Depth

In segment 0615 Secchi depth was determined at 3 locations from 1990 to 2002 for a total of 133 measurements. Average Secchi depths at stations ranged from 0.24 meter to 0.41 meter. Of the 133 samples, 132 were less than the ecoregional screening value. The mean Secchi depth for segment 0610 is 1.31 meters, which is consistent with the mean Secchi depth reported by TCEQ in its Reservoir Assessment (1998). Table 4A-5 summarizes the Secchi depth data for segment 0615.

Nutrients

Phosphorus is often considered a limiting nutrient with respect to algal productivity in reservoirs. In fact, the relationship between total phosphorus and algal biomass is so strong that total phosphorus is considered a leading indicator used by limnologists to assess reservoir eutrophication. EPA's ecoregional reference values for reservoirs for total phosphorus is 0.0325 mg/L, while TCEQ's screening value is 0.18 mg/L. Soluble or reactive phosphorus is measured as ortho-phosphate. This fraction is the available phosphorus in waters. TCEQ's screening level value for ortho-phosphorus is 0.05 mg/L.

Segment 0610: Total and Ortho-Phosphorus

In segment 0610, total phosphorus averaged between 0.03 and 0.5 mg/L as total phosphorus (Table 4A-6). Data were collected at 11 stations from 1990 to 2002 for a total of 242 measurements. Of these, 218 samples exceeded EPA's ecoregional reference values, while 47 samples exceeded TCEQ's screening value for total phosphorus. TCEQ's 1998 reservoir assessment found a mean total phosphorus value for Sam Rayburn of 0.06 mg/L, and the mean of these data was 0.17 mg/L total phosphorus. EPA's 1974 reservoir assessment found 0.035 to 0.143 mg/L total phosphorus.

Ortho-phosphorus in segment 0610 was measured at 17 locations over the time period 1990 to 2002, resulting in 242 samples (Table 4A-7). Mean ortho-phosphorus concentrations ranged from 0.01 mg/L to 0.2 mg/L. Of the 242 samples, 36 exceeded TCEQ's screening value. Compared to EPA's 1974 Reservoir Assessment, mean ortho-phosphorus values ranged from 0.004 to 0.106 mg/L. Data from this assessment indicate very similar trends in ortho-phosphorus.

Segment 0615: Total and Ortho-Phosphorus

In segment 0615 total phosphorus was measured at four stations from 1990 to 2002, with a total of 114 measurements (Table 4A-6). Mean total phosphorus across the sites ranged from 0.11 to 0.76 mg/L; 113 of the samples exceeded the ecoregional reference value, and 29 exceeded TCEQ's screening value. These mean values are higher than the range of means observed in segment 0610 and are also higher than the observed range of means for EPA's 1974 assessment.

Soluble ortho-phosphorus means in segment 0615 ranged from 0.11 to 0.53 mg/L (Table 4A-7) for data collected between 1991 and 1997. In total, 45 samples were collected from 4 stations, and 28 of the samples exceeded the TCEQ's screening levels for ortho-phosphorus. Similar to total phosphorus, ortho-phosphorus means were typically higher in segment 0615 when compared to segment 0610 and EPA's 1974 Reservoir Assessment data.

Segment 0610: Total Nitrogen

Total nitrogen is a derived value that considers the sum of organic and inorganic nitrogen avialable in water. Nitrogen is usually in excess concentrations in water relative to the needs of macrophytes and algae. EPA's ecoregional reference value for reservoirs for total nitrogen is 0.492 mg/L.

In segment 0610, total nitrogen averaged between 0.4 and 1.1 mg/L as total nitorgen (Table 4A-8). Data were derived from samples for nitrate plus nitrite nitrogen (NO_2+NO_3), total Kjeldahl nitrogen (TKN), and ammonia nitrogen (NH_4) collected at three sites from 1990 to 1997. Twenty-three calculated values resulted in 19 exceedances of EPA's ecoregional reference values. Total nitrogen reported as part of EPA's 1974 assessment of the reservoir ranged from 0.575 to 0.631 mg/L. Of the summed nitrogen fractions, TKN consistently constituted the larger proportion of the total nitrogen value.

Segment 0615: Total Nitrogen

In segment 0615, total nitrogen averaged between 1.6 and 4.8 mg/L as total nitrogen (Table 4A-8). Data were derived from samples for NO_2+NO_3, TKN, and NH_4 nitrogen collected at four sites spanning from 1993 to 1997. Thirty-five calculated values resulted in 32 exceedances of EPA's ecoregional reference values. Total nitrogen reported as part of EPA's 1974 assessment of the reservoir ranged from 0.575 to 0.631 mg/L. Segment 0610 total nitrogen concentrations are substantially higher than those observed in 1974 and in segment 0610. Of the summed nitrogen fractions, TKN consistently constituted the larger proportion of the total nitrogen value.

Segment 0610: Nitrate and Nitrite Nitrogen

Nitrate and nitrite nitrogen provide information on the inorganic fraction of nitrogen that enters the waterbody. Nitrite results from the denitrification of nitrate through bacterial reduction. EPA's ecoregional reference value for reservoirs for total nitrate+nitrite nitrogen is 0.033 mg/L, while TCEQ's screening level is 0.32 mg/L.

In segment 0610, NO_2+NO_3 nitrogen averaged between 0.03 and 0.81 mg/L (Table 4A-9). Data were collected at 18 stations from 1990 to 2002 for a total of 189 measurements. Of these, 168 samples exceeded EPA's ecoregional reference values, while 91 samples exceeded TCEQ's screening value for nitrate+nitrite nitrogen. The EPA's 1974 Reservoir Assessment found mean values of 0.021 to 0.151 mg/L.

Segment 0615: Nitrate and Nitrite Nitrogen

In segment 0615, total NO_2+NO_3 nitrogen averaged between 0.23 and 0.65 mg/L (Table 4A-9). Data were collected at 4 stations from 1990 to 1997 for a total of 46 measurements. Of these, all 46 samples exceeded EPA's ecoregional reference values, while 26 samples exceeded TCEQ's screening value for nitrate+nitrite nitrogen. The EPA's 1974 Reservoir Assessment found mean values of 0.021 to 0.151 mg/L.

Segment 0610 Total Kjeldahl Nitrogen

Total Kjeldahl nitrogen (TKN) measures the organic nitrogen fraction. EPA's ecoregional reference value for reservoirs for TKN is 0.459 mg/L.

In segment 0610, TKN averaged between 0.33 and 1.03 mg/L (Table 4A-10). Data were collected at 5 stations from 1990 to 2002 for a total of 115 measurements. Of these, 87 samples exceeded EPA's ecoregional reference value. EPA's 1974 Reservoir Assessment found mean values of 0.462 to 0.554 mg/L.

Segment 0615: Total Kjeldahl Nitrogen

In segment 0615, TKN averaged between 0.27 and 2.91 mg/L (Table 4A-10). Data were collected at 4 stations from 1993 to 2002 for a total of 109 measurements. Of these, 95 samples exceeded EPA's ecoregional reference value. Compared to the 1974 Reservoir Assessment and segment 0610, TKN in segment 0615 is considerably higher.

Segment 0610: Ammonia Nitrogen

Ammonia nitrogen is a measure of the total fraction of ammonia ions in water, which are produced through the decomposition of proteins and other nitrogenous organic compounds. TCEQ's screening value for total ammonia nitrogen is 0.106 mg/L.

In segment 0610, total ammonia nitrogen averaged between 0.02 and 0.19 mg/L (Table 4A-11). Data were collected at 20 stations from 1990 to 2002 for a total of 280 measurements. Of these, 66 samples exceeded TCEQ's screening levels. EPA's 1974 Reservoir Assessment found mean values of 0.049 to 0.201 mg/L. Segment 0610's mean ammonia nitrogen values fall within this range.

Segment 0615: Ammonia Nitrogen

In segment 0615, total ammonia nitrogen averaged between 0.04 and 1.28 mg/L (Table 4A-11). Data were collected at 4 stations from 1990 to 2002 for a total of 120 measurements. Of these, 47 samples exceeded the TCEQ's screening level. Ammonia nitrogen in segment 0615 tended to be higher than that in segment 0610 based on these data.

Segment 0610: Biochemical Oxygen Demand

Biochemical oxygen demand (BOD) is a measure of the oxygen consumption used during the biochemical degradation of organic matter. Typically the higher the BOD, the higher the organic loads of materials that will undergo degradation.

BOD in segment 0610 averaged between 2 and 7 mg/L (Table 4A-12). Data were collected at six stations from 1999 to 2000 for a total of 20 measurements. Natural waters tend to have BODs ranging from 1 mg/L to 5 mg/L. Segment 0610's levels generally indicate a range not far from that of natural waters. There are no BOD criteria.

Segment 0615: Biochemical Oxygen Demand

BOD in segment 0615 ranged from 3 mg/L to 4 mg/L (Table 4A-12). Too few data points were available to determine an average for each station. Data were collected at three stations in 1999 for a total of 3 measurements. Natural waters tend to have BODs ranging from 1 mg/L to 5 mg/L. Segment 0610 levels generally indicate a range not far from that of natural waters. There are no BOD criteria.

Segment 0610: Total Organic Carbon

There are no criteria or screening levels for organic carbon. Total organic carbon (TOC) is often measured because it provides insights on the amounts of allochthonous (inputs from outside the waterbody) and autochothonous (inputs from inside the waterbody) input to a water body. High TOC might also indicate large amounts of organic carbon undergoing degradation, a process that can ultimately affect dissolved oxygen concentrations.

TOC in segment 0610 averaged between 6 and 12 mg/L (Table 4A-13). Data were collected at five stations from 1990 to 2002 for a total of 127 measurements.

Segment 0615: Total Organic Carbon

Total organic carbon in segment 0615 averaged between 7.6 and 74 mg/L (Table 4A-13). Data were collected at four stations from 1990 to 2002 for a total of 117 measurements. These data show excessively high organic carbon concentrations relative to TOC values in segment 0610. Such high concentrations could be due to a direct source with high humic acids.

4.2.2.2 Metals and Dioxin

Aluminum

There are 107 records available for dissolved aluminum concentrations measured in the surface waters (0.3 m) of segment 0610 (period of record: August 1994-July 2002). The average dissolved aluminum concentration for all records is 152 µg/L. The minimum and maximum concentrations are <10 µg/L and 1,700 µg/L. Only three records exceed the Texas Water Quality Standards of 991 µg/L for dissolved aluminum. These exceedances occurred on August 20, 1996 (1,260 µg/L), March 03, 1997 (1,010 µg/L), and July 11, 2002 (1,700 µg/L) at stations 10615, 10613, and 15361, respectively. Table 4A-14 summarizes the available dissolved aluminum data for segment 0610.

For segment 0615, 61 water quality records collected from the Sam Rayburn Reservoir upstream of Paper Mill Creek (10623), Paper Mill Creek upstream of the confluence with the Sam Rayburn Reservoir (10502), and the Sam Rayburn Reservoir downstream of the confluence of Paper Mill Creek (10621) are available for dissolved aluminum. Table 4A-15 summarizes the dissolved aluminum data for these stations.

Dissolved aluminum criteria are based on a water-effects ratio (WER) (see Section 1.3). Recently, a WER of 8.39 developed by Champion International Corporation specifically for segments 0610 and 0615 was proposed and accepted by TCEQ. The EPA has approved the 8.39 WER for the segment 0615A mixing zone but has not approved the WER for segments 0615 and 0610. The TCEQ is currently evaluating a WER for segments 0615 and 0610. For the purposes of this data review, the WER was applied to segment 0615 and 0610. Applying the WER results in an acute dissolved aluminum criterion value of 8,310 µg/L. Using the new acute value, no exceedances are found in the available dissolved aluminum data for segments 0615 and 0610.

Dissolved aluminum concentrations in surface waters at stations 15524, 15523, 10612, 15527, 15526, 14906, and 1552 in segment 0610 were all measured at concentrations less than 4.0 µg/L. Three stations—15523, 15527, and 14906— had less-than-detectable aluminum concentrations (< 2.0 µg/L) in October 2002.

There are 76 records available for aluminum in bottom sediments, measured at 13 stations in segment 0610 (period of record from August 16, 1994 to June 18, 2002). Summary statistics are as follows for the entire 76 samples: average, 21,283 mg/kg; minimum, 0.19 mg/kg; maximum, 79,300 mg/kg. When screened against a No Effects Level (NOEL) of 58,030 mg/kg (EPA 1996), three exceedances are revealed. Two exceedances occurred at station 14906 in August 2000 (79,300 mg/kg) and January 2002 (69,500 mg/kg); one exceedance occurred at station 10612 in January 2002 (59,400 mg/kg).

One record is available for aluminum in bottom sediments of segment 0615. This record is from station 16023 (Sam Rayburn Reservoir above Paper Mill Creek) and was collected on April 10, 1997, with a measured concentration of 4,410 mg/kg.

Data indicate that dissolved aluminum does not pose a water quality threat in Sam Rayburn Reservoir based on the following:

- Few records exceed the current water quality criteria for dissolved aluminum, and no records exceed the recently proposed water quality criterion of 8,310 µg/L.

- Ameliorating water quality factors are present in Sam Rayburn Reservoir waters to reduce potential effects of dissolved aluminum. This is supported by the WER, which indicates dissolved aluminum in laboratory water was approximately eight times more toxic than waters from the reservoir.

- Truly bioavailable (e.g., ionic) aluminum does not form at pHs above 5.5. The waters of Sam Rayburn Reservoir in general have considerably higher pH levels.

Arsenic

There are 106 records available for dissolved arsenic in surface waters of segment 0610 (period of record: July 1991 to March 2002). Sixty-one records (period of record: August 1995 to April 2002) are available for dissolved arsenic in surface waters of segment 0615. No exceedances of the acute or chronic TSWQS (390 µg/L and 190 µg/L) were observed.

Dissolved arsenic concentrations in surface waters at stations 15524, 15523, 10612, 15527, 15526, 14906, and 15522 in segment 0610 were all measured at detectable concentrations; however, all concentrations were less than 2.0 µg/L in October 2000. Table 4A-16 summarizes the dissolved arsenic concentrations observed in segments 0610 and 0615.

There are 101 arsenic concentration records available for bottom sediments, measured at 13 stations in segment 0610 (period of record of June 1974 to December 2002). Summary statistics

are as follows for the entire 101 samples: average, 30.9 mg/kg; minimum, 0.33 mg/kg; maximum 90.1 mg/kg. When screened against a consensus-based threshold-effects concentration (TEC) of 9.79 mg/kg and a consensus-based probable effects concentration (PEC) of 33 mg/kg (MacDonald et al. 2000), 90 and 46 exceedances are revealed, respectively. Similar exceedances were found in TCEQ's *Sam Rayburn Reservoir Metals Study* (2003).

One arsenic concentration (3.05 mg/kg) record is available for bottom sediment at station 10623 in April 1997, for segment 0615.

Copper

There are 112 records available for dissolved copper in surface waters for segment 0610 (period of record from July 1991 to July 2002). Table 5 of *Procedures to Implement the TSWQS Guidance* (TCEQ 2000) provides a 15th percentile hardness value for segment 0610 of 29.8 mg/L as $CaCO_3$. Copper criteria calculated using this value for segment 0610 are 4.4 µg/L (chronic) and 5.9 µg/L (acute). Of the 112 records, 40 exceed the chronic and acute criteria. However, 36 of the 40 samples that exceeded both the chronic and acute criteria were nondetects with detection limits of 6 µg/L. Table 4A-17 includes those detection records for segment 0610, which exceed the calculated chronic and acute criteria for dissolved copper. Table 4A-18 summarizes the available dissolved copper data for segment 0610.

There are 61 records available for dissolved copper in surface waters for segment 0615 (period of record from August 1995 to April 2002). Table 5 of *Procedures to Implement the TSWQS Guidance* (TCEQ 2000) provides a 15th percentile hardness value for segment 0615 of 29.8 mg/L as $CaCO_3$. Copper criteria calculated using this value for segment 0615 are 4.4 µg/L (chronic) and 5.9 µg/L (acute). Of the 61 records, 37 exceed the calculated chronic and acute criteria. However, 28 of the 37 samples that exceeded both the chronic and acute criteria were non-detects with detection limits of 6 µg/L. An additional three samples were non-detects with detection limits of 11 µg/L and 25 µg/L. Table 4A-19 summarizes dissolved copper detections that exceed both the chronic and acute criteria for segment 0615. Table 4A-20 summarizes the available dissolved copper data for segment 0615.
There are 99 copper concentration records available for bottom sediments, measured at 13 stations in segment 0610 (period of record: June 1974 to December 2002). Summary statistics are as follows for the 99 samples: average, 11.01 mg/kg; minimum, 1.48 mg/kg; maximum, 63 mg/kg. Two samples exceed a consensus-based threshold-effects concentration (TEC) of 31.6 mg/kg (MacDonald et al. 2000). These exceedances occurred at station 10613 (Sam Rayburn Reservoir at SH 103) on June 14, 1978 (32 mg/kg) and May 14, 1986 (63 mg/kg). No values exceeded the consensus-based PEC of 149 mg/kg (MacDonald et al. 2000).

One copper concentration (3.2 mg/kg) record is available for bottom sediment at station 10623 on segment 0615 in April 1997.

Occasional exceedances of the copper crtieria occur in Sam Rayburn Reservoir waters. However, because the detection limits are often above water quality criteria, assessment of impairment based on the available data might not be representative of actual conditions. Recently, the Angelina and Neched River Authority (ANRA) instituted a Clean Metals Assessment Strategy. Data collected under this effort indicate that copper concentrations were all less than 0.3 µg/L.

Lead

There are 113 records available for dissolved lead in surface waters for segment 0610 (period of record: July 1991 to July 2002). Using the 15th percentile hardness value (29.8 mg/L as $CaCO_3$), the calculated chronic criterion for lead for segment 0610 is 0.54 µg/L and the acute criterion is calculated to be 15.54 µg/L. All records exceeded the calculated chronic criterion. However, 110 of the 113 samples that exceeded the chronic criterion were reported as nondetects with detection limits of 1 µg/L, 2 µg/L, or 3 µg/L. One sample from station 10613 collected on August 16, 1994, was reported as nondetect with a detection limit of 31 µg/L, exceeding the acute criterion of 15.54 µg/L. Table 4A-21 summarizes dissolved lead concentrations measured above the detection limits that exceed the chronic criterion for segment 0610. Table 4A-22 summarizes the available dissolved lead data for segment 0610.

There are 61 records available for dissolved lead in surface waters for segment 0615, with a period of record from August 1995 to April 2002. Using the 15th percentile hardness value (29.8 mg/L as $CaCO_3$), the chronic criterion for lead is 0.54 µg/L and the acute criterion is 15.54 µg/L. All 61 observations exceeded the chronic criterion. However, 50 of these exceedances are nondetects with detection limits of 1 to 2 µg/L. No samples exceeded the acute criterion of 15.54 µg/L. Table 4A-23 summarizes dissolved lead concentrations measured above the detection limits that exceed the chronic criteria. Dissolved lead concentrations in surface waters at stations 15524, 15523, 10612, 15527, 15526, 14906, and 15522 in segment 0610 were all less than 0.1 µg/L in October 2002. Table 4-12 summarizes the available dissolved lead data for segment 0615.

There are 100 records available for lead in bottom sediments, from 13 stations in segment 0610 (period of record: June 1974 to December 2002). Summary statistics are as follows for the 100 samples: average, 19.49 mg/kg; minimum, 0.32 mg/kg; maximum, 84 mg/kg. Four samples exceed a consensus-based TEC of 35.8 mg/kg (MacDonald et al. 2000). These exceedances occurred at station 10612 (Sam Rayburn Reservoir at SH 147) on September 18, 2002 (45.5 mg/kg) and station 10613 (Sam Rayburn Reservoir at SH 103) on September 14, 1983 (38 mg/kg), June 11, 1984 (84 mg/kg), and May 24, 1988 (38 mg/kg). No values exceeded the consensus-based PEC of 128 mg/kg (MacDonald et al. 2000).

One lead concentration (5.58 mg/kg) record is available for bottom sediment at station 10623 in April 1997, for segment 0615.

Selenium

Sixty records are available for total selenium in surface waters for segment 0610 (period of record: June 1989 to March 2002). No exceedances of the acute or chronic TSWQS (20 µg/L and 5 µg/L) were observed. All 60 records are reported as nondetects with the exception of one record from station 10615 on May 6, 1996 (2.38 µg/L). Table 4A-24 summarizes the available total selenium data for segment 0610.

There are 39 records available for total selenium in surface waters for segment 0615 (period of record: August 1996 to April 2002). All 39 records are reported as nondetects; however, the reporting limits for 5 records exceed the chronic TSWQS of 5 µg/L. These exceedances occurred at station 10502 on July 27, 1999 (5.5 µg/L) and January 13, 2000 (11 µg/L); station 10621 on February 17, 1998 (8 µg/L) and January 13, 2000 (11 µg/L); and station 10623 on February 17, 1998 (8 µg/L). No exceedances of the acute TSWQS for total selenium (20 µg/L) were observed. Table 4A-25 summarizes the available total selenium data for segment 0615.

Total selenium concentrations in surface waters at stations 15524, 15523, 10612, 15527, 15526, 14906, and 15522 in segment 0610 were all measured at less than 0.2 µg/L in October 2002. Stations 15524 and 15523 had detectable concentrations of 0.105 µg/L and 0.116 µg/L, respectively.

Zinc

There are 113 records available for dissolved zinc in surface waters for segment 0610 (period of record: July 1991 to July 2002). Using the 15th percentile hardness value (29.8 mg/L as $CaCO_3$), the calculated chronic criterion for zinc for segment 0610 is 37.5 µg/L and the acute criterion is 41.0 µg/L. One record exceeded the chronic criterion. This exceedance occurred at station 10613 on July 30, 1991 (40 µg/L). Table 4A-26 summarizes the available dissolved zinc data for segment 0610.

There are 61 records available for dissolved zinc in surface waters for segment 0615 (period of record: August 1995 to April 2002). Using the 15th percentile hardness value (29.8 mg/L as $CaCO_3$), a calculated chronic criterion for dissolved zinc for segment 0615 is 37.5 µg/L and the acute criterion is calculated to be 41.0 µg/L. There were nine exceedances of the calculated chronic criteria. Seven of these exceedances also exceeded the acute criterion. Table 4A-27 summarizes dissolved zinc detections that exceeded the chronic criterion for segment 0615, when using the 15th percentile hardness value of 29.8 mg/L. Dissolved zinc concentrations in surface waters at stations 15524, 15523, 10612, 15527, 15526, 14906, and 15522 in segment 0610 were all less than detection (< 0.5 µg/L) in October 2002. Table 4A-28 summarizes the available dissolved zinc data for segment 0615.

There are 101 zinc concentration records available for bottom sediments, measured at 13 stations for segment 0610 (period of record: June 1974 to December 2002). Summary statistics are as follows for the entire 101 samples: average, 96.18 mg/kg; minimum, 16.7 mg/kg; maximum, 620 mg/kg. When screened against the consensus-based TEC of 121 mg/kg (MacDonald et al. 2000),

27 exceedances are revealed. These exceedances occurred at station 10612, 10613, 10615, 15523, 15524, 15525, and 15526. A single record at station 10613 (620 µg/L) exceeded the consensus-based PEC of 459 mg/kg (MacDonald et al. 2000).

One zinc concentration (31.5 mg/kg) record is available for bottom sediment at station 10623 in April 1997, for segment 0615.

Dioxin

The TRACS database was queried for dioxin and dioxin-like compounds, including furans. No records containing ambient concentration data for surface waters, sediments, or fish tissues were found.

4.2.2.3 Bacteria

Bacteria, specifically fecal coliform bacteria and *E. coli*, are measured for the protection of human health. These counts provide an estimate of contamination due to discharges of human wastes or animal waste, and they indicate the potential presence of pathogens. TCEQ standards indicate that fecal coliform bacteria levels should not exceed the instantaneous criterion of 400 counts/100 mL. *E. coli* should not exceed the instantaneous criterion of 394 counts/100 mL.

Segment 0610: Fecal Coliform Bacteria

In segment 0610, average fecal coliform bacteria ranged from 1.0 counts/100 mL to 857 counts/100 mL (Table 4A-29). Data were collected at 30 stations from 1990 to 2002 for a total of 470 measurements. Of these, 36 samples exceeded TCEQ's criterion. It is important to note that the highest concentrations of fecal coliform bacteria were measured in the riverine sections of Ayish Bayou.

Segment 0615 - Fecal Coliform Bacteria

In segment 0615, average fecal coliform bacteria ranged from 173 counts/100 mL to 671 counts/100 mL (Table 4A-29). Data were collected at three stations from 1990 to 2002 for a total of 130 measurements. Of these, 20 samples exceeded TCEQ's criterion.

Segment 0610: Escherichia Coli

In segment 0610, average *E. coli* ranged from 1.0 counts/100 mL to 156 counts/100 mL (Table 4A-30). Data were collected at 11 stations from 2001 to 2002 for a total of 135 measurements. Of these, one sample exceeded TCEQ's criterion.

Segment 0615: Escherichia Coli

In segment 0615, average *E. coli* ranged from 701 counts/100 mL to 1,053 counts/100 mL (Table 4A-30). Data were collected at three stations during 2002 for a total of 10 measurements. Of these, four samples exceeded TCEQ's criterion.

4.2.2.4 Conventional Parameters

Segment 0610: Alkalinity

In segment 0610, total alkalinity average concentrations ranged from 16 mg/L to 48 mg/L (Table 4A-31). Data were collected at 5 stations from 1990 to 2002 for a total of 123 measurements. No criteria for alkalinity are promulgated for Texas and most other states. Given these concentrations, however, the buffering capacity of the reservoir is low.

Segment 0615: Alkalinity

In segment 0615, total alkalinity average concentrations ranged from 1 mg/L to 41 mg/L (Table 4A-31). Data were collected at 4 stations from 1990 to 2002 for a total of 120 measurements. Compared to segment 0610, alkalinity at several sites is very low and would reduce the water's ability to neutralize additional positive hydrogen (H+) ions that may result from the addition of constituents that might lower the pH.

Segment 0610: Chloride

In segment 0610, total chloride average concentrations ranged from 5.2 mg/L to 52 mg/L (Table 4A-32). Data were collected at 17 stations from 1990 to 2002 for a total of 231 measurements. The TCEQ criterion for chloride in segment 0610 is 100 mg/L. It was exceeded only three times over the period of record.

Segment 0615: Chloride

In segment 0610, total chloride average concentrations ranged from 19.2 to 362 mg/L (Table 4A-32). Data were collected at four stations from 1990 to 2002 for a total of 120 measurements. The TCEQ criterion for chloride in segment 0610 is 150 mg/L. This was exceeded 29 times over the period of record. Segment 0615's chlorides are considerably higher and more variable than those observed in Segment 0610.

Segment 0610: Sulfate

In segment 0610, sulfate average concentrations ranged from 5.3 mg/L to 41.8 mg/L (Table 4A-33). Data were collected at 18 stations from 1990 to 2002 for a total of 231 measurements. The TCEQ criterion for sulfate in segment 0610 is 100 mg/L. This was exceeded two times over the period of record.

Segment 0615: Sulfate

In segment 0615, sulfate average concentrations ranged from 25 mg/L to 245 mg/L (Table 4A-33). Data were collected at four stations from 1990 to 2002 for a total of 131 measurements. The TCEQ criterion for sulfate in segment 0615 is 100 mg/L. This was exceeded 32 times over the period of record. Sulfate concentrations in segment 0615 are considerably higher than in segment 0610.

Segment 0610: Total Suspended Solids

In segment 0610, total suspended solids (TSS) average concentrations ranged from 1 mg/L to 19.9 mg/L (Table 4A-34). Data were collected at 15 stations from 1990 to 2002 for a total of 182 measurements. TCEQ has no criteria for TSS; however, these concentrations of TSS were relatively low.

Segment 0615: Total Suspended Solids

In segment 0615, TSS average concentrations ranged from 10 mg/L to 21.6 mg/L (Table 4A-34). Data were collected at four stations from 1990 to 2002 for a total of 119 measurements. Segment 0615 concentrations of TSS are relatively similar to those found in segment 0610.

Segment 0610: Total Dissolved Solids

In segment 0610, total dissolved solids (TDS) average concentrations ranged from 12 mg/L to 23 mg/L (Table 4A-35). Data were collected at 6 stations from 1994 to 2002 for a total of 120 measurements. TCEQ's criterion for TDS is 400 mg/L, and 5 values exceeded this criterion. Clearly, these results differ from those observed for TSS, where concentrations were generally lower. Not all TDS concentrations are the result of paired samples (e.g., TSS and TDS samples collected together at a site).

Segment 0615: Total Dissolved Solids

In segment 0615, TDS average concentrations ranged from 179 mg/L to 1,218 mg/L (Table 4A-35). Data were collected at 4 stations from 1994 to 2002 for a total of 105 measurements. TCEQ's criterion for TDS is 500 mg/L in segment 0615, and 30 samples exceeded the criterion. Site 10502 had a maximum concentration of 2,660 mg/L. This concentration is noted because of its magnitude. Segment 0615 TDS concentrations are substantially higher than those observed in segment 0610. Although chloride and sulfate can make up large proportions of the TDS, concentrations of these parameters suggest that other factors influence the TDS in segment 0615.

Segment 0610: Water Temperature

Water temperature in a reservoir can be highly variable depending on the vertical depth at which the temperature is measured. Cooler, more dense waters are often located in the deeper portions of the reservoir or hypolimnion. Warmer temperatures (but not as warm as the surface

temperatures) are found in a middle layer called the metalimnion, and surficial layers called the epilimnion often very nearly reflect surficial temperatures, although this layer might be several meters thick. TCEQ's criterion for water temperature in Sam Rayburn Reservoir is 33.9 °C. Because of the potential variability of temperature in a reservoir, the criterion is applied in Texas to surficial samples, and thus all data presented as part of this summary are for sampled collected about 1 foot below the surface.

In segment 0610, temperature averages ranged from 17 °C to 31 °C (Table 4A-36). Data were collected at 41 stations from 1990 to 2002 for a total of 668 measurements. Of these, 2 measurements exceeded the criterion.

Segment 0615: Water Temperature

In segment 0615, temperatures averages ranged from 20.9 °C to 23.8 °C (Table 4A-36). Data were collected at 3 stations from 1990 to 2002 for a total of 133 measurements. None of the measured temperatures exceeded the criterion.

Segment 0610: pH

Like dissolved oxygen, pH is regulated within the mixed surface layer. TCEQ's pH criteria for segment 0610 are based on a range of 6.0 to 8.5. These criteria are applied to those waters depending on the location that may be considered surficial or several meters below the surface. For this reason, pH data presented and summarized in Table 4A-37 include all pH values measured at multiple depths for a site. Averages were calculated for a site and depth, resulting in more than 3,000 records. pH averages ranged from 5.9 to 8.1. Sixty-seven measurements exceeded either the lower or upper criteria limits. Assuming the thermocline is approximately 30 feet below the surface at many sites, and that the defined mixed surface layer is 30 feet or less, 39 pH values exceeded the criteria in this depth profile. Nineteen records exceeded the upper limit of 8.5, and 48 exceeded the lower limit of 6.0.

Segment 0615: pH

TCEQ's pH criteria for segment 0615 are based on a range of 6.5 to 9.0. pH data for segment 0615 are presented and summarized in Table 4A-37, and they include all pH values measured at multiple depths for a site. Averages were calculated for a site and depth, resulting in 374 records. pH averages ranged from 6.45 to 7.65. Thirty-four measurements exceeded the lower or upper criteria limits. All pH values measured in this segment were at depths of less than about 12 feet. All 34 records exceeded the lower limit of 6.5.

Segment 0610: Conductivity

In segment 0610, conductivity averages ranged from 63.7 µmos/cm to 314 µmos/cm (Table 4A-36). Data were collected at 30 stations from 1990 to 2002 for a total of 440 measurements.

Segment 0615: Conductivity

In segment 0615, conductivity averages ranged from 168 µmos/cm to 1872 µmos/cm (Table 4A-36). Data were collected at three stations from 1990 to 2002 for a total of 133 measurements. These conductivity data reflect the high TDS values observed in segment 0615.

4.2.3 Impairment Summary

This section presents a summary of all exceedances of the analyzed parameters in Sam Rayburn Reservoir. For more detailed information on the data see the following sections, which present detailed information for each of the pollutants. Summaries of the dissolved oxygen and metals impairments are presented first because DO and aluminum are the two parameters that the reservoir is listed for on the 303(d) list. A summary of the nutrient data is presented with the DO data because the two are often dependent on each other. Summaries of additional parameters analyzed at the request of TCEQ are presented after DO and metals.

Assessment of a number of parameters over a 10-plus year period in segment 0610 and 0615 indicates that a number of parameters exceed criteria or screening levels. Dissolved oxygen and metals tend to have low or no exceedances, whereas nutrients, chlorophyll a, and water transparency tend to have a number of high observations. Chlorides, sulfates, and TDS exceeded criteria, but more often in segment 0615 than in segment 0610. Bacteria exceedances also occur.

Dissolved Oxygen

In segment 0610, the lowest mean dissolved oxygen was calculated as 5.33 mg/L at station 15357. There were few criterion exceedances for these surficial samples (e.g., <3.0 mg/L); only two samples were measured as less than 3.0 mg/L. These exceedances were recorded at sites 15357 and 15358 in Ayish Bayou tributary streams (unclassified segment 0610a). Based on these data, no exceedances of the criteria were observed from sites within the reservoir portion of segment 0610.

Relatively few data were available for 24-hour average dissolved oxygen data for segment 0610. Two 24-hour average dissolved oxygen values exceeded the criterion (5.0 mg/L) at sites 14907 and 15361 in the Ayish Bayou arm of the reservoir. Only station 14907 is located within the reservoir. At station 14907 the 24-hour mean dissolved oxygen was 2.3 mg/L, while at station 15361 the 24-hour mean dissolved oxygen was 4.63 mg/L.

Overall, the depth profile data indicate that at the sites evaluated, dissolved oxygen stratification occurs during the summer months, resulting in hypolimnetic oxygen deficits. Mixed surface layers differ widely depending upon the time of year, but dissolved oxygen concentrations in this layer do not exceed the minimum criterion of 3.0 mg/L. Station 10613 is much less similar in profile to the other stations evaluated during the summer months; during the winter months, however, dissolved oxygen at all sites suggests the reservoir is well mixed and unstratified.

Only three locations in segment 0615 had dissolved oxygen grab samples. Lower dissolved oxygen minima were found at these sites, with the lowest surficial grab sample recording a dissolved oxygen concentration of 1.9 mg/L. Over the period evaluated, a total of 19 sample measurements fell below the dissolved oxygen minimum criterion of 3.0 mg/L. This is a sharp contrast to segment 0610, which had only two dissolved oxygen concentrations below the minimum criterion.

The 24-hour dissolved oxygen average for sites in segment 0615 showed six sample means that fell below the 24-hour mean dissolved oxygen criterion of 5.0 mg/L. Stations 10621 and 10623 are on the Angelina River near Papermill Creek; station 10502 is in Papermill Creek.

Application of a mixed surface layer criterion for DO that is based on a net change of 0.5 °C in temperature provides a moving target to assess criterion exceedances. This evaluation examined DO in three different manners and found that overall, DO in the reservoir generally does not exceed criteria, however, the mixed surface layer at times is very shallow and does not constitute the full range of the epilimnion. Implications of this are that the DO may actually fall below criteria if the depth of the epilimnion were the basis for the assessment. Like many eutrophic reservoirs, periods of low DO are likely small, occurring during the pre-dawn hours when respiration is maximized.

Nutrients and Transparency

Nutrients, transparency, and chlorophyll a samples in the reservoir were compared to the available Texas nutrient screening levels and EPA's reference criteria for lakes and reservoir since these parameters are often associated with depressed oxygen levels in waterbodies. Note that the screening levels and EPA's reference criteria are not standards but only a benchmark used to indicate potential pollutant loadings to the reservoir. Chlorophyll a, total phosphorus, orthophosphorus, nitrate and nitrite, and ammonia all had data that were higher than the Texas nutrient screening levels for these parameters. There does not appear to be a strong difference in the number of high observations in segments 0610 and 0615. Secchi depth, chlorophyll a, total phosphorus, total nitrogen, nitrate and nitrite, and total kjeldahl nitrogen all had data in the reservoir that were higher than EPA's nutrient reference criteria for lakes and reservoirs. The number of high observations was fairly large at both segments 0610 and 0615.

Measures of these parameters suggest, regardless of the screening criteria used, that the mechanisms for eutrophication in Sam Rayburn Reservoir are present. Comparison to the 1998 Texas Reservoir Assessment and EPA's 1974 assessment of the reservoir indicate that for some parameters, present day concentrations are higher, possibly due to greater inputs from upstream point and non point sources. While higher nutrients and algal growth have not necessarily caused low DO consistently throughout the reservoir, these data do suggest that the conditions are present for nutrients to play a large role in oxygen dynamics of the reservoir and its tributaries.

Metals and pH

Dissolved aluminum, dissolved copper, dissolved lead, and dissolved zinc all showed exceedances of criteria within the segments assessed. However, the number of exceedances was very small and high detection limits made much of the data unusable for assessing impairment. ANRA and TCEQ have instituted a new clean metals program with new, substantially lower detection limits. These data will provide the level of data integrity needed to evaluate whether metals in surface waters of the reservoir is an issue.

There were three dissolved aluminum exceedances of the 991 µg/L acute criterion segment 0610 and 21 exceedances on segment 0615.

There were 40 exceedances of the dissolved copper criterion in segment 0610 and 37 exceedances on segment 0615, but 36 and 28 observations were below detection limits, respectively. Compared to sample and time specific hardness, four and three samples, respectively, exceeded the chronic copper criterion during the assessment period.

There were values that exceeded the dissolved lead criterion, but most of these were reported as below detection limits (although concentrations were greater than the criteria). Three samples in segment 0610 were measured above the detection limits and exceeded the criterion in segment 0610. Likewise, in segment 0615, eight samples exceeded the criterion. For both segments, exceedances were of the chronic criterion.

In segment 0610, dissolved zinc showed only one exceedance at station 10613 on July 30, 1991. In segment 0615, all observations were nondetects. Comparison of the nondetected values to site and time specific hardness values shows that even though the measure below the detection limit is unknown, the detection limit does not exceed hardness measured at the time of sampling.

Overall, metals concentrations in surface waters have a relatively low potential to impair uses in segment 0610 and 0615. Numbers of exceedances for each metal parameter assessed are relatively low given the period for which the assessment was conducted. However, analytical detection limits hinder a proper assessment of long-term metals issues. Additional sampling, currently implemented by ANRA and TCEQ using lower detection limits, will aid in making a more accurate assessment of potential metals issues in these segments.

There were some exceedances of the pH criteria in segment 0610 and 0615. There were 19 high observations and 48 low observations in segment 0610, and 34 observations were below the lower threshold of 6.5 in segment 0615.

Bacteria

Thirty-six fecal coliform bacteria samples exceeded the 400 counts/100 mL criterion in segment 0610, which is approximately 8 percent of the samples. It is important to note that the highest concentrations of fecal coliform bacteria were measured in the riverine sections of Ayish Bayou. Twenty samples exceeded the criterion in segment 0615. There was only one exceedance of the

E. coli criterion in segment 0610 and four exceedances of the *E. coli* criterion in segment 0615. The four exceedances on segment 0615 represented 40 percent of the samples in that portion of the reservoir. Continued monitoring at this and other sites is recommended to determine if there is a bacteria impairment.

Chloride and Sulfate

There were not many exceedances of the chloride and sulfate criteria in segment 0610 and 0615. There were three exceedances of chloride crition at segment 0610 and 29 exceedances at segment 0615. There were two sulfate exceedances at segment 0610 and 30 sulfate exceedances at segment 0615. Overall the chloride and sulfate observations exceeded the criteria more often in segment 0615 than in segment 0610.

Total Dissolved Solids

There were 5 exceedances of the TDS criterion in segment 0610 and 30 exceedances in segment 0615.

4.3 Sam Rayburn Reservoir STORET Water Quality

This section includes a summary and analysis of all of the water quality monitoring data available in EPA's STORET database from 1990 through the present for the Sam Rayburn Reservoir (segment 0610). There were no data available in STORET for segment 0615. The summary includes only data collected from 1990 through the present even though additional data from prior to 1990 are available for many of the monitoring stations. Analysis of the more recent data results in a better understanding of the current conditions in the reservoir, which led to its placement on the 2000 section 303(d) list of impaired waters for the state of Texas.

4.3.1 STORET Monitoring Stations at Sam Rayburn Reservoir (Segment 0610)

A total of 51 monitoring stations in the STORET database have water quality data from Sam Rayburn Reservoir; however, only 14 stations have profile data from after 1990 (USGS and TCEQ stations). The 14 stations with recent profile data were the only stations analyzed for water quality trends in the watershed. There were no recent water quality data for any of the stations on segment 0615 (Angelina River/Sam Rayburn Reservoir). Table 4-2 presents the Sam Rayburn Reservoir monitoring stations in the watershed with post-1990 water quality data. Figure 4-5 shows the locations of the STORET stations in the watershed.

Table 4-2. Water Quality Monitoring Stations in the Sam Rayburn Reservoir with Post-1990 Data

Segment ID	Station ID	Agency	Station Name
0610 (Sam Rayburn Reservoir)	14907	USGS	Sam Rayburn Reservoir at FM 83
	14906	USGS	Sam Rayburn Reservoir at Main Pool
	310437094065501	TCEQ	Sam Rayburn Reservoir CC
	310802094112201	TCEQ	Sam Rayburn Reservoir FC
	310816094041401	TCEQ	Sam Rayburn Reservoir AC
	311000094010301	TCEQ	Sam Rayburn Reservoir LC
	311039094141201	TCEQ	Sam Rayburn Reservoir GC
	311137094051401	TCEQ	Sam Rayburn Reservoir MC
	311804094234901	TCEQ	Sam Rayburn Reservoir JC
	311817094190701	TCEQ	Sam Rayburn Reservoir NC
	311828094191801	TCEQ	Sam Rayburn Reservoir IC
	312216094280601	TCEQ	Sam Rayburn Reservoir KC
	06100100	USGS	Sam Rayburn Reservoir
	06100200	USGS	Sam Rayburn Reservoir at SH 103
0615 (Angelina River/Sam Rayburn Reservoir)	There are no monitoring stations in EPA's STORET database with recent data for this segment		

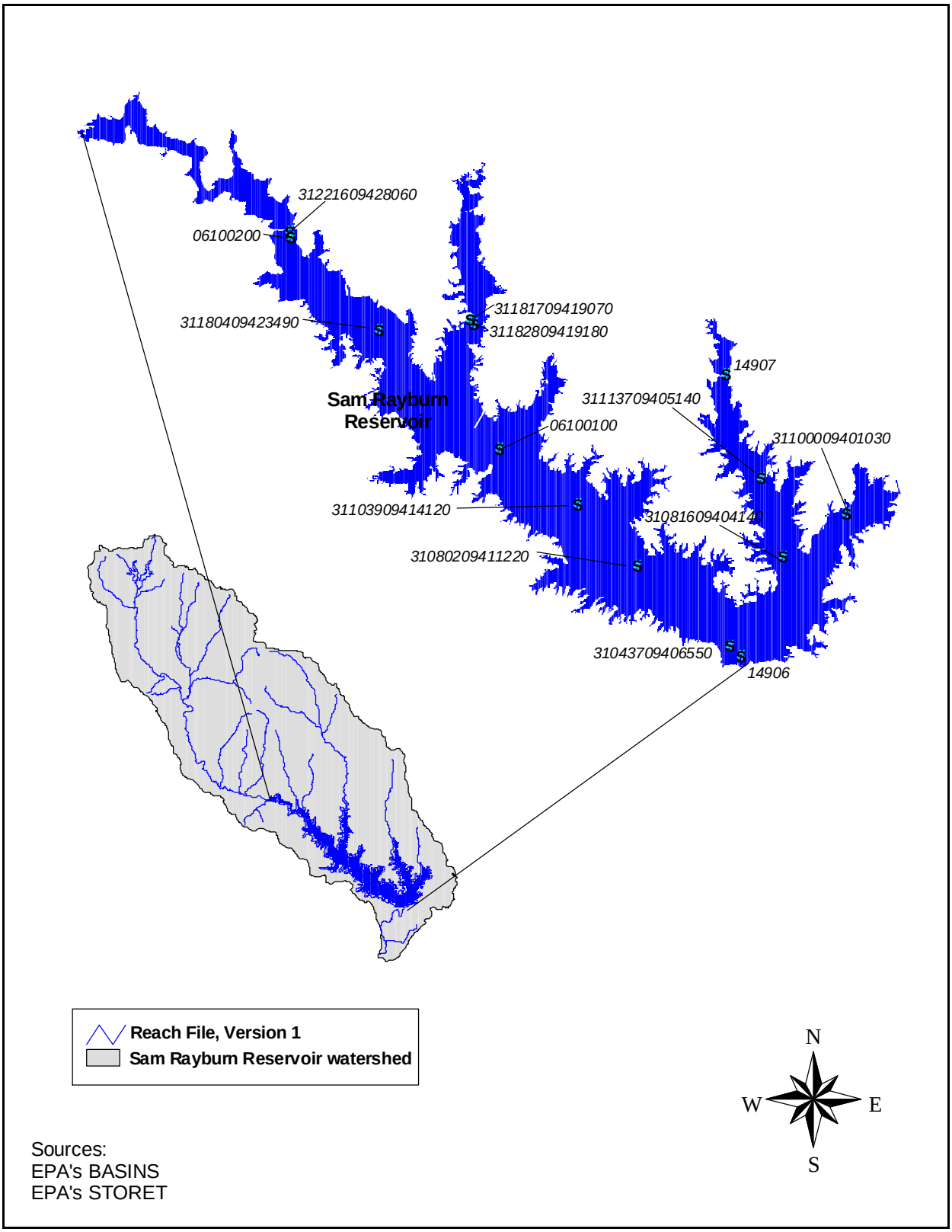

Figure 4-5. Location of STORET Water Quality Monitoring Stations in Sam Rayburn Reservoir

4.3.2 Water Quality Data Analysis

Because Sam Rayburn Reservoir was placed on Texas's 2000 section 303(d) list of impaired waterbodies for dissolved oxygen, pH, and aluminum impairments, these three parameters were analyzed for the reservoir. Any parameters that affect dissolved oxygen (i.e., nutrients and chlorophyll a) were also included in the analysis. Additional parameters were included in the analysis at the request of TCEQ to determine whether there are any other potential impairments of the reservoir. For parameters that have water quality criteria or screening levels, the number of exceedances was determined for each of the stations. Section 1.3 discusses the appropriate water quality criteria and screening levels. All stations were analyzed for the following parameters:

- Water temperature
- Transparency
- Conductivity
- Dissolved oxygen
- Biolochemical oxygen demand
- pH
- Total alkalinity
- Total solids
- Dissolved solids
- Ammonia
- Nitrate and nitrite
- Total Kjeldahl nitrogen
- Total nitrogen
- Phosphorus
- Total organic carbon
- Chlorophyll a
- Fecal coliform bacteria
- Chloride
- Sulfate
- Dissolved arsenic
- Dissolved aluminum
- Dissolved copper
- Dissolved lead
- Total selenium
- Dissolved zinc
- Dioxin

4.3.2.1 Dissolved Oxygen and Nutrients

Dissolved Oxygen

The 14 monitoring stations on segment 0610 have a total of 645 dissolved oxygen observations. The lowest dissolved oxygen observation was 0.0 mg/L at station 06100100 on June 24, 1991, beginning at a depth of 30 feet and continuing to the bottom of the reservoir (56 feet). The maximum dissolved oxygen observation was 12.6 mg/L at station 310437094065501 on February 8, 1995, at between 10 and 30 feet.

Dissolved oxygen and pH criteria apply to the entire mixed water column, or to only measurements made in the mixed surface layer if the water column is stratified. For reservoirs, the mixed surface layer is defined as the portion of the water column from the surface to the depth at which water temperature decreases by greater than 0.5 °C (TNRCC 2002). Dissolved oxygen observations in the mixed layer were compared to the dissolved oxygen water quality criterion of 3.0 mg/L for grab samples on segment 0610. There was only one exceedance of the 3.0 mg/L dissolved oxygen criterion in the mixed layer of segment 0610. The exceedance occurred at station 14906 in August 1996. That exceedance occurred at the end of a severe drought with lower-than-normal reservoir levels (NCDC 2001). Table 4C-1 presents a summary of the dissolved oxygen data available for segment 0610. Figures 4D-2 through 4D-11 in Appendix 4D at the end of Section 4.0 present dissolved oxygen observations at representative stations in the reservoir at the upper, middle, and lower sections, as well as the Attoyac Bayou and Ayish Bayou arms of the reservoir.

Chlorophyll a

There are 4 monitoring stations on segment 0610 with a total of 13 chlorophyll a observations. Nine of the observations are at the surface of the reservoir. The minimum chlorophyll a observation was 1.0 µg/L at station 06100200 on February 27, 1992. The maximum observation was 29.3 µg/L at station 14907 on August 21, 1996. The maximum observation at station 14907 is above the 21.4 µg/L screening level for chlorophyll a in Texas reservoirs. In comparison to the EPA reference conditions for chlorophyll a in lakes and reservoirs, seven observations are higher than the 2.834-µg/L reference conditions. The high concentrations occurred in August 1990, June and July 1991, February and July 1992, and August 1996. Table 4C-2 presents a summary of the available surface chlorophyll a data at segment 0610.

Transparency

Transparency was measured as Secchi disc depth for segment 0610. Twelve monitoring stations in segment 0610 have Secchi depth observations. The number of observations at each station ranges from 1 to 10. The minimum Secchi depth was measured as 0.20 meter at station 312216094280601 on February 14, 1997. The maximum Secchi depth of 2.7 meters was observed at three stations in the reservoir (310437094065501, 310802094112201, and 310816094041401) in August 1994. Secchi depth observations were compared to EPA's reference conditions because Texas does not have Secchi depth criteria. There were 33 Secchi depth observations lower than the 1.1-meter Secchi depth reference conditions for Texas lakes and reservoirs. Table 4C-3 presents the Secchi depth data summary for segment 0610.

Nutrients

Total Phosphorus

There are 4 monitoring stations with a total of 17 total phosphorus observations in segment 0610. Eleven of those observations were at the surface of the reservoir and were compared to the total phosphorus criteria. The minimum total phosphorus observation was 0.01 mg/L at station 14906 on August 21, 1996, and the maximum observation was 0.18 mg/L at station 06100100 on July 16, 1992. No observations were higher than the 0.18-mg/L screening level for phosphorus in Texas reservoirs; however, the maximum observation at station 06100100 was right at the screening level. Ten observations were higher than the EPA reference conditions of 0.0325 mg/L for lakes and reservoirs. Table 4C-4 presents a summary of the total phosphorus data available for the surface of segment 0610.

Total Ortho-Phosphorus

There are two stations (14907 and 14906) on segment 0610 with total ortho-phosphorus observations at the surface of the reservoir, however, each station only has one observation. The ortho-phosphorus observations at stations 14907 and 14906 were both 0.1 mg/L on August 21, 1996. Both of these observations were higher than the 0.05 mg/L screening level for ortho-phosphorus in Texas reservoirs, however, the STORET remark code for both samples indicates

that the ortho-phosphorus value is known to be lower than the reported value. The detection limit used for sampling ortho-phosphorus was too high, resulting in observations that were greater than the applicable screening level. The ortho-phosphorus concentrations may actually be less than the screening level. Table 4C-5 presents a summary of the total ortho-phosphorus data available at the surface of segment 0610.

Total Nitrogen

Organic and inorganic nitrogen (NO_2+NO_3+NH_4+TKN) were combined at all stations in segment 0610 containing those data types to calculate total nitrogen. Stations 06100100 and 06100200 had enough data to calculate total nitrogen concentrations at the surface of the reservoir and resulted in a total of four observations. The minimum observation, 0.47 mg/L, was at station 06100100 on June 24, 1991. The remaining three observations were all higher than the 0.492-mg/L lake and reservoir reference conditions (USEPA 2000). Table 4C-6 presents a summary of the total nitrogen data for the surface of segment 0610.

Nitrite and Nitrate

Two monitoring stations in segment 0610 have nitrite (NO_2) and nitrate (NO_3) observations. There is a total of 13 NO_2+NO_3 observations in segment 0610. Eight of those observations were at the surface of the reservoir and were compared to the Texas screening level and EPA's reference conditions for NO_2+NO_3. The minimum concentration was 0.02 mg/L, which was observed at both stations on several dates (August 20, 1990, June 24, 1991, July 30,1991, and July 16, 1992). The maximum concentration, 0.14 mg/L, was observed on February 26, 1991, at station 06100200. The NO_2 + NO_3 observations were compared to the Texas screening level of 0.32 mg/L for nitrate and nitrite in Texas reservoirs as well as EPA's reference condition of 0.033 mg/L. All observations were below the Texas screening level of 0.32 mg/L; however, four observations were higher than EPA's reference concentration of 0.033 mg/L. Each of the three monitoring stations had high concentrations during February 1991 and February 1992. Table 4C-7 presents a summary of the surface NO_2 + NO_3 data available for segment 0610.

Total Kjeldahl Nitrogen

Segment 0610 had four monitoring stations with a total of 10 total Kjeldahl nitrogen (TKN) observations. Six of the observations were made at the surface of the reservoir and were compared to the reference conditions for TKN. The minimum observation was 0.45 mg/L at station 06100100 on February 26, 1991, and June 24, 1991. The maximum observation, 0.80 mg/L, was at station 06100200 on August 20, 1990. The TKN data were compared to EPA's reference conditions of 0.459 mg/L for lakes and reservoirs. Four observations that were higher than the reference conditions. The high concentrations were observed at three stations in August 1990 and August 1996. Table 4C-8 presents a summary of the surface TKN data available for segment 0610.

Ammonia

Nine monitoring stations have ammonia (un-ionized NH_3) data for segment 0610. The 9 stations have a total of 154 ammonia observations. The minimum ammonia observation was 0.000005 mg/L at station 312216094280601 on February 14, 1997. The maximum ammonia observation was 0.015 mg/L at station 311828094191801 on August 22, 1996. The ammonia observations were compared to the screening-level for NH_3 of 0.106 mg/L for Texas lakes and reservoirs. All ammonia observations were below the screening level concentration. Table 4C-9 presents a summary of the ammonia data in segment 0610.

Biological Oxygen Demand

There are no BOD_5 data for segment 0610 in the STORET database.

Total Organic Carbon

Segment 0610 contains 17 total organic carbon (TOC) observations among 4 water quality monitoring stations. The minimum TOC observation was 5.0 mg/L at station 06100100 on July 16, 1992. The maximum TOC observation was 12.0 mg/L at station 06100200 on February 27, 1992. There are no TOC criteria to which the data can be compared. Table 4C-10 presents a summary of the available TOC data at segment 0610.

4.3.2.2 Metals and Dioxin

Metals

Metals data, including dissolved arsenic, dissolved copper, dissolved lead, total selenium, and dissolved zinc, were analyzed for segment 0610. There was only one monitoring station with metals data on segment 0610. The station had only 1 day of monitoring data for each of the metals. Arsenic, copper, lead, and zinc samples were collected on July 30, 1991, and one total selenium sample was collected on August 20, 1990. The station, 06100200, had no exceedances of any of the applicable metals water quality criteria (see Section 1.3). Table 4C-11 presents a summary of the available metals data for segment 0610.

Dioxin

There were no dioxin data for segment 0610 in the STORET database.

4.3.2.3 Fecal Coliform Bacteria

There are 7 stations with a total of 37 fecal coliform bacteria observations at the surface of segment 0610. The minimum observations were 0 counts/100 mL at stations 311828094191801 and 310437094065501 on January 26, 1994, and January 25, 1994, respectively. The maximum observed fecal coliform bacteria concentration, 220 counts/100 mL, was observed at station 311828094191801 on February 13, 1997. There were no exceedances of the 400 counts/100mL

fecal coliform bacteria instantaneous criterion in segment 0610. Table 4C-12 presents a summary of the available fecal coliform bacteria data at segment 0610.

4.3.2.4 Conventional Parameters

Total Alkalinity

There are seven monitoring stations with total alkalinity data in segment 0610. The 7 stations have a combined total of 53 total alkalinity observations. The minimum total alkalinity concentration of 8 mg/L was observed at station 06100100 on February 26, 1991. The maximum observed total alkalinity concentration was 59 mg/L at station 06100200 on August 20, 1990. There are no total alkalinity criteria to which the observed data can be compared. Table 4C-13 presents a summary of the total alkalinity data for segment 0610.

Chloride

There are 7 stations with 72 chloride observations at segment 0610. Thirty-nine of the observations are at the surface of the reservoir. The average chloride concentrations from surface samples at each monitoring station were compared to the chloride criterion. The minimum average chloride concentration was 9.5 mg/L at station 06100100 and the maximum average chloride concentration was 35.9 mg/L at station 312216094280601. There were no exceedances of the 100 mg/L chloride criterion for segment 0610. Table 4C-14 presents a summary of the available surface chloride data for segment 0610.

Sulfate

Segment 0610 contains 7 monitoring stations with a total of 72 sulfate observations. Thirty-eight of the observations are at the surface of the reservoir. The average sulfate concentrations at each of the monitoring stations were compared to the sulfate water quality criterion. The minimum average sulfate concentration was 12.0 mg/L at station 312216094280601; the maximum average concentration was 50.0 mg/L at station 31221609480601. There were no exceedances of the 100 mg/L sulfate criterion for segment 0610. Table 4C-15 presents a summary of the available surface sulfate data at segment 0610.

Total Suspended and Dissolved Solids

Four monitoring stations have total suspended solids (TSS) data for segment 0610. Total suspended solids are reported in the STORET database as total nonfiltered residue. The 4 stations have a combined total of 17 TSS observations. The minimum TSS value, 2.0 mg/L, was observed at station 06100100 on February 26, 1991, at 60 feet and in June 1991 and February 1992 at the surface of the reservoir. The maximum observed TSS value was 25.0 mg/L at station 14907 on August 21, 1996. There are no TSS criteria to which the data can be compared.

Two stations on segment 0610 had total dissolved solids (TDS) data. Total dissolved solids are reported in the STORET database as dissolved residue. Each station had one observation on August 21, 1996. The minimum observation was 118.0 mg/L at station 14906, and the maximum observation was 144.0 mg/L at station 14907. There were no exceedances of the 400 mg/L TDS criterion for segment 0610. Table 4C-16 presents a summary of the TSS and TDS data for segment 0610.

Water Temperature

There are 645 water temperature observations for Sam Rayburn Reservoir, and 108 of them are surface samples that can be compared to the water quality criterion of 93.0 °F for surface water temperature. Each of the 14 stations with recent data for the reservoir have surface water temperature data. The minimum temperature, 48.2 °F, was observed at station 312216094280601 on January 27, 1994. The maximum temperature, 93.2 °F, was observed at station 311000094010301 on August 29, 1995. There was only one exceedance of the 93.0 °F temperature criterion for the Sam Rayburn Reservoir. Table 4C-17 presents a summary of the surface water temperature data available for segment 0610.

pH

There are 644 pH observations for the 14 monitoring stations in segment 0610. The minimum pH value of 6.3 was observed at station 311000094010301 on April 20, 1994. The maximum observed pH value was 8.7 at station 311804094234901 on August 30, 1995. The observations were compared to the Texas pH criteria for segment 0610, which require a pH of 6 to 8.5 in the Sam Rayburn Reservoir. The pH criteria apply only to the mixed water column; therefore, if the water column is stratified, the criteria apply to the mixed area above the thermocline. There were two exceedances of the criteria, and both exceedances were just slightly higher than the upper threshold of 8.5 at the surface of the reservoir. Table 4C-18 presents a summary of the pH data at segment 0610.

Conductivity

All 14 monitoring stations in segment 0610 have conductivity observations (645 observations). The lowest conductivity observation was 85 µmos at station 311817094190701 on February 9, 1995, throughout the entire water column. The maximum conductivity observation was 435 µmos at station 312216094280601 on April 25, 1996, at the surface of the reservoir. There are no conductivity criteria for comparison to available water quality data. Table 4C-19 presents a summary of the conductivity data for segment 0610.

4.3.3 Impairment Analysis

4.3.3.1 Impairment Summary (Based on STORET Data)

This section discusses any apparent impairments in the reservoir as well as any trends observed in the STORET data. More detailed information regarding the number of observations, minimum observation, maximum observation, average, and number of exceedances of the applicable criterion or target for each parameter is found in Section 4.3.2 and the tables in Appendix 4C.

Dissolved Oxygen

There were exceedances of the TWQS for dissolved oxygen on segment 0610. Dissolved oxygen as well as any other parameters that have an effect on DO (i.e., temperature, nutrients, transparency) were analyzed for segment 0610.

Overall, the dissolved oxygen concentrations tended to be very low in the hypolimnion of the reservoir during thermal stratification; however, the concentrations in the mixed layer of the epilimnion (where the dissolved oxygen criterion is applied) were usually above the 3.0 mg/L grab sample criterion. There was one exceedance of the 3.0 mg/L criterion in the mixed layer during August 1996. August 1996 was the end of a severe drought year and reservoir levels were unusually low. The exceedance occurred at station 14906, which is in the main pool of the reservoir near the dam. Although there were no additional exceedances of the DO criterion, the DO did get very low in the Attoyac Bayou and Ayish Bayou arms in August 1996 as well.

Low dissolved oxygen is often associated with increased water temperatures. There was only one exceedance of the temperature criterion during the period of record on an arm of the reservoir in August 1996. The temperature was only 0.2 °F higher than the criterion, and the reservoir levels were unusually low at the time because of a severe drought. High temperatures in the reservoir do not appear to be a problem since this was the only exceedance of the criterion out of 645 samples.

Nutrients and transparency samples in the reservoir were compared to the available Texas nutrient screening levels and EPA's reference criteria for lakes and reservoirs since these parameters are often associated with depressed oxygen levels in waterbodies. Note that the screening levels and EPA's reference criteria are not standards but only a benchmark used to indicate potential pollutant loadings to the reservoir. Chlorophyll a was the only parameter that had concentrations higher than the Texas screening levels for secondary concerns. The chlorophyll a concentration was very high during a sampling event in August 1996 on the Ayish Bayou arm, which coincides with the low dissolved oxygen observations and low reservoir levels at that time.

Secchi depth, nitrogen, phosphorus, and chlorophyll a all had concentrations higher than EPA's reference criteria for nutrients. Several areas of the reservoir showed low Secchi depths. The largest numbers of low Secchi depth observations were observed at Attoyac Bayou and the upper portion of the reservoir just below segment 0615. Most other low observations were on the arms of the reservoir as well, except for three observations in the middle of the reservoir at station

06100100. There does not seem to be any seasonal trend with the low Secchi observations.

There were 8 nitrite and nitrate samples in the early 1990s available for the middle and upper portions of the reservoir. Fifty percent of those samples were higher than the reference criteria, however, there are no more recent data to characterize current conditions in the reservoir. Four of the six TKN observations on the reservoir were higher than the reference conditions. Two of the observations were in the upper portion of the reservoir near segment 0615 in the early 1990s (August 1990 and February 1991). The two additional high observations were at the Ayish Bayou and the reservoir dam (main pool) stations in August 1996. These high concentrations coincide with the low dissolved oxygen and low reservoir levels at the time. There was also a significant amount of rain in August 1996 (see Section 3.4), after a long period drought. The rain may have provided a pathway to the reservoir for a large amount of nutrients that had accumulated in the watershed during the drought period. The only total nitrogen data available were from the early 1990s in the upper and middle portions of the reservoir. Three of four observations of total nitrogen were above the reference criteria with the highest observations being in the upper portion of the reservoir near segment 0615.

There were 11 total phosphorus observations available for segment 0610 and ten were higher than the reference criteria. Two of the observations were from August 1996 and the remaining observations were all from the early 1990s. There are no more recent data. One of the high observation was in August 1996 on the Ayish Bayou arm during a month with significant rainfall after a drought, and the remaining high observations were in the early 1990s in the middle and upper sections of the reservoir.

Two high chlorophyll a observations occurred in August 1996 at the Ayish Bayou arm and the reservoir dam, which also coincide with the low DO, high nutrient levels, low reservoir levels, and post-drought rainfall at this time. There were also 7 observations from the early 1990s in the middle and upper portions of the reservoir. Five of the 7 observations were higher than the reference criteria.

Overall, there were nutrient observations at only four stations in the reservoir during 1990, 1991, and August 1996. It is possible that the low dissolved oxygen and and increased nutrient loading in the reservoir were the result of a long drought period followed by significant amounts of rainfall in August 1996. The long dry period might have enabled nutrients to build up for a lengthy period of time on the land in the watershed and be washed off with the first large rainfall. However, because no long-term, continuous monitoring data were available in the STORET database, it was difficult to determine whether there were any consistent nutrient problems at particular times or areas in the reservoir.

pH and Metals

There were two slight exceedances of the upper limit of the pH criteria in August 1995 in the upper section of the reservoir and on the Attoyac Bayou arm. These were the only exceedances out of 644 pH observations in the reservoir.

The STORET database contained very limited metals data for segment 0610. There were only five observations collected from five stations on two days in 1990 and 1991. None of these data showed exceedances of the applicable metals criteria for dissolved arsenic, dissolved copper, dissolved lead, total selenium, and dissolved zinc.

Fecal Coliform Bacteria

There were no exceedances of the fecal coliform bacteria criterion in segment 0610.

Chloride and Sulfate

There were no exceedances of the chloride or sulfate criteria in segment 0610.

Appendix 4A
Summary of TRACS Water Quality Monitoring Data for Sam Rayburn Reservoir

Table 4A-1. Summary of Surficial DO Grab Samples for Segments 0610 and 0615

Segment ID	Station ID	Period Begin	Period End	Sample Depth	Storet ID	Parameter	Min	Max	Avg	N	N < Criteria
610	10612	2/26/1991	8/14/2002	0.3	00300	DO (mg/l)	6.5	11.7	8.73	52	
610	10613	8/20/1990	12/10/2002	0.3	00300	DO (mg/l)	3.7	10.8	7.51	41	
610	10614	10/28/1996	12/10/2002	0.3	00300	DO (mg/l)	3.9	10.2	7.95	21	
610	14906	12/10/1996	8/22/2002	0.3	00300	DO (mg/l)	6.2	11.8	8.54	38	
610	14907	8/21/1996	12/10/2002	0.3	00300	DO (mg/l)	4.5	11	7.64	24	
610	15357	12/4/1996	8/19/1997	0.3	00300	DO (mg/l)	2.3	7.9	5.33	6	1
610	15358	12/4/1996	8/19/1997	0.3	00300	DO (mg/l)	2.7	9.4	6.07	6	1
610	15359	12/4/1996	8/19/1997	0.3	00300	DO (mg/l)	4.4	8.8	7.20	5	
610	15360	12/4/1996	8/19/1997	0.3	00300	DO (mg/l)	3.7	9.6	6.63	7	
610	15361	12/4/1996	8/7/2002	0.3	00300	DO (mg/l)	5	11.8	8.43	26	
610	15362	11/12/1996	8/21/1997	0.3	00300	DO (mg/l)	6.6	10.1	8.11	7	
610	15363	11/12/1996	8/21/1997	0.3	00300	DO (mg/l)	7.5	11.2	9.09	7	
610	15364	11/12/1996	8/9/1996	0.3	00300	DO (mg/l)	6.5	10.8	8.28	9	
610	15365	11/12/1996	8/21/1997	0.3	00300	DO (mg/l)	6	8.8	7.35	6	
610	15366	11/12/1996	8/21/1997	0.3	00300	DO (mg/l)	6.4	10.9	8.67	7	
610	15522	3/13/2001	8/22/2002	0.3	00300	DO (mg/l)	6.9	11.7	8.72	15	
610	15523	3/8/2001	8/14/2002	0.3	00300	DO (mg/l)	6.8	13.2	8.48	15	
610	15524	3/8/2001	8/14/2002	0.3	00300	DO (mg/l)	6.8	10.4	8.49	15	
610	15526	3/13/2001	8/22/2002	0.3	00300	DO (mg/l)	6.8	11.4	8.62	15	
610	15527	3/13/2001	8/22/2002	0.3	00300	DO (mg/l)	7.2	10.8	8.49	15	
610	15666	1/26/1994	2/14/1996	0.3	00300	DO (mg/l)	5.4	10.8	8.53	7	
610	15667	1/26/1994	2/14/1996	0.3	00300	DO (mg/l)	7.2	11.2	8.89	7	
610	15668	1/27/1994	2/14/1996	0.3	00300	DO (mg/l)	5.9	10.3	8.17	7	
610	15669	1/26/1994	2/14/1996	0.3	00300	DO (mg/l)	7.2	10.3	8.60	7	
610	15670	1/26/1994	2/14/1996	0.3	00300	DO (mg/l)	6.9	11	8.90	7	
610	15671	1/26/1994	2/14/1996	0.3	00300	DO (mg/l)	6.9	11	8.96	7	
610	15672	1/25/1994	2/14/1996	0.3	00300	DO (mg/l)	6.9	12.5	9.80	7	
610	15673	1/25/1994	2/13/1996	0.3	00300	DO (mg/l)	6.7	11.6	9.51	7	
610	15674	1/25/1994	2/13/1996	0.3	00300	DO (mg/l)	6.4	11.9	8.73	7	
610	15675	1/25/1994	2/13/1996	0.3	00300	DO (mg/l)	6.6	11.7	9.57	7	
610	16784	6/1/1998	7/6/1999	0.3	00300	DO (mg/l)	5.6	9	7.78	9	
610	16785	6/1/1998	7/6/1999	0.3	00300	DO (mg/l)	5.6	8	7.26	10	
610	16786	6/1/1998	7/6/1999	0.3	00300	DO (mg/l)	6.5	8.1	7.71	10	

610	16787	6/1/1998	7/6/1999	0.3	00300	DO (mg/l)	5.7	8.8	7.76	9	
610	16788	5/6/1999	8/13/1999	0.3	00300	DO (mg/l)	5.9	9.7	7.26	9	
610	16789	5/6/1999	8/13/1999	0.3	00300	DO (mg/l)	3.5	7.7	6.08	9	
610	16790	5/6/1999	8/13/1999	0.3	00300	DO (mg/l)	6.3	8.6	7.80	9	
610	16791	6/1/1998	7/6/1999	0.3	00300	DO (mg/l)	6.3	9.6	8.22	10	
610	16792	5/6/1999	8/13/1999	0.3	00300	DO (mg/l)	4.8	8.7	7.33	9	
610	16793	5/6/1999	8/13/1999	0.3	00300	DO (mg/l)	5.3	9.2	7.92	10	
615	10502	6/25/1991	11/12/2002	0.3	00300	DO (mg/l)	1.9	9.7	4.11	33	14
615	10621	8/21/1990	11/12/2002	0.3	00300	DO (mg/l)	2.2	10	5.90	51	5
615	10623	6/25/1991	11/12/2002	0.3	00300	DO (mg/l)	4.1	10.6	6.87	49	

Table 4A-2. Summary of 24-hour Minimum DO Data for Segments 610 and 615

Segment ID	Station ID	Period Begin	Period End	Sample Depth	Storet ID	Parameter	Min	Max	Avg	N	N < Criteria
610	10614	9/18/2002	9/18/2002	0.49	89857	DISSOLVED OXYGEN, 24-HOUR AVG. (MG/L) MIN. 4 MEA	7.6	7.6	7.6	1	
610	10614	3/27/2001	3/27/2001	0.7	89857	DISSOLVED OXYGEN, 24-HOUR AVG. (MG/L) MIN. 4 MEA	8.9	8.9	8.9	1	
610	10614	6/19/2001	6/19/2001	1.1	89857	DISSOLVED OXYGEN, 24-HOUR AVG. (MG/L) MIN. 4 MEA	5.7	5.7	5.7	1	
610	14907	3/27/2001	3/27/2001	0.6	89857	DISSOLVED OXYGEN, 24-HOUR AVG. (MG/L) MIN. 4 MEA	2.3	2.3	2.3	1	1
610	14907	6/19/2001	6/19/2001	0.9	89857	DISSOLVED OXYGEN, 24-HOUR AVG. (MG/L) MIN. 4 MEA	7.4	7.4	7.4	1	
610	15361	5/16/2001	8/2/2001	0.3	89857	DISSOLVED OXYGEN, 24-HOUR AVG. (MG/L) MIN. 4 MEA	4.62	6.37	5.495	2	1
615	10502	7/12/2000	7/12/2000	0.3	89857	DISSOLVED OXYGEN, 24-HOUR AVG. (MG/L) MIN. 4 MEA	2.7	2.7	2.7	1	1
615	10502	4/12/2000	4/12/2000	0.4	89857	DISSOLVED OXYGEN, 24-HOUR AVG. (MG/L) MIN. 4 MEA	7.3	7.3	7.3	1	
615	10502	7/28/1999	8/15/2001	0.6	89857	DISSOLVED OXYGEN, 24-HOUR AVG. (MG/L) MIN. 4 MEA	2.3	2.8	2.55	2	1
615	10502	5/23/2001	5/23/2001	0.7	89857	DISSOLVED OXYGEN, 24-HOUR AVG. (MG/L) MIN. 4 MEA	5.7	5.7	5.7	1	
615	10502	6/16/1999	6/16/1999	0.8	89857	DISSOLVED OXYGEN, 24-HOUR AVG. (MG/L) MIN. 4 MEA	4.2	4.2	4.2	1	1
615	10621	7/21/1998	7/21/1998	0.2	89857	DISSOLVED OXYGEN, 24-HOUR AVG. (MG/L) MIN. 4 MEA	2.7	2.7	2.7	1	1
615	10621	7/27/1999	7/12/2000	0.6	89857	DISSOLVED OXYGEN, 24-HOUR AVG. (MG/L) MIN. 4 MEA	4	4.2	4.1	2	1
615	10621	5/23/2001	5/23/2001	0.7	89857	DISSOLVED OXYGEN, 24-HOUR AVG. (MG/L) MIN. 4 MEA	4.6	4.6	4.6	1	1
615	10621	4/11/2000	4/11/2000	0.8	89857	DISSOLVED OXYGEN, 24-HOUR AVG. (MG/L) MIN. 4 MEA	6.6	6.6	6.6	1	1
615	10621	6/16/1999	8/15/2001	0.9	89857	DISSOLVED OXYGEN, 24-HOUR AVG. (MG/L) MIN. 4 MEA	2.8	4.6	3.7	2	1
615	10621	5/5/1998	5/5/1998	1	89857	DISSOLVED OXYGEN, 24-HOUR AVG. (MG/L) MIN. 4 MEA	6.1	6.1	6.1	1	1
615	10623	7/11/2000	7/11/2000	0.3	89857	DISSOLVED OXYGEN, 24-HOUR AVG. (MG/L) MIN. 4 MEA	5	5	5	1	
615	10623	4/11/2000	4/11/2000	0.5	89857	DISSOLVED OXYGEN, 24-HOUR AVG. (MG/L) MIN. 4 MEA	9.2	9.2	9.2	1	
615	10623	7/21/1998	7/21/1998	0.6	89857	DISSOLVED OXYGEN, 24-HOUR AVG. (MG/L) MIN. 4 MEA	5.9	5.9	5.9	1	
615	10623	4/22/1998	4/22/1998	0.7	89857	DISSOLVED OXYGEN, 24-HOUR AVG. (MG/L) MIN. 4 MEA	6.9	6.9	6.9	1	
615	10623	7/27/1999	7/27/1999	0.8	89857	DISSOLVED OXYGEN, 24-HOUR AVG. (MG/L) MIN. 4 MEA	5.2	5.2	5.2	1	
615	10623	8/15/2001	8/15/2001	0.9	89857	DISSOLVED OXYGEN, 24-HOUR AVG. (MG/L) MIN. 4 MEA	3.6	3.6	3.6	1	1
615	10623	4/20/1999	4/20/1999	1	89857	DISSOLVED OXYGEN, 24-HOUR AVG. (MG/L) MIN. 4 MEA	8.2	8.2	8.2	1	

Table 4-3. Summary of 24-hour Average DO Data for Segments 0610 and 0615

Segment ID	Station ID	Period Begin	Period End	Sample Depth	Storet ID	Parameter	Min	Max	Avg	N	N < Criteria
610	10614	9/18/2002	9/18/2002	0.49	89857	DISSOLVED OXYGEN, 24-HOUR AVG. (MG/L) MIN. 4 MEA	7.6	7.6	7.6	1	
610	10614	3/27/2001	3/27/2001	0.7	89857	DISSOLVED OXYGEN, 24-HOUR AVG. (MG/L) MIN. 4 MEA	8.9	8.9	8.9	1	
610	10614	6/19/2001	6/19/2001	1.1	89857	DISSOLVED OXYGEN, 24-HOUR AVG. (MG/L) MIN. 4 MEA	5.7	5.7	5.7	1	
610	14907	3/27/2001	3/27/2001	0.6	89857	DISSOLVED OXYGEN, 24-HOUR AVG. (MG/L) MIN. 4 MEA	2.3	2.3	2.3	1	1
610	14907	6/19/2001	6/19/2001	0.9	89857	DISSOLVED OXYGEN, 24-HOUR AVG. (MG/L) MIN. 4 MEA	7.4	7.4	7.4	1	
610	15361	5/16/2001	8/2/2001	0.3	89857	DISSOLVED OXYGEN, 24-HOUR AVG. (MG/L) MIN. 4 MEA	4.62	6.37	5.495	2	1
615	10502	7/12/2000	7/12/2000	0.3	89857	DISSOLVED OXYGEN, 24-HOUR AVG. (MG/L) MIN. 4 MEA	2.7	2.7	2.7	1	1
615	10502	4/12/2000	4/12/2000	0.4	89857	DISSOLVED OXYGEN, 24-HOUR AVG. (MG/L) MIN. 4 MEA	7.3	7.3	7.3	1	
615	10502	7/28/1999	8/15/2001	0.6	89857	DISSOLVED OXYGEN, 24-HOUR AVG. (MG/L) MIN. 4 MEA	2.3	2.8	2.55	2	1
615	10502	5/23/2001	5/23/2001	0.7	89857	DISSOLVED OXYGEN, 24-HOUR AVG. (MG/L) MIN. 4 MEA	5.7	5.7	5.7	1	
615	10502	6/16/1999	6/16/1999	0.8	89857	DISSOLVED OXYGEN, 24-HOUR AVG. (MG/L) MIN. 4 MEA	4.2	4.2	4.2	1	1
615	10621	7/21/1998	7/21/1998	0.2	89857	DISSOLVED OXYGEN, 24-HOUR AVG. (MG/L) MIN. 4 MEA	2.7	2.7	2.7	1	1
615	10621	7/27/1999	7/12/2000	0.6	89857	DISSOLVED OXYGEN, 24-HOUR AVG. (MG/L) MIN. 4 MEA	4	4.2	4.1	2	
615	10621	5/23/2001	5/23/2001	0.7	89857	DISSOLVED OXYGEN, 24-HOUR AVG. (MG/L) MIN. 4 MEA	4.6	4.6	4.6	1	
615	10621	4/11/2000	4/11/2000	0.8	89857	DISSOLVED OXYGEN, 24-HOUR AVG. (MG/L) MIN. 4 MEA	6.6	6.6	6.6	1	
615	10621	6/16/1999	8/15/2001	0.9	89857	DISSOLVED OXYGEN, 24-HOUR AVG. (MG/L) MIN. 4 MEA	2.8	4.6	3.7	2	1
615	10621	5/5/1998	5/5/1998	1	89857	DISSOLVED OXYGEN, 24-HOUR AVG. (MG/L) MIN. 4 MEA	6.1	6.1	6.1	1	
615	10623	7/11/2000	7/11/2000	0.3	89857	DISSOLVED OXYGEN, 24-HOUR AVG. (MG/L) MIN. 4 MEA	5	5	5	1	
615	10623	4/11/2000	4/11/2000	0.5	89857	DISSOLVED OXYGEN, 24-HOUR AVG. (MG/L) MIN. 4 MEA	9.2	9.2	9.2	1	
615	10623	7/21/1998	7/21/1998	0.6	89857	DISSOLVED OXYGEN, 24-HOUR AVG. (MG/L) MIN. 4 MEA	5.9	5.9	5.9	1	
615	10623	4/22/1998	4/22/1998	0.7	89857	DISSOLVED OXYGEN, 24-HOUR AVG. (MG/L) MIN. 4 MEA	6.9	6.9	6.9	1	
615	10623	7/27/1999	7/27/1999	0.8	89857	DISSOLVED OXYGEN, 24-HOUR AVG. (MG/L) MIN. 4 MEA	5.2	5.2	5.2	1	
615	10623	8/15/2001	8/15/2001	0.9	89857	DISSOLVED OXYGEN, 24-HOUR AVG. (MG/L) MIN. 4 MEA	3.6	3.6	3.6	1	1
615	10623	4/20/1999	4/20/1999	1	89857	DISSOLVED OXYGEN, 24-HOUR AVG. (MG/L) MIN. 4 MEA	8.2	8.2	8.2	1	

Table 4A-4. Summary of Chlorophyll a Data for Segments 0610 and 0615

Segment ID	Station ID	Period Begin	Period End	Depth	Storet ID	Parameter	Min	Max	Avg	N	N > Criteria	N >TCEQ
610	10612	6/24/1991	12/11/2002	0.3	32211	CHLOROPHYLL-A UG/L	1	23.1	6.52	33	23	1
610	10612	8/18/1994	8/18/1994	0.30488	32211	CHLOROPHYLL-A UG/L	7.48	7.48	7.48	1	1	
610	10612	6/24/1991	6/24/1991	17.01	32211	CHLOROPHYLL-A UG/L	1.8	1.8	1.80	1		
610	10613	8/20/1990	12/10/2002	0.3	32211	CHLOROPHYLL-A UG/L	1	20.8	6.10	36	21	
610	10613	8/16/1994	8/16/1994	0.30488	32211	CHLOROPHYLL-A UG/L	28.4	28.4	28.40	1	1	1
610	10614	9/28/1999	12/10/2002	0.3	32211	CHLOROPHYLL-A UG/L	1	60.1	12.01	12	7	2
610	14906	8/21/1996	12/11/2002	0.3	32211	CHLOROPHYLL-A UG/L	1	6.94	2.67	21	8	
610	14906	8/17/1999	8/17/1999	0.30488	32211	CHLOROPHYLL-A UG/L	2.14	2.14	2.14	1		
610	14907	8/21/1996	12/10/2002	0.3	32211	CHLOROPHYLL-A UG/L	1	29.3	8.84	12	9	1
615	10621	8/21/1990	11/12/2002	0.3	32211	CHLOROPHYLL-A UG/L	1	16.4	3.55	40	13	
615	10621	11/29/1994	12/4/1996	0.30488	32211	CHLOROPHYLL-A UG/L	1.82	13.4	7.61	2	1	
615	10623	6/25/1991	11/12/2002	0.3	32211	CHLOROPHYLL-A UG/L	1	79.7	5.64	39	13	2
615	10623	11/29/1994	12/4/1996	0.30488	32211	CHLOROPHYLL-A UG/L	1.41	9.19	5.30	2	1	
615	10502	6/25/1991	11/12/2002	0.3	32211	CHLOROPHYLL-A UG/L	1	34.2	3.35	33	33	
615	10502	11/29/1994	12/4/1996	0.30488	32211	CHLOROPHYLL-A UG/L	3.45	4.34	3.90	2	1	2
615	10619	11/2/1995	11/2/1995	0.30488	32211	CHLOROPHYLL-A UG/L	3.41	3.41	3.41	1	1	

Table 4A-5. Summary of Secchi Depth Data for Segments 0610 and 0615

Segment ID	Station ID	Period Begin	Period End	Storet ID	Parameter	Min	Max	Avg	N	N > Criteria
610	10612	2/26/1991	8/14/2002	00078	TRANSPARENCY, SECCHI DISC (METERS)	0.63	3	1.35	52	14
610	10613	2/26/1991	12/10/2002	00078	TRANSPARENCY, SECCHI DISC (METERS)	0.1	1.1	0.54	40	39
610	10614	9/28/1999	12/10/2002	00078	TRANSPARENCY, SECCHI DISC (METERS)	0.2	0.8	0.45	14	14
610	14906	11/24/1997	8/22/2002	00078	TRANSPARENCY, SECCHI DISC (METERS)	1.2	4	2.18	35	
610	14907	8/21/1996	12/10/2002	00078	TRANSPARENCY, SECCHI DISC (METERS)	0.2	1.6	0.66	15	12
610	15361	10/21/1999	7/17/2001	00078	TRANSPARENCY, SECCHI DISC (METERS)	0.3	0.5	0.36	8	8
610	15522	3/13/2001	8/22/2002	00078	TRANSPARENCY, SECCHI DISC (METERS)	1.2	3	1.89	14	
610	15523	3/8/2001	8/14/2002	00078	TRANSPARENCY, SECCHI DISC (METERS)	0.5	1.5	1.05	15	11
610	15524	3/8/2001	8/14/2002	00078	TRANSPARENCY, SECCHI DISC (METERS)	1	2	1.33	15	8
610	15526	3/13/2001	8/22/2002	00078	TRANSPARENCY, SECCHI DISC (METERS)	1	3	2.10	15	1
610	15527	3/13/2001	8/22/2002	00078	TRANSPARENCY, SECCHI DISC (METERS)	1	2.1	1.63	15	2
610	15666	1/26/1994	4/21/1999	00078	TRANSPARENCY, SECCHI DISC (METERS)	0.4	1.45	0.89	18	14
610	15667	1/26/1994	4/17/1997	00078	TRANSPARENCY, SECCHI DISC (METERS)	0.7	1.9	1.35	16	5
610	15668	1/27/1994	4/29/1998	00078	TRANSPARENCY, SECCHI DISC (METERS)	0.2	1.8	0.68	17	16
610	15669	8/25/1994	8/26/1999	00078	TRANSPARENCY, SECCHI DISC (METERS)	0.42	1.3	0.89	15	10
610	15670	8/25/1994	8/26/1999	00078	TRANSPARENCY, SECCHI DISC (METERS)	1.1	2.48	1.71	15	
610	15671	8/25/1994	8/26/1999	00078	TRANSPARENCY, SECCHI DISC (METERS)	1.12	2.7	1.72	14	
610	15672	1/25/1994	4/17/1997	00078	TRANSPARENCY, SECCHI DISC (METERS)	1.3	2.7	1.91	18	
610	15673	4/20/1994	8/25/1999	00078	TRANSPARENCY, SECCHI DISC (METERS)	1.3	2.7	1.83	15	
610	15674	1/25/1994	4/20/1999	00078	TRANSPARENCY, SECCHI DISC (METERS)	0.9	2.4	1.50	17	2
610	15675	1/25/1994	8/25/1999	00078	TRANSPARENCY, SECCHI DISC (METERS)	1	2.35	1.60	18	2
615	10502	6/25/1991	11/12/2002	00078	TRANSPARENCY, SECCHI DISC (METERS)	0.08	2	0.24	34	33
615	10621	8/21/1990	11/12/2002	00078	TRANSPARENCY, SECCHI DISC (METERS)	0.1	0.6	0.27	53	53
615	10623	6/25/1991	11/12/2002	00078	TRANSPARENCY, SECCHI DISC (METERS)	0.1	0.8	0.41	46	46

Table 4A-6. Summary of Total Phosphorus Data for Segments 0610 and 0615

Segment ID	Station ID	Period Begin	Period End	Depth	Storet ID	Parameter	Min	Max	Avg	N	N > Criteria	N >TCEQ
610	10612	2/26/1991	12/11/2002	0.3	00665	PHOSPHORUS, TOTAL, WET METHOD (MG/L AS P)	0.01	2.25	0.15	50	42	6
610	10612	8/18/1994	8/18/1994	0.30488	00665	PHOSPHORUS, TOTAL, WET METHOD (MG/L AS P)	0.04	0.04	0.04	1	1	
610	10612	6/24/1991	6/24/1991	17.01	00665	PHOSPHORUS, TOTAL, WET METHOD (MG/L AS P)	0.11	0.11	0.11	1		
610	10612	2/26/1991	2/26/1991	18.01	00665	PHOSPHORUS, TOTAL, WET METHOD (MG/L AS P)	0.046	0.046	0.05	1	1	
610	10613	8/20/1990	12/10/2002	0.3	00665	PHOSPHORUS, TOTAL, WET METHOD (MG/L AS P)	0.04	1.08	0.15	38	38	6
610	10613	8/16/1994	8/16/1994	0.30488	00665	PHOSPHORUS, TOTAL, WET METHOD (MG/L AS P)	0.1	0.1	0.10	1	1	
610	10613	8/20/1990	8/20/1990	5.79	00665	PHOSPHORUS, TOTAL, WET METHOD (MG/L AS P)	0.094	0.094	0.09	1	1	
610	10613	7/30/1991	7/30/1991	8.29	00665	PHOSPHORUS, TOTAL, WET METHOD (MG/L AS P)	0.09	0.09	0.09	1	1	
610	10613	2/26/1991	2/26/1991	10	00665	PHOSPHORUS, TOTAL, WET METHOD (MG/L AS P)	0.062	0.062	0.06	1	1	
610	10614	9/28/1999	12/10/2002	0.3	00665	PHOSPHORUS, TOTAL, WET METHOD (MG/L AS P)	0.06	0.17	0.10	12	12	
610	14906	8/21/1996	12/11/2002	0.3	00665	PHOSPHORUS, TOTAL, WET METHOD (MG/L AS P)	0.01	0.77	0.10	36	26	4
610	14906	8/17/1999	8/17/1999	0.30488	00665	PHOSPHORUS, TOTAL, WET METHOD (MG/L AS P)	0.03	0.03	0.03	1		
610	14907	8/21/1996	12/10/2002	0.3	00665	PHOSPHORUS, TOTAL, WET METHOD (MG/L AS P)	0.05	0.12	0.07	13	13	
610	15361	5/11/1999	7/17/2001	0.3	00665	PHOSPHORUS, TOTAL, WET METHOD (MG/L AS P)	0.036	1.048	0.35	10	8	
610	15522	3/13/2001	8/22/2002	0.3	00665	PHOSPHORUS, TOTAL, WET METHOD (MG/L AS P)	0.01	1.65	0.30	15	14	5
610	15523	3/8/2001	8/14/2002	0.3	00665	PHOSPHORUS, TOTAL, WET METHOD (MG/L AS P)	0.04	4.5	0.51	15	15	8
610	15524	3/8/2001	8/14/2002	0.3	00665	PHOSPHORUS, TOTAL, WET METHOD (MG/L AS P)	0.042	3.9	0.48	15	15	8
610	15526	3/13/2001	8/22/2002	0.3	00665	PHOSPHORUS, TOTAL, WET METHOD (MG/L AS P)	0.06	0.6	0.20	15	15	5
610	15527	3/13/2001	8/22/2002	0.3	00665	PHOSPHORUS, TOTAL, WET METHOD (MG/L AS P)	0.018	0.74	0.19	15	14	5
615	10502	6/25/1991	11/12/2002	0.3	00665	PHOSPHORUS, TOTAL, WET METHOD (MG/L AS P)	0.06	7.17	0.76	32	32	
615	10502	11/29/1994	11/29/1994	0.30488	00665	PHOSPHORUS, TOTAL, WET METHOD (MG/L AS P)	0.11	0.11	0.11	1	1	
615	10619	11/2/1995	11/2/1995	0.30488	00665	PHOSPHORUS, TOTAL, WET METHOD (MG/L AS P)	0.3	0.3	0.30	1	1	1
615	10621	8/21/1990	11/12/2002	0.3	00665	PHOSPHORUS, TOTAL, WET METHOD (MG/L AS P)	0.01	0.75	0.22	40	40	
615	10621	11/29/1994	12/4/1996	0.30488	00665	PHOSPHORUS, TOTAL, WET METHOD (MG/L AS P)	0.16	0.16	0.16	2	1	22
615	10623	6/25/1991	11/12/2002	0.3	00665	PHOSPHORUS, TOTAL, WET METHOD (MG/L AS P)	0.06	0.73	0.17	36	36	5
615	10623	11/29/1994	12/4/1996	0.30488	00665	PHOSPHORUS, TOTAL, WET METHOD (MG/L AS P)	0.1	0.38	0.24	2	2	1

Table 4A-7. Summary of Orthophosphorus Data for Segments 0610 and 0615

Segment ID	Station ID	Period Begin	Period End	Depth	Storet ID	Parameter	Min	Max	Avg	N	N > Criteria
610	10612	2/26/1991	8/14/2002	0.3	00671	PHOSPHORUS, DISSOLVED ORTHOPHOSPHORUS(MG/L AS P)	0.001	0.266	0.05	25	5
610	10612	8/18/1994	8/18/1994	0.30488	00671	PHOSPHORUS, DISSOLVED ORTHOPHOSPHORUS(MG/L AS P)	0.01	0.01	0.01	1	
610	10613	8/20/1990	11/24/1997	0.3	00671	PHOSPHORUS, DISSOLVED ORTHOPHOSPHORUS(MG/L AS P)	0.02	0.11	0.06	14	7
610	10613	8/16/1994	8/16/1994	0.30488	00671	PHOSPHORUS, DISSOLVED ORTHOPHOSPHORUS(MG/L AS P)	0.04	0.04	0.04	1	
610	14906	11/24/1997	8/22/2002	0.3	00671	PHOSPHORUS, DISSOLVED ORTHOPHOSPHORUS(MG/L AS P)	0.001	0.256	0.05	16	4
610	15361	10/21/1999	7/17/2001	0.3	00671	PHOSPHORUS, DISSOLVED ORTHOPHOSPHORUS(MG/L AS P)	0.024	0.582	0.20	8	1
610	15522	3/13/2001	8/22/2002	0.3	00671	PHOSPHORUS, DISSOLVED ORTHOPHOSPHORUS(MG/L AS P)	0.001	0.312	0.05	15	2
610	15523	3/8/2001	8/14/2002	0.3	00671	PHOSPHORUS, DISSOLVED ORTHOPHOSPHORUS(MG/L AS P)	0.001	0.79	0.09	15	3
610	15524	3/8/2001	8/14/2002	0.3	00671	PHOSPHORUS, DISSOLVED ORTHOPHOSPHORUS(MG/L AS P)	0.012	0.54	0.09	15	4
610	15526	3/13/2001	8/22/2002	0.3	00671	PHOSPHORUS, DISSOLVED ORTHOPHOSPHORUS(MG/L AS P)	0.001	0.195	0.05	15	5
610	15527	3/13/2001	8/22/2002	0.3	00671	PHOSPHORUS, DISSOLVED ORTHOPHOSPHORUS(MG/L AS P)	0.001	0.111	0.03	15	4
610	15666	1/26/1994	2/14/1996	0.3	00671	PHOSPHORUS, DISSOLVED ORTHOPHOSPHORUS(MG/L AS P)	0.01	0.01	0.01	7	
610	15666	8/26/1999	4/21/1999	0.3048	00671	PHOSPHORUS, DISSOLVED ORTHOPHOSPHORUS(MG/L AS P)	0.01	0.015	0.01	11	
610	15667	1/26/1994	2/14/1996	0.3	00671	PHOSPHORUS, DISSOLVED ORTHOPHOSPHORUS(MG/L AS P)	0.01	0.01	0.01	7	
610	15667	4/24/1996	4/17/1997	0.3048	00671	PHOSPHORUS, DISSOLVED ORTHOPHOSPHORUS(MG/L AS P)	0.01	0.011	0.01	10	
610	15668	1/27/1994	2/14/1996	0.3	00671	PHOSPHORUS, DISSOLVED ORTHOPHOSPHORUS(MG/L AS P)	0.01	0.03	0.01	7	
610	15668	8/21/1997	4/29/1998	0.3048	00671	PHOSPHORUS, DISSOLVED ORTHOPHOSPHORUS(MG/L AS P)	0.01	0.07	0.02	10	1
610	15672	4/20/1994	2/14/1996	0.3	00671	PHOSPHORUS, DISSOLVED ORTHOPHOSPHORUS(MG/L AS P)	0.01	0.01	0.01	6	
610	15672	4/23/1996	4/17/1997	0.3048	00671	PHOSPHORUS, DISSOLVED ORTHOPHOSPHORUS(MG/L AS P)	0.01	0.011	0.01	11	
610	15674	1/25/1994	2/13/1996	0.3	00671	PHOSPHORUS, DISSOLVED ORTHOPHOSPHORUS(MG/L AS P)	0.01	0.01	0.01	7	
610	15674	8/25/1999	4/20/1999	0.3048	00671	PHOSPHORUS, DISSOLVED ORTHOPHOSPHORUS(MG/L AS P)	0.01	0.016	0.01	11	
610	15675	1/25/1994	2/13/1996	0.3	00671	PHOSPHORUS, DISSOLVED ORTHOPHOSPHORUS(MG/L AS P)	0.01	0.01	0.01	7	
610	15675	4/23/1996	8/25/1999	0.3048	00671	PHOSPHORUS, DISSOLVED ORTHOPHOSPHORUS(MG/L AS P)	0.01	0.011	0.01	11	
615	10502	6/25/1991	7/9/1997	0.3	00671	PHOSPHORUS, DISSOLVED ORTHOPHOSPHORUS(MG/L AS P)	0.06	0.9	0.51	14	
615	10502	11/29/1994	12/4/1996	0.30488	00671	PHOSPHORUS, DISSOLVED ORTHOPHOSPHORUS(MG/L AS P)	0.08	0.97	0.53	2	
615	10619	11/2/1995	11/2/1995	0.30488	00671	PHOSPHORUS, DISSOLVED ORTHOPHOSPHORUS(MG/L AS P)	0.3	0.3	0.30	1	1
615	10621	2/22/1991	8/8/1995	0.3	00671	PHOSPHORUS, DISSOLVED ORTHOPHOSPHORUS(MG/L AS P)	0.06	0.32	0.16	13	13
615	10621	11/29/1994	12/4/1996	0.30488	00671	PHOSPHORUS, DISSOLVED ORTHOPHOSPHORUS(MG/L AS P)	0.13	0.14	0.14	2	2
615	10623	6/25/1991	11/2/1995	0.3	00671	PHOSPHORUS, DISSOLVED ORTHOPHOSPHORUS(MG/L AS P)	0.04	0.21	0.11	11	10
615	10623	11/29/1994	12/4/1996	0.30488	00671	PHOSPHORUS, DISSOLVED ORTHOPHOSPHORUS(MG/L AS P)	0.09	0.38	0.24	2	2

Table 4A-8. Summary of Total Nitrogen Data for Segment 0610 and 0615

Segment ID	Station ID	Period Begin	Period End	Parameter	Min	Max	Avg	N	N> Criteria
610	10612	2/26/1991	11/24/1997	Total Nitrogen (mg/l)	0.48	0.9	0.6	9	8
610	10613	8/20/1990	11/24/1997	Total Nitrogen (mg/l)	0.43	5	1.096923077	13	11
610	14906	11/24/1997	11/24/1997	Total Nitrogen (mg/l)	0.4	0.4	0.4	1	
615	10502	8/5/1993	7/9/1997	Total Nitrogen (mg/l)	0.46	13.3	4.785714286	14	13
615	10619	11/2/1995	11/2/1995	Total Nitrogen (mg/l)	2.8	2.8	2.8	1	1
615	10621	2/18/1993	12/4/1996	Total Nitrogen (mg/l)	0.59	5.39	1.626	10	10
615	10623	8/5/1993	12/4/1996	Total Nitrogen (mg/l)	0.45	8.87	1.631	10	8

Table 4A-9. Summary of Nitrate and Nitrite Nitrogen Data for Segments 0610 and 0615

Segment ID	Station ID	Period Begin	Period End	Storet ID	Parameter	Min	Max	Avg	N	N > Criteria	N > TCEQ
610	10612	2/26/1991	8/14/2002	00630	NITRITE PLUS NITRATE, TOTAL 1 DET. (MG/L AS N)	0.01	2.1	0.36	26	22	9
610	10612	8/18/1994	8/18/1994	00630	NITRITE PLUS NITRATE, TOTAL 1 DET. (MG/L AS N)	0.03	0.03	0.03	1		
610	10613	8/20/1990	11/24/1997	00630	NITRITE PLUS NITRATE, TOTAL 1 DET. (MG/L AS N)	0.02	0.6	0.11	14	9	1
610	10613	8/16/1994	8/16/1994	00630	NITRITE PLUS NITRATE, TOTAL 1 DET. (MG/L AS N)	0.03	0.03	0.03	1		
610	14906	11/24/1997	8/22/2002	00630	NITRITE PLUS NITRATE, TOTAL 1 DET. (MG/L AS N)	0.02	1.9	0.52	16	14	10
610	15357	11/7/1996	8/19/1997	00630	NITRITE PLUS NITRATE, TOTAL 1 DET. (MG/L AS N)	0.1	0.6	0.40	4	4	2
610	15358	11/7/1996	8/19/1997	00630	NITRITE PLUS NITRATE, TOTAL 1 DET. (MG/L AS N)	0.01	0.6	0.33	4	3	2
610	15359	11/7/1996	8/19/1997	00630	NITRITE PLUS NITRATE, TOTAL 1 DET. (MG/L AS N)	0.1	0.8	0.43	4	4	2
610	15360	11/7/1996	8/19/1997	00630	NITRITE PLUS NITRATE, TOTAL 1 DET. (MG/L AS N)	0.1	0.6	0.38	4	4	3
610	15361	11/7/1996	7/17/2001	00630	NITRITE PLUS NITRATE, TOTAL 1 DET. (MG/L AS N)	0.01	3.2	0.81	19	18	13
610	15362	11/12/1996	8/21/1997	00630	NITRITE PLUS NITRATE, TOTAL 1 DET. (MG/L AS N)	0.1	1	0.50	4	4	3
610	15363	11/12/1996	8/21/1997	00630	NITRITE PLUS NITRATE, TOTAL 1 DET. (MG/L AS N)	0.1	0.4	0.25	4	4	1
610	15364	11/12/1996	8/19/1997	00630	NITRITE PLUS NITRATE, TOTAL 1 DET. (MG/L AS N)	0.1	0.7	0.40	5	5	3
610	15365	11/12/1996	8/21/1997	00630	NITRITE PLUS NITRATE, TOTAL 1 DET. (MG/L AS N)	0.1	0.9	0.45	4	4	2
610	15366	11/12/1996	8/21/1997	00630	NITRITE PLUS NITRATE, TOTAL 1 DET. (MG/L AS N)	0.1	0.6	0.28	4	4	1
610	15522	3/13/2001	8/22/2002	00630	NITRITE PLUS NITRATE, TOTAL 1 DET. (MG/L AS N)	0.02	2.2	0.56	15	14	7
610	15523	3/8/2001	8/14/2002	00630	NITRITE PLUS NITRATE, TOTAL 1 DET. (MG/L AS N)	0.1	2	0.61	15	15	10
610	15524	3/8/2001	8/14/2002	00630	NITRITE PLUS NITRATE, TOTAL 1 DET. (MG/L AS N)	0.1	2	0.59	15	15	9
610	15526	3/13/2001	8/22/2002	00630	NITRITE PLUS NITRATE, TOTAL 1 DET. (MG/L AS N)	0.02	2.2	0.55	15	12	7
610	15527	3/13/2001	8/22/2002	00630	NITRITE PLUS NITRATE, TOTAL 1 DET. (MG/L AS N)	0.02	2.2	0.55	15	13	6
615	10502	6/25/1991	7/9/1997	00630	NITRITE PLUS NITRATE, TOTAL 1 DET. (MG/L AS N)	0.1	0.88	0.49	14	16	10
615	10502	11/29/1994	12/4/1996	00630	NITRITE PLUS NITRATE, TOTAL 1 DET. (MG/L AS N)	0.21	0.52	0.37	2		
615	10619	11/2/1995	11/2/1995	00630	NITRITE PLUS NITRATE, TOTAL 1 DET. (MG/L AS N)	0.4	0.4	0.40	1	1	1
615	10621	8/21/1990	8/8/1995	00630	NITRITE PLUS NITRATE, TOTAL 1 DET. (MG/L AS N)	0.07	0.71	0.34	14	16	8
615	10621	11/29/1994	12/4/1996	00630	NITRITE PLUS NITRATE, TOTAL 1 DET. (MG/L AS N)	0.11	0.34	0.23	2		
615	10623	6/25/1991	11/2/1995	00630	NITRITE PLUS NITRATE, TOTAL 1 DET. (MG/L AS N)	0.1	0.55	0.34	11	13	7
615	10623	11/29/1994	12/4/1996	00630	NITRITE PLUS NITRATE, TOTAL 1 DET. (MG/L AS N)	0.07	1.22	0.65	2		

Table 4A-10. Summary of Total Kjeldahl Nitrogen Data for Segments 0610 and 0615

Segment ID	Station ID	Period Begin	Period End	Storet ID	Parameter	Min	Max	Avg	N	N > Criteria
610	10612	2/26/1991	12/11/2002	00625	NITROGEN, KJELDAHL, TOTAL (MG/L AS N)	0.27	0.92	0.52	33	26
610	10613	8/20/1990	9/18/2002	00625	NITROGEN, KJELDAHL, TOTAL (MG/L AS N)	0.05	6.91	1.03	35	34
610	10613	8/16/1994	8/16/1994	00625	NITROGEN, KJELDAHL, TOTAL (MG/L AS N)	0.64	0.64	0.64	1	
610	10614	9/28/1999	9/17/2002	00625	NITROGEN, KJELDAHL, TOTAL (MG/L AS N)	0.34	1.09	0.72	11	8
610	14906	8/21/1996	12/11/2002	00625	NITROGEN, KJELDAHL, TOTAL (MG/L AS N)	0.28	1.33	0.47	21	7
610	14906	8/17/1999	8/17/1999	00625	NITROGEN, KJELDAHL, TOTAL (MG/L AS N)	0.33	0.33	0.33	1	
610	14907	8/21/1996	12/10/2002	00625	NITROGEN, KJELDAHL, TOTAL (MG/L AS N)	0.27	0.92	0.64	13	12
615	10502	8/5/1993	11/12/2002	00625	NITROGEN, KJELDAHL, TOTAL (MG/L AS N)	0.35	9.6	2.85	31	30
615	10502	11/29/1994	12/4/1996	00625	NITROGEN, KJELDAHL, TOTAL (MG/L AS N)	0.1	0.43	0.27	2	
615	10619	11/2/1995	11/2/1995	00625	NITROGEN, KJELDAHL, TOTAL (MG/L AS N)	1.54	1.54	1.54	1	1
615	10621	2/18/1993	11/12/2002	00625	NITROGEN, KJELDAHL, TOTAL (MG/L AS N)	0.48	3.26	0.98	35	37
615	10621	11/29/1994	12/4/1996	00625	NITROGEN, KJELDAHL, TOTAL (MG/L AS N)	0.78	0.98	0.88	2	
615	10623	8/5/1993	11/12/2002	00625	NITROGEN, KJELDAHL, TOTAL (MG/L AS N)	0.29	0.91	0.57	36	27
615	10623	11/29/1994	12/4/1996	00625	NITROGEN, KJELDAHL, TOTAL (MG/L AS N)	0.7	5.11	2.91	2	

Table 4A-11. Summary of Total Ammonia Nitrogen Data for Segments 0610 and 0615

Segment ID	Station ID	Period Begin	Period End	Storet ID	Parameter	Min	Max	Avg	N	N > Criteria
610	10612	2/26/1991	12/11/2002	00610	NITROGEN, AMMONIA, TOTAL (MG/L AS N)	0.01	0.55	0.07	50	8
610	10612	8/18/1994	8/18/1994	00610	NITROGEN, AMMONIA, TOTAL (MG/L AS N)	0.02	0.02	0.02	1	
610	10613	8/20/1990	9/18/2002	00610	NITROGEN, AMMONIA, TOTAL (MG/L AS N)	0.01	4.74	0.19	37	6
610	10613	8/16/1994	8/16/1994	00610	NITROGEN, AMMONIA, TOTAL (MG/L AS N)	0.04	0.04	0.04	1	
610	10614	9/28/1999	9/17/2002	00610	NITROGEN, AMMONIA, TOTAL (MG/L AS N)	0.05	0.08	0.05	11	
610	14906	8/21/1996	12/11/2002	00610	NITROGEN, AMMONIA, TOTAL (MG/L AS N)	0.01	0.67	0.07	36	6
610	14906	8/17/1999	8/17/1999	00610	NITROGEN, AMMONIA, TOTAL (MG/L AS N)	0.05	0.05	0.05	1	
610	14907	8/21/1996	12/10/2002	00610	NITROGEN, AMMONIA, TOTAL (MG/L AS N)	0.01	0.14	0.07	13	3
610	15357	11/7/1996	8/19/1997	00610	NITROGEN, AMMONIA, TOTAL (MG/L AS N)	0.03	0.36	0.16	4	3
610	15358	11/7/1996	8/19/1997	00610	NITROGEN, AMMONIA, TOTAL (MG/L AS N)	0.03	0.2	0.10	4	2
610	15359	11/7/1996	8/19/1997	00610	NITROGEN, AMMONIA, TOTAL (MG/L AS N)	0.03	0.24	0.14	4	3
610	15360	11/7/1996	8/19/1997	00610	NITROGEN, AMMONIA, TOTAL (MG/L AS N)	0.03	0.18	0.12	4	2
610	15361	11/7/1996	7/17/2001	00610	NITROGEN, AMMONIA, TOTAL (MG/L AS N)	0.01	0.32	0.07	19	5
610	15362	11/12/1996	8/21/1997	00610	NITROGEN, AMMONIA, TOTAL (MG/L AS N)	0.03	0.17	0.07	4	1
610	15363	11/12/1996	8/21/1997	00610	NITROGEN, AMMONIA, TOTAL (MG/L AS N)	0.03	0.09	0.05	4	
610	15364	11/12/1996	8/19/1997	00610	NITROGEN, AMMONIA, TOTAL (MG/L AS N)	0.03	0.26	0.12	5	2
610	15365	11/12/1996	8/21/1997	00610	NITROGEN, AMMONIA, TOTAL (MG/L AS N)	0.03	0.16	0.09	4	2
610	15366	11/12/1996	8/21/1997	00610	NITROGEN, AMMONIA, TOTAL (MG/L AS N)	0.03	0.14	0.07	4	1
610	15522	3/13/2001	8/22/2002	00610	NITROGEN, AMMONIA, TOTAL (MG/L AS N)	0.01	0.39	0.08	15	5
610	15523	3/8/2001	8/14/2002	00610	NITROGEN, AMMONIA, TOTAL (MG/L AS N)	0.01	0.348	0.09	15	5
610	15524	3/8/2001	8/14/2002	00610	NITROGEN, AMMONIA, TOTAL (MG/L AS N)	0.01	0.19	0.06	14	4
610	15526	3/13/2001	8/22/2002	00610	NITROGEN, AMMONIA, TOTAL (MG/L AS N)	0.01	0.84	0.11	15	4
610	15527	3/13/2001	8/22/2002	00610	NITROGEN, AMMONIA, TOTAL (MG/L AS N)	0.01	0.64	0.10	15	4
615	10502	6/25/1991	11/12/2002	00610	NITROGEN, AMMONIA, TOTAL (MG/L AS N)	0.01	5.02	1.24	33	25
615	10502	11/29/1994	12/4/1996	00610	NITROGEN, AMMONIA, TOTAL (MG/L AS N)	0.02	0.1	0.06	2	
615	10619	11/2/1995	11/2/1995	00610	NITROGEN, AMMONIA, TOTAL (MG/L AS N)	0.86	0.86	0.86	1	1
615	10621	8/21/1990	11/12/2002	00610	NITROGEN, AMMONIA, TOTAL (MG/L AS N)	0.01	1.69	0.28	41	20
615	10621	11/29/1994	12/4/1996	00610	NITROGEN, AMMONIA, TOTAL (MG/L AS N)	0.01	0.32	0.17	2	
615	10623	6/25/1991	11/12/2002	00610	NITROGEN, AMMONIA, TOTAL (MG/L AS N)	0.01	0.09	0.04	39	1
615	10623	11/29/1994	12/4/1996	00610	NITROGEN, AMMONIA, TOTAL (MG/L AS N)	0.01	2.54	1.28	2	

Table 4A-12. Summary of Biochemical Oxygen Demand Data for Segments 0610 and 0615

Segment ID	Station ID	Period Begin	Period End	Depth	Storet ID	Parameter	Min	Max	Avg	N	N > Criteria
610	10612	9/27/1999	3/8/2000	0.3	00310	BIOCHEMICAL OXYGEN DEMAND (MG/L, 5 DAY - 20DEG C	3	3	3	3	NA
610	10613	9/28/1999	3/7/2000	0.3	00310	BIOCHEMICAL OXYGEN DEMAND (MG/L, 5 DAY - 20DEG C	3	10	5.3	3	NA
610	10614	9/28/1999	3/7/2000	0.3	00310	BIOCHEMICAL OXYGEN DEMAND (MG/L, 5 DAY - 20DEG C	4	10	7	2	NA
610	14906	9/27/1999	3/8/2000	0.3	00310	BIOCHEMICAL OXYGEN DEMAND (MG/L, 5 DAY - 20DEG C	3	3	3	3	NA
610	14907	9/28/1999	3/7/2000	0.3	00310	BIOCHEMICAL OXYGEN DEMAND (MG/L, 5 DAY - 20DEG C	4	10	7	2	NA
610	15361	11/17/1998	4/18/2000	0.3	00310	BIOCHEMICAL OXYGEN DEMAND (MG/L, 5 DAY - 20DEG C	2.07	2.07	2.07	7	NA
615	10502	10/13/1999	10/13/1999	0.3	00310	BIOCHEMICAL OXYGEN DEMAND (MG/L, 5 DAY - 20DEG C	4	4	4	1	NA
615	10621	10/13/1999	10/13/1999	0.3	00310	BIOCHEMICAL OXYGEN DEMAND (MG/L, 5 DAY - 20DEG C	3	3	3	1	NA
615	10623	10/13/1999	10/13/1999	0.3	00310	BIOCHEMICAL OXYGEN DEMAND (MG/L, 5 DAY - 20DEG C	3	3	3	1	NA

Table 4A-13. Summary of Total Organic Carbon Data for Segments 0610 and 0615

Segment ID	Station ID	Period Begin	Period End	Depth	Storet ID	Parameter	Min	Max	Avg	N	N > Criteria
610	10612	2/26/1991	12/11/2002	0.3	00680	CARBON, TOTAL ORGANIC (MG/L AS C)	4	11	7.49	35	NA
610	10612	8/18/1994	8/18/1994	0.30488	00680	CARBON, TOTAL ORGANIC (MG/L AS C)	6	6	6.00	1	NA
610	10612	6/24/1991	6/24/1991	17.01	00680	CARBON, TOTAL ORGANIC (MG/L AS C)	10	10	10.00	1	NA
610	10612	2/26/1991	2/26/1991	18.01	00680	CARBON, TOTAL ORGANIC (MG/L AS C)	6	6	6.00	1	NA
610	10613	8/20/1990	12/10/2002	0.3	00680	CARBON, TOTAL ORGANIC (MG/L AS C)	5	24	11.74	38	NA
610	10613	8/16/1994	8/16/1994	0.30488	00680	CARBON, TOTAL ORGANIC (MG/L AS C)	12	12	12.00	1	NA
610	10613	8/20/1990	8/20/1990	5.79	00680	CARBON, TOTAL ORGANIC (MG/L AS C)	10	10	10.00	1	NA
610	10613	7/30/1991	7/30/1991	8.29	00680	CARBON, TOTAL ORGANIC (MG/L AS C)	11	11	11.00	1	NA
610	10613	2/26/1991	2/26/1991	10	00680	CARBON, TOTAL ORGANIC (MG/L AS C)	6	6	6.00	1	NA
610	10614	9/28/1999	12/10/2002	0.3	00680	CARBON, TOTAL ORGANIC (MG/L AS C)	3	10	6.25	12	NA
610	14906	8/21/1996	12/11/2002	0.3	00680	CARBON, TOTAL ORGANIC (MG/L AS C)	4	9	6.00	21	NA
610	14906	8/17/1999	8/17/1999	0.30488	00680	CARBON, TOTAL ORGANIC (MG/L AS C)	6	6	6.00	1	NA
610	14907	8/21/1996	12/10/2002	0.3	00680	CARBON, TOTAL ORGANIC (MG/L AS C)	4	10	7.46	13	NA
615	10502	6/25/1991	11/12/2002	0.3	00680	CARBON, TOTAL ORGANIC (MG/L AS C)	5	135	71.66	32	NA
615	10502	11/29/1994	12/4/1996	0.30488	00680	CARBON, TOTAL ORGANIC (MG/L AS C)	9	139	74.00	2	NA
615	10619	11/2/1995	11/2/1995	0.30488	00680	CARBON, TOTAL ORGANIC (MG/L AS C)	30	30	30.00	1	NA
615	10621	8/21/1990	11/12/2002	0.3	00680	CARBON, TOTAL ORGANIC (MG/L AS C)	1	73	20.48	40	NA
615	10621	11/29/1994	12/4/1996	0.30488	00680	CARBON, TOTAL ORGANIC (MG/L AS C)	21	21	21.00	2	NA
615	10623	6/25/1991	11/12/2002	0.3	00680	CARBON, TOTAL ORGANIC (MG/L AS C)	3	26	7.61	38	NA
615	10623	11/29/1994	12/4/1996	0.30488	00680	CARBON, TOTAL ORGANIC (MG/L AS C)	10	123	66.50	2	NA

Table 4A-14. Summary of Dissolved Aluminum Data for Segment 0610

Station	Start Date	End Date	Dissolved Aluminum (µg/L)				
			Number of Observations	Average	Minimum	Maximum	Number of Exceedances[a]
10612	12/14/1995	3/14/2002	16	58.5	<25	161	0
10613	7/30/1991	3/13/2002	17	300	<25	1010	1
10614	9/28/1999	3/13/2002	11	185.5	39	378	0
10615	12/5/1995	8/20/1996	3	755	240	1260	1
14906	3/6/1996	3/14/2002	15	41.5	<25	79	0
14907	8/21/1996	1/17/2002	14	160	<25	691	0
15361	5/1/2001	7/11/2002	4	437.5	<10	1700	1
15522	3/6/1996	7/11/2002	5	38	<34	50	0
15523	12/6/1995	7/10/2001	5	37	<33	50	0
15524	12/6/1995	7/10/2001	4	60.5	<33	120	0
15525	12/5/1995	8/20/1996	3	94	<34	131	0
15526	12/7/1995	7/11/2001	5	40.6	<34	51	0
15527	3/6/1996	7/11/2001	5	39	34	50	0

[a] Exceedances of TWQS 991 µg/L.

Table 4A-15. Summary of Dissolved Aluminum Data for Segment 0615

Station	Start Date	End Date	Dissolved Aluminum (µg/L)				
			Number of Observations	Average	Minimum	Maximum	Number of Exceedances[a]
10623	2/6/1997	4/29/2002	22	208.95	67	573	0
10502	8/9/1995	4/29/2002	17	2289.23	<26	3680	14
10621	8/8/1996	4/29/2002	22	889.85	222	3020	7

[a] Exceedances of TWQS 991 µg/L.

Table 4A-16. Summary of Dissolved Arsenic Data for Segments 0610 and 0615

Station	Start Date	End Date	Dissolved Arsenic (µg/L)				
			Number of Observations	Average	Minimum	Maximum	Number of Exceedances[a]
Segment 0610							
10612	3/12/1996	3/14/2002	15	2.29	1	10	0
10613	7/30/1991	3/13/2002	21	4.62	1	34	0
10614	9/28/1999	3/13/2002	11	1.84	1	2.77	0
10615	12/5/1995	8/20/1996	4	3.8	3.3	4.56	0
14906	3/6/1996	3/14/2002	14	2.36	1	10	0
14907	8/21/1996	1/7/2002	14	2.21	1	3.55	0
15522	3/6/1996	7/11/2001	4	4.05	2	10	0
15523	12/6/1995	7/10/2001	5	3.99	2	10	0
15524	12/6/1995	7/10/2001	5	4.04	2	10	0
15525	12/5/1995	8/20/1996	4	4.48	2.67	6.63	0
15526	12/7/1995	7/11/2001	5	3.60	2	10	0
15527	3/6/1996	7/11/2001	4	4.1	2	10	0
Segment 0615							
10502	8/9/1995	4/29/2002	17	4.38	1	10	0
10621	8/8/1996	4/29/2002	22	3.21	1	10	0
10623	2/6/1997	4/29/2002	22	2.47	1	8	0

[a] Exceedance of chronic or acute TWQS (190 µg/L and 390 µg/L).

Table 4A-17. Dissolved Copper Detections That Exceed Chronic and Acute Criteria for Segment 0610

Station	Date	Dissolved Copper (µg/L)	Sample Specific Hardness (mg/L)	Sample Specific Criteria (µg/L)	
				Chronic	Acute
14906	8/21/1996	8	29.2	4.3	5.8
15522	7/10/2001	6	NA	NA	NA
15523	7/10/2002	9	NA	NA	NA
15524	7/10/2001	9	NA	NA	NA

Table 4A-18. Summary of Dissolved Copper Data for Segment 0610

Station	Start Date	End Date	Dissolved Copper (µg/L)				
			Number of Observations	Average	Minimum	Maximum	Number of Exceedances[a]
10612	12/14/1995	3/14/2002	16	4.5	2	<6	7[b]
10613	7/30/1991	3/13/2002	21	4.4	<1	<6	8[b]
10614	9/28/1999	3/13/2002	11	4.9	<3	<6	7[b]
10615	12/5/1995	8/20/1996	4	4	<4	<4	0
14906	3/6/1996	3/14/2002	15	4.7	3	8	7[c]
14907	8/21/1996	1/17/2002	14	5	<3	<6	8[b]
15361	5/1/2001	7/11/2002	2	3.89	0.74	2	0
15522	3/6/1996	7/11/2002	5	4.4	<4	6	1
15523	12/6/1995	7/10/2001	5	5	<4	9	1
15524	12/6/1995	7/10/2001	5	5	<4	9	1
15525	12/5/1995	8/20/1996	4	4	<4	<4	0
15526	12/7/1995	7/11/2001	5	3.6	<2	<4	0
15527	3/6/1996	7/11/2001	5	3.8	3	<4	0

[a] Exceedances of calculated acute (5.9 µg/L) and chronic (4.4 µg/L) criteria for segment 0610.
[B] Exceedances based on non-detects.
[C] All but one exceedance based on non-detects.

Table 4A-19. Dissolved Copper Detections That Exceed Chronic and Acute Criteria for Segment 0615

Station	Date	Dissolved Copper (µg/L)	Sample Specific Hardness (mg/L)	Sample Specific Criteria (µg/L)	
				Chronic	Acute
10502	8/8/1996	21	117.7	14.1	21.5
10502	1/20/1999	19	138.1	16.2	25.0
10621	10/30/2001	17	41.6	5.8	8.1
10621	7/23/1998	6	67.3	8.8	12.7
10623	7/23/1998	6	35.9	5.1	7.0

Table 4A-20. Summary of Dissolved Copper Data for Segment 0615

Station	Start Date	End Date	Dissolved Copper (µg/L)				
			Number of Observations	Average	Minimum	Maximum	Number of Exceedances[a]
10502	8/9/1995	4/29/2002	17	8.82	3.98	<25	15[b]
10621	8/8/1996	4/29/2002	22	5.59	3	17	13[b]
10623	2/6/1997	4/29/2002	22	4.31	3	6	9[c]

[a] Exceedances of calculated acute (5.9 µg/L) and chronic (4.4 µg/L) criteria for segment 0610.
[b] All but two or three exceedances based on non-detects.
[c] All but one exceedance based on non-detects.

Table 4A-21. Dissolved Lead Detections That Exceed Chronic Criteria for Segment 0610

Station	Date	Dissolved Lead (µg/L)	Sample Specific Hardness (mg/L)	Sample Specific Criterion (µg/L)	
				Chronic	Acute
10613	8/19/1993	4.86	38	0.74	21.2
10613	5/6/1996	1.31	45.3	0.92	26.5
15361	7/11/2002	1.21	NA	NA	NA

Table 4A-22. Summary of Dissolved Lead Data for Segment 0610

Station	Start Date	End Date	Dissolved Lead (µg/L)				
			Number of Observations	Average	Minimum	Maximum	Number of Exceedances[a]
10612	12/14/1995	3/14/2002	16	1.25	<1	<2	16[b]
10613	7/30/1991	3/13/2002	21	2.87	<1	<31	21[d]
10614	9/28/1999	3/13/2002	11	1.27	<1	<2	11[b]
10615	12/5/1995	8/20/1996	4	1	<1	<1	4[b]
14906	3/6/1996	3/14/2002	15	1.26	<1	<2	15[b]
14907	8/21/1996	1/17/2002	14	1.14	<1	<2	14[b]
15361	5/1/2001	7/11/2002	3	1.14	1.21	<2	2[c]
15522	3/6/1996	7/11/2002	5	1.2	<1	<2	5[b]
15523	12/6/1995	7/10/2001	5	1.2	<1	<2	5[b]
15524	12/6/1995	7/10/2001	5	1.2	<1	<2	15[b]
15525	12/5/1995	8/20/1996	4	1	<1	<1	4[b]
15526	12/7/1995	7/11/2001	5	1.2	<1	<2	5[b]
15527	3/6/1996	7/11/2001	5	1.2	<1	<2	5[b]

[a] Exceedances of the chronic criterion (0.54 µg/L) segment 0610.
[b] Exceedances based on nondetects.
[c] All but one exceedance based on nondetects.
[d] All but two exceedances based on nondetects.

Table 4A-23. Dissolved Lead Detection That Exceed Chronic Criterion for Segment 0615

Station	Date	Dissolved Lead (µg/L)	Sample Specific Hardness (mg/L)	Sample Specific Criteria (µg/L)	
				Chronic	Acute
10502	8/8/1996	1.47	117.7	3.1	89.3
10502	10/21/1998	1.53	67.3	1.52	43.8
10502	4/10/2000	2.26	138.5	3.8	109.9
10502	7/11/2000	1.82	92.1	2.3	65.4
10502	10/25/2000	2.77	58.6	1.3	36.8
10621	7/23/1998	2.93	67.3	1.5	43.8
10621	7/11/2000	1.17	56.7	1.2	35.2
10621	10/25/2000	1.44	58.6	1.3	36.8

Table 4A-24. Summary of Dissolved Lead Data for Segment 0615

Station	Start Date	End Date	Dissolved Lead (µg/L)				
			Number	Avg	Min	Max	Exceedances[a]
10502	8/9/1995	4/29/2002	17	2.18	<1	<10	17[d]
10621	8/8/1996	4/29/2002	22	1.44	<1	<4	22[c]
10623	2/6/1997	4/29/2002	22	1.23	<1	<2	22[b]

[a] Exceedances of calculated chronic (0.54 µg/L).
[b] Exceedances based on nondetects.
[c] All but three exceedances based on nondetects.
[d] All but six exceedances based on nondetects.

Table 4A-25. Summary of Total Selenium Data for Segment 0610

Station	Start Date	End Date	Total Selenium (µg/L)				
			Number of Observations	Average	Minimum	Maximum	Number of Exceedances[a]
10612	12/14/1995	3/14/2002	8	1.41	<1	<2	0
10613	7/30/1991	3/13/2002	10	1.93	<1	<5	0
10614	9/28/1999	3/13/2002	5	1.06	<1	<1.1	0
10615	12/5/1995	8/20/1996	2	2.19	<2	2.38	0
14906	3/6/1996	3/14/2002	8	1.41	<1	<2	0
14907	8/21/1996	1/17/2002	5	1.44	<1	<2	0
15361	5/1/2001	7/11/2002	4	1.51	<0.04	<2	0
15364	8/19/1997	8/19/1997	11	5	<5	<5	0
15522	3/6/1996	7/11/2002	3	2	<2	<2	0
15523	12/6/1995	7/10/2001	3	2	<2	<2	0
15524	12/6/1995	7/10/2001	3	2	<2	<2	0
15525	12/5/1995	8/20/1996	2	2	<2	<2	0
15526	12/7/1995	7/11/2001	3	2	<2	<2	0
15527	3/6/1996	7/11/2001	3	2	<2	<2	0

[a] Exceedances of chronic and acute TSWQS for total selenium (5 µg/L and 20 µg/L, respectively).

Table 4A-26. Summary of Total Selenium Data for Segment 0615

Station	Start Date	End Date	Total Selenium (µg/L)				
			Number of Observations	Average	Minimum	Maximum	Number of Exceedances[a]
10502	8/8/1996	2/7/2002	9	2.18	<1	<11	2[b]
10621	8/8/1996	4/29/2002	15	1.44	<1	<11	2[b]
10623	2/6/1997	4/29/2002	15	1.23	<1	<8	1[b]

[a] Exceedances of chronic TSWQS for total selenium (5 µg/L).
[b] Exceedances based on nondetects.

Table 4A-27. Summary of Dissolved Zinc Data for Segment 0610

Station	Start Date	End Date	Dissolved Zinc (µg/L)				
			Number of Observations	Average	Minimum	Maximum	Number of Exceedances[a]
10612	12/14/1995	3/14/2002	16	8.44	<3	31	0
10613	7/30/1991	3/13/2002	21	10.42	<3	40	1
10614	9/28/1999	3/13/2002	11	8	<8	<8	0
10615	12/5/1995	8/20/1996	4	5.5	<3	13	0
14906	3/6/1996	3/14/2002	15	7.47	<3	18	0
14907	8/21/1996	1/17/2002	14	7.86	<3	<22	0
15361	5/1/2001	7/11/2002	2	8.72	<1	21	0
15522	3/6/1996	7/11/2002	5	4.6	<3	11	0
15523	12/6/1995	7/10/2001	5	15.8	<3	35	0
15524	12/6/1995	7/10/2001	5	9.4	<3	34	0
15525	12/5/1995	8/20/1996	4	9.75	<3	28	0
15526	12/7/1995	7/11/2001	5	2.8	2	3	0
15527	3/6/1996	7/11/2001	5	3.2	3	4	0

[1] Exceedance of calculated chronic criterion (37.5 µg/L) for segment 0610.

Table 4A-28. Dissolved Zinc Detections for Segment 0615 That Exceed the Chronic or Acute Criteria

Station	Date	Dissolved Zinc (µg/L)	Sample Specific Hardness (mg/L)	Sample Specific Criterion (µg/L)	
				Chronic	Acute
10502	8/8/1996	38	117.7	131.4	119.9
10502	1/20/1999	51	138.1	150.5	137.4
10502	7/27/1999	39	103.4	117.7	107.5
10502	10/13/1999	47	110.3	124.4	113.6
10502	4/10/2000	52	138.5	150.8	137.7
10502	10/25/2000	52	102.3	116.7	106.5
10502	10/30/2001	42	115.6	129.4	118.2

Table 4A-29. Summary of dissolved zinc data for segment 0615

Station	Start Date	End Date	Dissolved Zinc (µg/L)				
			Number of Observations	Average	Minimum	Maximum	Number of Exceedances[a]
10502	8/8/1996	2/7/2002	17	34.69	8	<100	8[c]
10621	8/8/1996	4/29/2002	22	16.36	5	<44	1[b]
10623	2/6/1997	4/29/2002	22	8.0	4	14.1	0

[a] Exceedances of chronic (37.5 µg/L) criterion for segment 0615.
[b] Exceedance based on nondetect.
[c] One exceedance based on nondetect.

Table 4A-30. Summary of Fecal Coliform Bacteria Data for Segments 0610 and 0615

Segment ID	Station ID	Period Beg	Period End	Storet ID	Parameter	Min	Max	Avg	N	N > Criteria
610	10612	2/26/1991	8/14/2002	31616	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH, #/100ML	1	6	2.51	49	
610	10613	8/20/1990	12/10/2002	31616	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH, #/100ML	1	290	28.66	38	
610	10614	10/28/1996	12/10/2002	31616	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH, #/100ML	3	780	120.59	22	2
610	14906	12/10/1996	8/22/2002	31616	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH, #/100ML	1	4	2.00	35	
610	14907	8/21/1996	12/10/2002	31616	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH, #/100ML	2	1300	150.57	23	3
610	15357	11/7/1996	8/19/1997	31616	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH, #/100ML	70	740	354.44	9	4
610	15358	11/7/1996	8/19/1997	31616	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH, #/100ML	60	770	380.00	9	3
610	15359	11/7/1996	8/19/1997	31616	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH, #/100ML	30	1000	290.00	8	2
610	15360	11/7/1996	8/19/1997	31616	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH, #/100ML	20	650	269.00	10	3
610	15361	11/7/1996	8/7/2002	31616	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH, #/100ML	2	590	163.52	29	2
610	15362	11/12/1996	8/21/1997	31616	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH, #/100ML	170	1000	503.33	9	5
610	15363	11/12/1996	7/14/1997	31616	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH, #/100ML	170	1400	598.75	8	4
610	15364	11/12/1996	8/19/1997	31616	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH, #/100ML	90	3100	857.00	10	4
610	15365	11/12/1996	8/21/1997	31616	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH, #/100ML	130	740	291.11	9	2
610	15366	11/12/1996	8/21/1997	31616	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH, #/100ML	30	450	197.14	7	1
610	15522	3/13/2001	8/22/2002	31616	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH, #/100ML	1	1	1.00	14	
610	15523	3/8/2001	8/14/2002	31616	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH, #/100ML	1	7	1.57	14	
610	15524	3/8/2001	8/14/2002	31616	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH, #/100ML	1	6	1.36	14	
610	15526	3/13/2001	8/22/2002	31616	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH, #/100ML	1	2	1.07	15	
610	15527	3/13/2001	8/22/2002	31616	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH, #/100ML	1	6	1.73	15	
610	16784	6/1/1998	7/6/1999	31616	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH, #/100ML	2	320	75.86	14	
610	16785	6/1/1998	7/6/1999	31616	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH, #/100ML	1	55	11.05	19	
610	16786	6/1/1998	7/6/1999	31616	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH, #/100ML	1	66	14.33	18	
610	16787	6/1/1998	7/6/1999	31616	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH, #/100ML	1	180	28.00	19	
610	16788	5/6/1999	8/13/1999	31616	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH, #/100ML	1	800	130.00	7	1
610	16789	5/6/1999	8/13/1999	31616	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH, #/100ML	2	26	14.14	7	
610	16790	5/6/1999	8/13/1999	31616	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH, #/100ML	1	21	8.71	7	
610	16791	6/1/1998	7/6/1999	31616	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH, #/100ML	1	64	14.17	18	
610	16792	5/6/1999	8/13/1999	31616	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH, #/100ML	1	29	13.57	7	
610	16793	5/6/1999	8/13/1999	31616	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH, #/100ML	1	580	102.57	7	1
615	10502	6/25/1991	11/12/2002	31616	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH, #/100ML	7	13100	671.53	32	8
615	10621	8/21/1990	11/12/2002	31616	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH, #/100ML	17	12200	591.08	51	7
615	10623	6/25/1991	7/9/2002	31616	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH, #/100ML	10	1260	173.17	47	5

Table 4A-31. Summary of *E.Coli* Data for Segments 0610 and 0615

Segment ID	Station ID	Period Beg	Period End	Storet ID	Parameter	Min	Max	Avg	N	N > Criteria
610	10612	3/8/2001	8/14/2002	31699	E. COLI, COLILERT, IDEXX METHOD, MPN/100ML	1	4	1.47	19	
610	10613	3/13/2002	12/10/2002	31699	E. COLI, COLILERT, IDEXX METHOD, MPN/100ML	2	125	36.50	4	
610	10614	1/7/2002	12/10/2002	31699	E. COLI, COLILERT, IDEXX METHOD, MPN/100ML	2	290	85.60	5	
610	14906	3/13/2001	8/22/2002	31699	E. COLI, COLILERT, IDEXX METHOD, MPN/100ML	1	2	1.33	18	
610	14907	3/13/2002	12/10/2002	31699	E. COLI, COLILERT, IDEXX METHOD, MPN/100ML	2	240	76.00	4	
610	15361	11/15/2000	8/7/2002	31699	E. COLI, COLILERT, IDEXX METHOD, MPN/100ML	62.7	416	159.81	10	1
610	15522	3/13/2001	8/22/2002	31699	E. COLI, COLILERT, IDEXX METHOD, MPN/100ML	1	2	1.13	15	
610	15523	3/8/2001	8/14/2002	31699	E. COLI, COLILERT, IDEXX METHOD, MPN/100ML	1	10	1.94	15	
610	15524	3/8/2001	8/14/2002	31699	E. COLI, COLILERT, IDEXX METHOD, MPN/100ML	1	12.2	2.01	15	
610	15526	3/13/2001	8/22/2002	31699	E. COLI, COLILERT, IDEXX METHOD, MPN/100ML	1	2	1.07	15	
610	15527	3/13/2001	8/22/2002	31699	E. COLI, COLILERT, IDEXX METHOD, MPN/100ML	1	7	2.22	15	
615	10502	2/7/2002	11/12/2002	31699	E. COLI, COLILERT, IDEXX METHOD, MPN/100ML	102	2407	1053.33	3	2
615	10621	2/7/2002	11/12/2002	31699	E. COLI, COLILERT, IDEXX METHOD, MPN/100ML	99	2599	802.75	4	1
615	10623	2/7/2002	7/9/2002	31699	E. COLI, COLILERT, IDEXX METHOD, MPN/100ML	57	1961	701.33	3	1

Table 4A-32. Summary of Total Alkalinity Data for Segments 0610 and 0615

Segment ID	Station ID	Period Begin	Period End	Storet ID	Parameter	Min	Max	Avg	N	N > Criteria
610	10612	2/26/1991	12/11/2002	00410	ALKALINITY, TOTAL (MG/L AS CACO3)	8.0	40.0	20.6	35.0	NA
610	10612	8/18/1994	8/18/1994	00410	ALKALINITY, TOTAL (MG/L AS CACO3)	20.0	20.0	20.0	1.0	NA
610	10613	8/20/1990	12/10/2002	00410	ALKALINITY, TOTAL (MG/L AS CACO3)	5.0	250.0	35.4	38.0	NA
610	10613	8/16/1994	8/16/1994	00410	ALKALINITY, TOTAL (MG/L AS CACO3)	48.0	48.0	48.0	1.0	NA
610	10614	9/28/1999	12/10/2002	00410	ALKALINITY, TOTAL (MG/L AS CACO3)	10.0	34.0	23.3	12.0	NA
610	14906	8/21/1996	12/11/2002	00410	ALKALINITY, TOTAL (MG/L AS CACO3)	18.0	34.0	22.8	22.0	NA
610	14906	8/17/1999	8/17/1999	00410	ALKALINITY, TOTAL (MG/L AS CACO3)	16.0	16.0	16.0	1.0	NA
610	14907	8/21/1996	12/10/2002	00410	ALKALINITY, TOTAL (MG/L AS CACO3)	21.0	48.0	30.7	13.0	NA
615	10502	6/25/1991	11/12/2002	00410	ALKALINITY, TOTAL (MG/L AS CACO3)	10.0	417.0	199.9	33.0	NA
615	10502	11/29/1994	12/4/1996	00410	ALKALINITY, TOTAL (MG/L AS CACO3)	28.0	356.0	192.0	2.0	NA
615	10619	11/2/1995	11/2/1995	00410	ALKALINITY, TOTAL (MG/L AS CACO3)	92.0	92.0	92.0	1.0	NA
615	10621	8/21/1990	11/12/2002	00410	ALKALINITY, TOTAL (MG/L AS CACO3)	14.0	213.0	56.5	41.0	NA
615	10621	11/29/1994	12/4/1996	00410	ALKALINITY, TOTAL (MG/L AS CACO3)	34.0	54.0	44.0	2.0	NA
615	10623	6/25/1991	11/12/2002	00410	ALKALINITY, TOTAL (MG/L AS CACO3)	5.0	70.0	26.6	39.0	NA
615	10623	11/29/1994	12/4/1996	00410	ALKALINITY, TOTAL (MG/L AS CACO3)	8.0	250.0	129.0	2.0	NA

Table 4A-33. Summary of Chloride Data for Segments 0610 and 0615

Segment ID	Station ID	Period Begin	Period End	Depth	Storet ID	Parameter	Min	Max	Avg	N	N > Criteria
610	10612	2/26/1991	12/11/2002	0.3	00940	CHLORIDE (MG/L AS CL)	4	30	15.35	35	
610	10612	8/18/1994	8/18/1994	0.30488	00940	CHLORIDE (MG/L AS CL)	15	15	15.00	1	
610	10613	8/20/1990	12/10/2002	0.3	00940	CHLORIDE (MG/L AS CL)	7	440	43.66	38	2
610	10613	8/16/1994	8/16/1994	0.30488	00940	CHLORIDE (MG/L AS CL)	52	52	52.00	1	
610	10614	9/28/1999	12/10/2002	0.3	00940	CHLORIDE (MG/L AS CL)	6	15	10.25	12	
610	14906	8/21/1996	12/11/2002	0.3	00940	CHLORIDE (MG/L AS CL)	12	19	14.59	22	
610	14906	8/17/1999	8/17/1999	0.30488	00940	CHLORIDE (MG/L AS CL)	13	13	13.00	1	
610	14907	8/21/1996	12/10/2002	0.3	00940	CHLORIDE (MG/L AS CL)	8	19	11.85	13	
610	15357	11/7/1996	8/19/1997	0.3	00940	CHLORIDE (MG/L AS CL)	12.5	25	17.98	4	
610	15358	11/7/1996	8/19/1997	0.3	00940	CHLORIDE (MG/L AS CL)	9	25.2	16.20	4	
610	15359	11/7/1996	8/19/1997	0.3	00940	CHLORIDE (MG/L AS CL)	7	22.5	15.15	4	
610	15360	11/7/1996	8/19/1997	0.3	00940	CHLORIDE (MG/L AS CL)	10.9	18	13.23	4	
610	15361	11/7/1996	7/17/2001	0.3	00940	CHLORIDE (MG/L AS CL)	5.9	16.5	11.16	19	
610	15362	11/12/1996	8/21/1997	0.3	00940	CHLORIDE (MG/L AS CL)	2.5	7.5	5.83	4	
610	15363	11/12/1996	8/21/1997	0.3	00940	CHLORIDE (MG/L AS CL)	6	8.7	7.00	4	
610	15364	11/12/1996	8/19/1997	0.3	00940	CHLORIDE (MG/L AS CL)	4	7.8	6.46	5	
610	15365	11/12/1996	8/21/1997	0.3	00940	CHLORIDE (MG/L AS CL)	2.7	7.8	5.38	4	
610	15366	11/12/1996	8/21/1997	0.3	00940	CHLORIDE (MG/L AS CL)	2.7	7	5.20	4	
610	15667	1/26/1994	2/14/1996	0.3	00940	CHLORIDE (MG/L AS CL)	12	20	15.43	7	
610	15667	4/24/1996	4/17/1997	0.3048	00940	CHLORIDE (MG/L AS CL)	13.994	30	18.48	10	
610	15668	2/9/1995	2/9/1995	0	00940	CHLORIDE (MG/L AS CL)	12	12	12.00	1	
610	15668	1/27/1994	2/14/1996	0.3	00940	CHLORIDE (MG/L AS CL)	10	53	33.71	7	
610	15668	8/21/1997	4/29/1998	0.3048	00940	CHLORIDE (MG/L AS CL)	10.112	127.75	33.81	10	1
610	15672	4/20/1994	2/14/1996	0.3	00940	CHLORIDE (MG/L AS CL)	13	16	14.50	6	
610	15672	4/23/1996	4/17/1997	0.3048	00940	CHLORIDE (MG/L AS CL)	12.33	21	16.18	11	
615	10502	6/25/1991	11/12/2002	0.3	00940	CHLORIDE (MG/L AS CL)	8	639	320.58	33	20
615	10502	11/29/1994	12/4/1996	0.30488	00940	CHLORIDE (MG/L AS CL)	19	705	362.00	2	1
615	10619	11/2/1995	11/2/1995	0.30488	00940	CHLORIDE (MG/L AS CL)	147	147	147.00	1	
615	10621	8/21/1990	11/12/2002	0.3	00940	CHLORIDE (MG/L AS CL)	4	341	76.49	41	7
615	10621	11/29/1994	12/4/1996	0.30488	00940	CHLORIDE (MG/L AS CL)	74	75	74.50	2	
615	10623	6/25/1991	11/12/2002	0.3	00940	CHLORIDE (MG/L AS CL)	8	95	19.22	39	
615	10623	11/29/1994	12/4/1996	0.30488	00940	CHLORIDE (MG/L AS CL)	23	442	232.50	2	1

Table 4A-34. Summary of Sulfate Data for Segments 0610 and 0615

Segment ID	Station ID	Period Begin	Period End	Depth	Storet ID	Parameter	Min	Max	Avg	N	N > Criteria
610	10612	2/26/1991	12/11/2002	0.3	00945	SULFATE (MG/L AS SO4)	15	30	20.60	35	
610	10612	8/18/1994	8/18/1994	0.30488	00945	SULFATE (MG/L AS SO4)	20	20	20.00	1	
610	10613	8/20/1990	12/10/2002	0.3	00945	SULFATE (MG/L AS SO4)	11	263	41.83	38	2
610	10613	8/16/1994	8/16/1994	0.30488	00945	SULFATE (MG/L AS SO4)	33	33	33.00	1	
610	10614	9/28/1999	12/10/2002	0.3	00945	SULFATE (MG/L AS SO4)	8	33	15.17	12	
610	14906	8/21/1996	12/11/2002	0.3	00945	SULFATE (MG/L AS SO4)	15.9	23	18.46	22	
610	14906	8/17/1999	8/17/1999	0.30488	00945	SULFATE (MG/L AS SO4)	16	16	16.00	1	
610	14907	8/21/1996	12/10/2002	0.3	00945	SULFATE (MG/L AS SO4)	11	25	15.85	13	
610	15357	11/7/1996	8/19/1997	0.3	00945	SULFATE (MG/L AS SO4)	16.55	30.7	22.64	4	
610	15358	11/7/1996	8/19/1997	0.3	00945	SULFATE (MG/L AS SO4)	7.5	34.8	16.44	4	
610	15359	11/7/1996	8/19/1997	0.3	00945	SULFATE (MG/L AS SO4)	18.5	27.57	24.02	4	
610	15360	11/7/1996	8/19/1997	0.3	00945	SULFATE (MG/L AS SO4)	5.9	16.1	11.34	4	
610	15361	11/7/1996	7/17/2001	0.3	00945	SULFATE (MG/L AS SO4)	4.61	45.9	22.50	19	
610	15362	11/12/1996	8/21/1997	0.3	00945	SULFATE (MG/L AS SO4)	1	12	5.33	4	
610	15363	11/12/1996	8/21/1997	0.3	00945	SULFATE (MG/L AS SO4)	23.2	42.24	29.59	4	
610	15364	11/12/1996	8/19/1997	0.3	00945	SULFATE (MG/L AS SO4)	5.44	24.4	13.31	5	
610	15365	11/12/1996	8/21/1997	0.3	00945	SULFATE (MG/L AS SO4)	4.78	10	7.87	4	
610	15366	11/12/1996	8/21/1997	0.3	00945	SULFATE (MG/L AS SO4)	4.2	19.3	8.18	4	
610	15667	1/26/1994	2/14/1996	0.3	00945	SULFATE (MG/L AS SO4)	14	21	17.86	7	
610	15667	4/24/1996	4/17/1997	0.3048	00945	SULFATE (MG/L AS SO4)	15.62	31	20.52	10	
610	15668	2/9/1995	2/9/1995	0	00945	SULFATE (MG/L AS SO4)	17	17	17.00	1	
610	15668	1/27/1994	2/14/1996	0.3	00945	SULFATE (MG/L AS SO4)	12	46	26.43	7	
610	15668	8/21/1997	4/29/1998	0.3048	00945	SULFATE (MG/L AS SO4)	13.148	50	24.59	10	
610	15672	4/20/1994	2/14/1996	0.3	00945	SULFATE (MG/L AS SO4)	14	18	16.17	6	
610	15672	4/23/1996	4/17/1997	0.3048	00945	SULFATE (MG/L AS SO4)	15.99	23.218	18.25	11	
615	10502	6/25/1991	11/12/2002	0.3	00945	SULFATE (MG/L AS SO4)	13	514	245.61	33	25
615	10502	11/29/1994	12/4/1996	0.30488	00945	SULFATE (MG/L AS SO4)	24	346	185.00	2	1
615	10619	11/2/1995	11/2/1995	0.30488	00945	SULFATE (MG/L AS SO4)	92	92	92.00	1	
615	10621	8/21/1990	11/12/2002	0.3	00945	SULFATE (MG/L AS SO4)	13	205	62.66	41	5
615	10621	11/29/1994	12/4/1996	0.30488	00945	SULFATE (MG/L AS SO4)	50	52	51.00	2	
615	10623	6/25/1991	11/12/2002	0.3	00945	SULFATE (MG/L AS SO4)	9	68	25.13	39	
615	10623	11/29/1994	12/4/1996	0.30488	00945	SULFATE (MG/L AS SO4)	28	260	144.00	2	1

Table 4A-35. Summary of Total Suspended Solids Data for Segments 0610 and 0615

Segment ID	Station ID	Period Begin	Period End	Depth	Storet ID	Parameter	Min	Max	Avg	N	N > Criteria
610	10612	2/26/1991	12/11/2002	0.3	00530	RESIDUE, TOTAL NONFILTRABLE (MG/L)	2	48	5.50	34	NA
610	10612	8/18/1994	8/18/1994	0.30488	00530	RESIDUE, TOTAL NONFILTRABLE (MG/L)	1	1	1.00	1	NA
610	10612	6/24/1991	6/24/1991	17.01	00530	RESIDUE, TOTAL NONFILTRABLE (MG/L)	7	7	7.00	1	NA
610	10612	2/26/1991	2/26/1991	18.01	00530	RESIDUE, TOTAL NONFILTRABLE (MG/L)	2	2	2.00	1	NA
610	10613	8/20/1990	12/10/2002	0.3	00530	RESIDUE, TOTAL NONFILTRABLE (MG/L)	1	23	8.68	38	NA
610	10613	8/16/1994	8/16/1994	0.30488	00530	RESIDUE, TOTAL NONFILTRABLE (MG/L)	9	9	9.00	1	NA
610	10613	8/20/1990	8/20/1990	5.79	00530	RESIDUE, TOTAL NONFILTRABLE (MG/L)	19	19	19.00	1	NA
610	10613	7/30/1991	7/30/1991	8.29	00530	RESIDUE, TOTAL NONFILTRABLE (MG/L)	5	5	5.00	1	NA
610	10613	2/26/1991	2/26/1991	10	00530	RESIDUE, TOTAL NONFILTRABLE (MG/L)	7	7	7.00	1	NA
610	10614	9/28/1999	12/10/2002	0.3	00530	RESIDUE, TOTAL NONFILTRABLE (MG/L)	3	40	17.42	12	NA
610	14906	8/21/1996	12/11/2002	0.3	00530	RESIDUE, TOTAL NONFILTRABLE (MG/L)	1	19	3.36	22	NA
610	14906	8/17/1999	8/17/1999	0.30488	00530	RESIDUE, TOTAL NONFILTRABLE (MG/L)	1	1	1.00	1	NA
610	14907	8/21/1996	12/10/2002	0.3	00530	RESIDUE, TOTAL NONFILTRABLE (MG/L)	3	28	12.92	13	NA
610	15357	11/7/1996	8/19/1997	0.3	00530	RESIDUE, TOTAL NONFILTRABLE (MG/L)	7	13	11.00	4	NA
610	15358	11/7/1996	8/19/1997	0.3	00530	RESIDUE, TOTAL NONFILTRABLE (MG/L)	2	12.5	7.75	4	NA
610	15359	11/7/1996	8/19/1997	0.3	00530	RESIDUE, TOTAL NONFILTRABLE (MG/L)	5	15.5	10.38	4	NA
610	15360	11/7/1996	8/19/1997	0.3	00530	RESIDUE, TOTAL NONFILTRABLE (MG/L)	3	10.6	6.15	4	NA
610	15361	11/7/1996	7/17/2001	0.3	00530	RESIDUE, TOTAL NONFILTRABLE (MG/L)	1.33	21.5	11.49	19	NA
610	15362	11/12/1996	8/21/1997	0.3	00530	RESIDUE, TOTAL NONFILTRABLE (MG/L)	3.5	24	14.33	3	NA
610	15363	11/12/1996	8/21/1997	0.3	00530	RESIDUE, TOTAL NONFILTRABLE (MG/L)	1	14.5	9.63	4	NA
610	15364	11/12/1996	8/19/1997	0.3	00530	RESIDUE, TOTAL NONFILTRABLE (MG/L)	1	14	8.20	5	NA
610	15365	11/12/1996	8/21/1997	0.3	00530	RESIDUE, TOTAL NONFILTRABLE (MG/L)	7.5	32	19.88	4	NA
610	15366	11/12/1996	8/21/1997	0.3	00530	RESIDUE, TOTAL NONFILTRABLE (MG/L)	1	16.7	9.93	4	NA
615	10502	6/25/1991	11/12/2002	0.3	00530	RESIDUE, TOTAL NONFILTRABLE (MG/L)	5	194	21.64	33	NA
615	10502	11/29/1994	12/4/1996	0.30488	00530	RESIDUE, TOTAL NONFILTRABLE (MG/L)	10	11	10.50	2	NA
615	10619	11/2/1995	11/2/1995	0.30488	00530	RESIDUE, TOTAL NONFILTRABLE (MG/L)	21	21	21.00	1	NA
615	10621	8/21/1990	11/12/2002	0.3	00530	RESIDUE, TOTAL NONFILTRABLE (MG/L)	4	108	19.38	40	NA
615	10621	11/29/1994	12/4/1996	0.30488	00530	RESIDUE, TOTAL NONFILTRABLE (MG/L)	10	12	11.00	2	NA
615	10623	6/25/1991	11/12/2002	0.3	00530	RESIDUE, TOTAL NONFILTRABLE (MG/L)	4	38	14.41	39	NA
615	10623	11/29/1994	12/4/1996	0.30488	00530	RESIDUE, TOTAL NONFILTRABLE (MG/L)	11	16	13.50	2	NA

Table 4A-36. Summary of Total Dissolved Solids Data for Segments 0610 and 0615

Segment ID	Station ID	Period Begin	Period End	Storet ID	Parameter	Min	Max	Avg	N	N > Criteria
610	10612	8/18/1994	12/11/2002	70300	RESIDUE,TOTAL FILTRABLE (DRIED AT 180C) (MG/L)	80	244	111.34	29	
610	10613	8/16/1994	12/10/2002	70300	RESIDUE,TOTAL FILTRABLE (DRIED AT 180C) (MG/L)	79	1630	240.35	31	4
610	10614	9/28/1999	12/10/2002	70300	RESIDUE,TOTAL FILTRABLE (DRIED AT 180C) (MG/L)	71	232	106.75	12	
610	14906	8/21/1996	12/11/2002	70300	RESIDUE,TOTAL FILTRABLE (DRIED AT 180C) (MG/L)	71	124	93.00	23	
610	14907	8/21/1996	12/10/2002	70300	RESIDUE,TOTAL FILTRABLE (DRIED AT 180C) (MG/L)	74	188	112.46	13	
610	15361	11/17/1998	7/17/2001	70300	RESIDUE,TOTAL FILTRABLE (DRIED AT 180C) (MG/L)	82	4106	439.67	12	1
615	10502	6/8/1994	11/12/2002	70300	RESIDUE,TOTAL FILTRABLE (DRIED AT 180C) (MG/L)	86	2660	1218.03	32	23
615	10619	11/2/1995	11/2/1995	70300	RESIDUE,TOTAL FILTRABLE (DRIED AT 180C) (MG/L)	540	540	540.00	1	1
615	10621	6/8/1994	11/12/2002	70300	RESIDUE,TOTAL FILTRABLE (DRIED AT 180C) (MG/L)	107	1220	344.00	35	5
615	10623	6/8/1994	11/12/2002	70300	RESIDUE,TOTAL FILTRABLE (DRIED AT 180C) (MG/L)	79	1370	179.95	37	1

Table 4A-37. Summary of Water Temperature Data for Segments 0610 and 0615

Segment ID	Station ID	Period Begin	Period End	Depth	Storet ID	Parameter	Min	Max	Avg	N	N > Criteria
610	10612	2/26/1991	8/14/2002	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	7.4	32.8	21.81	52	
610	10613	8/20/1990	12/10/2002	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	7.6	33.4	21.38	41	
610	10613	8/16/1994	8/16/1994	0.30488	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	31	31	31.00	1	
610	10614	10/28/1996	12/10/2002	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	6.3	34.6	18.89	22	1
610	14906	12/10/1996	8/22/2002	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	8	32.1	21.92	38	
610	14907	8/21/1996	12/10/2002	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	6.5	32.3	20.04	25	
610	15357	11/7/1996	8/19/1997	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	10.8	26.6	18.43	8	
610	15358	11/7/1996	8/19/1997	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	10.8	27	18.30	8	
610	15359	11/7/1996	8/19/1997	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	10.4	27.7	17.11	7	
610	15360	11/7/1996	8/19/1997	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	10.4	27	19.04	9	
610	15361	11/7/1996	8/7/2002	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	8.6	27.2	17.48	29	
610	15362	11/12/1996	8/21/1997	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	10.8	26.1	18.11	8	
610	15363	11/12/1996	8/21/1997	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	11.2	26.2	18.06	8	
610	15364	11/12/1996	8/9/1996	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	11.3	27.4	19.85	10	
610	15365	11/12/1996	8/21/1997	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	11.5	26.6	19.07	7	
610	15366	11/12/1996	8/21/1997	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	12.6	28.8	19.55	8	
610	15522	3/13/2001	8/22/2002	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	10.7	30.6	23.73	15	
610	15523	3/8/2001	8/14/2002	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	11.5	30.8	24.25	15	
610	15524	3/8/2001	8/14/2002	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	14.8	31.9	24.42	15	
610	15526	3/13/2001	8/22/2002	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	12.5	30.3	23.96	15	
610	15527	3/13/2001	8/22/2002	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	13.4	31	24.34	15	
610	15666	1/26/1994	2/14/1996	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	11	31.5	20.36	7	
610	15666	8/26/1999	4/21/1999	0.3048	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	9.5	32	22.36	11	
610	15667	1/26/1994	2/14/1996	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	10.5	31.5	19.71	7	
610	15667	4/24/1996	4/17/1997	0.3048	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	10	31	22.00	10	
610	15668	1/27/1994	2/14/1996	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	9	31.5	20.36	7	
610	15668	8/21/1997	4/29/1998	0.3048	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	9	32.5	21.20	10	
610	15669	1/26/1994	2/14/1996	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	10	31.5	20.14	7	
610	15669	4/24/1996	8/26/1999	0.3048	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	10	32	22.14	11	
610	15670	1/26/1994	2/14/1996	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	10	31	19.36	7	
610	15670	4/24/1996	8/26/1999	0.3048	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	10	31	21.45	11	
610	15671	1/26/1994	2/14/1996	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	10	31.5	19.43	7	
610	15671	4/24/1996	8/26/1999	0.3048	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	10	31	21.27	11	
610	15672	1/25/1994	2/14/1996	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	10	32	19.71	7	

610	15672	4/23/1996	4/17/1997	0.3048	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	10	31.5	21.45	11	
610	15673	1/25/1994	2/13/1996	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	11	31.5	20.21	7	
610	15673	4/23/1996	8/25/1999	0.3048	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	10	32	21.80	10	
610	15674	1/25/1994	2/13/1996	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	11.5	34	20.93	7	1
610	15674	8/25/1999	4/20/1999	0.3048	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	10.5	32.5	22.55	11	
610	15675	1/25/1994	2/13/1996	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	12	33	21.00	7	
610	15675	4/23/1996	8/25/1999	0.3048	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	10	32.5	22.32	11	
610	16784	6/1/1998	7/6/1999	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	27.3	32.5	30.68	14	
610	16785	6/1/1998	7/6/1999	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	25.9	32.5	29.91	19	
610	16786	6/1/1998	7/6/1999	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	26.2	33.2	29.72	19	
610	16787	6/1/1998	7/6/1999	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	27.6	32.9	30.67	19	
610	16788	5/6/1999	8/13/1999	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	23.7	32.8	28.99	9	
610	16789	5/6/1999	8/13/1999	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	23.2	32.4	28.34	9	
610	16790	5/6/1999	8/13/1999	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	23.4	31.2	28.02	9	
610	16791	6/1/1998	7/6/1999	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	27.3	33.6	30.51	18	
610	16792	5/6/1999	8/13/1999	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	23.8	32.7	28.67	9	
610	16793	5/6/1999	8/13/1999	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	24.2	34	30.01	10	1
615	10502	6/25/1991	11/12/2002	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	9.1	32.6	23.87	33	
615	10621	8/21/1990	11/12/2002	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	7.5	32.2	20.98	51	
615	10623	6/25/1991	11/12/2002	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	6.9	31.6	20.94	49	

Table 4A-38. Summary of pH Data for Segments 0610 and 0615

Segment ID	Station ID	Period Begin	Period End	Depth	Storet ID	Parameter	Min	Max	Avg	N	N < or > Criteria
610	10612	2/26/1991	8/14/2002	0.3	00400	PH (STANDARD UNITS)	6.7	8.8	7.53	52	3
610	10612	2/27/1992	12/11/2002	1	00400	PH (STANDARD UNITS)	6.7	8.8	7.52	33	3
610	10612	2/26/1991	6/24/1991	1.01	00400	PH (STANDARD UNITS)	6.6	7.1	6.85	2	
610	10612	7/16/1992	8/4/1993	1.52	00400	PH (STANDARD UNITS)	7.5	8.4	7.95	2	
610	10612	2/27/1992	12/11/2002	2	00400	PH (STANDARD UNITS)	6.7	8.8	7.47	33	2
610	10612	2/26/1991	6/24/1991	2.01	00400	PH (STANDARD UNITS)	6.5	6.9	6.70	2	
610	10612	2/26/1991	6/24/1991	2.99	00400	PH (STANDARD UNITS)	6.5	6.8	6.65	2	
610	10612	2/27/1992	12/11/2002	3	00400	PH (STANDARD UNITS)	6.6	8.7	7.36	33	1
610	10612	7/16/1992	8/4/1993	3.05	00400	PH (STANDARD UNITS)	7.4	8.1	7.75	2	
610	10612	2/26/1991	6/24/1991	3.99	00400	PH (STANDARD UNITS)	6.5	6.7	6.60	2	
610	10612	2/27/1992	12/11/2002	4	00400	PH (STANDARD UNITS)	6.5	8.6	7.26	33	1
610	10612	7/16/1992	8/4/1993	4.57	00400	PH (STANDARD UNITS)	7.4	8	7.70	2	
610	10612	2/26/1991	12/11/2002	5	00400	PH (STANDARD UNITS)	6.4	8.5	7.17	35	
610	10612	2/26/1991	12/11/2002	6	00400	PH (STANDARD UNITS)	6.3	8	7.07	35	
610	10612	7/16/1992	8/4/1993	6.1	00400	PH (STANDARD UNITS)	7.3	7.9	7.60	2	
610	10612	2/27/1992	12/11/2002	7	00400	PH (STANDARD UNITS)	6	8	7.05	33	
610	10612	2/26/1991	6/24/1991	7.01	00400	PH (STANDARD UNITS)	6.4	6.5	6.45	2	
610	10612	7/16/1992	8/4/1993	7.62	00400	PH (STANDARD UNITS)	7.2	7.9	7.55	2	
610	10612	2/26/1991	6/24/1991	7.99	00400	PH (STANDARD UNITS)	6.4	6.5	6.45	2	
610	10612	2/27/1992	12/11/2002	8	00400	PH (STANDARD UNITS)	5.8	8	6.99	33	1
610	10612	2/26/1991	6/24/1991	8.99	00400	PH (STANDARD UNITS)	6.5	6.5	6.50	2	
610	10612	2/27/1992	12/11/2002	9	00400	PH (STANDARD UNITS)	5.8	8	6.97	33	1
610	10612	7/16/1992	8/4/1993	9.14	00400	PH (STANDARD UNITS)	6.9	7.7	7.30	2	
610	10612	2/26/1991	12/11/2002	10	00400	PH (STANDARD UNITS)	5.8	8	6.90	35	1
610	10612	7/16/1992	8/4/1993	10.67	00400	PH (STANDARD UNITS)	6.8	7.4	7.10	2	
610	10612	2/26/1991	12/11/2002	11	00400	PH (STANDARD UNITS)	5.8	8	6.87	35	1
610	10612	2/27/1992	12/11/2002	12	00400	PH (STANDARD UNITS)	5.7	8.1	6.88	32	1
610	10612	2/26/1991	6/24/1991	12.01	00400	PH (STANDARD UNITS)	6.4	6.5	6.45	2	
610	10612	7/16/1992	8/4/1993	12.19	00400	PH (STANDARD UNITS)	6.8	7.4	7.10	2	
610	10612	8/8/1996	8/8/1996	12.5	00400	PH (STANDARD UNITS)	6.7	6.7	6.70	1	
610	10612	2/27/1992	12/11/2002	13	00400	PH (STANDARD UNITS)	5.7	8.1	6.87	31	1
610	10612	2/26/1991	6/24/1991	13.01	00400	PH (STANDARD UNITS)	6.4	6.6	6.50	2	
610	10612	7/16/1992	8/4/1993	13.72	00400	PH (STANDARD UNITS)	6.7	7.4	7.05	2	
610	10612	2/26/1991	6/24/1991	13.99	00400	PH (STANDARD UNITS)	6.4	6.6	6.50	2	

Table 4A-38. Summary of pH Data for Segments 0610 and 0615

Segment ID	Station ID	Period Begin	Period End	Depth	Storet ID	Parameter	Min	Max	Avg	N	N < or > Criteria
610	10612	2/27/1992	12/11/2002	14	00400	PH (STANDARD UNITS)	5.7	8.1	6.87	31	1
610	10612	2/26/1991	12/11/2002	15	00400	PH (STANDARD UNITS)	5.6	8.1	6.78	28	1
610	10612	7/16/1992	8/4/1993	15.24	00400	PH (STANDARD UNITS)	6.7	7.4	7.05	2	
610	10612	11/24/1997	9/27/1999	15.5	00400	PH (STANDARD UNITS)	6.5	7.2	6.80	3	
610	10612	2/26/1991	12/11/2002	16	00400	PH (STANDARD UNITS)	5.6	8	6.75	22	1
610	10612	6/22/1999	6/18/2002	16.5	00400	PH (STANDARD UNITS)	6.6	6.7	6.63	3	
610	10612	7/16/1992	8/4/1993	16.76	00400	PH (STANDARD UNITS)	6.7	7.4	7.05	2	
610	10612	2/18/1993	3/14/2002	17	00400	PH (STANDARD UNITS)	5.6	8	6.64	13	1
610	10612	2/26/1991	6/24/1991	17.01	00400	PH (STANDARD UNITS)	6.4	6.8	6.60	2	
610	10612	4/22/1998	4/22/1998	17.5	00400	PH (STANDARD UNITS)	6.8	6.8	6.80	1	
610	10612	2/23/1995	6/19/2001	18	00400	PH (STANDARD UNITS)	5.5	6.8	6.40	7	1
610	10612	2/26/1991	6/24/1991	18.01	00400	PH (STANDARD UNITS)	6.4	6.9	6.65	2	
610	10612	4/14/1997	6/19/2001	18.5	00400	PH (STANDARD UNITS)	6.6	6.7	6.67	3	
610	10612	2/23/1995	4/2/2001	19	00400	PH (STANDARD UNITS)	6.2	6.7	6.40	3	
610	10612	4/2/2001	4/2/2001	19.5	00400	PH (STANDARD UNITS)	6.3	6.3	6.30	1	
610	10612	2/23/1995	2/23/1995	20	00400	PH (STANDARD UNITS)	6.2	6.2	6.20	1	
610	10613	8/20/1990	12/10/2002	0.3	00400	PH (STANDARD UNITS)	5.8	8.4	7.20	40	1
610	10613	8/16/1994	8/16/1994	0.30488	00400	PH (STANDARD UNITS)	8.1	8.1	8.10	1	
610	10613	2/27/1992	12/10/2002	1	00400	PH (STANDARD UNITS)	5.7	8.3	7.08	35	1
610	10613	8/20/1990	7/30/1991	1.01	00400	PH (STANDARD UNITS)	7	7.4	7.20	3	
610	10613	7/15/1992	8/4/1993	1.52	00400	PH (STANDARD UNITS)	7.3	7.8	7.55	2	
610	10613	2/27/1992	12/10/2002	2	00400	PH (STANDARD UNITS)	5.7	8.1	6.97	35	1
610	10613	8/20/1990	7/30/1991	2.01	00400	PH (STANDARD UNITS)	6.8	7.3	7.03	3	
610	10613	8/20/1990	7/30/1991	2.99	00400	PH (STANDARD UNITS)	6.7	7.3	6.97	3	
610	10613	2/27/1992	12/10/2002	3	00400	PH (STANDARD UNITS)	5.6	8.1	6.90	35	1
610	10613	7/15/1992	8/4/1993	3.05	00400	PH (STANDARD UNITS)	7.2	7.6	7.40	2	
610	10613	8/20/1990	7/30/1991	3.99	00400	PH (STANDARD UNITS)	6.7	7.4	6.97	3	
610	10613	2/27/1992	12/10/2002	4	00400	PH (STANDARD UNITS)	5.6	8	6.85	35	1
610	10613	9/18/2002	9/18/2002	4.5	00400	PH (STANDARD UNITS)	7.2	7.2	7.20	1	
610	10613	7/15/1992	8/4/1993	4.57	00400	PH (STANDARD UNITS)	7.2	7.5	7.35	2	
610	10613	8/20/1990	12/10/2002	5	00400	PH (STANDARD UNITS)	5.6	8	6.81	36	1
610	10613	1/29/1996	10/17/2001	5.5	00400	PH (STANDARD UNITS)	6.3	7.4	6.84	5	
610	10613	8/20/1990	8/20/1990	5.79	00400	PH (STANDARD UNITS)	6.7	6.7	6.70	1	
610	10613	2/26/1991	12/10/2002	6	00400	PH (STANDARD UNITS)	5.6	8	6.77	29	1

Table 4A-38. Summary of pH Data for Segments 0610 and 0615

Segment ID	Station ID	Period Begin	Period End	Depth	Storet ID	Parameter	Min	Max	Avg	N	N < or > Criteria
610	10613	7/15/1992	8/4/1993	6.1	00400	PH (STANDARD UNITS)	7.1	7.4	7.25	2	
610	10613	11/23/1998	11/23/1998	6.5	00400	PH (STANDARD UNITS)	6.2	6.2	6.20	1	
610	10613	2/18/1993	12/10/2002	7	00400	PH (STANDARD UNITS)	5.5	8	6.69	24	1
610	10613	2/26/1991	7/30/1991	7.01	00400	PH (STANDARD UNITS)	6.6	7.6	7.10	2	
610	10613	7/15/1992	7/15/1992	7.32	00400	PH (STANDARD UNITS)	7.1	7.1	7.10	1	
610	10613	7/10/1997	8/4/1998	7.5	00400	PH (STANDARD UNITS)	6.3	6.9	6.60	2	
610	10613	8/4/1993	8/4/1993	7.62	00400	PH (STANDARD UNITS)	7.3	7.3	7.30	1	
610	10613	2/26/1991	2/26/1991	7.99	00400	PH (STANDARD UNITS)	6.6	6.6	6.60	1	
610	10613	2/18/1993	12/10/2002	8	00400	PH (STANDARD UNITS)	5.5	7.9	6.61	16	1
610	10613	7/30/1991	7/30/1991	8.29	00400	PH (STANDARD UNITS)	7.6	7.6	7.60	1	
610	10613	3/3/1997	3/13/2002	8.5	00400	PH (STANDARD UNITS)	6.1	7.1	6.77	3	
610	10613	2/26/1991	2/26/1991	8.99	00400	PH (STANDARD UNITS)	6.5	6.5	6.50	1	
610	10613	2/22/1995	6/18/2001	9	00400	PH (STANDARD UNITS)	5.5	6.6	6.24	7	1
610	10613	5/16/1995	3/26/2001	9.5	00400	PH (STANDARD UNITS)	5.5	6.4	6.10	4	1
610	10613	2/26/1991	6/18/2001	10	00400	PH (STANDARD UNITS)	6.1	6.6	6.40	3	
610	10613	2/18/1999	2/18/1999	10.5	00400	PH (STANDARD UNITS)	6.5	6.5	6.50	1	
610	10614	10/28/1996	12/10/2002	0.3	00400	PH (STANDARD UNITS)	6.4	8.1	7.08	22	
610	10614	9/28/1999	12/10/2002	1	00400	PH (STANDARD UNITS)	6.3	8	6.92	12	
610	10614	9/28/1999	12/10/2002	2	00400	PH (STANDARD UNITS)	6.2	7.8	6.69	12	
610	10614	9/28/1999	12/10/2002	3	00400	PH (STANDARD UNITS)	6.1	7.7	6.61	11	
610	10614	1/8/2001	1/8/2001	3.5	00400	PH (STANDARD UNITS)	6.5	6.5	6.50	1	
610	10614	3/26/2001	12/10/2002	4	00400	PH (STANDARD UNITS)	6.1	7.6	6.60	8	
610	10614	12/10/2002	12/10/2002	4.5	00400	PH (STANDARD UNITS)	6.7	6.7	6.70	1	
610	10614	3/26/2001	9/17/2002	5	00400	PH (STANDARD UNITS)	6	7.6	6.66	7	
610	10614	10/17/2001	10/17/2001	5.5	00400	PH (STANDARD UNITS)	6.2	6.2	6.20	1	
610	10614	3/26/2001	3/13/2002	6	00400	PH (STANDARD UNITS)	6	7.6	6.77	3	
610	10614	1/7/2002	3/13/2002	6.5	00400	PH (STANDARD UNITS)	6.7	7.6	7.15	2	
610	10614	3/26/2001	3/26/2001	7	00400	PH (STANDARD UNITS)	6	6	6.00	1	
610	10614	3/26/2001	3/26/2001	8	00400	PH (STANDARD UNITS)	6	6	6.00	1	
610	10614	3/26/2001	3/26/2001	8.5	00400	PH (STANDARD UNITS)	6	6	6.00	1	
610	14906	12/10/1996	8/22/2002	0.3	00400	PH (STANDARD UNITS)	6.5	8.4	7.35	37	
610	14906	8/21/1996	12/11/2002	1	00400	PH (STANDARD UNITS)	5.9	8.2	7.29	20	1
610	14906	8/21/1996	12/11/2002	2	00400	PH (STANDARD UNITS)	5.8	8.2	7.26	20	1
610	14906	8/21/1996	12/11/2002	3	00400	PH (STANDARD UNITS)	5.8	7.9	7.20	20	1

Table 4A-38. Summary of pH Data for Segments 0610 and 0615

Segment ID	Station ID	Period Begin	Period End	Depth	Storet ID	Parameter	Min	Max	Avg	N	N < or > Criteria
610	14906	8/21/1996	12/11/2002	4	00400	PH (STANDARD UNITS)	5.8	7.8	7.15	20	1
610	14906	8/21/1996	12/11/2002	5	00400	PH (STANDARD UNITS)	5.8	7.8	7.08	20	1
610	14906	8/21/1996	12/11/2002	6	00400	PH (STANDARD UNITS)	5.8	7.7	7.01	19	1
610	14906	8/21/1996	12/11/2002	7	00400	PH (STANDARD UNITS)	5.8	7.7	6.96	19	1
610	14906	8/21/1996	12/11/2002	8	00400	PH (STANDARD UNITS)	5.8	7.6	6.93	19	1
610	14906	8/21/1996	12/11/2002	9	00400	PH (STANDARD UNITS)	5.8	7.6	6.90	19	1
610	14906	8/21/1996	12/11/2002	10	00400	PH (STANDARD UNITS)	5.8	7.6	6.85	19	1
610	14906	8/21/1996	12/11/2002	11	00400	PH (STANDARD UNITS)	5.8	7.6	6.80	19	1
610	14906	8/21/1996	12/11/2002	12	00400	PH (STANDARD UNITS)	5.8	7.6	6.78	19	1
610	14906	8/21/1996	12/11/2002	13	00400	PH (STANDARD UNITS)	5.8	7.6	6.76	19	1
610	14906	8/21/1996	12/11/2002	14	00400	PH (STANDARD UNITS)	5.8	7.6	6.76	19	1
610	14906	8/21/1996	12/11/2002	15	00400	PH (STANDARD UNITS)	5.8	7.6	6.76	19	1
610	14906	8/21/1996	12/11/2002	16	00400	PH (STANDARD UNITS)	5.8	7.6	6.76	19	1
610	14906	8/21/1996	12/11/2002	17	00400	PH (STANDARD UNITS)	5.8	7.6	6.76	19	1
610	14906	8/21/1996	3/14/2002	18	00400	PH (STANDARD UNITS)	5.8	7.3	6.72	18	1
610	14906	8/21/1996	3/14/2002	19	00400	PH (STANDARD UNITS)	5.8	7.2	6.71	18	1
610	14906	8/21/1996	1/8/2002	20	00400	PH (STANDARD UNITS)	5.8	7.2	6.69	17	1
610	14906	11/24/1997	11/24/1997	20.5	00400	PH (STANDARD UNITS)	7.1	7.1	7.10	1	
610	14906	8/21/1996	1/8/2002	21	00400	PH (STANDARD UNITS)	5.8	7.2	6.67	16	1
610	14906	10/10/2000	1/8/2002	21.5	00400	PH (STANDARD UNITS)	5.6	7.1	6.35	2	1
610	14906	8/21/1996	6/19/2001	22	00400	PH (STANDARD UNITS)	6.3	7.2	6.74	13	
610	14906	12/16/1999	12/16/1999	22.5	00400	PH (STANDARD UNITS)	7	7	7.00	1	
610	14906	2/18/1998	4/2/2001	23	00400	PH (STANDARD UNITS)	6.3	7.2	6.72	10	
610	14906	2/18/1998	4/2/2001	24	00400	PH (STANDARD UNITS)	6.3	7.2	6.76	8	
610	14906	8/17/1999	8/17/1999	24.5	00400	PH (STANDARD UNITS)	6.6	6.6	6.60	1	
610	14906	2/18/1998	4/2/2001	25	00400	PH (STANDARD UNITS)	6.3	7	6.68	5	
610	14906	11/23/1998	11/23/1998	25.5	00400	PH (STANDARD UNITS)	6.6	6.6	6.60	1	
610	14906	2/18/1998	4/2/2001	26	00400	PH (STANDARD UNITS)	6.7	7	6.85	2	
610	14906	2/18/1998	2/18/1998	27	00400	PH (STANDARD UNITS)	7	7	7.00	1	
610	14907	8/21/1996	12/10/2002	0.3	00400	PH (STANDARD UNITS)	6.5	7.8	7.04	25	
610	14907	8/21/1996	12/10/2002	1	00400	PH (STANDARD UNITS)	6.5	7.7	6.88	14	
610	14907	8/21/1996	12/10/2002	2	00400	PH (STANDARD UNITS)	6.2	7.6	6.77	14	
610	14907	9/28/1999	12/10/2002	3	00400	PH (STANDARD UNITS)	6	7.6	6.71	13	
610	14907	12/15/1999	6/13/2000	3.5	00400	PH (STANDARD UNITS)	6.7	6.8	6.75	2	

Table 4A-38. Summary of pH Data for Segments 0610 and 0615

Segment ID	Station ID	Period Begin	Period End	Depth	Storet ID	Parameter	Min	Max	Avg	N	N < or > Criteria
610	14907	9/28/1999	12/10/2002	4	00400	PH (STANDARD UNITS)	5.9	7.6	6.67	11	1
610	14907	9/28/1999	12/10/2002	4.5	00400	PH (STANDARD UNITS)	5.9	6.9	6.40	2	1
610	14907	3/26/2001	6/7/2002	5	00400	PH (STANDARD UNITS)	6	7.6	6.64	7	
610	14907	3/13/2002	3/13/2002	5.5	00400	PH (STANDARD UNITS)	6.8	6.8	6.80	1	
610	14907	3/26/2001	1/7/2002	6	00400	PH (STANDARD UNITS)	6	7.6	6.68	4	
610	14907	3/26/2001	10/17/2001	7	00400	PH (STANDARD UNITS)	5.9	6.9	6.40	2	1
610	14907	3/26/2001	3/26/2001	7.5	00400	PH (STANDARD UNITS)	5.9	5.9	5.90	1	1
610	14907	10/17/2001	10/17/2001	8	00400	PH (STANDARD UNITS)	6.9	6.9	6.90	1	
610	14907	10/17/2001	10/17/2001	9	00400	PH (STANDARD UNITS)	6.9	6.9	6.90	1	
610	14907	10/17/2001	10/17/2001	10	00400	PH (STANDARD UNITS)	6.9	6.9	6.90	1	
610	14907	10/17/2001	10/17/2001	11	00400	PH (STANDARD UNITS)	6.9	6.9	6.90	1	
610	14907	10/17/2001	10/17/2001	12	00400	PH (STANDARD UNITS)	6.9	6.9	6.90	1	
610	14907	10/17/2001	10/17/2001	13	00400	PH (STANDARD UNITS)	6.9	6.9	6.90	1	
610	14907	10/17/2001	10/17/2001	14	00400	PH (STANDARD UNITS)	6.9	6.9	6.90	1	
610	14907	10/17/2001	10/17/2001	15	00400	PH (STANDARD UNITS)	6.9	6.9	6.90	1	
610	14907	10/17/2001	10/17/2001	16	00400	PH (STANDARD UNITS)	6.9	6.9	6.90	1	
610	14907	10/17/2001	10/17/2001	17	00400	PH (STANDARD UNITS)	6.9	6.9	6.90	1	
610	14907	10/17/2001	10/17/2001	18	00400	PH (STANDARD UNITS)	6.9	6.9	6.90	1	
610	14907	10/17/2001	10/17/2001	19	00400	PH (STANDARD UNITS)	6.9	6.9	6.90	1	
610	14907	10/17/2001	10/17/2001	20	00400	PH (STANDARD UNITS)	6.7	6.7	6.70	1	
610	14907	10/17/2001	10/17/2001	21	00400	PH (STANDARD UNITS)	6.7	6.7	6.70	1	
610	14907	10/17/2001	10/17/2001	22	00400	PH (STANDARD UNITS)	6.7	6.7	6.70	1	
610	14907	10/17/2001	10/17/2001	23	00400	PH (STANDARD UNITS)	6.8	6.8	6.80	1	
610	14907	10/17/2001	10/17/2001	24	00400	PH (STANDARD UNITS)	6.8	6.8	6.80	1	
610	15357	11/7/1996	8/19/1997	0.3	00400	PH (STANDARD UNITS)	6.7	7.1	6.88	8	
610	15358	11/7/1996	8/19/1997	0.3	00400	PH (STANDARD UNITS)	6.6	7.1	6.83	8	
610	15359	11/7/1996	8/19/1997	0.3	00400	PH (STANDARD UNITS)	6.6	7	6.81	7	
610	15360	11/7/1996	8/19/1997	0.3	00400	PH (STANDARD UNITS)	6.6	7.3	6.88	9	
610	15361	11/7/1996	8/7/2002	0.3	00400	PH (STANDARD UNITS)	6.4	7.7	7.07	29	
610	15362	11/12/1996	8/21/1997	0.3	00400	PH (STANDARD UNITS)	7	7.6	7.21	7	
610	15363	11/12/1996	8/21/1997	0.3	00400	PH (STANDARD UNITS)	6.8	7.8	7.24	8	
610	15364	11/12/1996	8/9/1996	0.3	00400	PH (STANDARD UNITS)	6.5	7.3	7.01	10	
610	15365	11/12/1996	8/21/1997	0.3	00400	PH (STANDARD UNITS)	6.3	7.2	6.81	7	
610	15366	11/12/1996	8/21/1997	0.3	00400	PH (STANDARD UNITS)	7	8.7	7.36	8	1

Table 4A-38. Summary of pH Data for Segments 0610 and 0615

Segment ID	Station ID	Period Begin	Period End	Depth	Storet ID	Parameter	Min	Max	Avg	N	N < or > Criteria
610	15522	3/13/2001	8/22/2002	0.3	00400	PH (STANDARD UNITS)	7	8.4	7.48	15	
610	15523	3/8/2001	8/14/2002	0.3	00400	PH (STANDARD UNITS)	6.6	8.8	7.47	15	1
610	15524	3/8/2001	8/14/2002	0.3	00400	PH (STANDARD UNITS)	6.7	8.7	7.44	15	2
610	15526	3/13/2001	8/22/2002	0.3	00400	PH (STANDARD UNITS)	6.9	8.5	7.47	15	
610	15527	3/13/2001	8/22/2002	0.3	00400	PH (STANDARD UNITS)	6.7	8.3	7.50	15	
610	15666	1/26/1994	2/14/1996	0.3	00400	PH (STANDARD UNITS)	6.6	8.5	7.20	7	
610	15666	8/26/1999	4/21/1999	0.3048	00400	PH (STANDARD UNITS)	6.6	7.6	6.96	11	
610	15666	1/26/1994	2/14/1996	3.03	00400	PH (STANDARD UNITS)	6.6	7.3	6.90	7	
610	15666	4/24/1996	8/26/1999	3.048	00400	PH (STANDARD UNITS)	6.2	7.5	6.78	11	
610	15666	1/26/1994	2/14/1996	6.06	00400	PH (STANDARD UNITS)	6.6	7.3	6.84	7	
610	15666	8/22/1996	8/26/1999	6.096	00400	PH (STANDARD UNITS)	6.1	7.4	6.74	9	
610	15666	4/24/1996	4/24/1996	6.7056	00400	PH (STANDARD UNITS)	6.7	6.7	6.70	1	
610	15666	9/3/1998	9/3/1998	7.3152	00400	PH (STANDARD UNITS)	6.6	6.6	6.60	1	
610	15666	2/14/1996	2/14/1996	7.88	00400	PH (STANDARD UNITS)	7.2	7.2	7.20	1	
610	15666	1/26/1994	1/26/1994	8.18	00400	PH (STANDARD UNITS)	7	7	7.00	1	
610	15666	8/26/1999	8/26/1999	8.5344	00400	PH (STANDARD UNITS)	6.9	6.9	6.90	1	
610	15666	8/25/1994	8/25/1994	8.79	00400	PH (STANDARD UNITS)	6.7	6.7	6.70	1	
610	15666	4/21/1994	8/30/1995	9.09	00400	PH (STANDARD UNITS)	6.4	7.3	6.78	4	
610	15666	2/19/1998	2/24/1999	9.144	00400	PH (STANDARD UNITS)	6.4	6.5	6.45	2	
610	15666	4/29/1998	4/29/1998	9.7536	00400	PH (STANDARD UNITS)	6.7	6.7	6.70	1	
610	15666	8/21/1997	8/21/1997	10.058	00400	PH (STANDARD UNITS)	6.1	6.1	6.10	1	
610	15666	4/21/1999	4/21/1999	10.21	00400	PH (STANDARD UNITS)	7.1	7.1	7.10	1	
610	15666	4/21/1994	4/21/1994	10.3	00400	PH (STANDARD UNITS)	7.3	7.3	7.30	1	
610	15666	4/17/1997	4/17/1997	10.668	00400	PH (STANDARD UNITS)	6.8	6.8	6.80	1	
610	15666	2/19/1998	2/19/1998	11.277	00400	PH (STANDARD UNITS)	6.4	6.4	6.40	1	
610	15666	2/24/1999	2/24/1999	11.43	00400	PH (STANDARD UNITS)	6.4	6.4	6.40	1	
610	15666	4/19/1995	4/19/1995	11.82	00400	PH (STANDARD UNITS)	6.5	6.5	6.50	1	
610	15666	2/9/1995	2/9/1995	12.12	00400	PH (STANDARD UNITS)	6.6	6.6	6.60	1	
610	15667	1/26/1994	2/14/1996	0.3	00400	PH (STANDARD UNITS)	6.7	8.6	7.43	7	1
610	15667	4/24/1996	4/17/1997	0.3048	00400	PH (STANDARD UNITS)	6.7	8	7.09	10	
610	15667	1/26/1994	2/14/1996	3.03	00400	PH (STANDARD UNITS)	6.7	8.2	7.31	7	
610	15667	4/24/1996	8/26/1999	3.048	00400	PH (STANDARD UNITS)	6.4	7.1	6.85	10	
610	15667	1/26/1994	2/14/1996	6.06	00400	PH (STANDARD UNITS)	6.6	7.1	6.83	7	
610	15667	4/24/1996	8/26/1999	6.096	00400	PH (STANDARD UNITS)	6.3	7.1	6.79	10	

Table 4A-38. Summary of pH Data for Segments 0610 and 0615

Segment ID	Station ID	Period Begin	Period End	Depth	Storet ID	Parameter	Min	Max	Avg	N	N < or > Criteria
610	15667	9/3/1998	9/3/1998	7.0104	00400	PH (STANDARD UNITS)	7	7	7.00	1	
610	15667	1/26/1994	2/14/1996	9.09	00400	PH (STANDARD UNITS)	6.5	7	6.74	7	
610	15667	4/24/1996	8/26/1999	9.144	00400	PH (STANDARD UNITS)	6.1	7.1	6.69	10	
610	15667	1/26/1994	2/14/1996	12.12	00400	PH (STANDARD UNITS)	6.6	6.9	6.79	7	
610	15667	4/24/1996	8/26/1999	12.192	00400	PH (STANDARD UNITS)	6.4	7.1	6.73	10	
610	15667	9/3/1998	9/3/1998	14.02	00400	PH (STANDARD UNITS)	7	7	7.00	1	
610	15667	4/24/1996	8/22/1996	14.325	00400	PH (STANDARD UNITS)	6.4	7	6.70	2	
610	15667	4/21/1994	8/30/1995	15.15	00400	PH (STANDARD UNITS)	6.6	6.8	6.72	5	
610	15667	2/13/1997	8/26/1999	15.24	00400	PH (STANDARD UNITS)	6.4	7.1	6.64	7	
610	15667	1/26/1994	2/14/1996	16.36	00400	PH (STANDARD UNITS)	6.9	6.9	6.90	2	
610	15667	8/25/1994	8/25/1994	16.97	00400	PH (STANDARD UNITS)	6.8	6.8	6.80	1	
610	15667	8/26/1999	8/26/1999	17.068	00400	PH (STANDARD UNITS)	6.7	6.7	6.70	1	
610	15667	8/30/1995	8/30/1995	17.27	00400	PH (STANDARD UNITS)	6.8	6.8	6.80	1	
610	15667	2/13/1997	2/13/1997	17.678	00400	PH (STANDARD UNITS)	7.1	7.1	7.10	1	
610	15667	4/21/1994	4/19/1995	18.18	00400	PH (STANDARD UNITS)	6.4	6.8	6.60	2	
610	15667	8/21/1997	2/24/1999	18.288	00400	PH (STANDARD UNITS)	6.5	6.6	6.53	3	
610	15667	4/21/1994	4/21/1994	18.79	00400	PH (STANDARD UNITS)	6.8	6.8	6.80	1	
610	15667	4/17/1997	2/19/1998	18.897	00400	PH (STANDARD UNITS)	6.6	6.8	6.70	2	
610	15667	2/9/1995	2/9/1995	19.7	00400	PH (STANDARD UNITS)	6.7	6.7	6.70	1	
610	15667	2/24/1999	2/24/1999	20.116	00400	PH (STANDARD UNITS)	6.6	6.6	6.60	1	
610	15667	4/19/1995	4/19/1995	21.21	00400	PH (STANDARD UNITS)	6.4	6.4	6.40	1	
610	15668	1/27/1994	2/14/1996	0.3	00400	PH (STANDARD UNITS)	6.4	8.5	7.14	7	
610	15668	8/21/1997	4/29/1998	0.3048	00400	PH (STANDARD UNITS)	6.4	8.3	7.04	10	
610	15668	8/30/1995	8/30/1995	1.52	00400	PH (STANDARD UNITS)	7.3	7.3	7.30	1	
610	15668	9/2/1998	9/2/1998	1.8288	00400	PH (STANDARD UNITS)	7.7	7.7	7.70	1	
610	15668	4/21/1994	2/14/1996	3.03	00400	PH (STANDARD UNITS)	6.4	7.3	6.85	6	
610	15668	2/14/1997	8/25/1999	3.048	00400	PH (STANDARD UNITS)	6.4	8.2	6.96	7	
610	15668	4/29/1998	4/29/1998	3.3528	00400	PH (STANDARD UNITS)	6.9	6.9	6.90	1	
610	15668	4/17/1997	4/17/1997	4.572	00400	PH (STANDARD UNITS)	6.6	6.6	6.60	1	
610	15668	4/25/1996	4/25/1996	5.4864	00400	PH (STANDARD UNITS)	6.5	6.5	6.50	1	
610	15668	1/27/1994	8/30/1995	6.06	00400	PH (STANDARD UNITS)	6.4	7.3	6.85	6	
610	15668	4/17/1997	4/21/1999	6.096	00400	PH (STANDARD UNITS)	6.5	7	6.68	5	
610	15668	2/14/1996	2/14/1996	6.36	00400	PH (STANDARD UNITS)	7.2	7.2	7.20	1	
610	15668	8/25/1999	8/25/1999	6.4008	00400	PH (STANDARD UNITS)	8	8	8.00	1	

Table 4A-38. Summary of pH Data for Segments 0610 and 0615

Segment ID	Station ID	Period Begin	Period End	Depth	Storet ID	Parameter	Min	Max	Avg	N	N < or > Criteria
610	15668	2/14/1997	2/14/1997	6.7056	00400	PH (STANDARD UNITS)	6.4	6.4	6.40	1	
610	15668	8/25/1994	8/30/1995	7.58	00400	PH (STANDARD UNITS)	7.1	7.4	7.25	2	
610	15668	8/21/1997	8/21/1997	7.9248	00400	PH (STANDARD UNITS)	6.6	6.6	6.60	1	
610	15668	4/21/1999	4/21/1999	8.9916	00400	PH (STANDARD UNITS)	7	7	7.00	1	
610	15668	4/21/1994	4/21/1994	9.09	00400	PH (STANDARD UNITS)	7	7	7.00	1	
610	15668	4/17/1997	4/17/1997	9.144	00400	PH (STANDARD UNITS)	6.7	6.7	6.70	1	
610	15668	2/19/1998	2/19/1998	9.4488	00400	PH (STANDARD UNITS)	6.5	6.5	6.50	1	
610	15668	4/19/1995	4/19/1995	10.3	00400	PH (STANDARD UNITS)	6.4	6.4	6.40	1	
610	15668	2/24/1999	2/24/1999	10.363	00400	PH (STANDARD UNITS)	6.6	6.6	6.60	1	
610	15668	2/9/1995	2/9/1995	10.61	00400	PH (STANDARD UNITS)	6.5	6.5	6.50	1	
610	15669	1/26/1994	2/14/1996	0.3	00400	PH (STANDARD UNITS)	6.6	8.7	7.40	7	1
610	15669	4/24/1996	8/26/1999	0.3048	00400	PH (STANDARD UNITS)	6.5	7.9	7.17	11	
610	15669	1/26/1994	2/14/1996	3.03	00400	PH (STANDARD UNITS)	6.6	7.6	6.96	7	
610	15669	4/24/1996	8/26/1999	3.048	00400	PH (STANDARD UNITS)	6.5	7.3	6.90	11	
610	15669	1/26/1994	2/14/1996	6.06	00400	PH (STANDARD UNITS)	6.4	7	6.79	7	
610	15669	8/22/1996	8/26/1999	6.096	00400	PH (STANDARD UNITS)	6.5	7.3	6.80	10	
610	15669	4/24/1996	4/24/1996	7.62	00400	PH (STANDARD UNITS)	7	7	7.00	1	
610	15669	8/22/1996	8/22/1996	7.9248	00400	PH (STANDARD UNITS)	7.2	7.2	7.20	1	
610	15669	4/21/1999	4/21/1999	8.8392	00400	PH (STANDARD UNITS)	7.1	7.1	7.10	1	
610	15669	1/26/1994	2/14/1996	9.09	00400	PH (STANDARD UNITS)	6.4	7.1	6.79	7	
610	15669	4/17/1997	8/26/1999	9.144	00400	PH (STANDARD UNITS)	6.4	6.8	6.63	6	
610	15669	2/13/1997	9/3/1998	9.7536	00400	PH (STANDARD UNITS)	6.8	6.8	6.80	2	
610	15669	8/30/1995	8/30/1995	10.91	00400	PH (STANDARD UNITS)	6.8	6.8	6.80	1	
610	15669	1/26/1994	8/25/1994	11.21	00400	PH (STANDARD UNITS)	6.8	6.9	6.85	2	
610	15669	4/21/1994	4/21/1994	11.52	00400	PH (STANDARD UNITS)	7.5	7.5	7.50	1	
610	15669	8/26/1999	8/26/1999	11.582	00400	PH (STANDARD UNITS)	6.8	6.8	6.80	1	
610	15669	2/9/1995	2/9/1995	12.12	00400	PH (STANDARD UNITS)	6.6	6.6	6.60	1	
610	15669	8/21/1997	4/29/1998	12.192	00400	PH (STANDARD UNITS)	6.5	6.7	6.57	3	
610	15669	2/24/1999	2/24/1999	12.496	00400	PH (STANDARD UNITS)	6.4	6.4	6.40	1	
610	15669	4/19/1995	4/19/1995	13.33	00400	PH (STANDARD UNITS)	6.4	6.4	6.40	1	
610	15669	4/17/1997	4/17/1997	13.411	00400	PH (STANDARD UNITS)	6.8	6.8	6.80	1	
610	15669	2/9/1995	2/9/1995	14.55	00400	PH (STANDARD UNITS)	6.6	6.6	6.60	1	
610	15669	2/19/1998	2/19/1998	15.24	00400	PH (STANDARD UNITS)	6.4	6.4	6.40	1	
610	15670	1/26/1994	2/14/1996	0.3	00400	PH (STANDARD UNITS)	7	8.2	7.41	7	

Table 4A-38. Summary of pH Data for Segments 0610 and 0615

Segment ID	Station ID	Period Begin	Period End	Depth	Storet ID	Parameter	Min	Max	Avg	N	N < or > Criteria
610	15670	4/24/1996	8/26/1999	0.3048	00400	PH (STANDARD UNITS)	6.7	7.7	7.10	11	
610	15670	1/26/1994	2/14/1996	3.03	00400	PH (STANDARD UNITS)	6.8	7.9	7.29	7	
610	15670	4/24/1996	8/26/1999	3.048	00400	PH (STANDARD UNITS)	6.6	7.5	7.04	10	
610	15670	1/26/1994	2/14/1996	6.06	00400	PH (STANDARD UNITS)	6.6	7.4	6.99	7	
610	15670	4/24/1996	8/26/1999	6.096	00400	PH (STANDARD UNITS)	6.5	7.3	6.96	11	
610	15670	1/26/1994	2/14/1996	9.09	00400	PH (STANDARD UNITS)	6.5	7.1	6.80	7	
610	15670	4/24/1996	8/26/1999	9.144	00400	PH (STANDARD UNITS)	6.1	7.2	6.80	11	
610	15670	1/26/1994	2/14/1996	12.12	00400	PH (STANDARD UNITS)	6.7	7.1	6.86	7	
610	15670	4/24/1996	8/26/1999	12.192	00400	PH (STANDARD UNITS)	6.2	7.2	6.76	11	
610	15670	4/21/1994	2/14/1996	15.15	00400	PH (STANDARD UNITS)	6.7	7.1	6.82	6	
610	15670	2/13/1997	8/26/1999	15.24	00400	PH (STANDARD UNITS)	6.4	7.2	6.70	8	
610	15670	8/22/1996	8/22/1996	16.154	00400	PH (STANDARD UNITS)	6.9	6.9	6.90	1	
610	15670	9/2/1998	9/2/1998	16.459	00400	PH (STANDARD UNITS)	7	7	7.00	1	
610	15670	4/24/1996	4/24/1996	16.764	00400	PH (STANDARD UNITS)	6.5	6.5	6.50	1	
610	15670	1/26/1994	1/26/1994	16.97	00400	PH (STANDARD UNITS)	7.1	7.1	7.10	1	
610	15670	4/21/1994	2/14/1996	18.18	00400	PH (STANDARD UNITS)	6.6	7.1	6.80	6	
610	15670	4/17/1997	4/21/1999	18.288	00400	PH (STANDARD UNITS)	6.4	6.9	6.65	6	
610	15670	2/13/1997	8/26/1999	18.897	00400	PH (STANDARD UNITS)	6.5	7.2	6.85	2	
610	15670	8/21/1997	8/21/1997	20.421	00400	PH (STANDARD UNITS)	6.4	6.4	6.40	1	
610	15670	4/21/1994	4/21/1994	20.61	00400	PH (STANDARD UNITS)	6.7	6.7	6.70	1	
610	15670	4/29/1998	4/29/1998	20.726	00400	PH (STANDARD UNITS)	6.4	6.4	6.40	1	
610	15670	8/25/1994	8/25/1994	21.21	00400	PH (STANDARD UNITS)	6.7	6.7	6.70	1	
610	15670	2/19/1998	2/19/1998	21.64	00400	PH (STANDARD UNITS)	6.8	6.8	6.80	1	
610	15670	2/24/1999	4/21/1999	21.945	00400	PH (STANDARD UNITS)	6.5	6.9	6.70	2	
610	15670	4/17/1997	4/17/1997	22.555	00400	PH (STANDARD UNITS)	6.9	6.9	6.90	1	
610	15670	2/9/1995	2/9/1995	23.03	00400	PH (STANDARD UNITS)	7.1	7.1	7.10	1	
610	15671	1/26/1994	2/14/1996	0.3	00400	PH (STANDARD UNITS)	6.9	8.1	7.37	7	
610	15671	4/24/1996	8/26/1999	0.3048	00400	PH (STANDARD UNITS)	6.5	7.6	7.11	11	
610	15671	1/26/1994	2/14/1996	3.03	00400	PH (STANDARD UNITS)	6.8	7.7	7.26	7	
610	15671	4/24/1996	8/26/1999	3.048	00400	PH (STANDARD UNITS)	6.4	7.4	7.04	11	
610	15671	1/26/1994	2/14/1996	6.06	00400	PH (STANDARD UNITS)	6.6	7.3	6.94	7	
610	15671	4/24/1996	8/26/1999	6.096	00400	PH (STANDARD UNITS)	6.1	7.2	6.91	11	
610	15671	1/26/1994	2/14/1996	9.09	00400	PH (STANDARD UNITS)	6.4	7.2	6.77	7	
610	15671	4/24/1996	8/26/1999	9.144	00400	PH (STANDARD UNITS)	6.1	7.2	6.79	11	

Table 4A-38. Summary of pH Data for Segments 0610 and 0615

Segment ID	Station ID	Period Begin	Period End	Depth	Storet ID	Parameter	Min	Max	Avg	N	N < or > Criteria
610	15671	1/26/1994	2/14/1996	12.12	00400	PH (STANDARD UNITS)	6.5	7.2	6.81	7	
610	15671	4/24/1996	8/26/1999	12.192	00400	PH (STANDARD UNITS)	6.1	7.2	6.77	11	
610	15671	1/26/1994	2/14/1996	15.15	00400	PH (STANDARD UNITS)	6.4	7.2	6.81	7	
610	15671	4/24/1996	8/26/1999	15.24	00400	PH (STANDARD UNITS)	6	7.2	6.74	11	
610	15671	8/22/1996	8/22/1996	17.678	00400	PH (STANDARD UNITS)	6.8	6.8	6.80	1	
610	15671	1/26/1994	2/14/1996	18.18	00400	PH (STANDARD UNITS)	6.4	7.2	6.81	7	
610	15671	2/13/1997	8/26/1999	18.288	00400	PH (STANDARD UNITS)	6	7.2	6.69	8	
610	15671	2/19/1998	2/19/1998	19.202	00400	PH (STANDARD UNITS)	6.8	6.8	6.80	1	
610	15671	2/14/1996	2/14/1996	19.7	00400	PH (STANDARD UNITS)	7.1	7.1	7.10	1	
610	15671	4/24/1996	4/24/1996	19.964	00400	PH (STANDARD UNITS)	6.7	6.7	6.70	1	
610	15671	9/2/1998	9/2/1998	20.726	00400	PH (STANDARD UNITS)	7	7	7.00	1	
610	15671	8/30/1995	8/30/1995	20.91	00400	PH (STANDARD UNITS)	6.6	6.6	6.60	1	
610	15671	4/21/1994	4/19/1995	21.21	00400	PH (STANDARD UNITS)	6.4	7.2	6.73	4	
610	15671	2/13/1997	2/24/1999	21.336	00400	PH (STANDARD UNITS)	6.9	7.2	7.00	3	
610	15671	4/29/1998	4/29/1998	21.945	00400	PH (STANDARD UNITS)	6.6	6.6	6.60	1	
610	15671	8/26/1999	8/26/1999	22.25	00400	PH (STANDARD UNITS)	6.4	6.4	6.40	1	
610	15671	1/26/1994	1/26/1994	22.42	00400	PH (STANDARD UNITS)	7.1	7.1	7.10	1	
610	15671	4/21/1994	8/25/1994	22.73	00400	PH (STANDARD UNITS)	6.4	6.6	6.50	2	
610	15671	4/21/1999	4/21/1999	22.86	00400	PH (STANDARD UNITS)	6.4	6.4	6.40	1	
610	15671	8/21/1997	8/21/1997	23.164	00400	PH (STANDARD UNITS)	6	6	6.00	1	
610	15671	2/9/1995	4/19/1995	24.24	00400	PH (STANDARD UNITS)	6.8	7.2	7.00	2	
610	15671	2/24/1999	2/24/1999	24.536	00400	PH (STANDARD UNITS)	6.9	6.9	6.90	1	
610	15671	4/17/1997	4/17/1997	24.993	00400	PH (STANDARD UNITS)	6.9	6.9	6.90	1	
610	15672	1/25/1994	2/14/1996	0.3	00400	PH (STANDARD UNITS)	6.9	8.2	7.33	7	
610	15672	4/23/1996	4/17/1997	0.3048	00400	PH (STANDARD UNITS)	6.2	7.6	7.15	11	
610	15672	1/25/1994	2/14/1996	3.03	00400	PH (STANDARD UNITS)	6.8	8.2	7.27	7	
610	15672	4/23/1996	8/25/1999	3.048	00400	PH (STANDARD UNITS)	6.2	7.4	7.07	11	
610	15672	1/25/1994	2/14/1996	6.06	00400	PH (STANDARD UNITS)	6.8	7.2	7.00	7	
610	15672	4/23/1996	8/25/1999	6.096	00400	PH (STANDARD UNITS)	6.1	7.4	7.01	11	
610	15672	1/25/1994	2/14/1996	9.09	00400	PH (STANDARD UNITS)	6.5	7.1	6.83	7	
610	15672	4/23/1996	8/25/1999	9.144	00400	PH (STANDARD UNITS)	6.1	7.3	6.94	11	
610	15672	1/25/1994	2/14/1996	12.12	00400	PH (STANDARD UNITS)	6.6	7.1	6.86	7	
610	15672	4/23/1996	8/25/1999	12.192	00400	PH (STANDARD UNITS)	6.2	7.2	6.87	11	
610	15672	1/25/1994	2/14/1996	15.15	00400	PH (STANDARD UNITS)	6.5	7.1	6.83	7	

Table 4A-38. Summary of pH Data for Segments 0610 and 0615

Segment ID	Station ID	Period Begin	Period End	Depth	Storet ID	Parameter	Min	Max	Avg	N	N < or > Criteria
610	15672	4/23/1996	8/25/1999	15.24	00400	PH (STANDARD UNITS)	6.1	7.2	6.77	11	
610	15672	1/25/1994	2/14/1996	18.18	00400	PH (STANDARD UNITS)	6.5	7.1	6.81	7	
610	15672	4/23/1996	8/25/1999	18.288	00400	PH (STANDARD UNITS)	6.1	7.2	6.76	11	
610	15672	8/24/1994	8/24/1994	19.7	00400	PH (STANDARD UNITS)	6.8	6.8	6.80	1	
610	15672	8/21/1996	8/21/1996	20.116	00400	PH (STANDARD UNITS)	6.8	6.8	6.80	1	
610	15672	1/25/1994	8/29/1995	21.21	00400	PH (STANDARD UNITS)	6.5	7.1	6.78	5	
610	15672	2/13/1997	8/25/1999	21.336	00400	PH (STANDARD UNITS)	6.1	7.1	6.68	8	
610	15672	4/23/1996	4/23/1996	21.945	00400	PH (STANDARD UNITS)	6.8	6.8	6.80	1	
610	15672	2/14/1996	2/14/1996	22.12	00400	PH (STANDARD UNITS)	6.9	6.9	6.90	1	
610	15672	9/2/1998	9/2/1998	22.555	00400	PH (STANDARD UNITS)	7	7	7.00	1	
610	15672	2/8/1995	8/29/1995	24.24	00400	PH (STANDARD UNITS)	6.6	7.1	6.87	3	
610	15672	2/13/1997	2/24/1999	24.384	00400	PH (STANDARD UNITS)	6.4	7	6.70	4	
610	15672	4/20/1994	4/20/1994	24.85	00400	PH (STANDARD UNITS)	6.8	6.8	6.80	1	
610	15672	8/21/1997	8/25/1999	24.993	00400	PH (STANDARD UNITS)	6.4	6.8	6.57	3	
610	15672	1/25/1994	1/25/1994	25.45	00400	PH (STANDARD UNITS)	6.8	6.8	6.80	1	
610	15672	4/17/1997	4/29/1998	25.908	00400	PH (STANDARD UNITS)	6.4	6.6	6.50	2	
610	15672	4/18/1995	4/18/1995	26.67	00400	PH (STANDARD UNITS)	6.6	6.6	6.60	1	
610	15672	2/8/1995	2/8/1995	27.42	00400	PH (STANDARD UNITS)	7	7	7.00	1	
610	15672	2/24/1999	2/24/1999	28.194	00400	PH (STANDARD UNITS)	6.7	6.7	6.70	1	
610	15673	1/25/1994	2/13/1996	0.3	00400	PH (STANDARD UNITS)	6.9	8.1	7.33	7	
610	15673	4/23/1996	8/25/1999	0.3048	00400	PH (STANDARD UNITS)	6.7	8.1	7.18	10	
610	15673	1/25/1994	2/13/1996	3.03	00400	PH (STANDARD UNITS)	6.7	7.4	7.10	7	
610	15673	4/23/1996	8/25/1999	3.048	00400	PH (STANDARD UNITS)	6.5	7.8	7.09	10	
610	15673	1/25/1994	2/13/1996	6.06	00400	PH (STANDARD UNITS)	6.6	7.1	6.93	7	
610	15673	4/23/1996	8/25/1999	6.096	00400	PH (STANDARD UNITS)	6.4	7.4	6.94	10	
610	15673	1/25/1994	2/13/1996	9.09	00400	PH (STANDARD UNITS)	6.4	7	6.80	7	
610	15673	4/23/1996	8/25/1999	9.144	00400	PH (STANDARD UNITS)	6.4	7.2	6.86	10	
610	15673	1/25/1994	2/13/1996	12.12	00400	PH (STANDARD UNITS)	6.6	7	6.83	7	
610	15673	8/21/1996	8/25/1999	12.192	00400	PH (STANDARD UNITS)	6.4	7	6.76	8	
610	15673	4/23/1996	9/2/1998	13.716	00400	PH (STANDARD UNITS)	6.9	7.1	7.00	3	
610	15673	2/13/1996	2/13/1996	14.24	00400	PH (STANDARD UNITS)	6.9	6.9	6.90	1	
610	15673	1/25/1994	4/18/1995	15.15	00400	PH (STANDARD UNITS)	6.6	7	6.87	3	
610	15673	4/18/1997	2/23/1999	15.24	00400	PH (STANDARD UNITS)	6.3	7	6.68	4	
610	15673	8/29/1995	8/29/1995	15.76	00400	PH (STANDARD UNITS)	6.7	6.7	6.70	1	

Table 4A-38. Summary of pH Data for Segments 0610 and 0615

Segment ID	Station ID	Period Begin	Period End	Depth	Storet ID	Parameter	Min	Max	Avg	N	N < or > Criteria
610	15673	4/29/1998	8/25/1999	15.849	00400	PH (STANDARD UNITS)	6.5	6.6	6.55	2	
610	15673	4/20/1994	8/24/1994	16.06	00400	PH (STANDARD UNITS)	6.7	6.9	6.80	2	
610	15673	4/18/1997	4/18/1997	17.678	00400	PH (STANDARD UNITS)	6.6	6.6	6.60	1	
610	15673	4/18/1995	4/18/1995	18.18	00400	PH (STANDARD UNITS)	6.5	6.5	6.50	1	
610	15673	2/19/1998	2/23/1999	19.202	00400	PH (STANDARD UNITS)	6.8	6.9	6.85	2	
610	15673	2/8/1995	2/8/1995	19.7	00400	PH (STANDARD UNITS)	7	7	7.00	1	
610	15674	1/25/1994	2/13/1996	0.3	00400	PH (STANDARD UNITS)	6.5	8	7.24	7	
610	15674	8/25/1999	4/20/1999	0.3048	00400	PH (STANDARD UNITS)	6.7	7.6	7.15	11	
610	15674	1/25/1994	2/13/1996	3.03	00400	PH (STANDARD UNITS)	6.4	7.4	7.00	7	
610	15674	4/23/1996	8/25/1999	3.048	00400	PH (STANDARD UNITS)	6.4	7.3	6.98	11	
610	15674	4/23/1996	4/23/1996	4.572	00400	PH (STANDARD UNITS)	7.2	7.2	7.20	1	
610	15674	9/2/1998	9/2/1998	5.1816	00400	PH (STANDARD UNITS)	7	7	7.00	1	
610	15674	8/21/1996	9/2/1998	5.4864	00400	PH (STANDARD UNITS)	6.6	6.8	6.70	2	
610	15674	1/25/1994	2/13/1996	6.06	00400	PH (STANDARD UNITS)	6.8	7.1	6.88	6	
610	15674	2/13/1997	8/25/1999	6.096	00400	PH (STANDARD UNITS)	6.6	7.1	6.89	8	
610	15674	4/20/1994	8/29/1995	7.58	00400	PH (STANDARD UNITS)	6.3	6.7	6.50	2	
610	15674	4/29/1998	4/29/1998	8.2296	00400	PH (STANDARD UNITS)	6.9	6.9	6.90	1	
610	15674	4/18/1995	4/18/1995	8.48	00400	PH (STANDARD UNITS)	6.5	6.5	6.50	1	
610	15674	2/13/1996	2/13/1996	8.79	00400	PH (STANDARD UNITS)	7	7	7.00	1	
610	15674	1/25/1994	8/24/1994	9.09	00400	PH (STANDARD UNITS)	6.9	7.1	7.00	2	
610	15674	2/13/1997	2/19/1998	9.144	00400	PH (STANDARD UNITS)	6.7	6.8	6.77	3	
610	15674	8/25/1999	8/25/1999	9.2964	00400	PH (STANDARD UNITS)	6.9	6.9	6.90	1	
610	15674	4/20/1999	4/20/1999	9.4488	00400	PH (STANDARD UNITS)	7.1	7.1	7.10	1	
610	15674	2/23/1999	2/23/1999	10.058	00400	PH (STANDARD UNITS)	6.8	6.8	6.80	1	
610	15674	4/18/1997	4/18/1997	10.363	00400	PH (STANDARD UNITS)	6.9	6.9	6.90	1	
610	15674	2/8/1995	2/8/1995	10.61	00400	PH (STANDARD UNITS)	6.8	6.8	6.80	1	
610	15674	2/13/1997	2/13/1997	11.277	00400	PH (STANDARD UNITS)	6.9	6.9	6.90	1	
610	15675	1/25/1994	2/13/1996	0.3	00400	PH (STANDARD UNITS)	6.8	8.3	7.31	7	
610	15675	4/23/1996	8/25/1999	0.3048	00400	PH (STANDARD UNITS)	6.7	8.2	7.23	11	
610	15675	1/25/1994	2/13/1996	3.03	00400	PH (STANDARD UNITS)	6.5	7.8	7.11	7	
610	15675	4/23/1996	8/25/1999	3.048	00400	PH (STANDARD UNITS)	6.4	7.9	7.11	11	
610	15675	1/25/1994	2/13/1996	6.06	00400	PH (STANDARD UNITS)	6.5	7	6.87	7	
610	15675	4/23/1996	8/25/1999	6.096	00400	PH (STANDARD UNITS)	6.2	7.3	6.85	11	
610	15675	2/13/1996	2/13/1996	7.58	00400	PH (STANDARD UNITS)	7.1	7.1	7.10	1	

Table 4A-38. Summary of pH Data for Segments 0610 and 0615

Segment ID	Station ID	Period Begin	Period End	Depth	Storet ID	Parameter	Min	Max	Avg	N	N < or > Criteria
610	15675	4/23/1996	4/23/1996	8.382	00400	PH (STANDARD UNITS)	6.9	6.9	6.90	1	
610	15675	8/24/1994	8/24/1994	8.79	00400	PH (STANDARD UNITS)	6.9	6.9	6.90	1	
610	15675	4/20/1994	8/29/1995	9.09	00400	PH (STANDARD UNITS)	6.5	6.8	6.67	3	
610	15675	8/21/1996	8/25/1999	9.144	00400	PH (STANDARD UNITS)	6.3	6.9	6.66	8	
610	15675	1/25/1994	1/25/1994	9.39	00400	PH (STANDARD UNITS)	7.1	7.1	7.10	1	
610	15675	2/8/1995	2/8/1995	10.3	00400	PH (STANDARD UNITS)	6.9	6.9	6.90	1	
610	15675	4/29/1998	4/29/1998	10.363	00400	PH (STANDARD UNITS)	6.9	6.9	6.90	1	
610	15675	4/18/1995	4/18/1995	10.91	00400	PH (STANDARD UNITS)	6.6	6.6	6.60	1	
610	15675	4/20/1994	4/20/1994	11.21	00400	PH (STANDARD UNITS)	6.8	6.8	6.80	1	
610	15675	8/29/1995	8/29/1995	11.82	00400	PH (STANDARD UNITS)	6.8	6.8	6.80	1	
610	15675	9/2/1998	9/2/1998	11.887	00400	PH (STANDARD UNITS)	7.1	7.1	7.10	1	
610	15675	4/18/1997	4/20/1999	12.192	00400	PH (STANDARD UNITS)	6.8	6.9	6.83	3	
610	15675	8/25/1999	8/25/1999	12.801	00400	PH (STANDARD UNITS)	6.6	6.6	6.60	1	
610	15675	8/21/1997	2/19/1998	13.411	00400	PH (STANDARD UNITS)	6.3	6.7	6.50	2	
610	15675	4/18/1997	4/18/1997	14.63	00400	PH (STANDARD UNITS)	6.9	6.9	6.90	1	
610	15675	4/20/1999	4/20/1999	15.24	00400	PH (STANDARD UNITS)	6.7	6.7	6.70	1	
610	15675	2/23/1999	2/23/1999	15.544	00400	PH (STANDARD UNITS)	6.8	6.8	6.80	1	
610	16784	6/1/1998	7/6/1999	0.3	00400	PH (STANDARD UNITS)	7.1	8.5	7.64	14	
610	16785	6/1/1998	7/6/1999	0.3	00400	PH (STANDARD UNITS)	6.7	7.9	7.21	19	
610	16786	6/1/1998	7/6/1999	0.3	00400	PH (STANDARD UNITS)	6.1	8	7.35	19	
610	16787	6/1/1998	7/6/1999	0.3	00400	PH (STANDARD UNITS)	7	8.2	7.52	19	
610	16788	5/6/1999	8/13/1999	0.3	00400	PH (STANDARD UNITS)	6.9	8.6	7.39	9	1
610	16789	5/6/1999	8/13/1999	0.3	00400	PH (STANDARD UNITS)	6.7	7.5	7.12	9	
610	16790	5/6/1999	8/13/1999	0.3	00400	PH (STANDARD UNITS)	7.3	7.9	7.54	9	
610	16791	6/1/1998	7/6/1999	0.3	00400	PH (STANDARD UNITS)	6.9	8.7	7.73	18	1
610	16792	5/6/1999	8/13/1999	0.3	00400	PH (STANDARD UNITS)	7.2	7.9	7.53	9	
610	16793	5/6/1999	8/13/1999	0.3	00400	PH (STANDARD UNITS)	7.2	8.7	7.96	10	1
615	10502	6/25/1991	11/12/2002	0.3	00400	PH (STANDARD UNITS)	6.2	8.6	7.39	33	1
615	10502	11/2/1995	10/30/2001	0.5	00400	PH (STANDARD UNITS)	7.3	7.8	7.55	6	
615	10502	6/8/1994	6/8/1994	0.7	00400	PH (STANDARD UNITS)	7.4	7.4	7.40	1	
615	10502	11/29/1994	11/12/2002	1	00400	PH (STANDARD UNITS)	6.1	8.4	7.33	17	1
615	10502	6/25/1991	6/25/1991	1.01	00400	PH (STANDARD UNITS)	6.8	6.8	6.80	1	
615	10502	2/6/1997	2/6/1997	1.3	00400	PH (STANDARD UNITS)	7.4	7.4	7.40	1	
615	10502	1/20/1999	5/22/2001	1.5	00400	PH (STANDARD UNITS)	7.6	7.7	7.65	2	

Table 4A-38. Summary of pH Data for Segments 0610 and 0615

Segment ID	Station ID	Period Begin	Period End	Depth	Storet ID	Parameter	Min	Max	Avg	N	N < or > Criteria
615	10502	2/22/1995	2/7/2002	2	00400	PH (STANDARD UNITS)	6.1	7.3	6.58	4	2
615	10502	2/7/2002	2/7/2002	2.5	00400	PH (STANDARD UNITS)	7.3	7.3	7.30	1	
615	10621	8/21/1990	11/12/2002	0.3	00400	PH (STANDARD UNITS)	6	8.2	7.09	51	3
615	10621	8/8/1996	8/8/1996	0.7	00400	PH (STANDARD UNITS)	7.4	7.4	7.40	1	
615	10621	2/27/1992	11/12/2002	1	00400	PH (STANDARD UNITS)	6.4	8.1	7.05	35	1
615	10621	8/21/1990	6/25/1991	1.01	00400	PH (STANDARD UNITS)	6.7	7.1	6.90	3	
615	10621	11/2/1995	7/9/2002	1.5	00400	PH (STANDARD UNITS)	6.7	7.5	7.05	4	
615	10621	7/15/1992	8/5/1993	1.52	00400	PH (STANDARD UNITS)	7.2	7.5	7.35	2	
615	10621	2/27/1992	11/12/2002	2	00400	PH (STANDARD UNITS)	6.4	8	6.99	28	1
615	10621	2/22/1991	6/25/1991	2.01	00400	PH (STANDARD UNITS)	6.7	6.8	6.75	2	
615	10621	6/8/1994	11/12/2002	2.5	00400	PH (STANDARD UNITS)	6.6	7.1	6.89	9	
615	10621	2/22/1991	6/25/1991	2.99	00400	PH (STANDARD UNITS)	6.6	6.8	6.70	2	
615	10621	2/27/1992	2/7/2002	3	00400	PH (STANDARD UNITS)	6.4	7.1	6.69	8	2
615	10621	2/7/2002	2/7/2002	3.5	00400	PH (STANDARD UNITS)	7	7	7.00	1	
615	10621	2/22/1995	3/13/2001	4	00400	PH (STANDARD UNITS)	6.4	6.6	6.48	4	2
615	10621	2/17/1998	2/17/1998	4.5	00400	PH (STANDARD UNITS)	6.6	6.6	6.60	1	
615	10623	6/25/1991	11/12/2002	0.3	00400	PH (STANDARD UNITS)	5.6	7.9	6.92	49	3
615	10623	10/27/1993	11/12/2002	1	00400	PH (STANDARD UNITS)	5.7	7.5	6.77	36	5
615	10623	6/25/1991	6/25/1991	1.01	00400	PH (STANDARD UNITS)	7	7	7.00	1	
615	10623	8/17/1994	8/17/1994	1.5	00400	PH (STANDARD UNITS)	6.9	6.9	6.90	1	
615	10623	7/15/1992	8/5/1993	1.52	00400	PH (STANDARD UNITS)	6.8	7.7	7.25	2	
615	10623	10/27/1993	11/12/2002	2	00400	PH (STANDARD UNITS)	5.8	7.4	6.73	34	6
615	10623	6/25/1991	6/25/1991	2.01	00400	PH (STANDARD UNITS)	6.9	6.9	6.90	1	
615	10623	1/25/1994	7/9/2002	2.5	00400	PH (STANDARD UNITS)	6.5	7.4	6.81	9	
615	10623	10/27/1993	10/27/1993	2.8	00400	PH (STANDARD UNITS)	7.1	7.1	7.10	1	
615	10623	6/25/1991	6/25/1991	2.99	00400	PH (STANDARD UNITS)	6.8	6.8	6.80	1	
615	10623	6/8/1994	11/12/2002	3	00400	PH (STANDARD UNITS)	6.2	6.9	6.55	15	4
615	10623	8/5/1993	8/5/1993	3.05	00400	PH (STANDARD UNITS)	7.5	7.5	7.50	1	
615	10623	1/20/1999	11/12/2002	3.5	00400	PH (STANDARD UNITS)	6.2	6.7	6.45	2	1
615	10623	2/22/1995	2/7/2002	4	00400	PH (STANDARD UNITS)	6.3	6.7	6.48	4	2

Table 4A-39. Summary of Conductivity Data for Segments 0610 and 0615

Segment ID	Station ID	Period Begin	Period End	Depth	Storet ID	Parameter	Min	Max	Avg	N	N > Criteria
610	10612	2/26/1991	8/14/2002	0.3	00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	91	191	134.52	52	NA
610	10613	8/20/1990	12/10/2002	0.3	00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	88	838	247.07	41	NA
610	10613	8/16/1994	8/16/1994	0.30488	00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	314	314	314.00	1	NA
610	10614	10/28/1996	12/10/2002	0.3	00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	86	185	112.05	22	NA
610	14906	12/10/1996	8/22/2002	0.3	00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	101	184	133.11	38	NA
610	14907	8/21/1996	12/10/2002	0.3	00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	85	185	139.04	25	NA
610	15357	11/7/1996	8/19/1997	0.3	00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	143	229	177.57	7	NA
610	15358	11/7/1996	8/19/1997	0.3	00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	95	197	132.57	7	NA
610	15359	11/7/1996	8/19/1997	0.3	00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	121	273	186.43	7	NA
610	15360	11/7/1996	8/19/1997	0.3	00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	92	149	115.29	7	NA
610	15361	11/7/1996	8/7/2002	0.3	00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	87	175	133.29	28	NA
610	15362	11/12/1996	8/21/1997	0.3	00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	80	176	143.43	7	NA
610	15363	11/12/1996	8/21/1997	0.3	00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	168	235	188.00	7	NA
610	15364	11/12/1996	8/9/1996	0.3	00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	45	149	101.67	9	NA
610	15365	11/12/1996	8/21/1997	0.3	00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	45	83	63.67	6	NA
610	15366	11/12/1996	8/21/1997	0.3	00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	121	165	134.43	7	NA
610	15522	3/13/2001	8/22/2002	0.3	00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	100	145	120.93	15	NA
610	15523	3/8/2001	8/14/2002	0.3	00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	94	121	110.47	15	NA
610	15524	3/8/2001	8/14/2002	0.3	00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	90	177	127.60	15	NA
610	15526	3/13/2001	8/22/2002	0.3	00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	98	145	122.33	15	NA
610	15527	3/13/2001	8/22/2002	0.3	00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	96	149	121.93	15	NA
610	16784	6/1/1998	7/6/1999	0.3	00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	77	131	98.78	9	NA
610	16785	6/1/1998	7/6/1999	0.3	00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	84	127	104.70	10	NA
610	16786	6/1/1998	7/6/1999	0.3	00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	68	131	102.00	10	NA
610	16787	6/1/1998	7/6/1999	0.3	00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	68	130	95.22	9	NA
610	16788	5/6/1999	8/13/1999	0.3	00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	142	205	174.22	9	NA
610	16789	5/6/1999	8/13/1999	0.3	00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	175	310	233.67	9	NA
610	16790	5/6/1999	8/13/1999	0.3	00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	75	133	104.11	9	NA
610	16791	6/1/1998	7/6/1999	0.3	00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	88	147	110.30	10	NA
610	16792	5/6/1999	8/13/1999	0.3	00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	105	150	129.56	9	NA
610	16793	5/6/1999	8/13/1999	0.3	00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	103	148	127.90	10	NA
615	10502	6/25/1991	11/12/2002	0.3	00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	96	3381	1872.79	33	NA
615	10621	8/21/1990	11/12/2002	0.3	00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	82	1844	599.20	51	NA
615	10623	6/25/1991	11/12/2002	0.3	00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	96	408	168.49	49	NA

Appendix 4B
Dissolved Oxygen Depth Profiles for Segments 0610 and 0615
(TRACS Data)

Dissolved oxygen at depth was assessed using a graphical approach to illustrate dissolved oxygen dynamics at several locations within the reservoir across depths and seasonal changes. Figure 4B-1 presents the locations of the locations where DO profiles were analyzed. These data were grouped into two primary seasonal categories, late spring, summer and fall, and winter and early spring. These groupings facilitate evaluation of what depth level the reservoir stratifies based on the time of year and the location within the reservoir. Figures 4B-2 through 4B-11 present the dissolved oxygen graphs. Note that the red line indicating the 3.0 mg/L minimum criterion only applies to the mixed layer, not the entire water column.

Figure 4B-2 illustrates dissolved oxygen stratification at site 14906 located near the Dam. This profile represents one of the deeper sections of the reservoir and illustrates the annual variability as well as seasonal variability in dissolved oxygen at depth. Temperature in the reservoir during the seasonal and monthly periods are likely a large factor in the observed profiles. The criterion applied to the reservoir to assess the potential for exceedances are within the estimated mixed surface layer, defined as the depth below surface where the temperature decreases by 0.5°C or more. The ranges of temperatures at site 14906 indicate that the mixed surface layer falls between <3 feet to 15 feet depending upon the time of year. Based on this estimated layer and a minimum dissolved oxygen criterion of 3.0 mg/L, no instantaneous dissolved oxygen concentrations at site 14906 exceed the criterion from 1996 to 2000. Despite this, there is a sharp decline in dissolved oxygen concentrations between about 15 and 30 feet below the surface and it is clear that during the hottest months (i.e., July, August, and September) thermal stratification as well as other factors result in a hypolimnetic dissolved oxygen deficit.

Figure 4B-3 shows dissolved oxygen concentrations at station 14906 during winter and early spring months. Turn over of the stratified layers has apparently occurred during the periods when most of these sample data were collected. 2000 data indicates preliminary stratification is beginning in March. For the most part, these data indicate that the reservoir is well mixed at this station during the winter and spring.

Due to potential spawning periods and presence of early life stages for aquatic organisms, particularly fish, dissolved oxygen criteria are higher during spring periods (defined as those periods when water temperatures are between 17.2 and 22.7°C). The minimum instantaneous dissolved oxygen for this period is 4.5 mg/L . No dissolved oxygen criterion exceedances occurred in the mixed surface layer for site 14906.

Figure 4B-4 and 4B-5 illustrate dissolved oxygen concentrations at depth for about six time periods, spanning from 1994 to 1999 at station 15675 located on the Ayish Bayou arm of the reservoir. Water temperature data corresponding to this site and the periods for which dissolved oxygen are illustrated were collected at large depth intervals. The mixed surface layer occurs somewhere between 1 and 9 feet below the surface. In this shallow arm of the reservoir as compared to the previous site, stratification appears to relatively consistently occur at or near about 10 feet below the water surface. No DO concentrations in the mixed surface layer during either the summer or winter profiles exceed criterion.

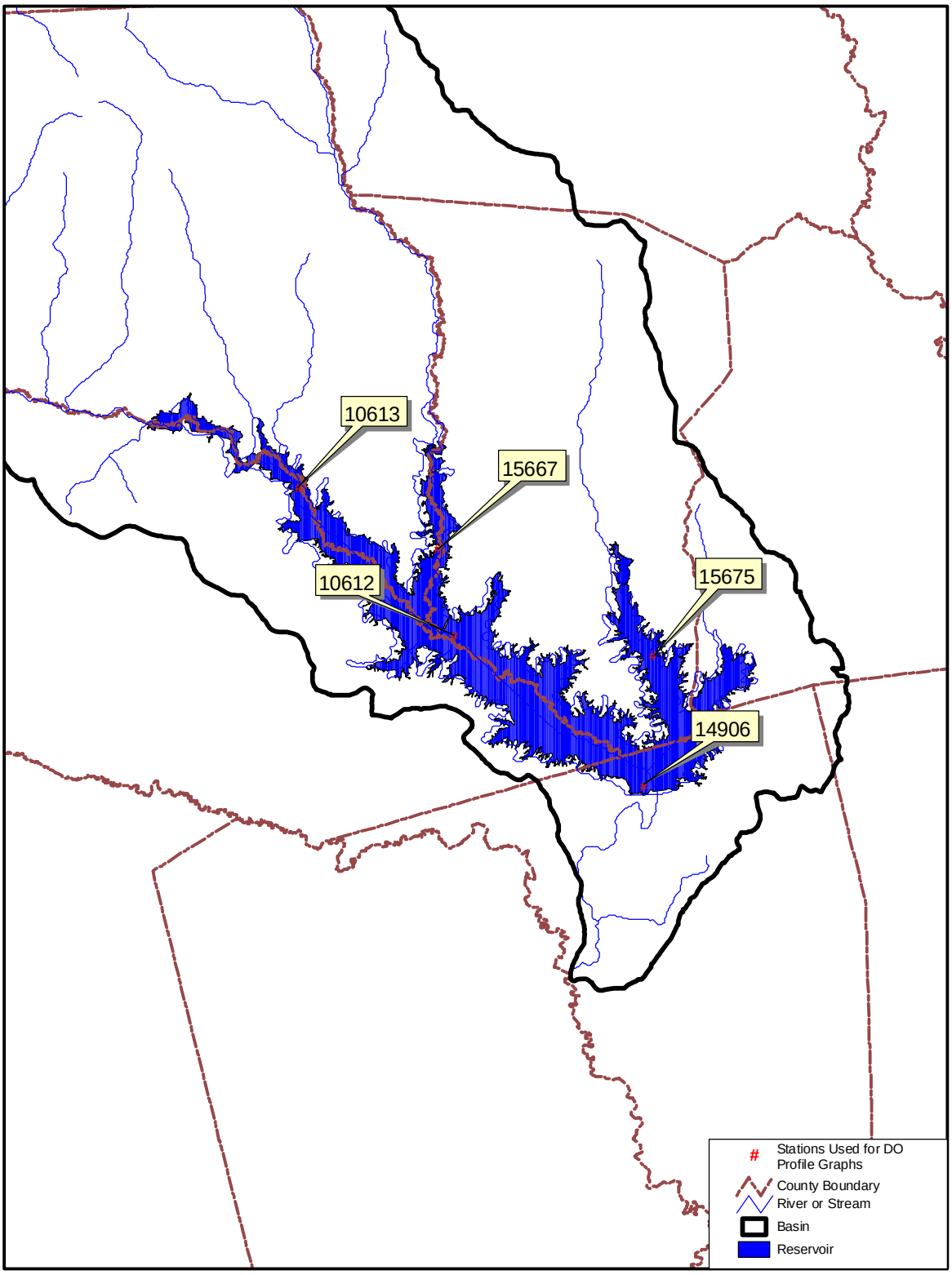

Figure 4B-1. Location of monitoring stations where DO depth profiles were analyzed

Figures 4B-6 and 4B-7 illustrate dissolved oxygen profiles at station 10612 located in the central portion of the Reservoir near the Hwy 147 crossing of the reservoir. This monitoring station, of the five evaluated, has the largest amount of dissolved oxygen data collected at depth. Data are available from 1991 to 2002. Reservoir depth at this station appears to be about 60 feet. Of the 15 profiles illustrated in Figure 4-6 during the summer months, all show a relatively consistent trend for surficial dissolved oxygen concentrations that range from about 6.5 to about 9.0 mg/L. Over the time span represented, the mixed surface layer, by definition, ranged from <3 feet to approximately 33 feet. Time periods included May through September, which may account for the widely varying temperatures in the upper 30 feet. Dissolved oxygen concentrations for all profiles did not exceed the minimum criterion for the respective mixed surface layers associated with the year and month in which the data were collected. Similar to station 14906, hypolimnetic oxygen deficits begin to appear depending upon the time period sampled below about 25 feet where the dissolved oxygen drops to from 1.0 to 0.0 mg/L.

Figure 4B-7 illustrates the winter and early spring dissolved oxygen profiles for station 10612, ranging over the same time period. The reservoir at this site during these cooler months is well mixed with dissolved oxygen ranging from about 7.5 to 11.5 mg/L near the surface. During most months, these concentrations are relatively static from surface to bottom.

Figures 4B-8 and 4B-9 show dissolved oxygen profiles at station 15667 in the Attoyac Bayou arm of the reservoir which is approximately 60 feet in depth. This much smaller data set ranges from 1994 to 1999 with a single profile each year. During the summer months, surficial dissolved oxygen ranged from 4.9 to 7.2 mg/L, although most of the surficial dissolved oxygen data were 6.5 mg/L or greater. Similar to measurement data for Ayish Bayou, temperature at depth was collected at a large depth interval, thus one can only estimate that the mixed surface layer lies between 1 and about 9 feet. It appears, however, that within the upper ten feet, dissolved oxygen concentrations are relatively similar to their respective surface concentrations. Unlike other sites, dissolved oxygen below about 20 feet ranged from < 1 mg/L to >6 mg/L. A local weather event in August of 1994 resulted in a profile that was more reminiscent of a winter profile rather than a summer profile.

Similar to other winter profiles discussed, station 15667 exhibits similarly mixed conditions during the winter months (Figure 4B-9). Surficial dissolved oxygen concentrations ranged from about 7 to 11 mg/L. Data from spring profiles indicate the beginning of stratification at this site as dissolved oxygen declined from the surface at about 7.0 mg/L to 4.0 or less near the bottom of the reservoir.

Figures 4B-10 and 4B-11 illustrate dissolved oxygen profiles for station 10613 near Hwy 103 in the upper Angelina Arm of the Reservoir. This station is very near the separation point between segments 0610 and 0615. Data for these profiles ranged in time from 1990 to 2002. Of the sites evaluated for vertical dissolved oxygen trends, this is the shallowest site with water depths of about 33 to 35 feet. Unlike other sites assessed, dissolved oxygen concentrations at the surface for this site are highly variable, ranging from 3.7 to 8.5 mg/L. The mixed surface layer at this site is shallower when compared to other sites, typically ranging from about 6 feet or less. On a few occasions, the mixed surface layer increased to about 9 to 18 feet. Even with the low concentration of 3.7 mg/L recorded in 1998, no dissolved oxygen concentration exceeded the minimum criterion within the mixed surface layer. However, during this period in August of

1998, dissolved oxygen concentrations were critically low, ranging at the surface from 3.7 to 2.8 mg/L just 9 feet below the surface. Similar to the surficial data, dissolved oxygen at depth was also highly variable, ranging from < 1 mg/L to >5 mg/L depending upon the time of year. Observations of higher variability in dissolved oxygen across all strata at this site may be due to among other factors, riverine influences, point source discharges, and/or shallower depth.

Mixing due to discharges from tributaries or prevailing winds may cause a mixing effect due to shallower depths that cause this section of the reservoir not to stratify as intensely as the deeper water sections. Discharges from point sources may affect nutrients, which in turn affect macrophytic and algal production. Numerous factors may account for why this station appears to be so different from the other stations during the summer months. Figure 4B-11 shows station 10613 during winter months, which illustrates strong similarities to other sites, with well mixed profiles, and higher levels of dissolved oxygen. Surficial dissolved oxygen concentrations ranged from about 6 mg/L to 11 mg/L, with no exceedances of the criterion observed during the winter months.

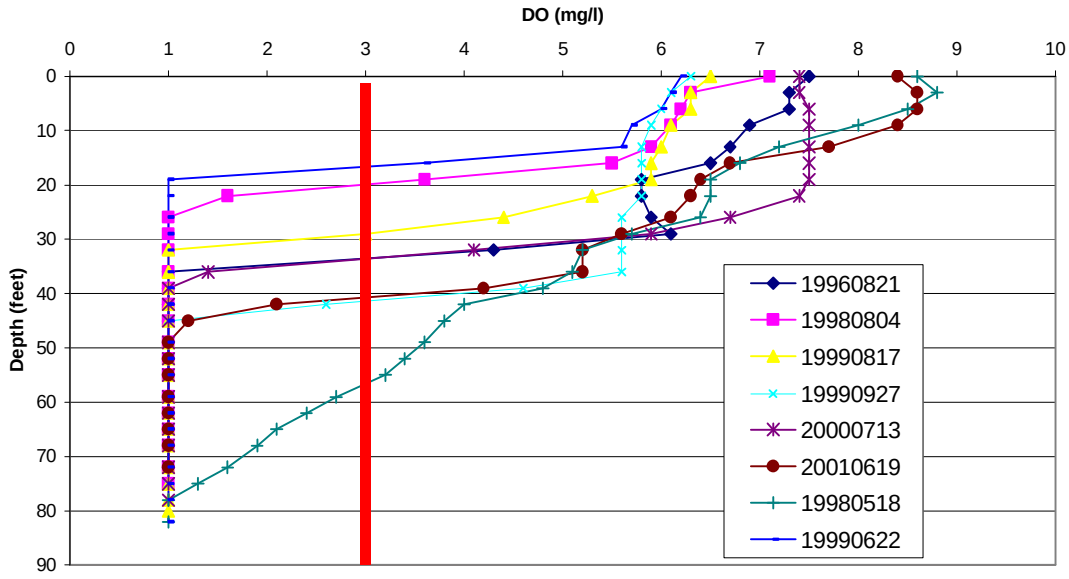

Figure 4B-2. Late spring, summer, and fall DO at site 14906 in Sam Rayburn Reservoir

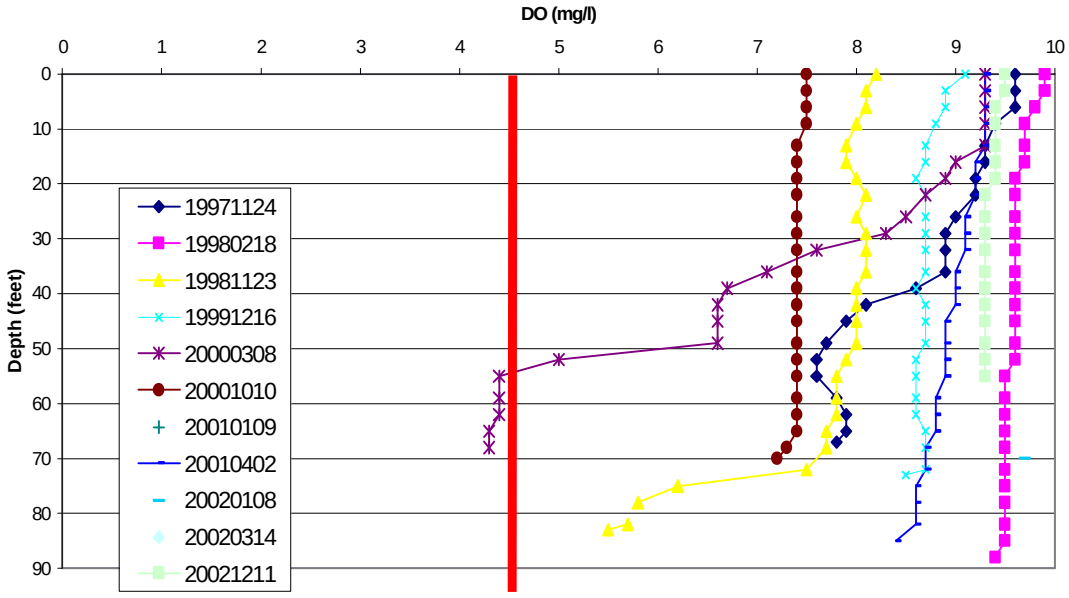

Figure 4B-3. Winter and early fall DO at site 14906 in Sam Rayburn Reservoir

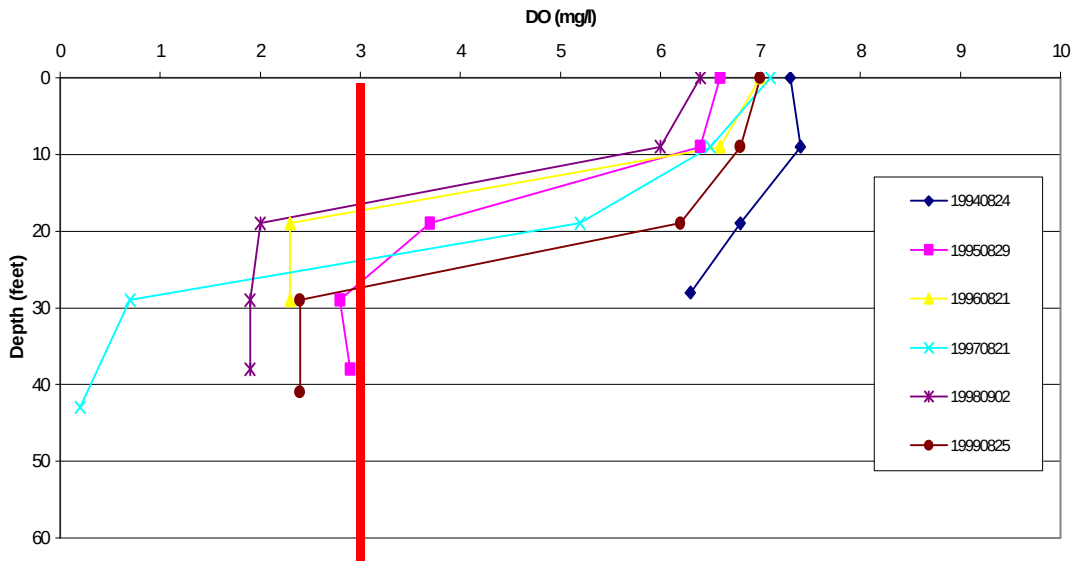

Figure 4B-4. Late spring, summer, and fall DO at site 15675 in Sam Rayburn Reservoir

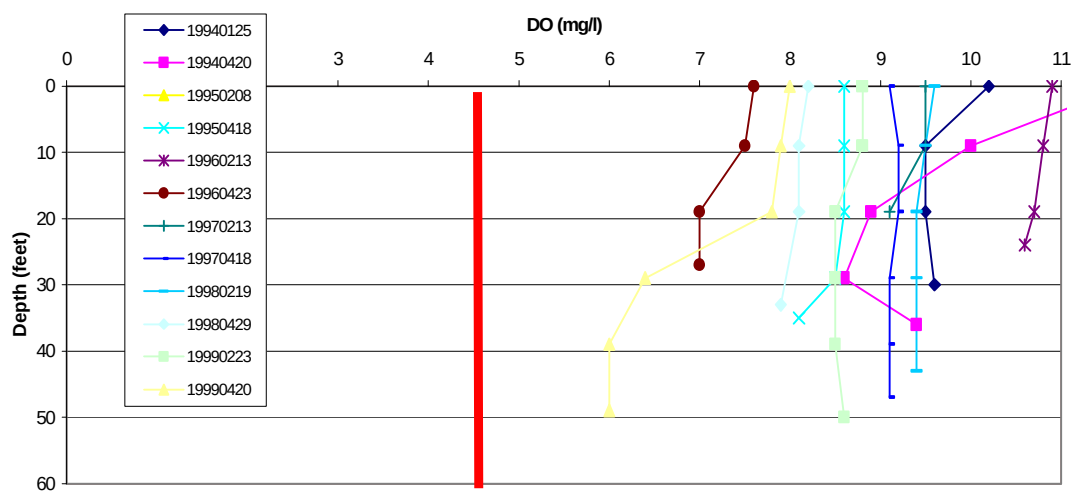

Figure 4B-5. Winter and early spring DO at site 15675 in Sam Rayburn Reservoir

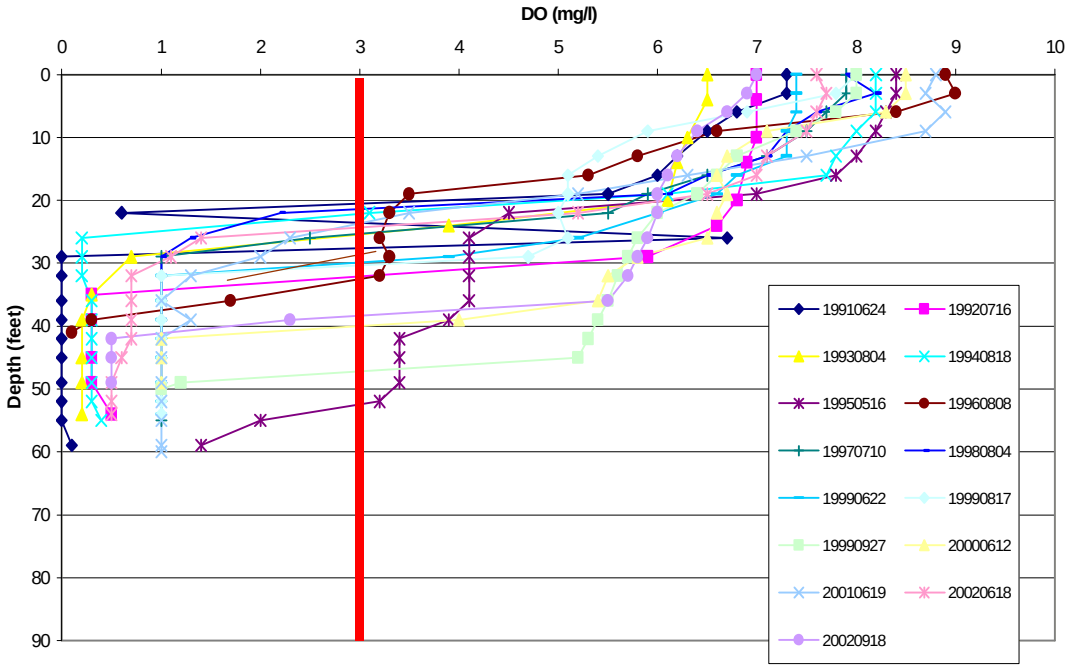

Figure 4B-6. Late spring, summer, and fall DO at site 10612 in Sam Rayburn Reservoir

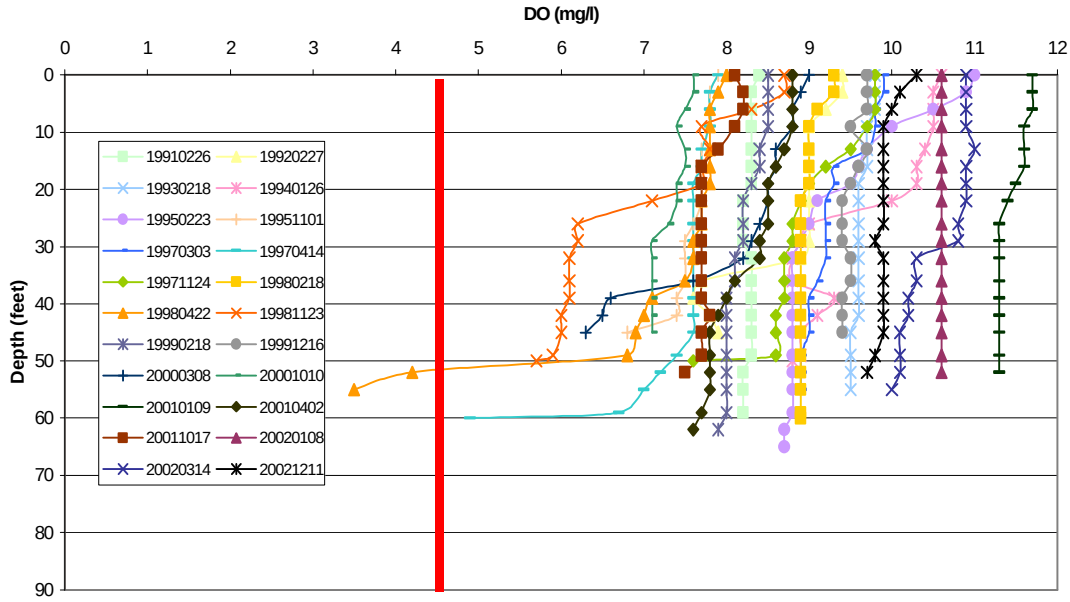

Figure 4B-7. Winter and spring DO at site 10612 in Sam Rayburn Reservoir

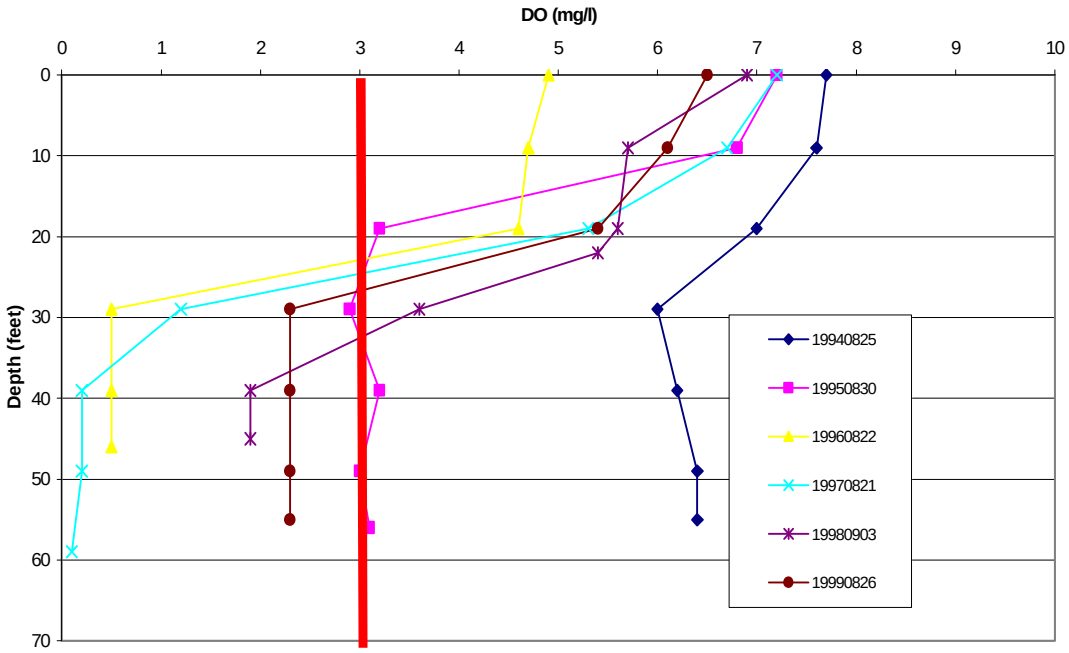

Figure 4B-8. Late spring, summer, and fall DO at site 15667 in Sam Rayburn Reservoir

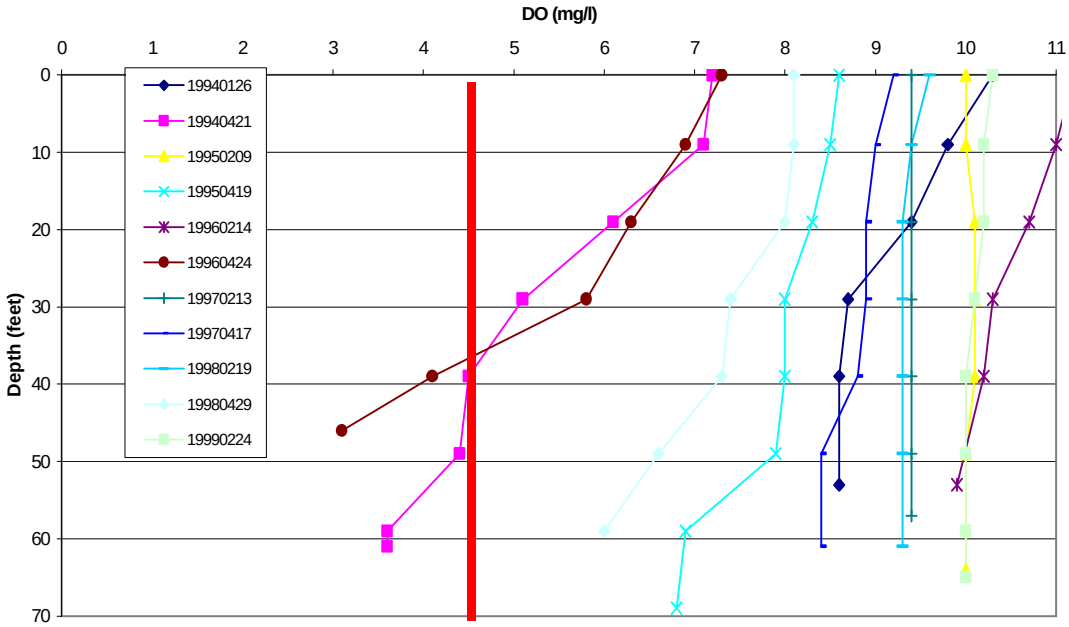

Figure 4B-9. Winter and early spring DO at site 15667 in Sam Rayburn Reservoir

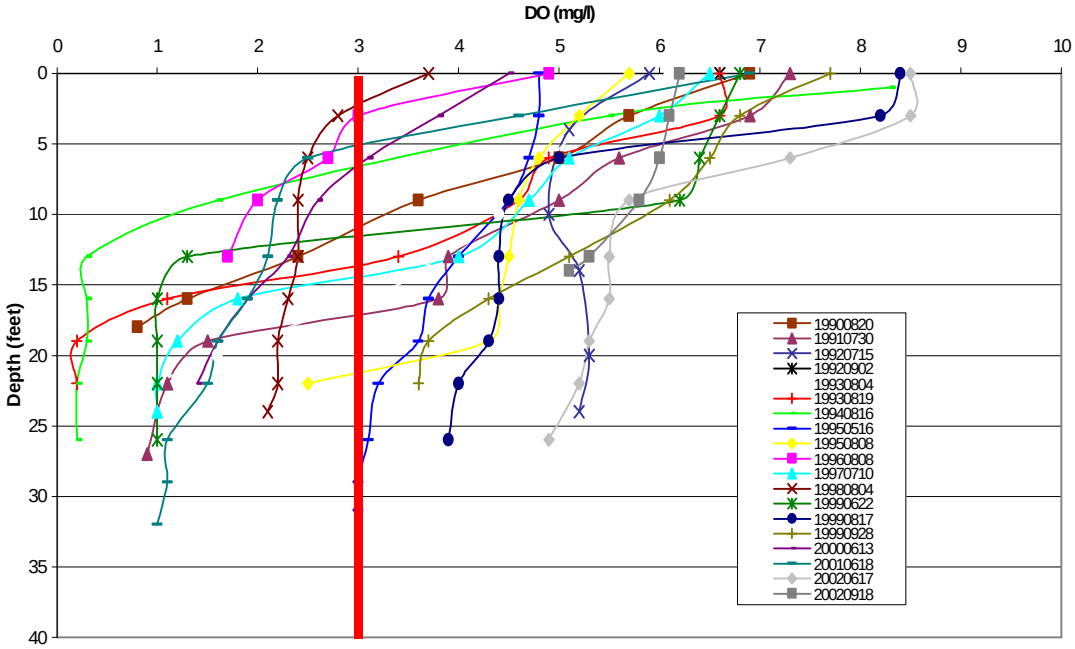

Figure 4B-10. Late spring, summer, and fall DO at site 10613 in Sam Rayburn Reservoir

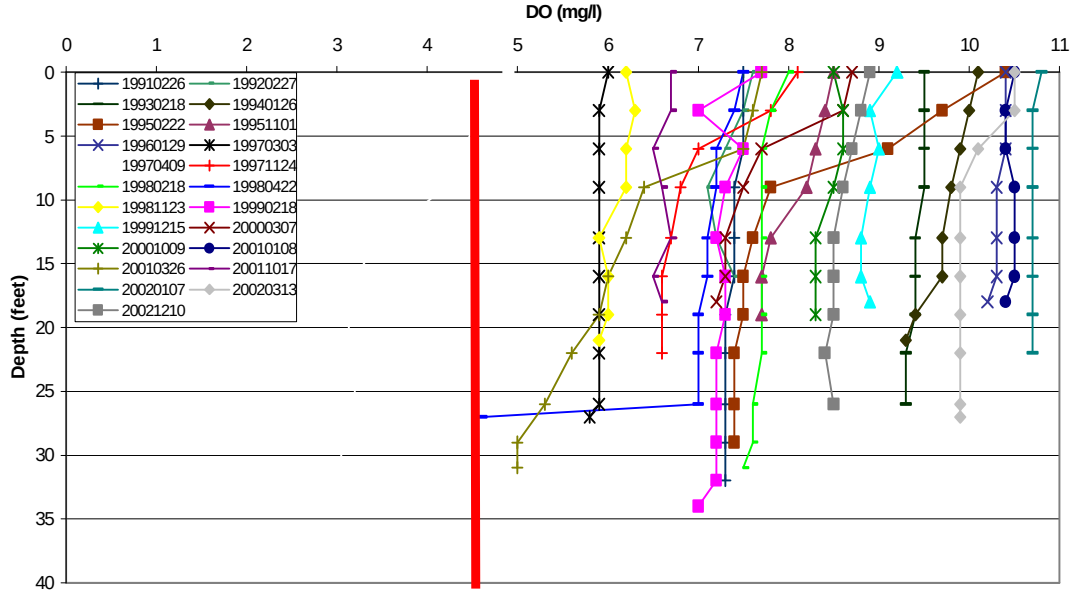

Figure 4B-11. Winter and early spring DO at site 10613 in Sam Rayburn Reservoir

Appendix 4C
Summary of STORET Water Quality Monitoring Data for Sam Rayburn Reservoir

Table 4C-1. Summary of Dissolved Oxygen Data for Segment 0610

Station ID	Start Date	End Date	Dissolved Oxygen (mg/L)				
			Number of Observations	Minimum	Maximum	Average	Number of Exceedances[a]
14907	8/21/96	8/21/96	2	1.0	2.5	1.8	0
14906	8/21/96	12/10/98	13	1.0	7.5	3.6	1
310437094065501	1/25/94	2/13/97	81	0.5	12.6	8.6	0
310802094112201	1/26/94	2/13/97	75	0.5	11.0	7.8	0
310816094041401	1/25/94	2/13/97	56	0.5	11.6	8.1	0
311000094010301	1/25/94	2/13/97	36	2.8	11.9	8.3	0
311039094141201	1/26/94	2/13/97	64	0.6	11.0	7.8	0
311137094051401	1/25/94	2/13/97	39	2.3	11.7	8.3	0
311804094234901	1/26/94	2/13/97	43	3.1	10.3	7.4	0
311817094190701	1/26/94	2/13/97	38	3.0	10.8	7.6	0
311828094191801	1/26/94	2/13/97	63	0.5	11.2	7.3	0
312216094280601	1/26/94	2/14/97	30	4.1	10.3	7.4	0
06100100	2/26/91	7/16/92	65	0.0	9.4	6.0	0
06100200	8/20/90	7/15/92	40	0.8	7.6	5.5	0

[a]Observations compared to the water quality criterion of 3.0 mg/L for segment 0610 (Source: Texas Administrative Code 307.10(1))

Table 4C-2. Summary of Surface Chlorophyll a Data for Segment 0610

Station ID	Start Date	End Date	Chlorophyll a (µg/L)				Number of Exceedances[a]	
			Number of Observations	Minimum	Maximum	Average	Reference Conditions	Screening Level
14907	8/21/96	8/21/96	1	29.3	29.3	29.3	1	1
14906	8/21/96	8/21/96	1	4.0	4.0	4.0	1	0
06100100	6/24/91	7/16/92	3	2.3	11.3	6.8	2	0
06100200	8/20/90	7/15/92	4	1.0	20.8	12.8	3	0

[a]Compared to 21.4µg/L screening level (Source: TNRCC 2002) and 2.834 µg/L reference condition (Source: USEPA 2000).

Table 4C-3. Summary of Secchi Depth Data for Segment 0610

Station ID	Start Date	End Date	Secchi Depth (m)				
			Number of Observations	Minimum	Maximum	Average	Number of Exceedances[a]
14907	8/21/96	8/21/96	1	0.33	0.33	0.33	1
310437094065501	1/25/1994	2/13/1997	10	1.30	2.70	2.01	0
310802094112201	8/25/1994	2/13/1997	6	1.20	2.70	1.83	0
310816094041401	1/25/1994	2/13/1997	8	1.40	2.70	1.89	0
311000094010301	1/25/1994	2/13/1997	9	0.90	2.40	1.69	1
311039094141201	8/25/1994	2/13/1997	7	1.50	2.48	1.97	0
311137094051401	1/25/1994	2/13/1997	10	1.00	2.35	1.66	1
311804094234901	8/25/1994	2/13/1997	7	0.50	1.20	0.88	5
311817094190701	1/26/1994	2/13/1997	10	0.55	1.45	0.96	8
311828094191801	1/26/1994	2/13/1997	10	0.70	1.90	1.43	2
312216094280601	1/26/1994	2/14/1997	9	0.20	1.80	0.77	8
06100100	2/26/1991	7/16/1992	4	0.63	1.80	1.04	3
06100200	2/26/1991	7/15/1992	4	0.35	0.89	0.66	4

[a] Compared to EPA's Reference Condition of 1.1 meters (Source: EPA, 2000)

Table 4C-4. Summary of Surface Total Phosphorus Data for Segment 0610

Station ID	Start Date	End Date	Total Phosphorus (mg/L)				Number of Exceedances[a]	
			Number of Observations	Minimum	Maximum	Average	Reference Conditions	Screening Level
14907	8/21/96	8/21/96	1	0.08	0.08	0.08	1	0
14906	8/21/96	8/21/96	1	0.01	0.01	0.01	0	0
06100100	2/26/91	7/16/92	4	0.04	0.18	0.10	4	0
06100200	8/20/90	7/15/92	5	0.06	0.11	0.08	5	0

[a]Compared to 0.18-mg/L screening level (Source: TNRCC 2002) and 0.0325-mg/L reference condition (Source: USEPA 2000).

Table 4C-5. Summary of Surface Total Orthophosphorus Data for Segment 0610

Station ID	Start Date	End Date	Total Orthophosphorus (mg/L)				
			Number of Observations	Minimum	Maximum	Average	Number of Exceedances[a]
14907	8/21/96	8/21/96	1	0.10	0.10	0.10	1
14906	12/10/96	12/10/96	1	0.10	0.10	0.10	1

[a]Compared to 0.05-mg/L screening level (Source: TNRCC 2002).

Table 4C-6. Summary of Surface Total Nitrogen Data for Segment 0610

Station ID	Start Date	End Date	Total Nitrogen (mg/L)				
			Number of Observations	Minimum	Maximum	Average	Number of Exceedances[a]
06100100	2/26/91	6/24/91	2	0.47	0.58	0.53	1
06100200	8/20/90	2/26/91	2	0.79	0.82	0.81	2

[a]Compared to 0.492-mg/L reference condition (Source: USEPA 2000).

Table 4C-7. Summary of Surface NO_2+NO_3 Data for Segment 0610

Station ID	Start Date	End Date	NO_2+NO_3 (mg/L)				Number of Exceedances[a]	
			Number of Observations	Minimum	Maximum	Average	Reference Conditions	Screening Level
06100100	2/26/91	7/16/92	3	0.02	0.13	0.07	2	0
06100200	8/20/90	7/15/92	5	0.02	0.14	0.06	2	0

[a]Compared to 0.32-mg/L screening level (Source: TNRCC 2002) and 0.033-mg/L reference conditions (Source: USEPA 2000).

Table 4C-8. Summary of Surface TKN Data for Segment 0610

Station ID	Start Date	End Date	TKN (mg/L)				
			Number of Observations	Minimum	Maximum	Average	Number of Exceedances[a]
14907	8/21/96	8/21/96	1	0.71	0.71	0.71	1
14906	8/21/96	8/21/96	1	0.47	0.47	0.47	1
06100100	2/26/91	6/24/91	2	0.45	0.45	0.45	0
06100200	8/20/90	2/26/91	2	0.62	0.80	0.73	2

[a]Compared to 0.459-mg/L screening level (Source: USEPA 2000).

Table 4C-9. Summary of Ammonia Data for Segment 0610

Station ID	Start Date	End Date	Unionized Ammonia (mg/L)				
			Number of Observations	Minimum	Maximum	Average	Number of Exceedances[a]
14907	8/21/96	8/21/96	1	0.01	0.01	0.01	0
14906	8/21/96	8/21/96	1	0.01	0.01	0.01	0
06100100	2/26/91	7/16/92	6	0.01	0.55	0.19	0
06100200	8/20/90	7/15/92	9	0.02	0.56	0.18	0

[a]Compared to 0.106 mg/L screening level (Source: TNRCC, 2002).

Table 4C-10. Summary of Total Organic Carbon Data for Segment 0610

Station ID	Start Date	End Date	TOC (mg/L)			
			Number of Observations	Minimum	Maximum	Average
14907	8/21/96	8/21/96	1	8.0	8.0	8.0
14906	8/21/96	8/21/96	1	6.0	6.0	6.0
06100100	2/26/91	7/16/92	6	5.0	11.0	8.0
06100200	8/20/90	7/15/92	9	6.0	12.0	9.8

Table 4C-11. Summary of Metals Data for Segment 0610

Metals (µg/L)	Station ID	Start Date	End Date	Number of Observations	Minimum	Maximum	Average	Number of Exceedances[a]
Dissolved arsenic (As)	06100200	7/30/91	7/30/91	1	10	10	10	0
Dissolved copper (Cu)	06100200	7/30/91	7/30/91	1	4	4	4	0
Dissolved lead (Pb)	06100200	7/30/91	7/30/91	1	3	3	3	0
Total selenium (Se)	06100200	8/20/90	8/20/90	1	2	2	2	0
Dissolved zinc (Zn)	06100200	7/30/91	7/30/91	1	40	40	40	0

[a]Observations compared to applicable water quality criterion for metals for segment 0610 (Source: Texas Administrative Code 307.6(c) and 307.6(c)(8)).

Table 4C-12. Summary of Fecal Coliform Bacteria Data for Segment 0610

Station ID	Start Date	End Date	Fecal Coliform Bacteria (counts/100 mL)				
			Number of Observations	Minimum	Maximum	Average	Number of Exceedances[a]
14907	8/21/96	8/21/96	1	9	9.0	9.0	0
14906	12/10/96	12/10/96	1	3	3.0	3.0	0
310437094065501	1/25/94	2/13/97	10	0	10.0	2.0	0
311828094191801	1/26/94	2/13/97	10	0	220.0	23.0	0
312216094280601	1/26/94	2/14/97	9	1	200.0	36.3	0
06100100	2/26/91	2/27/92	3	1	6.0	3.3	0
06100200	8/20/90	2/27/92	3	3	113.0	72.0	0

[a]Observations compared to the water quality criterion of 200 counts/100mL for segment 0610 (Source: Texas Administrative Code 307.10(1)).

Table 4C-13. Summary of Total Alkalinity Data for Segment 0610

Station ID	Start Date	End Date	Total Alkalinity as CACO3 (mg/L)			
			Number of Observations	Minimum	Maximum	Average
14907	8/21/96	8/21/96	1	34	34	34
14906	8/21/96	8/21/96	1	19	19	19
310437094065501	1/25/94	8/29/95	12	13	39	21
311828094191801	1/26/94	8/30/95	12	16	47	23
312216094280601	8/25/94	2/14/97	12	16	48	29
06100100	2/26/91	7/16/92	6	8	21	13
06100200	8/20/90	7/15/92	9	12	59	24

Table 4C-14. Summary of Surface Chloride Data for Segment 0610

Station ID	Start Date	End Date	Chloride (mg/L)				
			Number of Observations	Minimum	Maximum	Average	Number of Exceedances[a]
14907	8/21/96	8/21/96	1	10.0	10.0	10.0	0
14906	8/21/96	8/21/96	1	18.0	18.0	18.0	0
310437094065501	1/25/94	2/13/97	9	12.0	21.0	15.1	0
311828094191801	1/26/94	2/13/97	10	12.0	30.0	18.7	0
312216094280601	1/26/94	2/14/97	9	10.0	69.0	35.9	0
06100100	2/26/91	7/16/92	4	4.0	13.0	9.5	0
06100200	8/20/90	7/15/92	5	8.0	36.0	23.4	0

[a]Observations compared to the water quality criterion of 100 mg/L for segment 0610 (Source: Texas Administrative Code 307.10(1)).

Table 4C-15. Summary of Surface Sulfate Data for Segment 0610

Station ID	Start Date	End Date	Sulfate (mg/L)				
			Number of Observations	Minimum	Maximum	Average	Number of Exceedances[a]
14907	8/21/96	8/21/96	1	12	12	12	0
14906	8/21/96	8/21/96	1	20	20	20	0
310437094065501	1/25/94	2/13/97	9	14	21	17	0
311828094191801	1/26/94	2/13/97	10	14	31	20	0
312216094280601	1/26/94	2/14/97	9	12	50	29	0
06100100	2/26/91	7/16/92	4	21	28	24	0
06100200	8/20/90	7/15/92	4	19	28	24	0

[a]Observations compared to the water quality criterion of 100 mg/L for segment 0610 (Source: Texas Administrative Code 307.10(1)).

Table 4C-16. Summary of TSS and TDS Data for Segment 0610

Station ID	Start Date	End Date	TSS (mg/L)			
			Number of Observations	Minimum	Maximum	Average
14907	8/21/96	8/21/96	1	25.0	25.0	25.0
14906	8/21/96	8/21/96	1	3.0	3.0	3.0
06100100	2/26/91	7/16/92	6	2.0	7.0	3.3
06100200	8/20/90	7/15/92	9	4.0	19.0	7.4

Station ID	Start Date	End Date	TDS (mg/L)				
			Number of Observations	Minimum	Maximum	Average	Number of Exceedances[a]
14907	8/21/96	8/21/96	1	144.0	144.0	144.0	0
14906	8/21/96	8/21/96	1	118.0	118.0	118.0	0

[a]Observations compared to the water quality criterion of 400 mg/L for segment 0610 (Source: Texas Administrative Code 307.10(1))

Table 4C-17. Summary of Surface Water Temperature Data for Segment 0610

Station ID	Start Date	End Date	Water Temperature (°F)				
			Number of Observations	Minimum	Maximum	Average	Number of Exceedances[a]
14907	8/21/96	8/21/96	1	87.1	87.1	87.1	0
14906	8/21/96	12/10/96	2	84.9	84.9	84.9	0
310437094065501	1/25/94	2/13/97	10	50.0	89.6	67.5	0
310802094112201	1/26/94	2/13/97	9	50.0	88.7	67.1	0
310816094041401	1/25/94	2/13/97	10	50.0	88.7	68.5	0
311000094010301	1/25/94	2/13/97	10	50.9	93.2	70.0	1
311039094141201	1/26/94	2/13/97	9	50.0	87.8	67.0	0
311137094051401	1/25/94	2/13/97	10	50.0	91.4	69.6	0
311804094234901	1/26/94	2/13/97	9	50.0	88.7	68.0	0
311817094190701	1/26/94	2/13/97	10	49.1	88.7	68.7	0
311828094191801	1/26/94	2/13/97	10	50.0	88.7	67.7	0
312216094280601	1/26/94	2/14/97	9	48.2	88.7	66.3	0
06100100	2/26/91	7/16/92	4	53.4	87.8	70.8	0
06100200	8/20/90	7/15/92	5	55.6	89.2	75.6	0

[a] Observations compared to the water quality criterion of 93 °F for segment 0610 (Source: Texas Administrative Code 307.10(1)).

Table 4C-18. Summary of the pH data for segment 0610

Station ID	Start Date	End Date	pH				
			Number of Observations	Minimum	Maximum	Average	Number of Exceedances[a]
14907	8/21/96	8/21/96	2	6.7	7.3	7.0	0
14906	8/21/96	12/10/96	12	6.6	7.7	7.0	0
310437094065501	1/25/94	2/13/97	81	6.5	8.2	7.0	0
310802094112201	1/26/94	2/13/97	75	6.4	8.1	7.0	0
310816094041401	1/25/94	2/13/97	56	6.4	8.1	7.0	0
311000094010301	1/25/94	2/13/97	36	6.3	8.0	7.0	0
311039094141201	1/26/94	2/13/97	64	6.5	8.2	7.0	0
311137094051401	1/25/94	2/13/97	39	6.5	8.3	7.0	0
311804094234901	1/26/94	2/13/97	43	6.4	8.7	7.0	1
311817094190701	1/26/94	2/13/97	38	6.4	8.5	6.9	0
311828094191801	1/26/94	2/13/97	63	6.4	8.6	7.0	1
312216094280601	1/26/94	2/14/97	30	6.4	8.5	6.9	0
06100100	2/26/91	7/16/92	65	6.4	7.5	6.8	0
06100200	8/20/90	7/15/92	40	6.5	7.6	7.1	0

[a]Observations compared to the water quality criterion of pH 6–8.5 for segment 0610 (Source: Texas Administrative Code 307.10(1)).

Table 4C-19. Summary of Conductivity Data for Segment 0610

Station ID	Start Date	End Date	Conductivity (µmos)			
			Number of Observations	Minimum	Maximum	Average
14907	8/21/1996	8/21/1996	2	130	131	131
14906	8/21/1996	12/10/1997	13	151	168	157
310437094065501	1/25/1994	2/13/1997	81	100	165	136
310802094112201	1/26/1994	2/13/1997	75	115	180	141
310816094041401	1/25/1994	2/13/1997	56	100	210	133
311000094010301	1/25/1994	2/13/1997	36	95	155	128
311039094141201	1/26/1994	2/13/1997	64	120	180	144
311137094051401	1/25/1994	2/13/1997	39	100	155	125
311804094234901	1/26/1994	2/13/1997	43	100	325	189
311817094190701	1/26/1994	2/13/1997	38	85	190	130
311828094191801	1/26/1994	2/13/1997	63	115	280	161
312216094280601	1/26/1994	2/14/1997	30	100	435	234
06100100	2/26/1991	7/16/1992	65	103	159	122
06100200	8/20/1990	7/15/1992	40	131	305	184

APPENDIX 4D
Dissolved Oxygen Depth Profiles for Segment 0610
(STORET Data)

Appendix 4D presents water temperature and dissolved oxygen profile data for five water quality monitoring stations in the Sam Rayburn Reservoir. These five stations were chosen to represent the dissolved oxygen concentrations in various parts of the reservoir (upper, middle, lower, Attoyac Bayou arm, and Ayish Bayou arm). The five stations are presented in figure 4D-1.

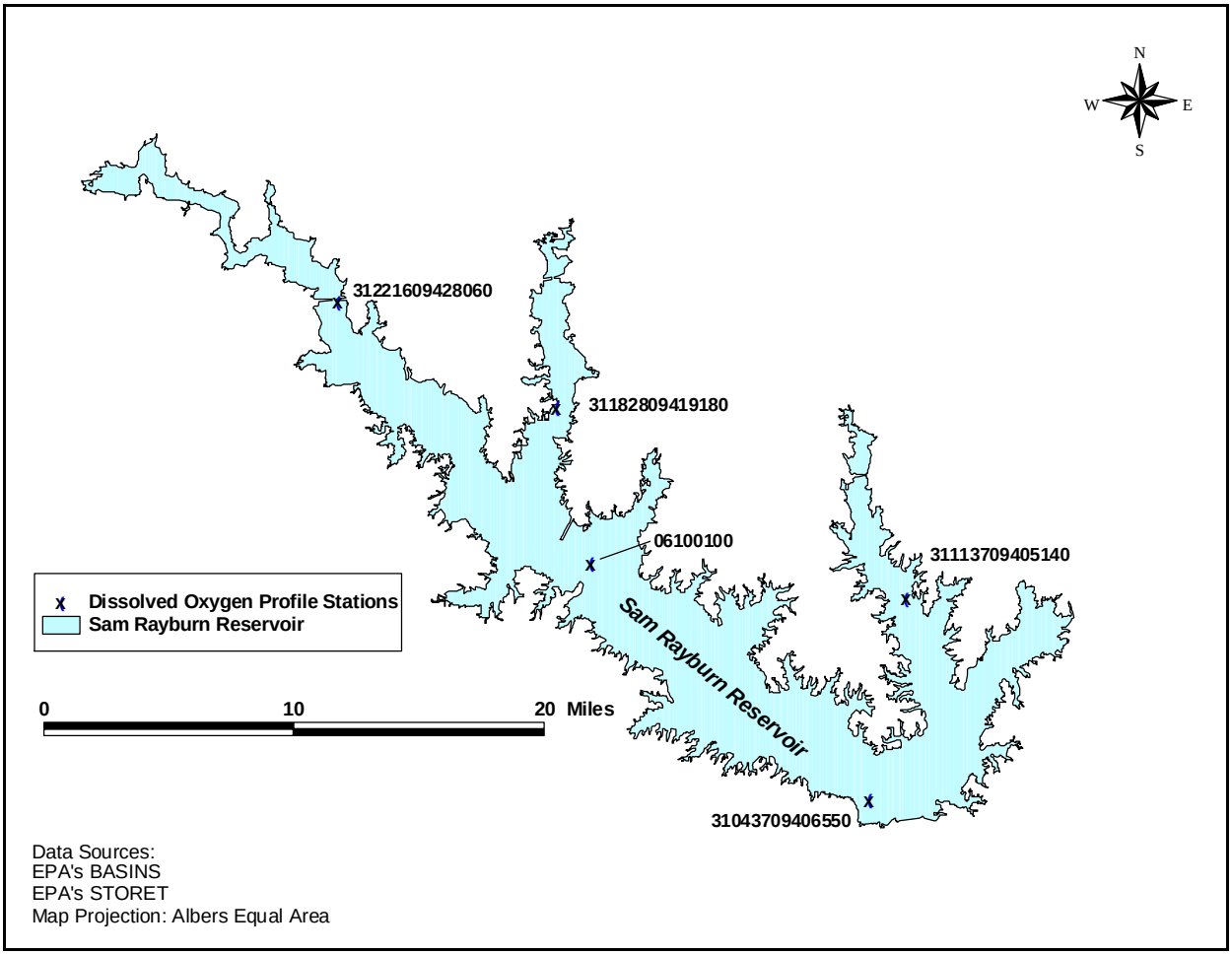

Figure 4D-1. Location of the five representative dissolved oxygen monitoring stations

Water temperature profile data were included for each station to show where the mixed layer was for each sample date. Texas water quality criteria for dissolved oxygen require that grab samples in the mixed layer meet the 3.0 mg/L dissolved oxygen criterion (see section 1.3). The mixed layer is defined as the portion of the water column from the surface to the depth at which water temperature decreases by greater than 0.5°C (TNRCC 2002). Table 4D-1 presents the mixed layer depth at each of the stations presented in this appendix on dates with dissolved oxygen observations less than 3.0 mg/L.

Table 4D-1. Mixed Layer Depth at Stations with Dissolved Oxygen Observations below 3.0 mg/L

Station ID	Date of Dissolved Oxygen Observations Below 3.0 mg/L	Depth of Mixed Layer
312216094280601	None	N/A
311828094191801	8/30/95	10 feet
	8/22/96	30 feet
06100100	6/24/91	4 feet
	7/16/92	35 feet
311137094051401	8/29/95	10 feet
	8/21/96	20 feet
310437094065501	8/29/95	10 feet
	8/21/96	10 feet

Figures 4D-2 through 4D-11 present the water temperature and dissolved oxygen data at five representative stations throughout the reservoir. None of the dissolved oxygen observations at these stations are exceeding the 3.0 mg/L criterion in the mixed layer based on water temperature.

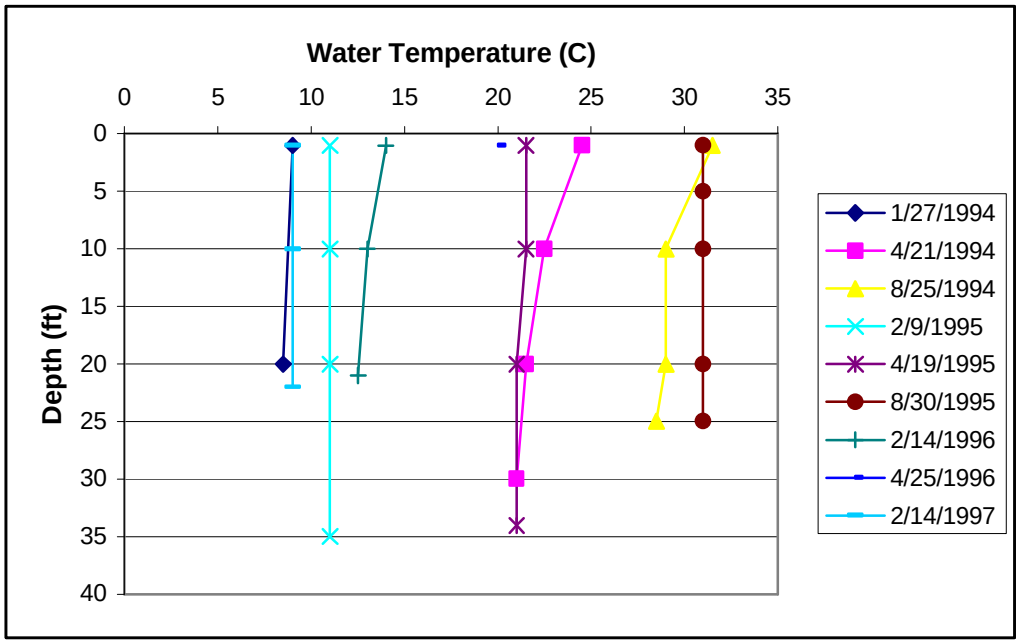

Figure 4D-2. Water temperature profile data for Sam Rayburn Reservoir at station 312216094280601 in the upper portion of the reservoir

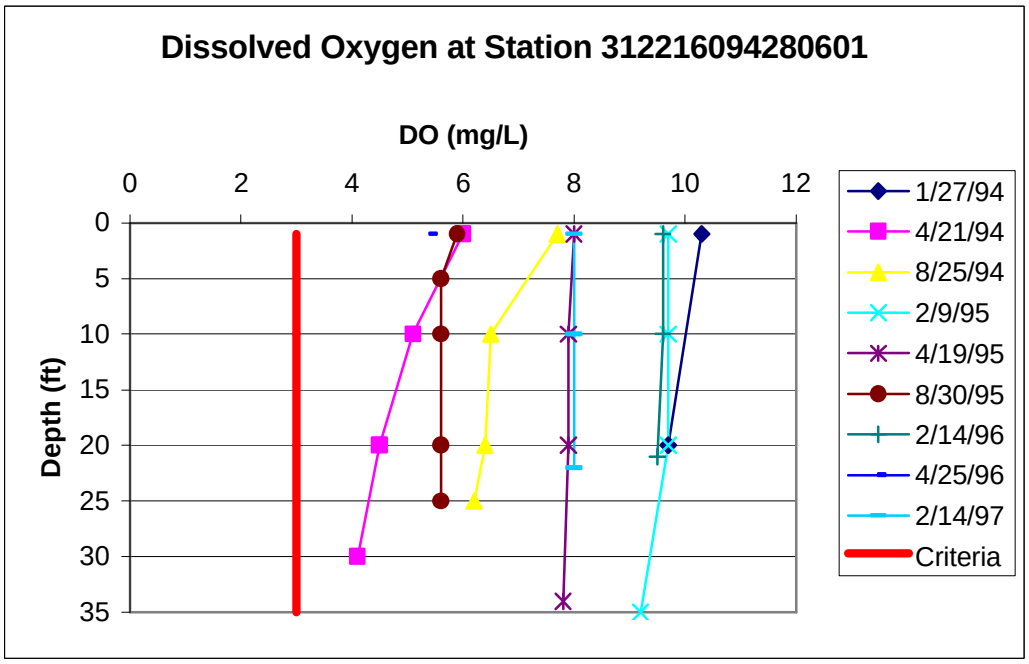

Figure 4D-3. Dissolved oxygen profile data for Sam Rayburn Reservoir at station 31221609428060 in the upper portion of the reservoir

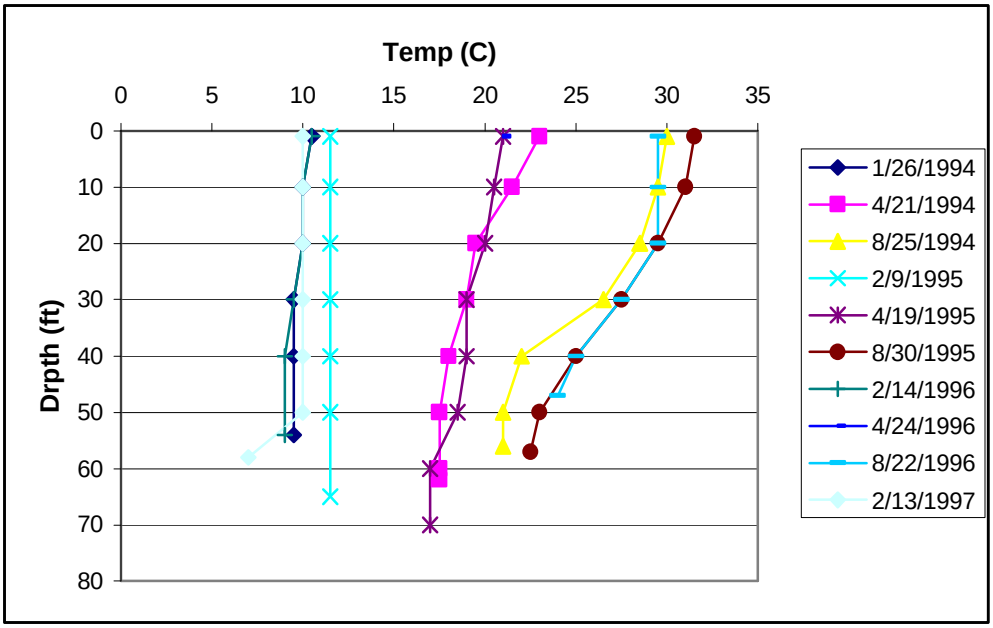

Figure 4D-4. Water temperature profile data for Sam Rayburn Reservoir at station 311828094191801 on the Attoyac Bayou arm

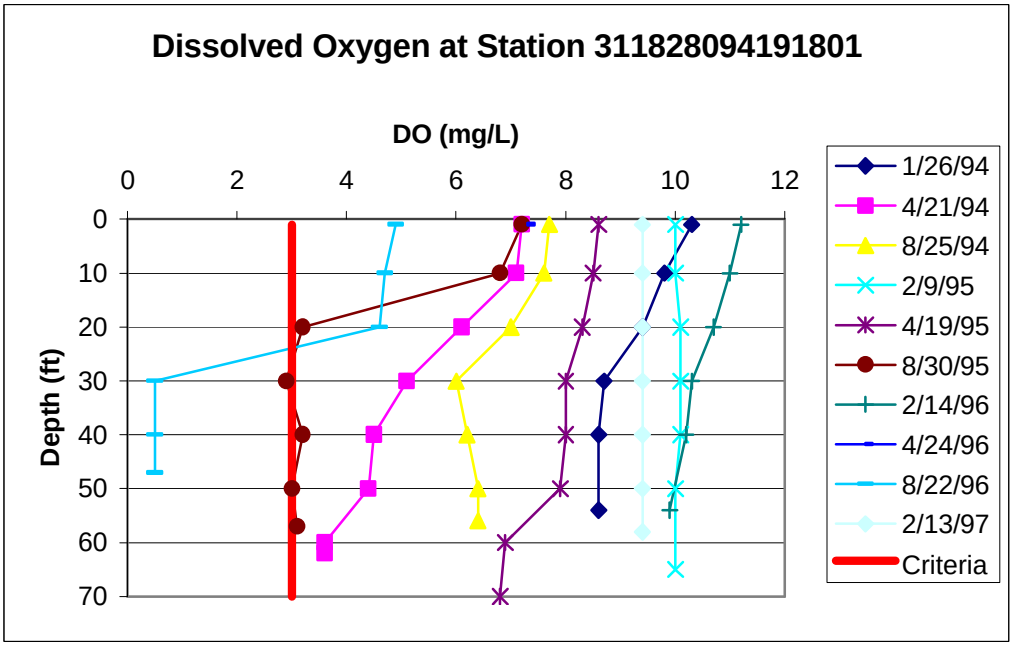

Figure 4D-5. Dissolved oxygen profile data for Sam Rayburn Reservoir at station 311828094191801 on the Attoyac Bayou arm

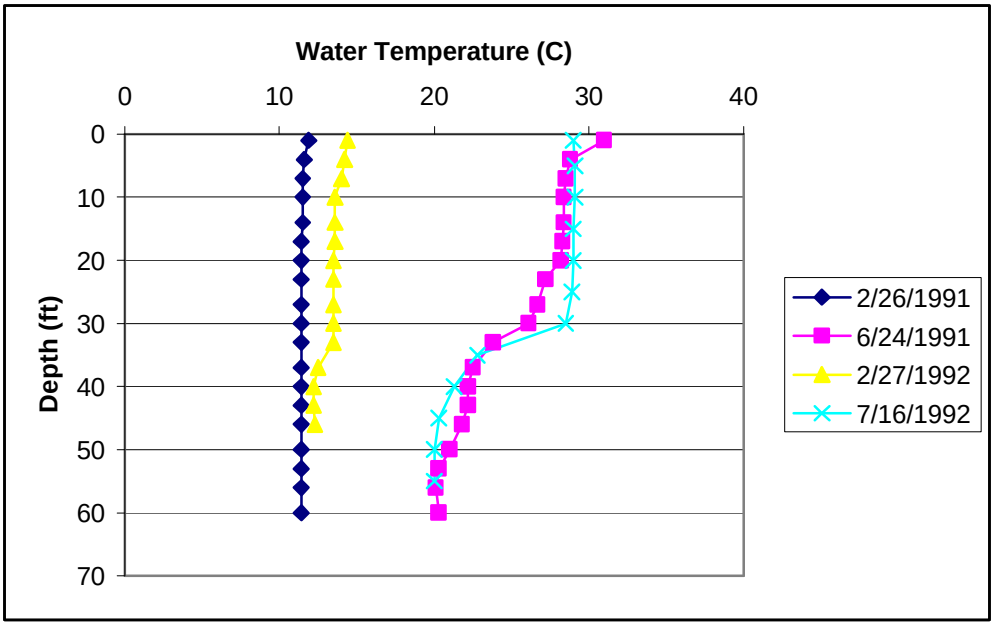

Figure 4D-6. Water temperature profile data for Sam Rayburn Reservoir at station 06100100 in the middle portion of the reservoir

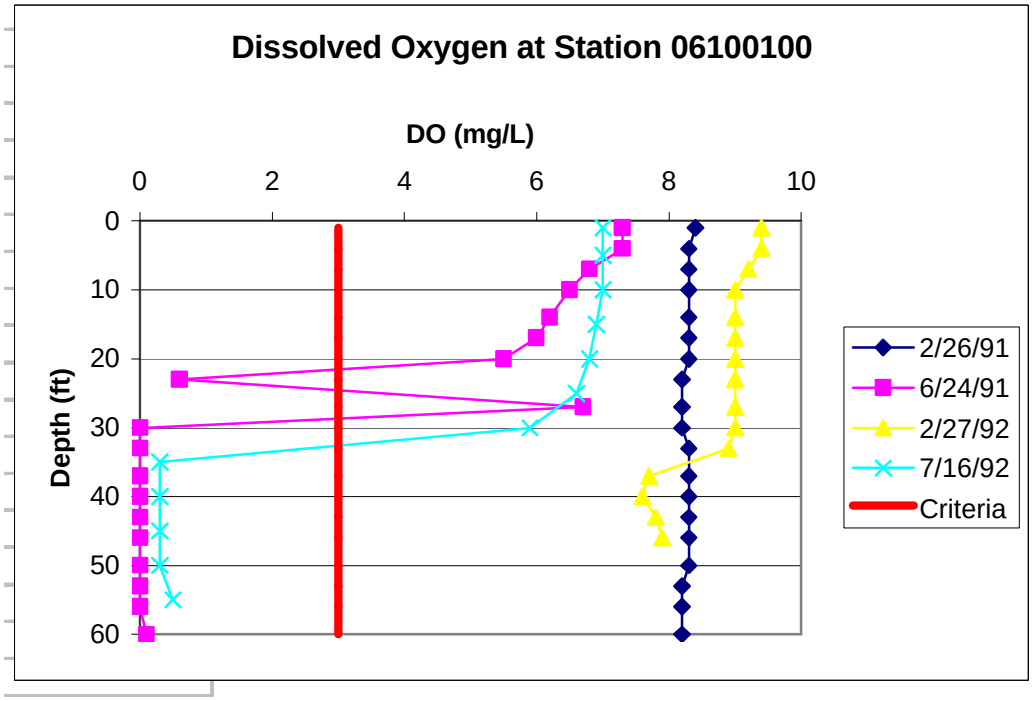

Figure 4D-7. Dissolved oxygen profile data for Sam Rayburn Reservoir at station 06100100 in the middle portion of the reservoir

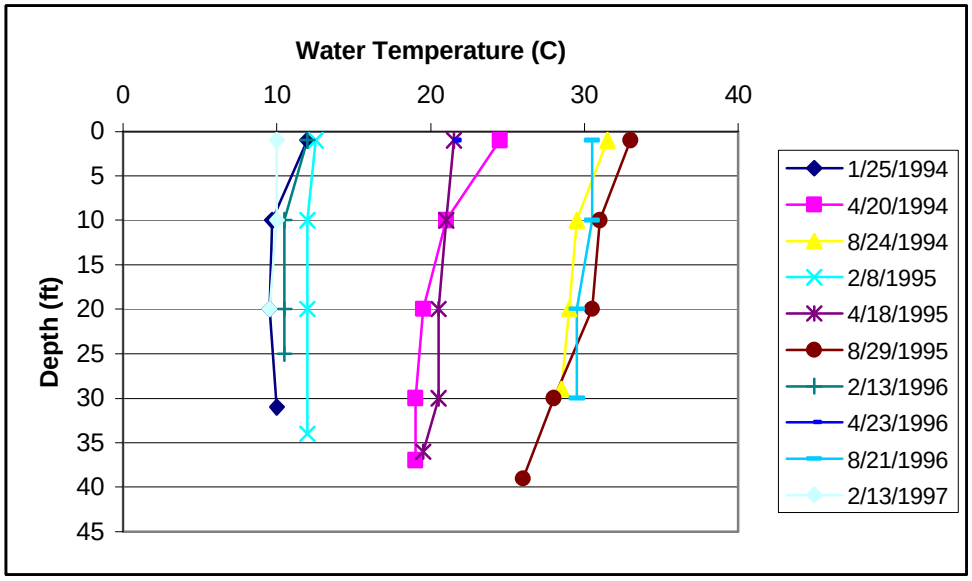

Figure 4D-8. Water temperature profile data for Sam Rayburn Reservoir at station 311137094051401 on the Ayish Bayou arm of the reservoir

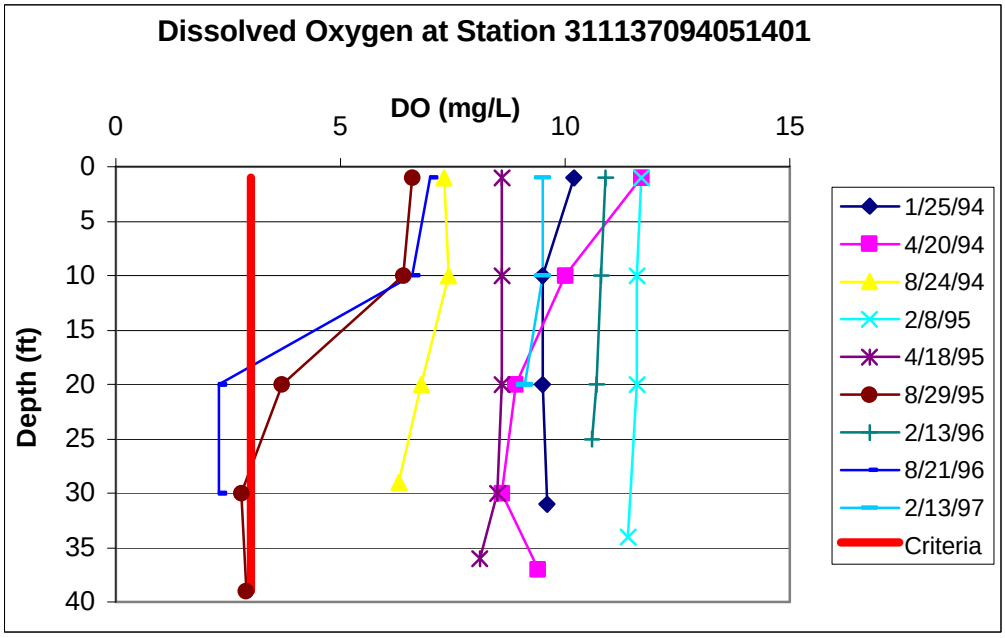

Figure 4D-9. Dissolved oxygen profile data at Sam Rayburn Reservoir at station 311137094051401 on the Ayish Bayou arm of the reservoir

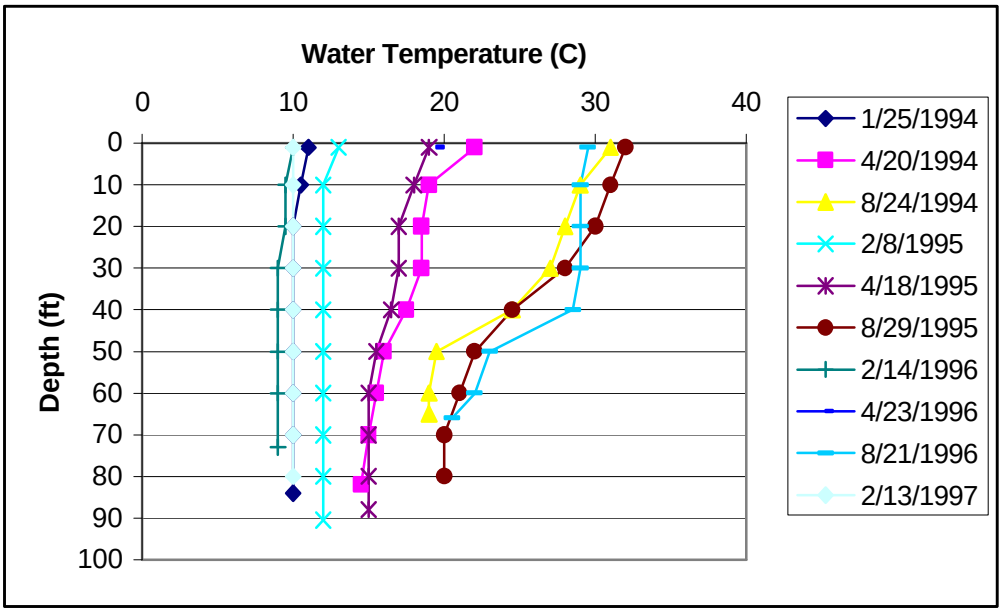

Figure 4D-10. Water temperature data for Sam Rayburn Reservoir at station 310437094065501 in the lower portion of the reservoir

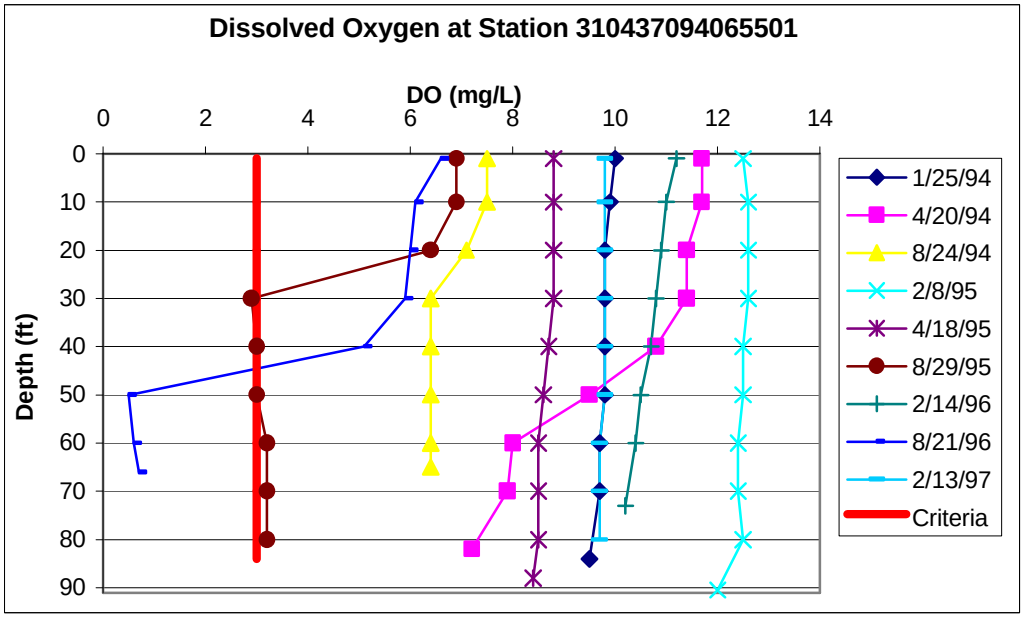

Figure 4D-11. Dissolved oxygen profile data for Sam Rayburn Reservoir at station 310437094065501 in the lower portion of the reservoir

5.0 Stream Characteristics

This section discusses the flow data available in the Sam Rayburn Reservoir watershed as well as the water quality data available for the tributaries to the reservoir. Water quality monitoring data were downloaded from the TRACS and STORET databases and analyzed. Analysis of the TRACS data is presented in Section 5.2 and the analysis of the STORET data is presented in Section 5.3.

5.1 Flow

Flow data for the stream segments in the Sam Rayburn Reservoir watershed were compiled from U.S. Geological Survey (USGS) stations, as well as other water quality monitoring stations.

5.1.1 Monitoring Stations

USGS has historically maintained 12 continuous-flow stations in the Sam Rayburn Reservoir watershed. Stations 08034500, 08036500, 08038000, and 08039100 are still active. Table 5-1 presents a summary of the available daily flow data for these stations, and Figure 5-1 shows the locations of the stations. Stations 08037500, 08039000, and 08039500 are not included in Figure 5-1 because their exact locations are unknown. In addition to the USGS stations there are 52 water quality stations with recorded instantaneous-flow data in TRACS. These stations and a summary of their data are presented in Table 5-2.

Table 5-1. Summary of Flow Data Available at USGS Gage Stations in the Sam Rayburn Reservoir Watershed

Station	Location	Start Date	End Date	Flow (cfs)		
				Average	Min	Max
08033700	Striker Creek near Summerfield, TX	10/1/1940	9/30/1949	200.3	0.7	9,640
08033900	E. Fork Angelina River near Cushing, TX	1/1/1964	9/30/1989	117.0	1	8,870
08034500	Mud Creek near Jacksonville, TX	6/1/1939	9/30/2001	253.6	0	22,700
08036500	Angelina River near Alto, TX	10/1/1940	9/30/2001	877.6	0	41,600
08037000	Angelina River near Lufkin, TX	10/1/1923	9/30/1979	117.5	0.8	36,800
08037050	Bayou Lanana at Nacogdoches, TX	10/1/1964	9/30/1993	32.4	0	5730
08037500	Arenoso Creek near San Augustine, TX	6/1/1938	9/30/1940	61.3	3.3	1,220
08038000	Attoyac Bayou near Chireno, TX	2/1/1924	9/30/1989	434.9	0	26,800
08038500	Angelina River near Zavalla, TX	10/1/1951	1/31/1965	1,786.2	22	36,700
08039000	Ayish Bayou at San Augustine, TX	4/1/1925	8/31/1925	3.5	1.3	18
08039100	Ayish Bayou at San Augustine, TX	3/1/1959	9/30/1985	83.5	0	6,890
08039500	Angelina River near Ebenezer, TX	4/1/1928	9/30/1973	2,751.3	0	49,300

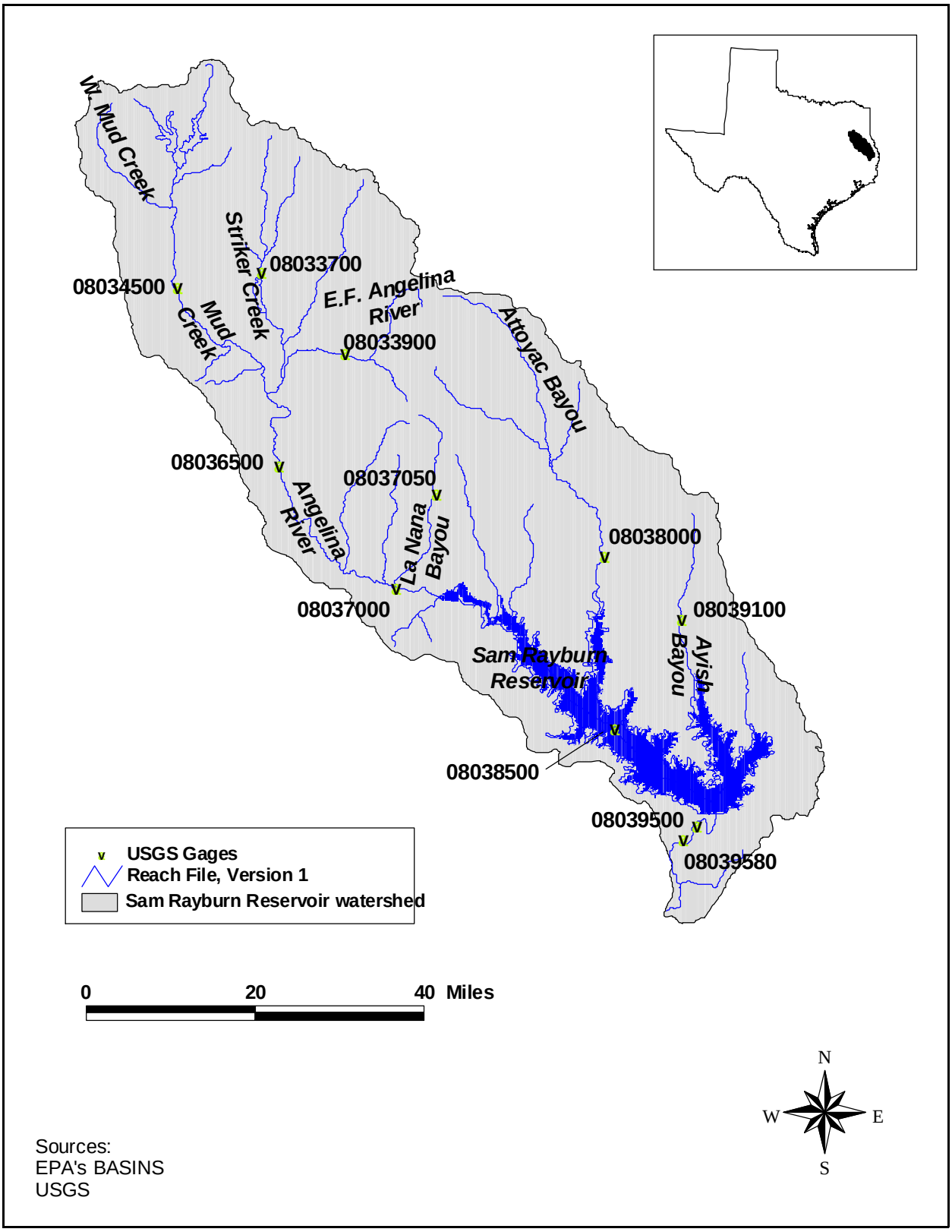

Figure 5-1. Location of USGS Gages in the Sam Rayburn Reservoir Watershed

Table 5-2. Summary of Flow Data Available at Water Quality Monitoring Stations

Station	Location	Start Date	End Date	InstantaneousFlow (cfs)			
				#	Avg	Min	Max
10474	La Nana Bayou at CR 526	3/20/1974	11/14/1996	57	38.2	2	324
10475	La Nana Bayou at Loop 224	11/14/1996	2/11/2002	21	25.3	1.1	88
10483	Ayish Bayou at US 96	11/20/1974	6/20/1979	21	15.7	1.61	40
10504	Paper Mill Creek	1/27/1986	5/1/1987	9	45.8	22.3	88.3
10532	Mud Creek at US 84	9/5/1996	9/6/1996	1	33	33	33
10535	Mud Creek on Unnamed CR	8/26/1986	8/26/1986	1	9.6	9.6	9.6
10537	Mud Creek at FM 2138	8/26/1986	8/26/1986	1	3.5	3.5	3.5
10538	West Mud Creek at FM 3052	8/26/1986	9/29/1987	2	13.8	9	18.6
10539	West Mud Creek at FM 344	6/26/1986	6/21/1995	13	30.2	8.8	60.4
10540	West Mud Creek at FM 346	9/29/1987	7/25/2001	19	13.3	3.6	26
10541	West Mud Creek at FM 2813	9/29/1987	9/29/1987	1	8.5	8.5	8.5
10542	West Mud Creek, Tyler WWTP	10/27/1998	8/30/1999	10	4.3	1.1	5.9
10543	West Mud Creek Holly Trees CC	8/26/1986	2/16/1989	9	3.7	1.3	12.5
10552	E. Fork Angelina River at FM 225	6/21/1995	6/21/1995	1	34	34	34
10613	Sam Rayburn Reservoir at SH 103	12/9/1981	12/9/1981	1	155.71	155.71	155.71
10627	Angelina River at US 59	9/20/1973	2/18/1998	95	1051.9	24.7	8000
10630	Angelina River at FM 21	11/17/1997	2/5/2001	22	994.5	13.6	4248
10633	Angelina River at SH 204	9/5/1996	7/12/2000	2	26.2	5.3	47
10635	Angelina River at SH 1798	5/1/2001	7/11/2001	2	35.0	31	39
10636	Attoyac Bayou at SH 21	9/19/1973	8/26/1999	95	450.7	22	2500
13674	Bowles Creek at SH 64	11/2/1981	8/27/1985	34	14.4	0	326
13788	East Fork Angelina River	10/26/1993	11/6/1996	6	10.6	3.6	15
14470	Angelina River at US 84	10/31/1995	6/25/1997	7	37.6	5.7	75
14477	Mud Creek at US 79	10/16/1995	6/12/1996	5	35.6	9.2	107
15357	Turkey Creek at FM 705	11/7/1996	8/19/1997	4	2.4	0.44	6.1
15358	Sandy Creek at FM 705	11/7/1996	8/19/1997	4	4.5	1.1	8.3
15359	Chiamon Bayou at FM 1751	11/7/1996	8/19/1997	4	1.1	0.09	3.1
15360	Chinquapin Creek FM 1751	11/7/1996	8/19/1997	4	1.4	0.1	3.5
15361	Ayish Bayou at SH 103	11/7/1996	7/17/2001	9	11.8	1	59
15362	Caney Creek at SH 147	11/12/1996	8/21/1997	4	6.9	0.94	15
15363	Venado Creek at SH 147	11/12/1996	8/21/1997	4	12.0	2.4	23
15364	Ayish Bayou at SH 147	8/9/1996	8/21/1997	6	10.6	1.93	21
15365	Ayish Bayou at FM 3230	11/12/1996	8/21/1997	4	4.9	0.51	11
15366	Carrizo Creek at FM 2213	11/12/1996	8/21/1997	4	3.1	0.28	11
15522	Sam Rayburn near Veach Basin	12/14/1995	12/14/1995	1	0.56	0.56	0.56
15806	Bromley Creek near Henderson	8/27/1996	10/21/1997	2	1.1	0.587	1.7
15807	Shawnee Creek at FM 225	8/27/1996	10/21/1997	2	0.1	0	0.103

Table 5-2. Summary of flow data available at water quality monitoring stations (Continued)

Station	Location	Start Date	End Date	Instantaneous Flow (cfs)			
				#	Avg	Min	Max
16082	Terrapin Creek at CR 234	11/19/1997	3/24/1998	5	0.2	0.02	0.74
16083	Waffelow Creek at SH 95	11/19/1997	5/27/1998	5	5.2	2.3	13
16084	Terrapin Creek at SH 95	11/19/1997	5/27/1998	7	13.9	3	32
16085	Waffelow Creek at FM 1878	11/19/1997	5/27/1998	7	0.9	0.08	2.8
16289	Everett Branch	10/12/1998	8/18/1999	6	2.7	0.48	7.23
16291	Wooten Creek	12/9/1998	8/18/1999	4	13.2	1	33.09
16294	Sulphur Springs Branch	10/12/1998	8/18/1999	6	11.8	1.4	33.64
16298	Ragsdale Creek	10/27/1998	5/31/2000	23	1.4	0.13	4.3
16300	Jones Creek	10/13/1998	8/18/1999	7	4.7	1	14.37
16301	La Nana Bayou Loop 224	12/28/1998	12/28/1998	1	6.89	6.89	6.89
16302	Beech Creek at CR 950	10/13/1998	8/18/1999	3	12.5	7.2	13.34
16303	Dill Creek at FM 2783	12/14/1998	6/22/1999	4	3.6	0.02	10.43
16586	Mud Creek at SH 110	7/15/1999	10/29/2001	3	4.0	1.7	5.7
16587	Caney Creek at SH 13	7/14/1999	7/14/1999	1	0.1	0.1	0.1
17103	Mud Creek at SH 135	12/5/2000	10/29/2001	2	36.4	24.9	47

5.1.2 Temporal Summary

The annual mean daily flows for the entire period of record for the USGS gaging stations are presented in Table 5-3. These data demonstrate how flow within the Sam Rayburn Reservoir watershed fluctuates during wet and dry years. Mean monthly flow for seven USGS stations was calculated to illustrate flow patterns in the main tributaries of the watershed over the course of the year. Results are graphically shown in Figures 5-2 through 5-8 indicate a significant increase in flow during the late spring and early summer months, a subsequent decrease during the late summer and early fall months, and a slow increase in flow during the winter months. This trend is consistent with regional rain patterns and vegetative growth.

Table 5-3. Annual Mean Daily Flow

Year	Annual Mean Daily Flow (cfs)	Year	Annual Mean Daily Flow (cfs)	Year	Annual Mean Daily Flow (cfs)	Year	Annual Mean Daily Flow (cfs)
USGS 08033700 Striker Creek near Summerfield, TX							
1941	217	1944	278	1945	301	1947	179
1942	158	1943	57.2	1946	302	1948	117
USGS 08033900 East Fork Angelina River near Cushing, TX							
1964	34	1971	43.2	1977	58.6	1983	180
1965	76	1972	54.7	1978	65.1	1984	119
1966	97.1	1973	210	1979	243	1985	150
1967	21.4	1974	147	1980	161	1986	135
1968	165	1975	142	1981	66.3	1987	125
1969	158	1976	106	1982	147	1988	88
1970	51.1						
USGS 08034500 Mud Creek near Jacksonville, TX							
1940	290	1950	258	1960	370	1970	157
1941	339	1951	82.4	1961	414	1971	48.3

Year	Annual Mean Daily Flow (cfs)	Year	Annual Mean Daily Flow (cfs)	Year	Annual Mean Daily Flow (cfs)	Year	Annual Mean Daily Flow (cfs)
1942	263	1952	184	1962	250	1972	78.2
1943	114	1953	249	1963	59.4	1973	542
1944	545	1954	120	1964	34.5	1974	365
1945	628	1955	152	1965	129	1975	274
1946	644	1956	93.7	1966	287	1976	261
1947	400	1957	427	1967	38.5	1977	212
1948	235	1958	299	1968	232	1978	66.9
1949	149	1959	323	1969	312		
USGS 08036500 Angelina River near Alto, TX							
1943	339	1970	545	1981	318	1991	2,049
1960	1,174	1971	201	1982	709	1992	1,207
1961	1,641	1972	361	1983	1,135	1993	1,325
1962	878	1973	1,637	1984	571	1994	1,162
1963	241	1974	1,133	1985	866	1995	1,350
1964	147	1975	974	1986	774	1996	297
1965	466	1976	977	1987	877	1997	1,365
1966	901	1977	577	1988	584	1998	1,229
1967	145	1978	269	1989	1,404	1999	1,141
1968	1,076	1979	1,463	1990	1,224	2000	605
1969	1,350	1980	863				
USGS 08037000 Angelina River near Lufkin, TX							
1924	1,661	1943	376	1955	653	1967	193
1925	906	1944	2,389	1956	401	1968	1,472
1926	1,176	1945	2,475	1957	1,956	1969	1,739
1927	1,190	1946	2,549	1958	1,424	1970	629
1928	612	1947	1,744	1959	974	1971	222
1929	1,021	1948	958	1960	1,411	1972	500
1930	1,174	1949	837	1961	2,106	1973	2,134
1931	1,116	1950	1,442	1962	1,098	1974	1,500
1932	2,248	1951	398	1963	297	1975	1,366
1933	1,156	1952	662	1964	225	1976	1,153
1940	1,581	1953	1,452	1965	603	1977	714
1941	1,950	1954	428	1966	1,104	1978	353
1942	1,191						
USGS 08037050 Bayou Lanana at Nacogdoches, TX							
1965	19.7	1972	22.6	1978	15.1	1984	29.3
1966	28.9	1973	61.7	1979	97.3	1985	42.9
1967	4.99	1974	34.3	1980	25.9	1989	38.6
1968	54.5	1975	42.8	1981	14.5	1990	34.1
1969	45.5	1976	17.3	1982	46.7	1991	52.1
1970	8.62	1977	15.8	1983	40.2	1992	30.6
1971	3.64						
USGS 08038000 Attoyac Bayou near Chireno, TX							
1940	871	1951	175	1964	134	1975	570
1941	960	1952	230	1965	233	1976	289
1942	475	1953	694	1966	337	1977	260
1943	141	1956	135	1967	96	1978	303

Year	Annual Mean Daily Flow (cfs)	Year	Annual Mean Daily Flow (cfs)	Year	Annual Mean Daily Flow (cfs)	Year	Annual Mean Daily Flow (cfs)
1944	766	1957	606	1968	629	1979	968
1945	590	1958	564	1969	559	1980	565
1946	721	1959	306	1970	170	1981	345
1947	513	1960	468	1971	92.8	1982	601
1948	316	1961	694	1972	202	1983	776
1949	429	1962	291	1973	747	1984	477
1950	583	1963	118	1974	567		
USGS 08038500 Angelina River near Zavalla, TX							
1952	1,258	1956	680	1959	1,726	1962	1,884
1953	3,125	1957	3,278	1960	2,466	1963	588
1954	714	1958	2,633	1961	3,631	1964	672
1955	1,075						
USGS 08039100 Ayish Bayou near San Augustine, TX							
1960	90.4	1967	15.2	1973	190	1979	185
1961	151	1968	149	1974	154	1980	81
1962	45.9	1969	106	1975	131	1981	25.1
1963	26.5	1970	28	1976	46.7	1982	113
1964	53.8	1971	16.1	1977	43	1983	140
1965	31.4	1972	46.7	1978	80.8	1984	84.2
1966	71.4						
USGS 08039500 Angelina River near Ebenezer, TX							
1929	3,186	1937	2,028	1944	5,269	1966	550
1930	2,712	1938	2,494	1945	5,119	1967	381
1931	2,438	1939	1,917	1946	5,810	1968	2,021
1932	4,489	1940	4,109	1947	3,654	1969	3,659
1933	2,844	1941	5,326	1948	2,054	1970	787
1934	3,173	1942	2,857	1949	2,775	1971	437
1935	3,706	1943	769	1950	4,462	1972	896
1936	912						

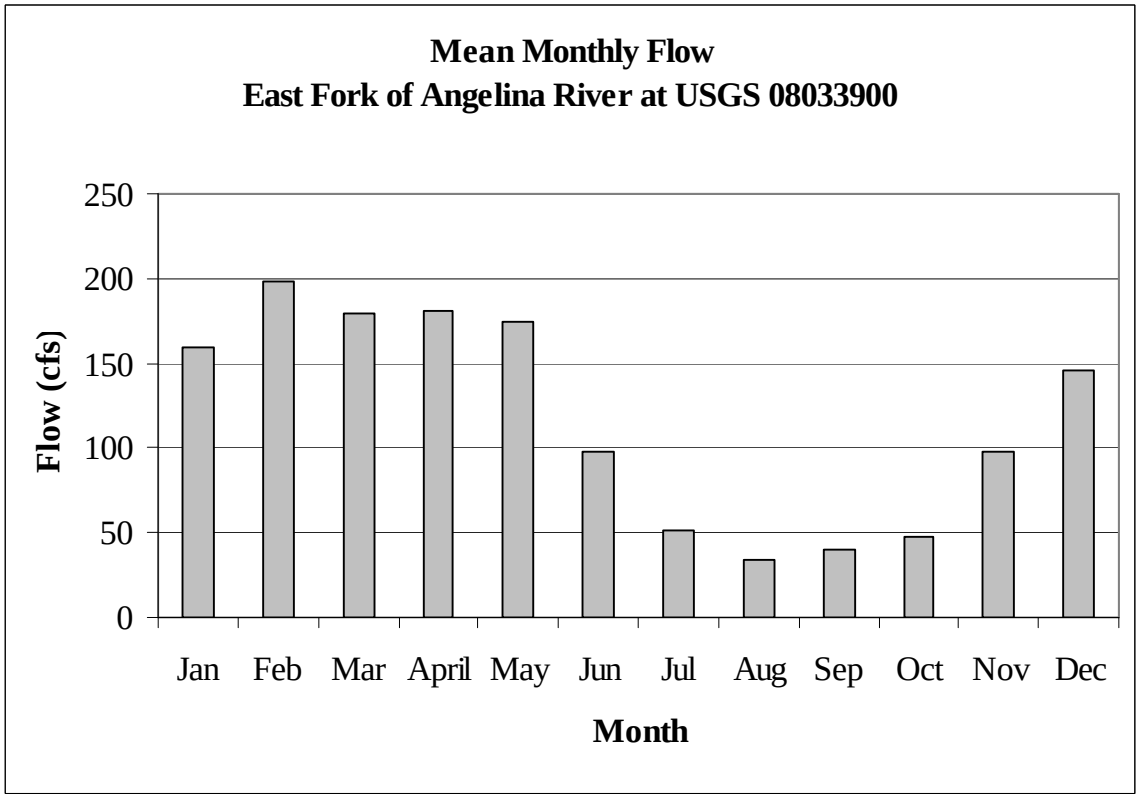

Figure 5-2. Mean Monthly Flow at USGS Gage 08033900 (East Fork Angelina River)

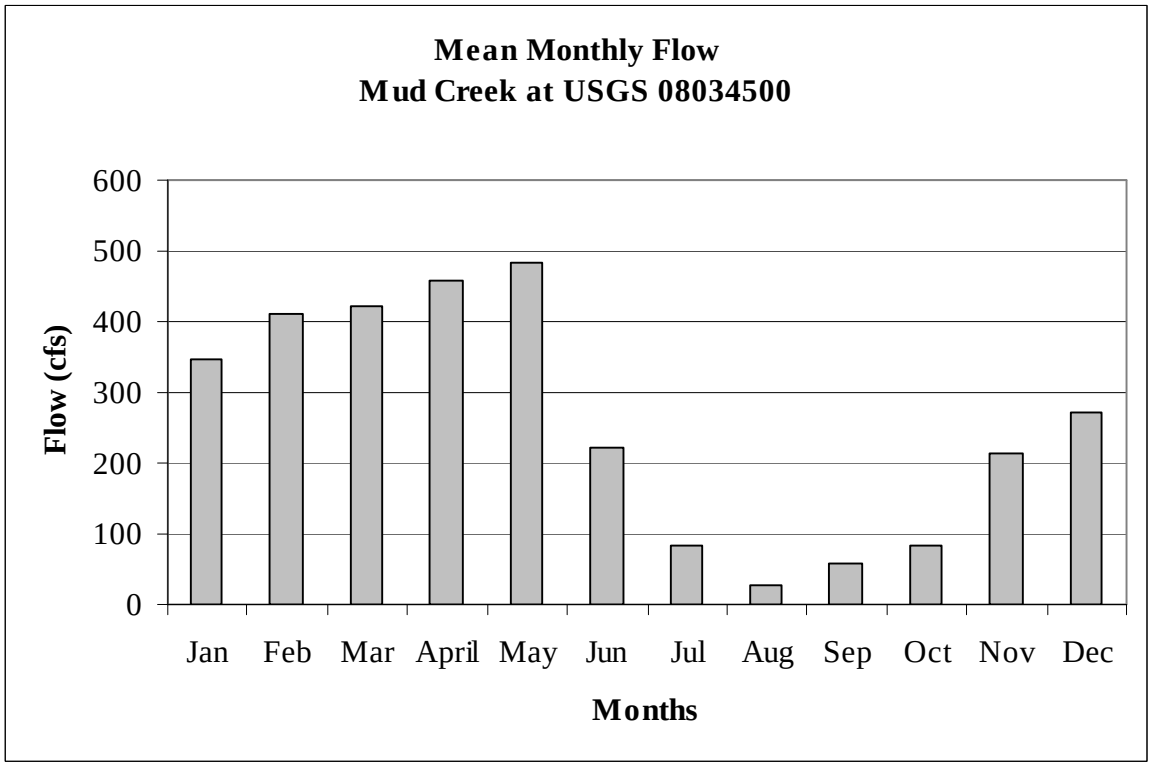

Figure 5-3. Mean Monthly Flow at USGS Gage 08034500 (Mud Creek).

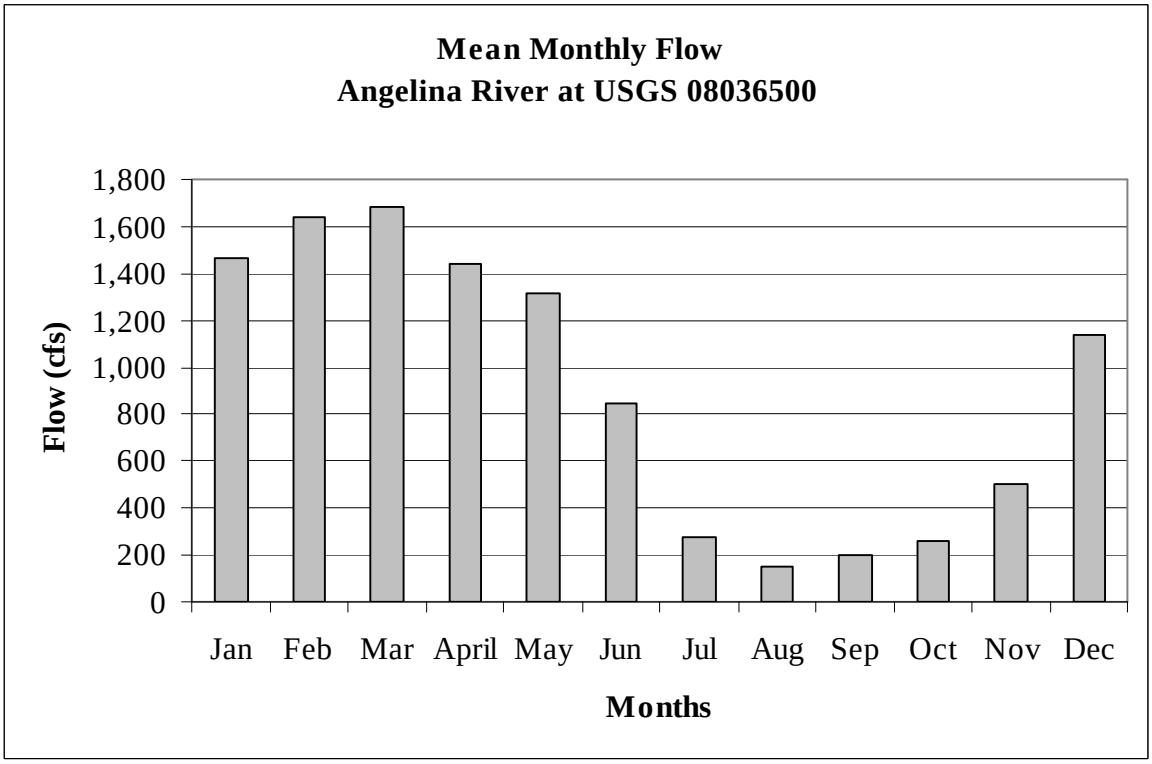

Figure 5-4. Mean Monthly Flow for USGS Gage 08036500 (Angelina River).

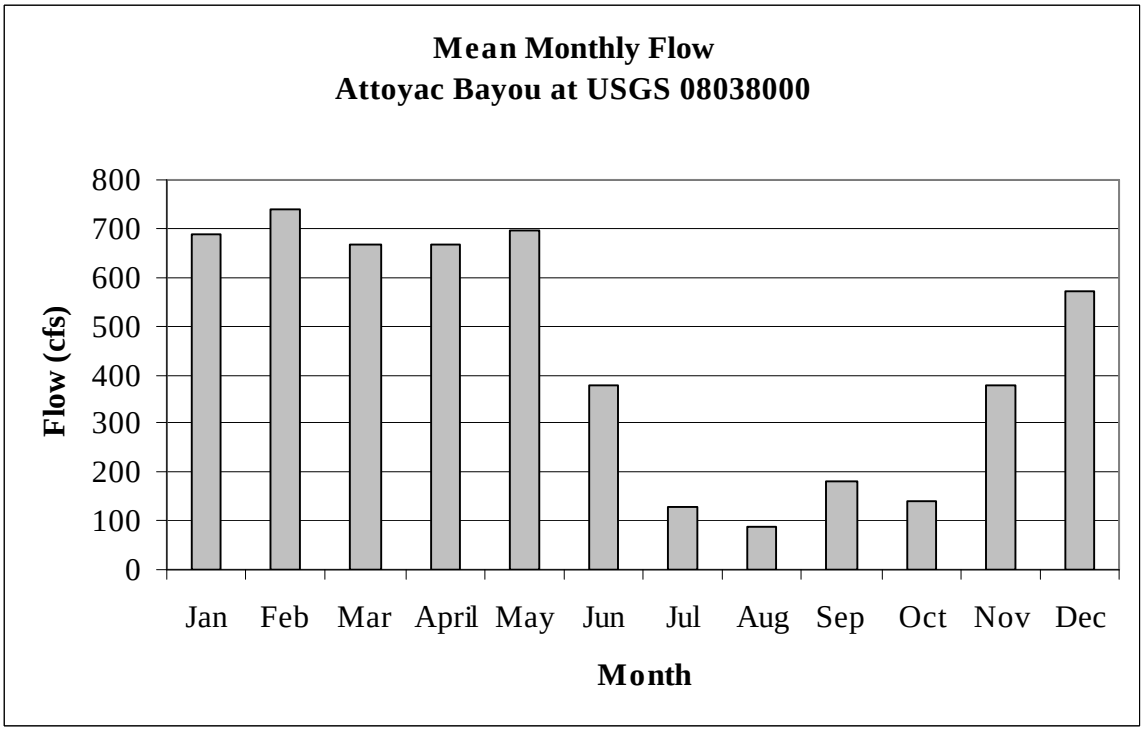

Figure 5-5. Mean Monthly Flow at USGS Gage 08038000 (Attoyac Bayou)

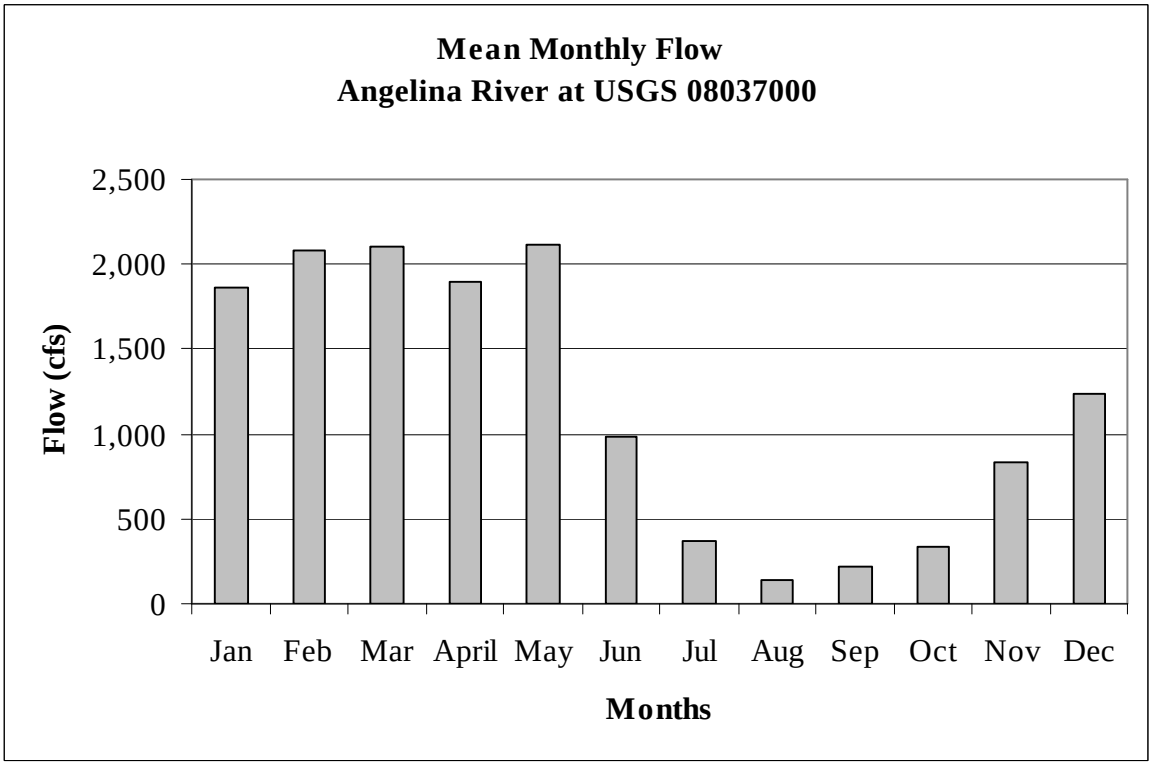

Figure 5-6. Mean Monthly Flow for USGS Gage 08037000 (Angelina River).

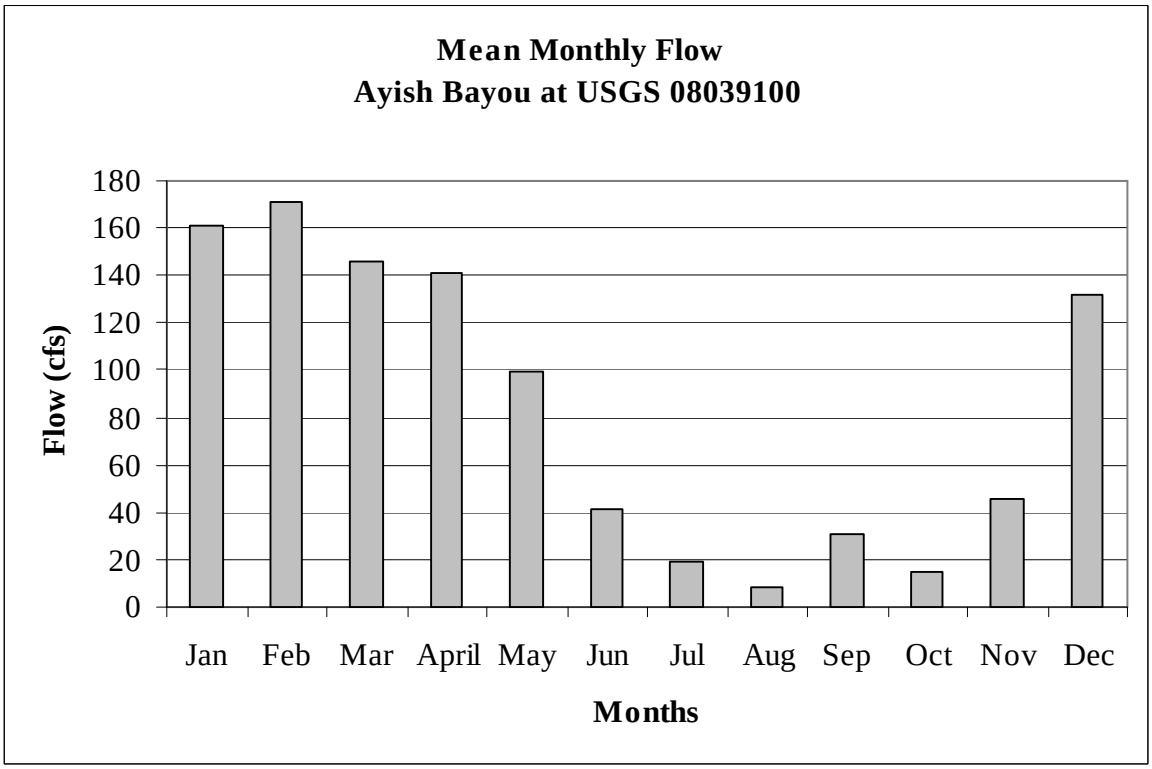

Figure 5-7. Mean Monthly Flow for USGS Gage 08039100 (Ayish Bayou).

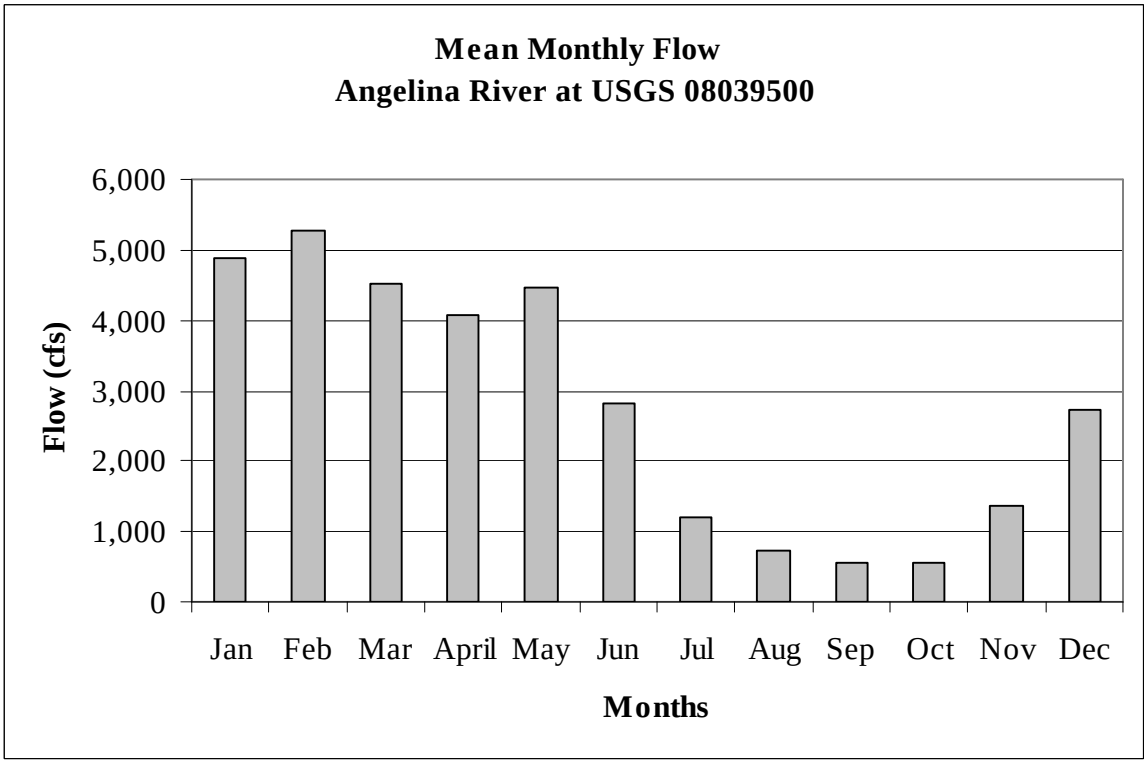

Figure 5-8. Mean Monthly Flow for USGS Gage 08039500 (Angelina River)

5.2 TRACS Water Quality Data for Segments 0611 and 0612

Water quality monitoring data were queried from TCEQ's TRACS database for the two segments that compose the portion of the Sam Rayburn Reservoir watershed upstream of the reservoir (segments 0611 and 0612). Most of the analyses focus on data from 1990 to the present, but 1980s data are included for some sites or segments with only limited data available for the years since 1990.

5.2.1 Monitoring Stations

The monitoring stations in segments 0611 and 0612 are listed in Table 5-4. For segment 0611, 54 monitoring stations were found in TRACS, whereas only eight stations were found for segment 0612. Figure 5-9 presents the locations of the TRACS monitoring stations.

Table 5-4. Monitoring Stations in Segments 0611 and 0612

Station	Station Location
Segment 0611	
10472	Lanana Bayou at Lowermost County Rd Crossing
10473	Lanana Bayou at Boozer Property upstream from South Pacific RR Bridge
10474	La Nana Bayou at Nacogdoches Cr526
10475	La Nana Bayou at Loop 224 S of Nacogdoches
10476	Lanana Bayou at FM 1878
10477	Keys Creek at Lowermost County Rd Crossing se of Jacksonville
10531	Striker Cr at County Rd Crossing ne of Reklaw
10532	Mud Creek at Us 84 sw of Reklaw
10535	Mud Creek on Unnamed County Rd, 2.5mi east of Tecula
10536	Mud Creek at Fm 2064 ne of Jacksonville
10537	Mud Creek at Fm2138, west of Troup
10538	West Mud Creek at FM3052, Approx. 4.5mi sw of the City of Troup and east of Bullard
10539	West Mud Creek at FM344 ne of Bullard
10540	West Mud Creek at FM 346 south of Tyler
10541	West Mud Creek at FM2813 south of Tyler
10542	West Mud Creek immediately upstream from Tyler
10543	West Mud Creek near south end of Holly Trees Country Club
10550	Anadarko Creek at FM 2753
10551	East Fork Angelina River at Lowermost County Rd Crossing
10552	East Fork Angelina River at FM 225
10624	Angelina River at River Crest Estates
10625	Angelina River Downstream from Southern Pacific RR Bridge, north of Kurth Lake
10626	Angelina River at Southern Pacific RR Bridge
10627	Angelina River Bridge on US 59 north of Lufkin
10628	Angelina River at SH 7 southwest of Nacogdoches
10629	Angelina River at FM 1911 southeast of Alto
10630	Angelina River at SH 21 east of Alto
10631	Angelina River at FM 343 east of Rusk
10632	Angelina River at County Rd Crossing Immediately Downstream from Mud Cr Confluence
10633	Angelina River at SH 204 west of Cushing
10634	Angelina River at FM 1662 west of Anadarko
10635	Angelina River at FM 1798 west of Laneville
13674	Bowles Creek at SH 64, 1.5 mi. west of Selman City
13788	East Fork Angelina River Approximately 5 mi sw of Mount Enterprise at CR 3218
14470	Angelina River at US 84 east of Reklaw
14477	Mud Creek at US 79 Between Jacksonville and New Summerfield
15801	Lake Nacogdoches in Main Pool near dam, 10 mi. west of Nacogdoches
15806	Bromley Creek, 1.0 mi south of US79
15807	Shawnee Creek at FM225, 1 mi. south of Henderson (Permit# Wq0010187-001)
16289	Everett Branch at Rusk CR3227, 0.6mi. downstream of US 84, west of Mount Enterprise
16290	East Fork Angelina River at Rusk CR3216, 1.9mi. downstream of US 84, sw of Henderson
16291	Wooten Creek at FM3055, sw of Mount Enterprise

Station	Station Location
16292	Ham Creek at Rusk CR3168, 1.4mi. upstream of FM2496, nw of Mount Enterprise
16294	Sulphur Springs Branch at Rusk CR3238
16298	Ragsdale Creek at Canada St. Immediately Upstream of Jacksonville
16300	Jones Creek at Nacogdoches CR817
16301	La Nana Bayou at Loop 224
16302	Beech Creek at Nacogdoches CR950, approx. 6mi. Ne of Cushing
16303	Dill Creek at FM2783, east of Cushing
16304	East Fork Angelina River at Nacogdoches CR3230, 2.3km north of Happy Valley
16586	Mud Creek at SH110, 6.0km nw of City of Troup
16587	Caney Creek at SH13, 0.80km se of City of Troup
16950	Lake Stricker Approx 0.5mi North of East End of Dam
17103	Mud Creek at SH135, Approx. 3.5mi sww of the City of Troup
Segment 0612	
10636	Attoyac Bayou at SH 21 east of Chireno
15253	Attoyac Bayou at SH 7 Approximately 1.75 Km ne of Martinsville
15802	Pinkston Reservoir in Main Pool near dam, 12 mi. sw of Center
16076	Attoyac Bayou at US 59 ne of Garrison
16082	Terrapin Creek at Nacogdoches Cr234, 5 mi. nw of Martinsville
16083	Waffelow Creek at SH95, 4 mi. north of Martinsville
16084	Terrapin Creek at SH95, 1 mi. south of Martinsville
16085	Waffelow Creek at FM1878, 8.5 mi. ne of Loop 224 in Nacogdoches

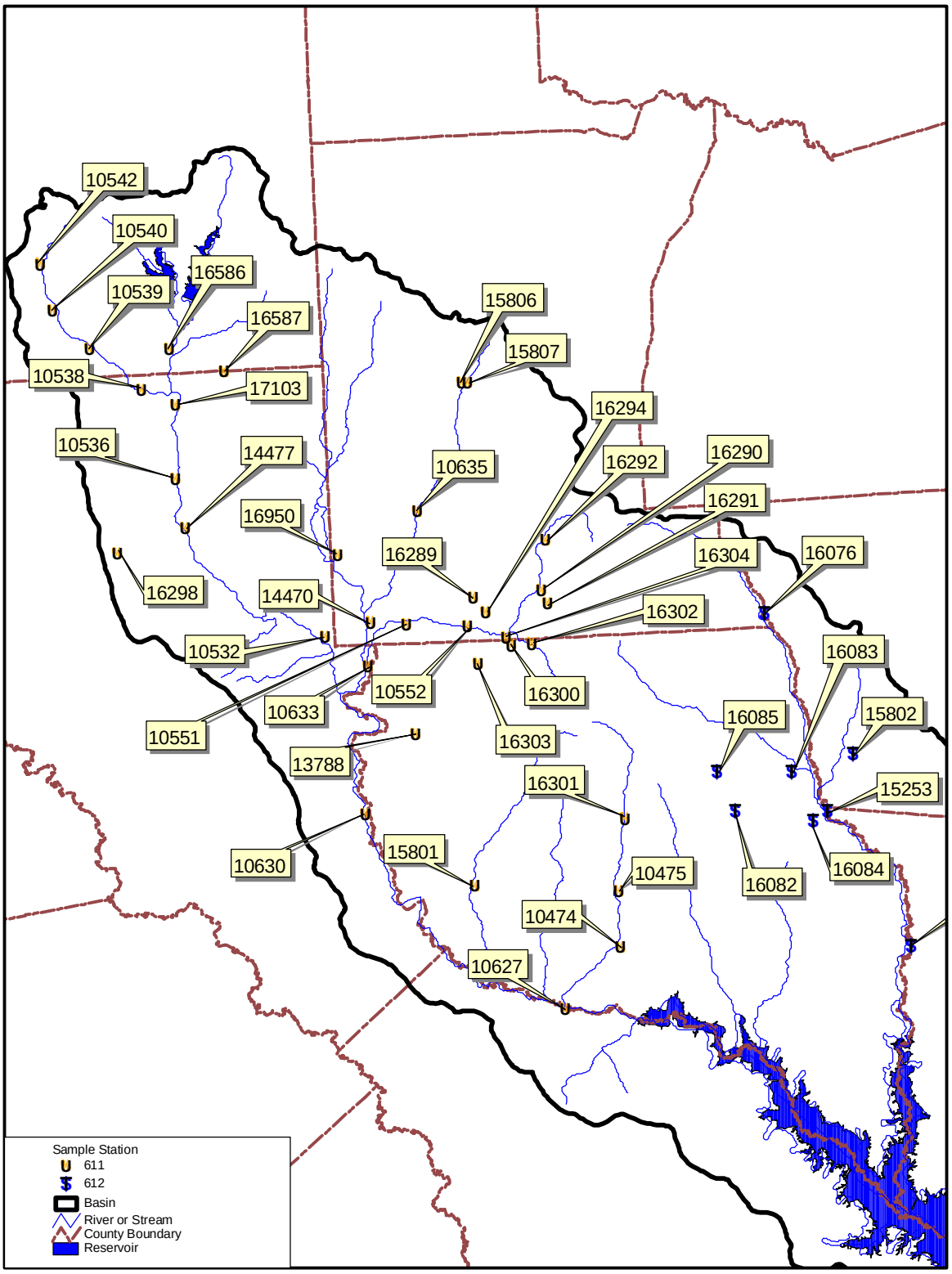

Figure 5-9. Locations of the TRACS water quality monitoring stations

5.2.2 Water Quality Data Analysis

5.2.2.1 Dissolved Oxygen and Nutrients

Segment 0611: Dissolved Oxygen

There are 436 records available for grab dissolved oxygen in surface waters for segment 0611 and its subsegments (period of record from January 1990 to November 2002). The data range from 1.3 mg/L to 14.5 mg/L. Of the 436 records, there were 3 exceedances of the 3.0 mg/L criterion. The data are presented in Table 5A-1. Tables 5A-1 through 5A-38 are presented in Appendix 5A at the end of Section 5.0 because if their large size.

There are 21 records available for 24-hour minimum dissolved oxygen in surface waters for segment 0611 and its subsegments (period of record from October 1997 to August 2002). The data range from 1.3 mg/L to 8.2 mg/L. There was one exceedance of the 3.0 mg/L criterion. The data are presented in Table 5A-2.

There are 21 records available for 24-hour average dissolved oxygen in surface waters for segment 0611 and its subsegments (period of record from October 1997 to August 2002). The data range from 2.9 mg/L to 9.0 mg/L. There were three exceedances of the 5.0 mg/L criterion. The data are presented in Table 5A-3.

Segment 0612: Dissolved Oxygen

There are 108 records available for grab dissolved oxygen in surface waters for segment 0612 and its subsegments (period of record from June 1990 to July 2002). The data range from 4.9 mg/L to 12.8 mg/L. There were no exceedances of the 3.0 mg/L criterion. The data are presented in Table A5-1.

There are two records available for 24-hour minimum dissolved oxygen in surface waters for segment 0612 and its subsegments (period of record from May 2001 to August 2001). The data range from 5.91 mg/L to 7.03 mg/L. There were no exceedances of the 3.0 mg/L criterion. The data are presented in Table 5A-2.

There are two records available for 24-hour average dissolved oxygen in surface waters for segment 0612 and its subsegments (period of record from May 2001 to August 2001). The data range from 6.08 mg/L to 7.1 mg/L. There were no exceedances of the 5.0 mg/L criterion. The data are presented in Table 5A-3.

Chlorophyll a and Secchi Depth

Segment 0611: Chlorophyll a

There are 105 records available for chlorophyll a in surface waters for segment 0611 and its subsegments (period of record from January 1990 to November 2002). The data range from 1.0 µg/L to 18.7 µg/L. There were 102 samples that were higher than the the 0.566 µg/L EPA reference criterion and 2 samples that were higher than the 11.6 µg/L TCEQ screening level. The

data are presented in Table 5A-4.

Segment 0612: Chlorophyll a

There are 35 records available for chlorophyll a in surface waters for segment 0612 and its subsegments (period of record from June 1990 to August 2002). The data range from 1.0 µg/L to 10.2 µg/L. There were 34 samples that were higher than the 0.566 µg/L EPA reference criterion and no samples that were higher than the 11.6 µg/L TCEQ screening level. The data are presented in Table 5A-4.

Segment 0611: Secchi Depth

There are 198 records available for Secchi depth in surface waters for segment 0611 and its subsegments (period of record from January 1990 to November 2002). The data range from 0.1 meter to 1.8 meters. There are no water quality criteria for Secchi depth in streams. The data are presented in Table 5A-5.

Segment 0612: Secchi Depth

There are 33 records available for Secchi depth in surface waters for segment 0612 and its subsegments, with a period of record from June 1990 to August 2002. The data range from 0.18 meter to 1.22 meters. There are no water quality criteria for Secchi depth in streams. The data are presented in Table 5A-5.

Nutrients

Segment 0611: Total Phosphorus

There are 254 records available for total phosphorus in surface waters for segment 0611 and its subsegments (period of record from January 1990 to November 2002). The data range from 0.006 mg/L to 8.3 mg/L. There were 225 samples that were higher than the 0.05 mg/L EPA reference criterion and 52 observations that were higher than the 0.8 mg/L TCEQ screening level. The data are presented in Table 5A-6.

Segment 0612: Total Phosphorus

There are 64 records are available for total phosphorus in surface waters for segment 0612 and its subsegments (period of record from January 1990 to November 2002). The data range from 0.01 mg/L to 1.622 mg/L. There were 42 observations that were higher than the 0.05 mg/L EPA reference criterion and 3 observations that were higher than the 0.8 mg/L TCEQ screening level. The data are presented in Table 5A-6.

Segment 0611: Orthophosphorus

There are 173 records available for orthophosphorus in surface waters for segment 0611 and its subsegments (period of record from January 1990 to August 2002). The data range from 0.001 mg/L to 4.12 mg/L. There were 31 observations that were higher than the 0.5 mg/L TCEQ

screening level for orthophosphorus. The data are presented in Table 5A-7.

Segment 0612: Orthophosphorus

There are 66 records available for ortho-phosphorus in surface waters for segment 0612 and its subsegments (period of record from June 1990 to July 2002). The data range from 0.01 mg/L to 0.87 mg/L. There were two observations that were higher than the 0.5 mg/L TCEQ screening level. The data are presented in Table 5A-7.

Segment 0611: Total Nitrogen

There are 23 records available for total nitrogen in surface waters for segment 0611 and its subsegments (period of record from February 1993 to January 1998). The data range from 0.36 mg/L to 6.7 mg/L. There were 15 observations that were higher than the 0.507 mg/L EPA reference criterion. The data are presented in Table 5A-8.

Segment 0612: Total Nitrogen

There are 9 records are available for total nitrogen in surface waters for segment 0612 and its subsegments (period of record from August 1993 to January 1998). The data range from 0.11 mg/L to 1.05 mg/L. There were five observations that were higher than the 0.507 mg/L EPA reference criterion. The data are presented in Table 5A-8.

Segment 0611: Nitrate/Nitrite

There are 253 records available for nitrate/nitrite in surface waters for segment 0611 and its subsegments (period of record from January 1990 to August 2002). The data range from 0.01 mg/L to 13.4 mg/L. There were 247 observations that were higher than the 0.067 mg/L EPA reference criterion and 32 observations that were higher than the 2.76 mg/L TCEQ screening level. The data are presented in Table 5A-9.

Segment 0612: Nitrate/Nitrite

There are 47 records available for nitrate/nitrite in surface waters for segment 0612 and its subsegments (period of record from June 1991 to July 2002). The data range from 0.02 mg/L to 5.4 mg/L. There were 45 observations that were higher than the 0.067 mg/L EPA reference criterion and 2 observations that were higher than the 0.2.76 mg/L TCEQ screening level. The data are presented in Table 5A-9.

Segment 0611: Total Kjeldahl Nitrogen

There are 93 records available for TKN in surface waters for segment 0611 and its subsegments (period of record from February 1993 to November 2002). The data range from 0.16 mg/L to 2.31 mg/L. There were 53 observations that were higher than the 0.44 mg/L EPA reference criterion. The data are presented in Table 5A-10.

Segment 0612: Total Kjeldahl Nitrogen

There are 38 records available for TKN in surface waters for segment 0612 and its subsegments (period of record from August 1993 to August 2002). The data range from 0.04 mg/L to 0.94 mg/L. There were 14 observations that were higher than the 0.44 mg/L EPA reference criterion. The data are presented in Table 5A-10.

Segment 0611: Ammonia

There are 321 records available for ammonia in surface waters for segment 0611 and its subsegments (period of record from January 1990 to November 2002). The data range from 0.01 mg/L to 8.95 mg/L. There were 37 samples that were higher than the 0.17 mg/L TCEQ screening level. The data are presented in Table 5A-11.

Segment 0612: Ammonia

There are 75 records available for ammonia in surface waters for segment 0612 and its subsegments (period of record from June 1990 to August 2002). The data range from 0.01 mg/L to 1.4 mg/L. There were four observations that were higher than the 0.17 mg/L TCEQ screening level. The data are presented in Table 5A-11.

Segment 0611: Biochemical Oxygen Demand

There are 145 records available for BOD in surface waters for segment 0611 and its subsegments (period of record from January 1994 to May 2000). The data range from 0.6 mg/L to 15.4 mg/L. There are no water quality criteria for BOD. The data are presented in Table 5A-12.

Segment 0612: Biochemical Oxygen Demand

There are 48 records available for BOD in surface waters for segment 0612 and its subsegments (period of record from November 1998 to April 2000). The data range from 0.5 mg/L to 2.5 mg/L. There are no water quality criteria for BOD. The data are presented in Table 5A-12.

Segment 0611: Total Organic Carbon

There are 138 records available for TOC in surface waters for segment 0611 and its subsegments (period of record from January 1990 to November 2002). The data range from 1 mg/L to 19 mg/L. There are no water quality criteria for TOC. The data are presented in Table 5A-13.

Segment 0612: Total Organic Carbon

There are 74 records available for TOC in surface waters for segment 0612 and its subsegments (period of record from June 1990 to August 2002). The data range from 1 mg/L to 14 mg/L. There are no water quality criteria for TOC. The data are presented in Table 5A-13.

5.2.2.2 Metals and Dioxin

Aluminum

There are 96 records available for dissolved aluminum concentrations measured in the surface waters (0.3 m) of segment 0611 and its subsegments (period of record: January 1985 to July 2002). The average dissolved aluminum concentration for all records is 335 µg/L. The minimum and maximum concentrations are 0.6 µg/L, and 2,720 µg/L. Of the 17 sites with dissolved aluminum records, only 2 sites (10532-Mud Creek at US 84 and 10627-Angelina River at US 59) had any records exceeding the TWQS of 991 µg/L for dissolved aluminum. Table 5A-14 summarizes the dissolved aluminum records for segment 0611.

There are 31 records available for dissolved aluminum concentrations measured in the surface waters (0.3 m) of segment 0612 and its subsegments (period of record: December 1984 to July 2002). The average dissolved aluminum concentration for all records is 404 µg/L. The minimum and maximum concentrations are 2.9 µg/L, and 3,800 µg/L. Of the 7 sites with dissolved aluminum records, only station 10636 (Attoyac Bayou at SH 21) showed any exceedances of the TWQS of 991 µg/L for dissolved aluminum. These exceedances occurred on October 14, 1986 (3,800 µg/L); August 7, 1989 (1,080 µg/L); and June 25, 1991 (3,560 µg/L). Table 5A-15 summarizes the dissolved aluminum records for segment 0612.

Twenty aluminum concentration records are available for bottom sediments, measured at 10 sites with a period of record from December 16, 1997 to May 10, 2000, for segment 0611 and its subsegments. Summary statistics are as follows for the 20 samples: average, 2,941.3 mg/kg; minimum, 0.25 mg/kg; maximum, 21,400 mg/kg. No samples exceed a PEC of 58,030 mg/kg (USEPA 1996).

Eight aluminum concentration records are available for bottom sediments, measured at six sites with a period of record from November 5, 1997, to March 18, 2000, for segment 0612 and its subsegments. Summary statistics are as follows for the eight samples: average, 5,585.1 mg/kg; minimum 0.17 mg/kg; maximum, 20,100 mg/kg. There were no exceedances of a PEC of 58,030 mg/kg (USEPA 1996).

Arsenic

There are 58 records available for dissolved arsenic in surface waters of segment 0611 and its subsegments (period of record: October 1993 to April 2002). Twenty-six records (period of record: January1994 to March 2002) are available for dissolved arsenic in the surface waters of segment 0612 and its subsegments. No exceedances of the acute or chronic TSWQS (390 µg/L and 190 µg/L) were observed. Table 5A-16 summarizes the dissolved arsenic concentrations observed in segments 0611 and 0612.

Copper

There are 82 records available for dissolved copper in surface waters for segment 0611 and its subsegments, with a period of record from October 1993 to July 2002. Table 5 in the *Procedures to Implement the TSWQS Guidance* (TCEQ 2000) provides a 15th percentile hardness value for segment 0611 of 30 mg/L as $CaCO_3$. Copper criteria calculated using this value for segment 0611 are 4.4 µg/L (chronic) and 5.9 µg/L (acute). Of the 82 available dissolved copper records, 42 exceed the calculated chronic and acute criteria. However, 30 of the 42 samples that exceeded both the chronic and acute criteria were nondetects with detection limits of 6 µg/L or 10 µg/L. Table 5A-17 includes the detection records for segment 0611 that exceed the calculated chronic and acute criteria for dissolved copper. Table 5A-18 summarizes the available dissolved copper data for segment 0611.

There are 29 records available for dissolved copper in surface waters for segment 0612, with a period of record from January 1994 to July 2002. Table 5 in the *Procedures to Implement the TSWQS Guidance* (TCEQ 2000) provides a 15th percentile hardness value for segment 0612 of 28 mg/L as $CaCO_3$. Copper criteria calculated using this value for segment 0612 are 4.1 µg/L (chronic) and 5.6 µg/L (acute). When the 29 records were screened using the calculated criteria, 19 exceedances of the chronic criterion were revealed. Of these, 18 also exceeded the acute criterion. However, 18 of the 19 samples that exceeded the chronic criterion were nondetects with detection limits of 6 µg/L or 10 µg/L, and all records exceeding the acute criterion were based on nondetects. One sample from station 16076 on March 7, 2001 (5 µg/L) exceeded the chronic criterion of 4.1 µg/L. Table 5A-19 summarizes the available dissolved copper data for segment 0612.

Lead

There are 80 records available for dissolved lead in surface waters for segment 0611, with a period of record from October 1993 to July 2002. Using the 15th percentile hardness value (30 mg/L as $CaCO_3$), the calculated chronic criterion for lead for segment 0611 is 0.54 µg/L and the acute criterion is 15.7 µg/L. When the 80 records were screened using the calculated criteria, 77 records exceeded the chronic criterion. However, of the 77 samples that exceeded the chronic criterion, some were reported as nondetects with detection limits of 1 µg/L, 2 µg/L, or 100 µg/L. Fifteen samples from station 10627 were reported as nondetects with a detection limit of 100 µg/L, exceeding the acute criterion of 15.7 µg/L. The remaining four detected concentrations that exceeded the chronic criterion are included in Table 5A-20. Table 5A-21 summarizes dissolved lead concentrations that exceeded the calculated chronic criteria for segment 0611.

There are 32 records available for dissolved lead in surface waters for segment 0612 (period of record from January 1994 to July 2002). Table 5 in *Procedures to Implement the TSWQS Guidance* (TCEQ 2000) provides a calculated 15th percentile hardness value for segment 0612 of 28 mg/L as $CaCO_3$. Using the 15th percentile hardness value, the chronic criterion for lead for segment 0612 is 0.5 µg/L and the acute criterion is 14.4 µg/L. Of the 32 records, 31 records exceeded the chronic criterion and 15 exceeded the acute criterion. However, 29 of these exceedances were nondetects with detection limits of 1 µg/L, 2µg/L, or 100 µg/L. The remaining two detections are presented in Table 5A-20. Table 5A-21 summarizes the available dissolved lead data for segment 0612.

Selenium

There are 84 records available for total selenium for segment 0611 (period of record from June 1975 to March 2002). Four exceedances of the chronic criterion (5 µg/L) were observed, one of which also exceeded the acute criterion (20 µg/L). However, these exceedances are based on records reported as nondetects with reporting limits of 20 µg/L or 25 µg/L. Table 5A-22 summarizes the available total selenium data for segment 0611.

There are 17 records available for total selenium for segment 0612 and its subsegments (period of record from July 1974 to March 2002). All 17 records are reported as nondetects. Therefore, there were no exceedances of the total selenium criteria. However, the detection limits for four records exceeded the chronic and acute criteria of 5 µg/L and 20 µg/L. Table 5A-23 summarizes the available total selenium data for segment 0612.

Zinc

There are 82 records available for dissolved zinc for segment 0611 and its subsegments (period of record from October 1993 to July 2002). Using the 15th percentile hardness value (30 mg/L as $CaCO_3$), the calculated chronic criterion for zinc for segment 0611 is 37.7 µg/L, and the acute criterion is calculated to be 41.3 µg/L. Of the 82 records, there were 10 exceedances of the chronic and acute criteria. These exceedances are presented in Table 5A-24. Table 5A-25 summarizes the available dissolved zinc data for segment 0611.

There are 32 records available for dissolved zinc in surface waters for segment 0612 and its subsegments (period of record from January 1994 to July 2002). Using the 15th percentile hardness value (28 mg/L as $CaCO_3$), the chronic criterion for zinc for segment 0611 is 35.5 µg/L and the acute criterion is calculated to be 38.9 µg/L. Of the 32 records, one exceeded the chronic and acute criteria. This exceedance occurred at station 10636 on May 1, 2001, with a dissolved zinc concentration of 41 µg/L and sample-specific hardness of 58 mg/L as $CaCO_3$. Table 5A-26 summarizes the available dissolved zinc data for segment 0612.

Dioxin

No data were located in TRACS for the identified STORET codes for dioxin or dioxin-like compounds in water, sediment, or tissues.

5.2.2.3 Bacteria

Segment 0611: Fecal Coliform Bacteria

There are 339 records available for fecal coliform bacteria in surface waters for segment 0611 and its subsegments (period of record from January 1990 to November 2002). The data range from 1 count/100 mL to 15,000 counts/100 mL. There were 59 exceedances of the instantaneous criterion of 400 counts/100 mL. The data are presented in Table 5A-27.

Segment 0612: Fecal Coliform Bacteria

There are 74 records available for fecal coliform bacteria in surface waters for segment 0612 and its subsegments, with a period of record from June 1990 to August 2002. The data range from 1 count/100 mL to 2,300 counts/100 mL. There were 16 exceedances of the 400 counts/100 mL instantaneous criterion. The data are presented in Table 5A-27.

Segment 0611: Escherichia coli

There are 103 records available for *E. coli* in surface waters for segment 0611 and its subsegments (period of record from October 2000 to November 2002). The data range from 14.8 MPN/100mL to 3,970 MPN/100mL. There were 16 exceedances of the 394 MPN/100mL instantaneous criterion. The data are presented in Table 5A-28.

Segment 0612: Escherichia coli

There are 17 records available for *E. coli* in surface waters for segment 0612 and its subsegments (period of record from November 2000 to August 2002). The data range from 32.4 MPN/100 mL to 1,373 MPN/100 mL. There were 5 exceedances of the 394 MPN/100 mL instantaneous criterion. The data are presented in Table 5A-28.

5.2.2.4 Conventional Parameters

Segment 0611: Alkalinity

There are 106 records available for alkalinity in surface waters for segment 0611 and its subsegments, with a period of record from October 1993 to November 2002. The data range from 4.0 mg/L to 130 mg/L. There are no water quality criteria for alkalinity. The data are presented in Table 5A-29.

Segment 0612: Alkalinity

There are 32 records available for alkalinity in surface waters for segment 0612 and its subsegments (period of record from June 1990 to August 2002). The data range from 5.0 mg/L to 69 mg/L. There are no water quality criteria for alkalinity. The data are presented in Table 5A-29.

Segment 0611: Chloride

There are 360 records available for chloride in surface waters for segment 0611 and its subsegments (a period of record from January 1990 to November 2002). The data range from 2.6 mg/L to 474.9 mg/L. There were eight exceedances of the 125 mg/L criterion. The data are presented in Table 5A-30.

Segment 0612: Chloride

There are 109 records available for chloride in surface waters for segment 0612 and its subsegments (period of record from June 1990 to August 2002). The data range from 3 mg/L to 84.4 mg/L. There was one exceedance of the 75 mg/L criterion. The data are presented in Table 5A-30.

Segment 0611: Sulfate

There are 360 records available for sulfate in surface waters for segment 0611 and its subsegments (period of record from January 1990 to November 2002). The data range from 0.3 mg/L to 3272 mg/L. There were 16 exceedances of the 50 mg/L criterion. The data are presented in Table 5A-31.

Segment 0612: Sulfate

There are 110 records available for sulfate in surface waters for segment 0612 and its subsegments (period of record from June 1990 to August 2002). The data range from 0.1 mg/L to 444 mg/L. There were two exceedances of the 50 mg/L criterion. The data are presented in Table 5A-31.

Segment 0611: Total Suspended Solids

There are 421 records available for TSS in surface waters for segment 0611 and its subsegments (period of record from October 1994 to November 2002). The data range from 1.0 to 198 mg/L. There are no water quality criteria for TSS. The data are presented in Table 5A-32.

Segment 0612: Total Suspended Solids

There are 110 records available for TSS in surface waters for segment 0612 and its subsegments (period of record from June 1990 to July 2002). The data range from 2 to 100 mg/L. There are no water quality criteria for TSS. The data are presented in Table 5A-32.

Segment 0611: Total Dissolved Solids

There are 284 records available for TDS in surface waters for segment 0611 and its subsegments (period of record from August 1993 to November 2002). The data range from 9 to 606 mg/L. There were 87 exceedances of the TDS criterion. The data are presented in Table 5A-33.

Segment 0612: Total Dissolved Solids

There are 68 records available for TDS in surface waters for segment 0611 and its subsegments (period of record from August 1994 to August 2002). The data range from 54 to 10,100 mg/L. There were 67 exceedances of the TDS criterion. The data are presented in Table 5A-33.

Segment 0611: Water Temperature

There are 456 records available for temperature in surface waters for segment 0611 and its subsegments (period of record from January 1990 to November 2002). The data range from 2.7 °C to 32 °C. There were no exceedances of the 32.2 °C criterion. The data are presented in Table 5A-34.

Segment 0612: Water Temperature

There are 110 records available for temperature in surface waters for segment 0612 and its subsegments (period of record from June 1990 to July 2002). The data range from 2.2 °C to 29 ° C. There were no exceedances of the 32.2 °C criterion. The data are presented in Table 5A-34.

Segment 0611: pH

There are 507 records available for pH in surface waters for segment 0611 and its subsegments (period of record from January 1990 to November 2002). The data range from 4.8 to 8.5. There were 20 exceedances of the 6.0 to 8.5 criterion. The data are presented in Table 5A-35.

Segment 0612: pH

There are 118 records available for pH in surface waters for segment 0612 and its subsegments (period of record from June 1990 to July 2002). The data range from 5.7 to 8.9. There were 14 exceedances of the 6.0 to 8.5 criterion. The data are presented in Table 5A-35.

Segment 0611: Conductivity

There are 415 records available for specific conductance in surface waters for segment 0611 and its subsegments (period of record from January 1990 to November 2002). The data range from 21 µmos/cm to 738 µmos/cm. There are no water quality criteria for conductivity. The data are presented in Table 5A-36.

Segment 0612: Conductivity

There are 75 records available for specific conductance in surface waters for segment 0612 and its subsegments (period of record from June 1990 to July 2002). The data range from 35 µmos/cm to 1,110 µmos/cm. There are no water quality criteria for conductivity. The data are presented in Table 5A-36.

5.2.3 Impairment Summary

This section provides a summary of the TRACS data that exceeded the Texas water quality criteria, Texas nutrient screening levels, and/or EPA nutrient reference criteria for any of the analyzed parameters. The following sections provide a more detailed account of the number of observations, minimum observation, maximum observation, average, and number of exceedances of the applicable criteria or target for each of the parameters.

Dissolved Oxygen and Nutrients

There were 436 available grab samples for dissolved oxygen in segment 0611 and only 3 records ranging from 1.3-2.8 mg/L exceeded the minimum criterion. Of the available 24-hour measurements, 3 records exceeded the average criterion. One of these also exceeded the minimum criteria (station 16587). No exceedances of the dissolved oxygen average or minimum criteria were observed within segment 0612 for both grab samples and 24-hour measurements. While DO appears to experience occasional exceedances of the criteria, these exceedances do not appear to be persistent.

Nutrient data were compared to TCEQ's nutrient screening levels and EPA's nutrient reference criteria. For some parameters, there are large differences in the screening values, for example, chlorphyll a concentrations for TCEQs screening levels are about 19 times higher than EPA's reference values. Only two chlorophyll a samples were higher than the Texas screening levels in segment 0611 and none were observed in segment 0612. When the data were compared to the EPA reference levels, 136 chlorophyll a concentrations in segments 0611 and 0612 exceeded the reference values.

For the remaining nutrient parameters, there were high observations of total phosphorus, orthophosphorus, nitrite and nitrate, and ammonia in segments 0611 and 0612 that exceeded both the TCEQ and EPA reference screening values.

Nutrient data for segments 0611 and 0612 were compared to EPA's nutrient reference criteria for streams and rivers. This comparison found high observations of chlorophyll a, total phosphorus, total nitrogen, nitrite and nitrate, and total kjeldahl nitrogen.

Much of the nutrient data suggests loading, either from point or nonpoint sources, of nitrogen and phosphorus that may affect algal growth and subsequent DO dynamics in the tributaries as well as in Sam Rayburn Reservoir. Chlorophyll a in flowing systems such as those represented by segments 0611 and 0612 may underestimate actual algal production, which may be due to periphytic (attached algae) growth rather than pelagic (floating algae) algal growth (assuming that the chlorphyll a samples for these segments are from a filtered water sample). Similar to the data for segments 0610 and 0615, nutrient data suggests that the mechanisms are in place for eutrophication of the reservoir. Tributary data further reinforces this observation.

Assessments of whether or not loading is predominant from one arm (Attoyac Bayou segment 0612) versus the other (Angelina River segment 0611) are difficult to make for nutrients. A number of sample locations are present in both tributaries and only through the conduct of a proper loading analysis would one be able to discern where loads may be originating from in the watershed.

Metals

Dissolved aluminum, dissolved copper, dissolved lead, dissolved zinc, and total selenium all had data that exceeded the Texas water quality criteria specific to those metals. The dissolved aluminum exceedances were small in number (4 and 3 exceedances at segments 0611 and 0612, respectively). These exceedances occured at stations 10532 and 10627 in segment 0611 and

station 10636 in segment 0612. Some copper, lead, and selenium observations did exceed their criteria, but most of the samples were below the detection limit, so it was difficult to get an accurate assessment of the potential impairment. Twelve dissolved copper exceedances were observed at 11 stations in segment 0611. Eight of these exceedances were in the Mud Creek and West Mud Creek subsegments (0611C and 0611D) in the northwestern portion of the watershed below the City of Tyler. In segment 0612 only one sample from station 16076 on March 7, 2001 (5 µg/L) exceeded the dissolved copper criterion. Four dissolved lead exceedances were observed at 4 stations in segment 0611, whereas only 2 exccedances were observed at station 10636 on segment 0612. All exceedances of the total selenium criterion in segment 0611 and 0612 were based on nondetects. There were 10 dissolved zinc exceedances in segment 0611 and one exceedance in segment 0612. Similar to segments 0610 and 0615, metal concentrations in the reservoir tributaries are generally low and a number of the exceedances are based on detection limits that are greater than the criteria. Sampling and analyses of metals using lower detection limits will clarify whether or not potential metals issues exist in these tributaries.

Bacteria

Bacteria is a potential impairment on segments 0611 and 0612. There were 59 exceedances of the instantaneous fecal coliform bacteria criterion on segment 0611(17 percent of the samples). With maximum counts ranging from 180 to 15,000 counts/100 mL. Of these 59 exceedances, 23 are reproted from La Nana Bayou downstream of the city of Nacogdoches. There were 16 exceedances of the criterion on segment 0612 (22 percent of the samples), with maximum counts ranging from 130 to 2,300 counts/100 mL. There were also 16 exceedances of the instaneous *E. coli* criterion on segment 0611 (16 percent of samples) and 5 exceedances of the criterion on segment 0612 (29 percent of samples), with maximum counts of 122 to 3,970 counts/100 mL and 461to 1,373 counts/100 mL. Nine of the 16 exceedances in segment 0611 were from the La Nana Bayou stations 10474 and 10475, downstream of Nacogdoches.

Chloride and Sulfate

There were exceedances of both the chloride and sulfate criteria for segments 0611 and 0612. However, the percentage of observations exceeding the criteria was less than five percent.

TDS and pH

There were also several TDS and pH exceedances on segments 0611 and 0612 with more occurring for both parameters in segment 0612 than in 0611.

5.3 STORET Water Quality Data for Segments 0611 and 0612

Water quality monitoring data for the tributaries to Sam Rayburn Reservoir were collected from EPA's STORET database for the two segments composing the upstream portion of the Sam Rayburn Reservoir watershed (segments 0611 and 0612). This section is a summary and analysis of all of the water quality monitoring data available in EPA's STORET database from 1990 through the present for the tributaries to the Sam Rayburn Reservoir. The summarized data include only data collected from 1990 through the present even though additional data for years prior to 1990 are available for many of the monitoring stations. The more recent data will better represent the current conditions that caused Sam Rayburn Reservoir and some of its tributaries to be placed on the 2000 Texas section 303(d) list of impaired waters.

Because Sam Rayburn Reservoir was placed on the 2000 Texas section 303(d) list of impaired waterbodies for dissolved oxygen, pH, and aluminum impairments, these three parameters were analyzed in the tributaries draining to the reservoir. Several of those tributaries are also on the 2000 Texas section 303(d) list for bacteria (see Section 1.2), and therefore any parameters that affect dissolved oxygen (i.e., nutrients, transparency, and chlorophyll a) and bacteria were included in the analysis. At the request of TCEQ, additional parameters were also included in the analysis to determine whether there are additional potential impairments. For parameters that have water quality criteria or screening levels, the number of exceedances was determined for each station. Section 1.3 discusses the appropriate water quality criteria and screening levels. All stations were analyzed for the following parameters:

- Temperature
- Biochemical oxygen demand
- Dissolved solids
- Total nitrogen
- Fecal coliform bacteria
- Dissolved aluminum
- Dissolved zinc
- Transparency
- pH
- Ammonia
- Phosphorus
- Chloride
- Dissolved copper
- Conductivity
- Total alkalinity
- Nitrate and nitrite
- Total organic carbon
- Sulfate
- Dissolved lead
- Dissolved oxygen
- Total solids
- Total Kjeldahl nitrogen
- Chlorophyll
- Dissolved arsenic
- Selenium

5.3.1 STORET Monitoring Stations for the Tributaries to the Sam Rayburn Reservoir

There are 83 monitoring stations in the STORET database with water quality data from Sam Rayburn Reservoir's tributaries; however, only 11 stations have post-1989 data. The 11 stations with recent data were the only stations analyzed for water quality trends in the watershed. There were nine monitoring stations on segment 0611 (including the Angelina River (0611), East Fork Angelina River (0611A), Mud Creek (0611C), and West Mud Creek (0611D)) and two on segment 0612 (Attoyac Bayou). Table 5-5 presents the stations in the tributaries to the Sam Rayburn Reservoir with post-1989 water quality data. Figure 5-10 shows the locations of the stations in the watershed.

Table 5-5. Water Quality Monitoring Stations with Data since 1990 on the Tributaries to Sam Rayburn Reservoir

Segment ID	Station ID	Station Name
0611 (Angelina River)	08037000	Angelina River near Lufkin
	06110100	Angelina River at US 59 north of L
	10633	Angelina River at SH 204
	14470	Angelina River at US 84
0611A (East Fork Angelina River)	10551	East Fork Angelina River
	13788	East Fork Angelina River
0611C (Mud Creek)	10532	Mud Creek at US 84
	14477	Mud Creek at US 79
0611D (West Mud Creek)	10540	West Mud Creek at FM 346
0612 (Attoyac Bayou)	06120100	Attoyac Bayou at SH 21 E
	08038000	Attoyac Bayou near Chiren

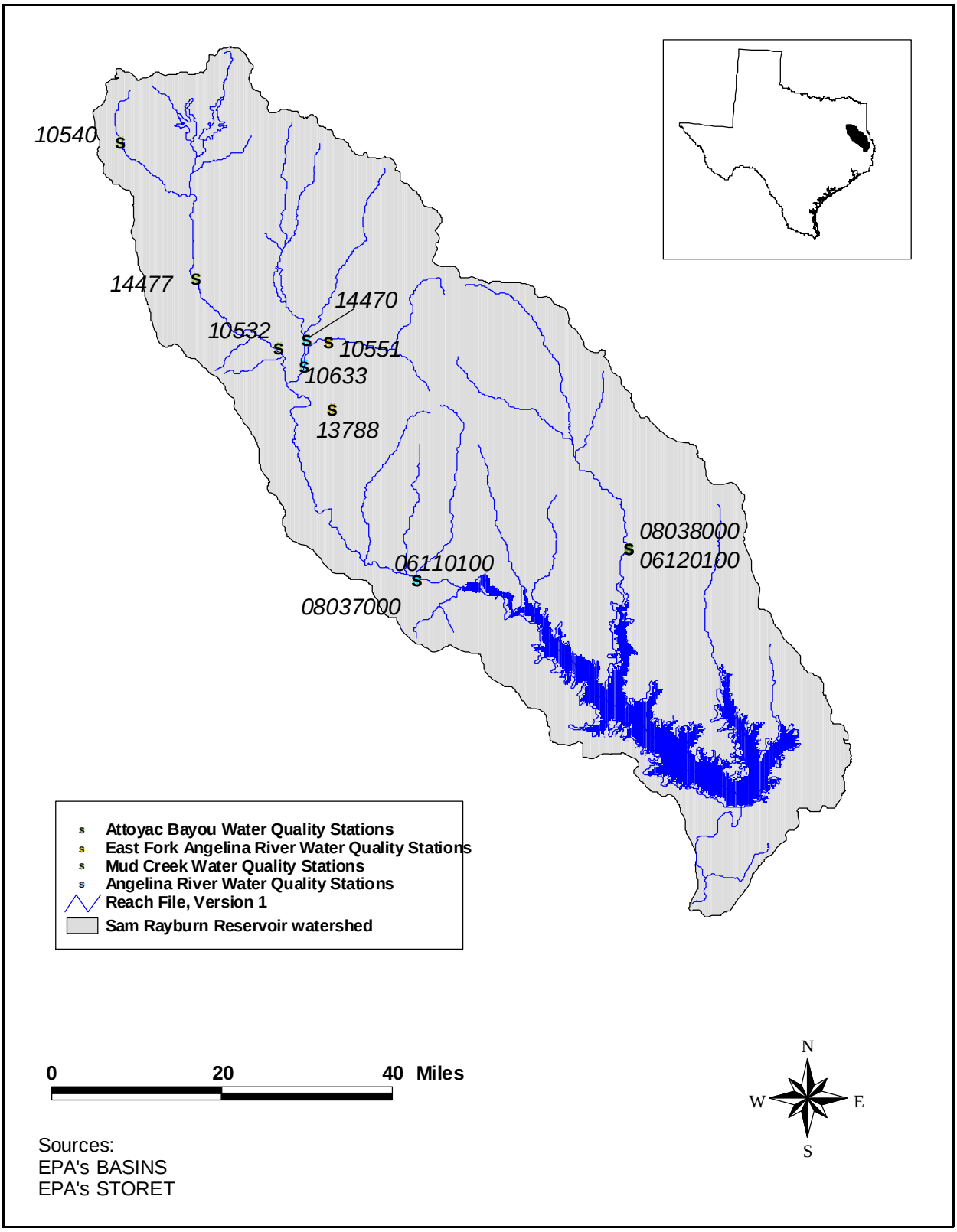

Figure 5-10. Locations of the STORET Water Quality Monitoring Stations on the Tributaries to Sam Rayburn Reservoir

5.3.2 Water Quality Data Analysis for Segment 0611 and 0612

5.3.2.1 Dissolved Oxygen and Nutrients

Segment 0611: Dissolved Oxygen

There are 9 monitoring stations on segment 0611 with a total of 84 dissolved oxygen observations. The lowest dissolved oxygen observation was 4.7 mg/L at station 14470 (Angelina River) on June 12, 1996. The maximum dissolved oxygen observation was 12.4 mg/L at station 14477 (Mud Creek) on January 9, 1996. There were no exceedances of the 3.0 mg/L criterion for dissolved oxygen grab samples. Table 5B-1 presents a summary of the dissolved oxygen data for segment 0611. Tables 5B-1 through 5B-36 are presented in Appendix 5B at the end of Section 5.0 because of their large size.

Segment 0612: Dissolved Oxygen

There are 2 monitoring stations on segment 0612 with a total of 26 dissolved oxygen observations. The lowest dissolved oxygen observation was 6.1 mg/L at station 06120100 on June 13, 1990, and June 25, 1991; therefore, there were no exceedances of the 3.0 mg/L dissolved oxygen criterion. The maximum dissolved oxygen observation was 11.6 mg/L at station 08038000 on February 9, 1995. Table 5B-2 presents a summary of the dissolved oxygen data available for segment 0612.

Segment 0611: Chlorophyll a

There are 4 stations on segment 0611 with 29 chlorophyll a observations. The minimum observation was 1.0 µg/L at several stations on multiple dates. The maximum observation was 17.7 µg/L at station 14470 on October 31, 1995. This was the only observation that was higher than the chlorophyll a screening level of 11.6 µg/L for freshwater Texas streams; however, 13 observations were higher than the EPA reference criterion for chlorophyll a of 0.566 µg/L. Table 5B-3 presents a summary of the available chlorophyll a data for segment 0611.

Segment 0612: Chlorophyll a

There is one station on segment 0612 with chlorophyll a data. Station 06120100 has three observations of chlorophyll a with a minimum concentration, 1.0 µg/L, on June 25, 1991, and a maximum concentration, 10.2 µg/L, on July 15, 1992. There were no observations higher than the 11.4 µg/L screening level for chlorophyll a in freshwater Texas streams, but there was one observation higher than the 2.834 mg/L chlorophyll a EPA reference criterion. The high observation occurred on July 15, 1992. Table 5B-4 presents a summary of the available chlorophyll a data for segment 0612.

Segment 0611: Transparency

Transparency was measured as Secchi disc depth in segment 0611. There are 6 monitoring stations with a total of 33 Secchi depth observations in segment 0611. The number of observations at each station ranges from 1 to 13. The minimum Secchi depth was 0.15 meter at station 10532 on May 21, 1998. The maximum Secchi depth of 0.9 meter was observed at station 13788 on both December 27, 1993, and November 6, 1996. There are no transparency criteria for Texas freshwater streams to which the data can be compared. Table 5B-5 presents the Secchi depth data summary for segment 0611.

Segment 0612: Transparency

Transparency was also measured as Secchi disc depth in segment 0612. There is one monitoring station with a total of three Secchi depth observations in segment 0612. Station 06120100 had a minimum Secchi depth of 0.18 meter on June 25, 1991. The maximum Secchi depth, 0.5 meter was observed on July 15, 1992. There are no transparency criteria for Texas freshwater streams to which the data can be compared. Table 5B-6 presents the Secchi depth data summary for segment 0612.

Segment 0611: Total Phosphorus

There are 4 stations with 28 total phosphorus observations on segment 0611. The minimum observation was 0.01 mg/L at station 13788 (East Fork Angelina River) on December 27, 1993. The maximum observation was 0.53 mg/L at station 14477 (Mud Creek) on October 16, 1995. There were no observations above the 0.8 mg/L screening level for Texas freshwater streams; however, there were 21 observations above the 0.05 mg/L EPA reference criterion. Table 5B-7 presents a summary of the total phosphorus data available for segment 0611.

Segment 0612: Total Phosphorus

There is only one monitoring station (06120100) with three total phosphorus observations on segment 0612. The minimum observations was 0.08 mg/L on July 15, 1992, and the maximum was 0.15 mg/L on June 25, 1991. No observations were higher than the 0.8 mg/L screening level for Texas freshwater streams; however, all three observations were higher than the 0.05 mg/L EPA reference criterion. Table 5B-8 presents a summary of the total phosphorus data available for segment 0612.

Segment 0611: Orthophosphorus

There are five monitoring stations on segment 0611 with a total of 10 orthophosphorus observations. Five of the observations are above the 0.5 mg/L screening level for orthophosphorus in Texas freshwater streams. The minimum observation was 0.1 mg/L at station 14470 on the Angelina River in both April and June 1996. The maximum observation was 2.2 mg/L at station 10540 on West Mud Creek on May 21, 1998. The three stations with high concentrations of orthophosphorus are 10633 (Angelina River), 10532 (Mud Creek), and 10540 (West Mud Creek). Table 5B-9 presents a summary of the ortho-phosphorus data available for segment 0611.

Segment 0612: Orthophosphorus

There are no monitoring stations with orthophosphorus data on segment 0612 in the STORET database.

Segments 0611 and 0612: Total Nitrogen

There were no monitoring stations on segments 0611 and 0612 with NH_4, TKN, and NO_2+NO_3 observations on the same dates. Ammonia, TKN, and NO_2+NO_3 data are necessary to calculate total nitrogen in the waterbodies.

Segment 0611: Nitrite and Nitrate

There were 7 water quality monitoring stations on segment 0611 with a total of 19 NO_2+NO_3 observations. The minimum observation was 0.01 mg/L at station 14470 in the Angelina River on October 28, 1996. The maximum observation was 10.40 mg/L at station 10540 in West Mud Creek on May 21, 1998. Three observations were higher than the Texas screening level for NO_2+NO_3 (2.76 mg/L), and all three elevated concentrations were inn West Mud Creek. Eighteen of the 19 samples were higher than the 0.067 mg/L EPA reference criterion for streams. Table 5B-10 presents a summary of the NO_2+NO_3 data for segment 0611.

Segment 0612: Nitrite and Nitrate

Segment 0612 contains one monitoring station with NO_2+NO_3 observations. There are two observations at this station. The minimum observation, 0.53 mg/L, was observed on June 25, 1991, and the maximum observation, 0.72 mg/L, was observed on July 15, 1992. There were no observations higher than the Texas screening level of 2.76 mg/L for NO_2+NO_3 in freshwater streams; however, both observations were higher than the EPA reference criterion of 0.067 mg/L for NO_2+NO_3. Table 5B-11 presents a summary of the NO_2+NO_3 data for segment 0612.

Segment 0611: Total Kjeldahl Nitrogen

There are four monitoring stations with a total of 17 TKN observations on segment 0611. The minimum TKN observation was 0.28 mg/L at stations 14470 (Angelina River) and 13788 (East Fork Angelina River) on the dates of 12/27/93, 5/26/94, and 4/10/96. The maximum TKN concentration was 0.88 mg/L at station 14477 on Mud Creek on April 10, 1996. Five observatiosn were higher than EPA's reference criterion of 0.44 mg/L for TKN. Table 5B-12 presents a summary of the TKN data available for segment 0611.

Segment 0612: Total Kjeldahl Nitrogen

There are no TKN data available in the STORET database for segment 0612.

Segment 0611: Ammonia

There are nine monitoring stations on segment 0611 with ammonia (un-ionized NH_3) observations. There are a total of 50 observations at those stations. The minimum observation of 0.000004 mg/L was observed at station 06110100 on November 6, 1991. The maximum observation of 0.0009 mg/L was observed at station 10540 on May 21, 1998. None of the ammonia observations were higher than the Texas screening level of 0.17 mg/L for ammonia. Table 5B-13 presents a summary of the ammonia data for segment 0611.

Segment 0612: Ammonia

There are 2 stations (06120100 and 08038000) on segment 0612 with a total of 23 un-ionized ammonia observations. The minimum ammonia observation was 0.00001 mg/L at station 08038000 on April 20, 1995. The maximum observation was 0.001 mg/L at station 06120100 on July 15, 1992. None of the ammonia observations were higher than the Texas screening level of 0.17 mg/L. Table 5B-14 presents a summary of total ammonia data available for segment 0612.

Segment 0611: Biochemical Oxygen Demand

There is one monitoring station that has BOD_5 data n segment 0611. Monitoring station 08037000 has 20 observations from January 27, 1994, through March 27, 1997. The lowest BOD_5 observation was 0.6 mg/L on June 30, 1995. The maximum BOD_5 observation was 2.4 mg/L on June 9, 1994, and February 13, 1997. There are no BOD_5 water quality criteria to which the data can be compared. Table 5B-15 presents a summary of the available BOD_5 data for segment 0611.

Segment 0612: Biochemical Oxygen Demand

There is one monitoring station that has BOD_5 observations on segment 0612. Monitoring station 08038000 has 20 observations from January 27, 1994, through March 27, 1997. The lowest BOD_5 observation was 0.5 mg/L on July 29, 1994. The maximum BOD_5 observation was 2.3 mg/L on February 15, 1996. There are no BOD_5 water quality criteria to which the data can be compared. Table 5B-16 presents a summary of the BOD_5 data for segment 0612.

Segment 0611: Total Organic Carbon

There are five monitoring stations and 48 TOC observations on segment 0611. The minimum TOC observation was 2.0 mg/L at station 13788 (East Fork Angelina River) on December 27, 1993. The maximum TOC observation, 19.0 mg/L, was at station 08037000 on the Angelina River on February 13, 1997. There are no TOC criteria to which the water quality data can be compared. Table 5B-17 presents a summary of the available TOC data for segment 0611.

Segment 0612: Total Organic Carbon

Segment 0612 has 2 monitoring stations with a total of 21 TOC observations. The minimum observation was 3.0 mg/L at station 06120100 on July 15, 1992. The maximum observation was 11.0 mg/L at station 08038000 on January 27, 1994, and April 26, 1996. There are no Texas

TOC criteria to which the water quality data can be compared. Table 5B-18 presents a summary of the available TOC data for segment 0612.

5.3.2.2 Metals and Dioxin

Segment 0611: Metals

Six metals were analyzed for segment 0611: dissolved arsenic, dissolved aluminum, dissolved copper, dissolved lead, total selenium, and dissolved zinc. The metals observations were compared to the appropriate water quality criteria. (See Section 1.3.)

Two monitoring stations on segment 0611 have dissolved arsenic data. There are 11 observations at these stations. The minimum observation, 1.0 µg/L, was observed on most days at station 08037000, except for 2 days that had observations of 2.0 µg/L. Both of these concentrations are well below the 360 µg/L and 50 µg/L aquatic life and human health water quality criteria, respectively. There was one dissolved arsenic observation at station 13788 with a concentration of 2.0 µg/L as well.

There is one monitoring station (06110100) with seven dissolved aluminum observations on segment 0611. The minimum observation was 310 µg/L on January 15, 1990. The maximum observation was 2,410 µg/L on August 8, 1990. The observations were compared to the acute dissolved aluminum criterion of 991 µg/L, which resulted in three exceedances of the criterion in August and October 1990 and April 1991.

There are two monitoring stations with dissolved copper data for segment 0611. Station 08037000 has 10 observations and station 13788 has one observation. All observations at station 08037000 were recorded as 10 µg/L, which was the detection limit. The 10 µg/L detection limit is higher than the calculated dissolved copper acute criterion of 5.9 µg/L and the chronic criterion of 4.4 µg/L. Therefore, it could not be determined if the waterbody is actually exceeding the dissolved copper criteria. The maximum dissolved copper observation is 11.0 µg/L at station 13788, which exceeds the calculated acute criterion of 5.9 µg/L.

Segment 0611 has 2 monitoring stations with dissolved lead data. Station 13788 has one observation and station 08037000 has 10 observations. The minimum dissolved lead observation was 1.0 µg/L at station 13788 on October 26, 1993. The maximum observation was 20.0 µg/L at station 08037000 on August 31, 1995. There is one exceedance of the aquatic life acute criterion of 15.7 µg/L in August 1995 at station 08037000. There were also 4 exceedances of the 4.98 µg/L human health criterion at station 08037000. Six of the observations were below the detection limit of 10 µg/L. The nondetect samples were not considered to be exceeding the criteria, although, that possibility does exist because the detection limit is above both the chronic criterion and human health criterion.

There is only one observation of total selenium on segment 0611. The observation was 5 µg/L at station 106333 on August 28, 1997. The 5 µg/L concentration does not exceed the total selenium acute aquatic life or human health criteria of 20 µg/L and 50 µg/L, respectively.

Segment 0611 has 2 monitoring stations with a total of 11 dissolved zinc observations. Station

13788 on the East Fork Angelina River has 1 day of data and station 08037000 on the Angelina River has 10 days of data. The minimum concentration of dissolved zinc (1.0 µg/L) was observed in August 1995 and February 1996 at station 08037000. The maximum observation was 48.0 µg/L at station 13788 in October 1993. This maximum concentration was the only observed exceedance of the calculated 41.3 µg/L dissolved zinc acute aquatic life criterion. There were no exceedances of the 37.7 µg/L chronic criterion. Table 5B-19 presents a summary of the available metals data for segment 0611.

Segment 0612: Metals

Six metals were analyzed for segment 0612: dissolved arsenic, dissolved aluminum, dissolved copper, dissolved lead, total selenium, and dissolved zinc. The metals observations were compared to the appropriate water quality criteria. (See Section 1.3.)

There is 1 monitoring station (08038000) with 10 dissolved arsenic observations on segment 0612. All 10 observations were 1.0 µg/L. There were no exceedances of the acute aquatic life, chronic aquatic life, or human health arsenic water quality criteria of 360 µg/L, 190 µg/L, and 50 µg/L, respectively.

There is one monitoring station with one dissolved aluminum observation on segment 0612. Station 06120100 reports a concentration of 3,560 µg/L on June 25, 1991, which exceeds the Texas aquatic life acute water quality criterion of 991 µg/L for dissolved aluminum.

Station 08038000 is the only station with dissolved copper data in segment 0612. There are a total of 10 observations at the station, and all observations are nondetects. The detection limit is 10 µg/L and is not considered to be exceeding the water quality criteria because the actual value of the sample is not known. The detection limit should be decreased for future sampling to allow for comparison of the data to the acute water quality criterion of 5.6 µg/L and the chronic water quality criterion of 4.4 µg/L.

Station 08038000 is the only station with dissolved lead data on segment 0612. It has 10 days of observation data. All observations were below the detection limit of 10 µg/L, and therefore, there were no exceedances of the calculated acute water quality criterion of 14.4 µg/L. The detection limit should be decreased for future sampling to allow for comparison of the data to the chronic criterion of 0.5 µg/L and the 4.98 µg/L human health criterion.

No total selenium data were available for segment 0612.

Station 08038000 has 10 observations of dissolved zinc on segment 0612. The minimum observation was 3 µg/L on August 29, 1995, and the maximum observation was 20 µg/L on August 25, 1994. There were no exceedances of the calculated acute and chronic water quality criteria of 38.9 µg/L and 35.5 µg/L, respectively.

Table 5B-20 presents a summary of the metals data for segment 0612.

Dioxin

There were no dioxin data for segment 0611 or 0612 in the STORET database.

5.3.2.3 Bacteria

Segment 0611: Fecal Coliform Bacteria

Segment 0611 has 8 monitoring stations with a total of 69 fecal coliform bacteria observations. The minimum fecal coliform bacteria observation was 10 counts/100 mL at station 06110100 (Angelina River) on January 5, 1990. The maximum fecal coliform bacteria concentration was 8,100 counts/100 mL at station 10532 (Mud Creek) on November 26, 1996. There was a total of 16 exceedances of the 400 counts/100 mL instantaneous criterion. Table 5B-21 presents a summary of the available fecal coliform bacteria data for segment 0611.

Segment 0612: Fecal Coliform Bacteria

There is only one station (06120100) with 8 fecal coliform bacteria observations on segment 0612. The minimum observation was 97 counts/100 mL on June 13, 1990 and the maximum concentration was 1,520 counts/100 mL on June 25, 1991, which was the only exceedance of the 400 counts/100 mL instantaneous criterion for Attoyac Bayou. Table 5B-22 presents a summary of the available fecal coliform bacteria data for segment 0612.

5.3.2.4 Conventional Parameters

Segment 0611: Total Alkalinity

There are five stations with total alkalinity observations on segment 0611 streams. The 5 stations have a combined total of 39 total alkalinity observations. The minimum total alkalinity concentration, 4 mg/L, was observed at station 06110100 on February 11, 1991. The maximum observed total alkalinity concentration was 66 mg/L at station 14470 on June 12, 1996. There are no total alkalinity criteria to which the observed data can be compared. Table 5B-23 presents a summary of the total alkalinity data available for segment 0611.

Segment 0612: Total Alkalinity

There are 2 stations with total alkalinity observations on segment 0612 streams. The 2 stations have a combined total of 14 total alkalinity observations. The minimum total alkalinity concentration, 16 mg/L, was observed at stations 06120100 and 08038000 on June 25, 1991, and March 22, 1994, respectively. The maximum observed total alkalinity concentration was 44 mg/L at station 06120100 on July 15, 1992. There are no total alkalinity criteria to which the observed data can be compared. Table 5B-24 presents a summary of the total alkalinity data available for segment 0612.

Segment 0611: Chloride

There are 9 monitoring stations with a total of 60 chloride observations on segment 0611. The average chloride concentration for each stream was calculated and compared to the 125 mg/L chloride criterion for segment 0611. The average chloride concentration in the Angelina River was 18.4 mg/L. The average chloride concentration in the East Fork Angelina River was 9.6 mg/L. There were not enough samples for Mud Creek or West Mud Creek to compare the concentrations to the criterion (at least 10 samples over a 5-year period are needed). There were no exceedances of the chloride criterion in the Angelina River or East Fork Angelina River. Table 5B-25 presents a summary of the available chloride data at segment 0611.

Segment 0612: Chloride

There are 2 stations with a total of 22 chloride observations on segment 0612. The average chloride concentration was 9.4 mg/L. There were no exceedances of the 75 mg/L chloride criterion for the Attoyac Bayou. Table 5B-26 presents a summary of the available chloride data for segment 0612.

Segment 0611: Sulfate

There are 60 sulfate observations among 9 monitoring stations on segment 0611. The average sulfate concentration on each stream segment was compared to the 50 mg/L criterion. The average sulfate concentration for the Angelina River was 22.2 mg/L, and the average sulfate concentration for the East Fork Angelina River was 40.9 mg/L. There were not enough observations (at least 10 samples over a 5-year period are needed) to calculate a sulfate average for Mud Creek or West Mud Creek. There were no exceedances of the criterion. Table 5B-27 presents a summary of the available sulfate data for segment 0611.

Segment 0612: Sulfate

There are 2 monitoring stations with a total of 22 sulfate observations on segment 0612. The average sulfate concentration on Attoyac Bayou was 14.7 mg/L. There were no exceedances of the 50 mg/L annual average sulfate criterion for the Attoyac Bayou. Table 5B-28 presents a summary of the available sulfate data for segment 0612.

Segment 0611: Total Suspended and Dissolved Solids

There are eight monitoring stations with total suspended solids observations and two stations with total dissolved solids observations in segment 0611. Total suspended solids (TSS) and total dissolved solids (TDS) are reported in the STORET database as total nonfiltered residue and dissolved residue, respectively. The eight stations have a combined total of 78 TSS observations. The minimum TSS value of 10.0 mg/L was observed at station 13788 (East Fork Angelina River) on December 27, 1993. The maximum observed TSS value was 64.0 mg/L at station 08037000 on February 13, 1997. Texas does not have TSS criteria to which the water quality data can be compared; however, none of the TSS observations were exceptionally high.

Two stations on segment 0611 have a total of nine TDS observations. Average TDS concentrations at each station were compared to the appropriate water quality criterion. The minimum average concentration was 172.4 mg/L at station 14470 (Angelina River), and the maximum average concentration was 188.5 mg/L at station 14470. There were no exceedances of the Texas TDS criterion of 250 mg/L for segment 0611. Table 5B-29 presents a summary of the TSS and TDS data for segment 0611.

Segment 0612: Total Suspended and Dissolved Solids

There are two monitoring stations with TSS observations on segment 0612. There are no stations with TDS observations. TSS is reported in the STORET database as total nonfiltered residue. The two stations have a combined total of 22 TSS observations. The minimum TSS value, 4.0 mg/L, was observed at station 08038000 on August 21, 1996. The maximum observed TSS value was 100.0 mg/L at station 08038000 on January 27, 1994. There are no TSS criteria to which the data can be compared. Table 5B-30 presents a summary of the TSS data available for segment 612.

Segment 0611: Water Temperature

There are 9 monitoring stations with water temperature data and 93 temperature observations on the tributaries that make up segment 0611. The minimum temperature observed in segment 0611 was 37 °F at station 14477 on January 9, 1996. The maximum temperature 86.7 °F was observed at station 10532 on May 22, 1997. There were no exceedances of the 90 °F temperature criterion for segment 0611. Table 5B-31 presents a summary of the water temperature data collected for segment 0611.

Segment 0612: Water Temperature

There are two monitoring stations on segment 0612, and both stations have water temperature observations. There are 26 water temperature observations for Attoyac Bayou since 1990. The minimum temperature of 48.2 °F was observed at station 08038000 on February 9, 1995. The maximum observed temperature in Attoyac Bayou was 84.2 °F at station 08038000 on July 23, 1996. There were no exceedances of the 90 °F temperature criterion for segment 0612. Table 5B-32 presents a summary of the water temperature data collected for segment 0612.

Segment 0611: pH

There are 9 monitoring stations with a total of 93 pH observations on segment 0611. The minimum pH value of 5.5 was observed at station 06110100 on August 8, 1990. The maximum observed pH value was 7.5 at station 08037000 on January 27, 1994. The observations were compared to the Texas pH criteria, which require the pH of segment 0611 to be between 6 and 8.5. There were 5 exceedances of the criteria, and all 5 exceedances were slightly below the lower threshold of 6.0. All exceedances were in the main stem of the Angelina River, not in its tributaries. Table 5B-34 presents a summary of the pH data available for segment 0611.

Segment 0612: pH

There are 2 stations with pH data on segment 0612, and they have a total of 26 pH observations. The minimum pH value, 5.9, was observed at station 08038000 on April 20, 1995. The maximum observed pH value was 7.5 at station 06120100 on June 25, 1991. The observations were compared to the Texas pH criteria, which require the pH of segment 0612 to be between 6.0 and 8.5. There was one exceedance of the criteria in April 1995 when the pH dropped below the lower threshold of 6.0. Table 5B-33 presents a summary of the pH data for segment 0612.

Segment 0611: Conductivity

There are 9 monitoring stations on segment 0611 with a total of 93 conductivity observations. The lowest conductivity observation was 42 µmos/cm at station 10551, and the maximum conductivity observation was 467 µmos/cm at station 10540, both on May 21, 1998. Texas does not have conductivity water quality criteria to which the data can be compared. Table 5B-34 presents a summary of the conductivity data for segment 0611.

Segment 0612: Conductivity

There are 2 monitoring stations with a total of 26 conductivity observations on segment 0612. The minimum conductivity observation was 84 µmos/cm at station 08038000 on August 29, 1995. The maximum observation was 200 µmos/cm, also at station 08038000, on January 27, 1994. Texas does not have conductivity criteria to which the data can be compared. Table 5B-35 presents a summary of the conductivity observations for segment 0612.

5.3.3 Impairment Summary

This section discusses any apparent impairments in the tributaries to the Sam Rayburn Reservoir (segments 0611 and 0612) as well as any tends observed in the STORET data. More detailed information of the number of observations, minimum observation, maximum observation, average, and number of exceedances of the applicable criterion or target for each parameter is found in Section 5.3.3 and the tables in Appendix 5B.

Dissolved Oxygen and Nutrients

There were no exceedances of the dissolved oxygen criteria for segments 0611 and 0612, however, the nutrient data for these segments were analyzed as potential contributions to the reservoir. Nitrite and nitrate, TKN, total phosphorus, orthophosphorus, and chlorophyll a all had exceedances of either the Texas nutrient screening levels or the EPA nutrient reference criteria or both on segments 0611 and 0612.

The only nitrite and nitrate observations that were higher than the Texas nutrient screening levels were all three samples on West Mud Creek (0611X) in November 1997, March 1998, and May 1998. Of the 19 observations of nitrite and nitrate on segment 0611, 18 were higher than EPA's nutrient reference criterion. The high observations were observed at all stations without any particular seasonal trend. There were also two observations of nitrite and nitrate for segment 0612 from the early 1990s and both were higher than EPA's nutrient reference criterion but below

Texas's nutrient screening levels. There were only 2 or 3 observations at each monitoring station, which makes it difficult to see any trends in the nitrite and nitrate loads entering the reservoir from the tributaries.

There were 17 TKN observations on segment 0611 streams and five observations were higher than EPA's nutrient reference criterion for TKN. Mud Creek had the largest number of high observations with three in October 1995, and April and June 1996. Two additional samples were higher than the reference criterion in February 1993 and June 1996 on the Angelina River. There were no TKN data available for segment 0612.

There were no total phosphorus observations that were higher than the Texas screening level for total phosphorus on segment 0611 and 0612. However, there were several observations that were above EPA's reference criteria for total phosphorus on both segments. There were 21 high observations of total phosphorus at the stations sampled on segment 0611. The largest percentage of high observations were on Angelina River and Mud Creek, but there were some high samples on the East Fork Angelina River also. There was no particular seasonal pattern to the high observations. There were three total phosphorus observations on Attoyac Bayou (0612) in the early 1990s and all three were higher than EPA's reference criterion.

There are two samples of orthophosphorus at each of the five monitoring stations on segment 0611. There were no orthophosphorus data available for segment 0612. There were 5 observations on segment 0611 that were higher than the Texas screening level for orthophosphorus. All of the observations at Mud Creek and West Mud Creek were above the screening level in March and May 1998 and one additional high value was observed in the Angelina River in May 1998. There are not enough data at these stations to see any particular trends in the data with regard to seasons or streamflow. However, orthophosphorus is the form of phosphorus that is available to plants for uptake. Therefore, sampling for this parameter should be continued on a regular basis to determine if these high levels of orthophosphorus have the potential to be a problem for the reservoir.

There was one chlorophyll a sample that was above Texas's screening level in the Angelina River in October 1995. Chlorophyll a also had 13 observations that were higher than EPA's reference criterion at all stations on segment 0611 without a particular seasonal pattern. There was also one chlorophyll a sample that was higher than EPA's reference criterion in July 1992 on Attoyac Bayou (segment 0612). There were no samples that were above the Texas screening level for chlorophyll a on Attoyac Bayou.

Overall, there were not enough continuous nutrient samples at the monitoring stations on segments 0611 and 0612 to get a good idea of whether there are any trends in the data associated with the seasons or streamflow in the watershed. Continuous sampling should occur in the watershed because the data do indicate that there are potentially high nutrient loads entering the reservoir from its tributaries.

pH and Metals

There were five pH exceedances below the lower threshold of 6.0 on the main stem of the Angelina River (0611) in August 1990, November 1991, April and August 1995, and October 1996. There was one pH exceedance on April 1995 that was below the lower pH threshold of 6.0 on segment 0612. These exceedances were a very small percentage of the total number of observations for both stream segments (5 percent and 4 percent for segments 0611 and 0612, respectively).

As for metals, dissolved aluminum, dissolved copper, and dissolved lead all exceeded their appropriate criteria on segments 0611 and 0612. The dissolved zinc criterion was also exceeded on segment 0611.

Dissolved aluminum exceeded the criterion in the Angelina River (0611) on three dates in August and October 1990 and April 1991. There was only one dissolved aluminum observation available for Attoyac Bayou (segment 0612) and it exceeded the criterion in June 1991. The most recent dissolved aluminum data available for segments 0611 and 0612 were from 1991, so more recent conditions are not represented by the data.

There were 21 dissolved copper observations between segments 0611 and 0612 and all observations but one were below the detection limit of 10 µg/L. One sample of 11 µg/L on the Angelina River in October 1993 exceeds the acute criterion for dissolved copper of 5.6 µg/L. It is not known if any of the nondetect samples exceed the criterion since the detection limit was higher than the criterion. The detection limit for dissolved copper needs to be decreased for future sampling events to obtain observations that can be compared to the criterion.

There was one exceedance of aquatic life criterion for dissolved lead on the Angelina River (0611) in August 1995 and there were 4 exceedances of the 4.98 µg/L human health criterion (April 1994, April and August 1995, and August 1996). Six of the samples were nondetects (below the detection limit of 10 µg/L). The detection limit is below the acute criterion of 15.7 µg/L, but higher than the human health and chronic criteria. Therefore, it is unknown if any of the nondetect samples are actually exceeding the human health or chronic criteria. All 10 samples on Attoyac Bayou (0612) were also nondetects. There were no exceedances of the acute criterion, but it is unknown whether there were any exceedances of the human health or chronic criteria at Attoyac Bayou. The detection limit needs to be decreased for future sampling to obtain observations that can be compared to the appropriate criteria.

There was also one exceedance of the dissolved zinc criterion on the East Fork Angelina River during October 1993.

In general, there were some high observations of metals in the waterbodies of segments 0611 and 0612, but detection limits need to be lowered for future sampling events so that more accurate data can be obtained and compared to the appropriate criteria.

Fecal Coliform Bacteria

The Angelina River, East Fork Angelina River, and Mud Creek all showed excceedances of the fecal coliform bacteria criterion on several occasions. There were seven exceedances on the main stem of the Angelina River. Six of those exceedances were at station 10633 at the confluence with the East Fork Angelina River. There were four exceedances on East Fork Angelina River and 5 exceedances on Mud Creek. There was also one exceedance on Attoyac Bayou in June 1991. The majority of the exceedances at all stations were in October and November of 1996 and May and June of 1997. There is not a strong relationship between flow and fecal coliform bacteria concentrations in the watershed. Therefore, it is likely that both point and nonpoint sources are contributing to the increased fecal coliform bacteria loading to the watershed.

Chloride and Sulfate

There were no exceedances of the chloride and sulfate criteria in segments 0611 and 0612.

Appendix 5A
Summary Tables for TRACS Water Quality Monitoring Data for Sam Rayburn Reservoir

Table 5A-1. Summary of Surficial DO grab samples for Segments 0611 and 0612

Segment ID	Station ID	Period Begin	Period End	Sample Depth	Storet ID	Parameter	Min	Max	Avg	N	N < Criteria
611	10474	10/28/1996	7/11/2002	0.3	00300	DO (mg/l)	2.8	12.5	7.62	27	1
611	10475	10/28/1996	7/11/2002	0.3	00300	DO (mg/l)	5	12.8	9.30	27	
611	10532	9/5/1996	7/22/2002	0.3	00300	DO (mg/l)	4.3	13.4	8.22	28	
611	10536	12/5/2000	8/1/2002	0.3	00300	DO (mg/l)	5.4	14.5	8.80	8	
611	10538	10/19/2000	7/25/2002	0.3	00300	DO (mg/l)	5.6	10	7.37	7	
611	10539	2/22/1995	6/21/1995	0.3	00300	DO (mg/l)	7.1	9.5	7.93	3	
611	10540	11/18/1997	7/22/2002	0.3	00300	DO (mg/l)	4.8	12	7.84	20	
611	10542	12/29/1998	7/30/1999	0.3	00300	DO (mg/l)	4.7	10.5	7.29	9	
611	10551	9/5/1996	7/12/2000	0.3	00300	DO (mg/l)	5.8	12.3	8.40	21	
611	10552	10/13/1998	11/21/2002	0.3	00300	DO (mg/l)	6.5	11.8	8.75	15	
611	10627	1/15/1990	11/12/2002	0.3	00300	DO (mg/l)	4.4	11.4	7.13	81	
611	10630	11/17/1997	11/21/2002	0.3	00300	DO (mg/l)	5.2	10.6	7.81	22	
611	10633	9/5/1996	7/22/2002	0.3	00300	DO (mg/l)	3.8	13.6	7.92	27	
611	10635	11/29/2000	11/21/2002	0.3	00300	DO (mg/l)	6.2	11.1	9.04	7	
611	13788	10/26/1993	11/6/1996	0.3	00300	DO (mg/l)	6.5	10.9	8.05	6	
611	14470	10/31/1995	6/25/1997	0.3	00300	DO (mg/l)	4.7	12	7.58	9	
611	14477	10/16/1995	8/1/2002	0.3	00300	DO (mg/l)	4.9	13.2	7.97	13	
611	15806	8/27/1996	8/27/1996	0.3	00300	DO (mg/l)	6.6	6.6	6.60	1	
611	15807	8/27/1996	8/27/1996	0.3	00300	DO (mg/l)	5.5	5.5	5.50	1	
611	16289	10/12/1998	8/18/1999	0.3	00300	DO (mg/l)	7.8	11.4	9.22	6	
611	16290	10/22/1998	8/18/1999	0.3	00300	DO (mg/l)	6.2	8.9	7.58	6	
611	16291	10/22/1998	8/18/1999	0.3	00300	DO (mg/l)	7.7	10.4	8.88	6	
611	16292	10/22/1998	3/26/1999	0.3	00300	DO (mg/l)	5.8	9	7.71	7	
611	16294	10/12/1998	3/26/1999	0.3	00300	DO (mg/l)	8.4	11.2	9.47	7	
611	16298	10/27/1998	8/30/2000	0.3	00300	DO (mg/l)	2.2	12.9	8.94	22	1
611	16300	10/13/1998	8/18/1999	0.3	00300	DO (mg/l)	6.7	10.1	7.93	7	
611	16301	11/5/1998	7/13/2000	0.3	00300	DO (mg/l)	4.1	13.9	8.59	9	
611	16302	10/13/1998	8/18/1999	0.3	00300	DO (mg/l)	8	9.5	8.60	6	
611	16303	10/13/1998	6/22/1999	0.3	00300	DO (mg/l)	5.1	11.2	7.90	5	
611	16304	10/12/1998	8/18/1999	0.3	00300	DO (mg/l)	7.8	9.8	8.45	6	
611	16586	10/19/2000	7/25/2002	0.3	00300	DO (mg/l)	3.3	10.2	6.10	8	
611	16587	7/14/1999	7/14/1999	0.3	00300	DO (mg/l)	1.3	1.3	1.30	1	1
611	17103	12/5/2000	7/25/2002	0.3	00300	DO (mg/l)	5.6	11.7	8.36	8	
612	10636	6/13/1990	7/11/2002	0.3	00300	DO (mg/l)	4.9	11.8	7.78	61	
612	15253	1/6/1997	7/10/1997	0.3	00300	DO (mg/l)	5.8	8.5	7.50	4	
612	16076	11/20/1997	7/11/2002	0.3	00300	DO (mg/l)	5	12.8	8.66	20	
612	16082	11/19/1997	3/24/1998	0.3	00300	DO (mg/l)	8.7	10.4	9.60	5	
612	16083	11/19/1997	4/22/1998	0.3	00300	DO (mg/l)	8.4	10.4	9.52	6	
612	16084	11/19/1997	4/22/1998	0.3	00300	DO (mg/l)	9.3	10.8	10.17	6	
612	16085	11/19/1997	4/22/1998	0.3	00300	DO (mg/l)	9.8	10.8	10.38	6	

Table 5A-2. Summary of Surficial 24-hour Minimum DO Data for Segments 0611 and 0612

Segment ID	Station ID	Period Begin	Period End	Sample Depth	Storet ID	Parameter	Min	Max	Avg	N	N < Criteria
611	10627	7/22/1998	7/22/1998	0.5	89855	DISSOLVED OXYGEN, 24-HOUR MIN. (MG/L) MIN. 4 MEA	6	6	6	1	
611	10627	7/28/1999	7/11/2000	0.6	89855	DISSOLVED OXYGEN, 24-HOUR MIN. (MG/L) MIN. 4 MEA	6.1	6.6	6.35	2	
611	10627	5/5/1998	4/12/2000	1	89855	DISSOLVED OXYGEN, 24-HOUR MIN. (MG/L) MIN. 4 MEA	6.5	8.2	7.5	3	
611	10630	8/28/1998	8/28/1998	0.3	89855	DISSOLVED OXYGEN, 24-HOUR MIN. (MG/L) MIN. 4 MEA	5.4	5.4	5.4	1	
611	10633	5/25/2001	8/16/2002	0.3	89855	DISSOLVED OXYGEN, 24-HOUR MIN. (MG/L) MIN. 4 MEA	5.43	6.47	6	4	
611	14477	6/28/2002	8/27/2002	0.3	89855	DISSOLVED OXYGEN, 24-HOUR MIN. (MG/L) MIN. 4 MEA	4.3	5.4	4.85	2	
611	15806	10/21/1997	10/21/1997	0.3	89855	DISSOLVED OXYGEN, 24-HOUR MIN. (MG/L) MIN. 4 MEA	7.7	7.7	7.7	2	
611	15807	10/21/1997	10/21/1998	0.3	89855	DISSOLVED OXYGEN, 24-HOUR MIN. (MG/L) MIN. 4 MEA	4.7	4.7	4.7	2	
611	16586	7/15/1999	7/15/1999	0.3	89855	DISSOLVED OXYGEN, 24-HOUR MIN. (MG/L) MIN. 4 MEA	4.2	4.2	4.2	1	
611	16587	7/14/1999	7/14/1999	0.3	89855	DISSOLVED OXYGEN, 24-HOUR MIN. (MG/L) MIN. 4 MEA	1.3	1.3	1.3	1	1
611	17103	6/28/2002	8/27/2002	0.3	89855	DISSOLVED OXYGEN, 24-HOUR MIN. (MG/L) MIN. 4 MEA	3.5	5.4	4.45	2	
612	10636	5/16/2001	8/1/2001	0.3	89855	DISSOLVED OXYGEN, 24-HOUR MIN. (MG/L) MIN. 4 MEA	5.91	7.03	6.47	2	

Table 5A-3. Summary of Surficial 24-hour Average DO Data for Segments 0611 and 0612

Segment ID	Station ID	Period Begin	Period End	Sample Depth	Storet ID	Parameter	Min	Max	Avg	N	N < Criteria
611	10627	7/22/1998	7/22/1998	0.5	89857	DISSOLVED OXYGEN, 24-HOUR AVG. (MG/L) MIN. 4 MEA	6.3	6.3	6.3	1	
611	10627	7/28/1999	7/11/2000	0.6	89857	DISSOLVED OXYGEN, 24-HOUR AVG. (MG/L) MIN. 4 MEA	6.6	6.6	6.6	2	
611	10627	5/5/1998	4/12/2000	1	89857	DISSOLVED OXYGEN, 24-HOUR AVG. (MG/L) MIN. 4 MEA	6.8	9	7.9	3	
611	10630	8/28/1998	8/28/1998	0.3	89857	DISSOLVED OXYGEN, 24-HOUR AVG. (MG/L) MIN. 4 MEA	5.9	5.9	5.9	1	
611	10633	5/25/2001	8/16/2002	0.3	89857	DISSOLVED OXYGEN, 24-HOUR AVG. (MG/L) MIN. 4 MEA	5.61	6.58	6.1	4	
611	14477	6/28/2002	8/27/2002	0.3	89857	DISSOLVED OXYGEN, 24-HOUR AVG. (MG/L) MIN. 4 MEA	4.9	5.5	5.2	2	1
611	15806	10/21/1997	10/21/1997	0.3	89857	DISSOLVED OXYGEN, 24-HOUR AVG. (MG/L) MIN. 4 MEA	8	8	8	2	
611	15807	10/21/1997	10/21/1998	0.3	89857	DISSOLVED OXYGEN, 24-HOUR AVG. (MG/L) MIN. 4 MEA	5.4	5.4	5.4	2	
611	16586	7/15/1999	7/15/1999	0.3	89857	DISSOLVED OXYGEN, 24-HOUR AVG. (MG/L) MIN. 4 MEA	4.4	4.4	4.4	1	1
611	16587	7/14/1999	7/14/1999	0.3	89857	DISSOLVED OXYGEN, 24-HOUR AVG. (MG/L) MIN. 4 MEA	2.9	2.9	2.9	1	1
611	17103	6/28/2002	8/27/2002	0.3	89857	DISSOLVED OXYGEN, 24-HOUR AVG. (MG/L) MIN. 4 MEA	5.6	5.7	5.65	2	
612	10636	5/16/2001	8/1/2001	0.3	89857	DISSOLVED OXYGEN, 24-HOUR AVG. (MG/L) MIN. 4 MEA	6.08	7.1	6.59	2	

Table 5A-4. Summary of Surficial Chlorophyll a Data for Segments 0611 and 0612

Segment ID	Station ID	Period Begin	Period End	Depth	Storet ID	Parameter	Min	Max	Avg	N	N > Criteria	>TCEQ
611	10539	10/6/1994	6/21/1995	0.3	32211	CHLOROPHYLL-A UG/L SPECTROPHOTOMETRIC ACID. METH	1	3.6	1.67	4	4	
611	10542	6/30/1999	6/30/1999	0.3	32211	CHLOROPHYLL-A UG/L SPECTROPHOTOMETRIC ACID. METH	3.7	3.7	3.70	1	1	
611	10552	2/5/2001	11/21/2002	0.3	32211	CHLOROPHYLL-A UG/L SPECTROPHOTOMETRIC ACID. METH	1	2.85	1.31	7	7	
611	10552	11/29/2000	11/29/2000	0.4	32211	CHLOROPHYLL-A UG/L SPECTROPHOTOMETRIC ACID. METH	1	1	1.00	1	1	
611	10627	1/15/1990	11/12/2002	0.3	32211	CHLOROPHYLL-A UG/L SPECTROPHOTOMETRIC ACID. METH	1	9.1	2.02	37	37	
611	10630	11/17/1997	11/21/2002	0.3	32211	CHLOROPHYLL-A UG/L SPECTROPHOTOMETRIC ACID. METH	1	18.7	2.45	22	22	1
611	10635	11/29/2000	11/21/2002	0.3	32211	CHLOROPHYLL-A UG/L SPECTROPHOTOMETRIC ACID. METH	1	3.56	1.50	8	8	
611	13788	10/26/1993	7/22/1997	0.3	32211	CHLOROPHYLL-A UG/L SPECTROPHOTOMETRIC ACID. METH	1	9.21	3.14	8	8	
611	14470	10/31/1995	6/25/1997	0.3	32211	CHLOROPHYLL-A UG/L SPECTROPHOTOMETRIC ACID. METH	1	17.7	3.98	8	8	1
611	14477	10/16/1995	6/12/1996	0.3	32211	CHLOROPHYLL-A UG/L SPECTROPHOTOMETRIC ACID. METH	1.67	8.55	3.63	4	4	
611	15801	11/4/1997	11/4/1997	0.3	32211	CHLOROPHYLL-A UG/L SPECTROPHOTOMETRIC ACID. METH	1	1	1.00	3		
611	16587	7/14/1999	7/14/1999	0.3	32211	CHLOROPHYLL-A UG/L SPECTROPHOTOMETRIC ACID. METH	2.52	2.52	2.52	1	1	
611	16950	3/27/2000	3/27/2000	0.30488	32211	CHLOROPHYLL-A UG/L SPECTROPHOTOMETRIC ACID. METH	1.62	1.62	1.62	1	1	
612	10636	6/13/1990	8/6/2002	0.3	32211	CHLOROPHYLL-A UG/L SPECTROPHOTOMETRIC ACID. METH	1	10.2	2.60	8	8	
612	10636	8/18/1994	8/18/1994	0.30488	32211	CHLOROPHYLL-A UG/L SPECTROPHOTOMETRIC ACID. METH	5.8	5.8	5.80	1	1	
612	15253	1/6/1997	7/10/1997	0.3	32211	CHLOROPHYLL-A UG/L SPECTROPHOTOMETRIC ACID. METH	1	4.54	1.89	4	4	
612	15802	11/5/1997	11/5/1997	0.3	32211	CHLOROPHYLL-A UG/L SPECTROPHOTOMETRIC ACID. METH	1	1	1.00	1		
612	16082	11/19/1997	3/24/1998	0.3	32211	CHLOROPHYLL-A UG/L SPECTROPHOTOMETRIC ACID. METH	1	4.32	2.47	4	4	
612	16083	11/19/1997	4/22/1998	0.3	32211	CHLOROPHYLL-A UG/L SPECTROPHOTOMETRIC ACID. METH	1	4.46	2.28	5	5	
612	16084	11/19/1997	5/27/1998	0.3	32211	CHLOROPHYLL-A UG/L SPECTROPHOTOMETRIC ACID. METH	1	6.82	2.66	6	6	
612	16085	11/19/1997	5/27/1998	0.3	32211	CHLOROPHYLL-A UG/L SPECTROPHOTOMETRIC ACID. METH	1	5.07	2.60	6	6	

Table 5A-5. Summary of Surficial Sulfate Data for Segments 0611 and 0612

Segment ID	Station ID	Period Begin	Period End	Storet ID	Parameter	Min	Max	Avg	N
611	10474	11/5/1998	7/11/2002	00078	TRANSPARENCY, SECCHI DISC (METERS)	0.3	1.1	0.72	10
611	10475	10/21/1999	7/11/2002	00078	TRANSPARENCY, SECCHI DISC (METERS)	0.15	1	0.51	8
611	10532	10/27/1999	7/23/2001	00078	TRANSPARENCY, SECCHI DISC (METERS)	0.2	1.4	0.54	8
611	10536	12/5/2000	5/23/2002	00078	TRANSPARENCY, SECCHI DISC (METERS)	0.5	1.5	0.87	4
611	10538	10/19/2000	5/21/2002	00078	TRANSPARENCY, SECCHI DISC (METERS)	0.4	0.65	0.50	3
611	10539	2/22/1995	6/21/1995	00078	TRANSPARENCY, SECCHI DISC (METERS)	0.15	0.9	0.52	3
611	10540	10/26/1999	7/22/2002	00078	TRANSPARENCY, SECCHI DISC (METERS)	0.3	0.7	0.48	11
611	10542	12/29/1998	6/4/1999	00078	TRANSPARENCY, SECCHI DISC (METERS)	0.3	0.5	0.39	4
611	10551	5/21/1998	7/12/2000	00078	TRANSPARENCY, SECCHI DISC (METERS)	0.32	1	0.53	5
611	10552	11/29/2000	11/21/2002	00078	TRANSPARENCY, SECCHI DISC (METERS)	0.4	1.2	0.68	9
611	10627	1/15/1990	11/12/2002	00078	TRANSPARENCY, SECCHI DISC (METERS)	0.1	0.72	0.36	47
611	10630	11/17/1997	11/21/2002	00078	TRANSPARENCY, SECCHI DISC (METERS)	0.2	0.75	0.43	18
611	10633	10/27/1999	7/23/2001	00078	TRANSPARENCY, SECCHI DISC (METERS)	0.2	1	0.48	6
611	10635	11/29/2000	11/21/2002	00078	TRANSPARENCY, SECCHI DISC (METERS)	0.2	0.7	0.48	8
611	13788	10/26/1993	11/6/1996	00078	TRANSPARENCY, SECCHI DISC (METERS)	0.4	0.9	0.67	6
611	14470	10/31/1995	6/25/1997	00078	TRANSPARENCY, SECCHI DISC (METERS)	0.34	1.2	0.63	9
611	14477	10/16/1995	5/23/2002	00078	TRANSPARENCY, SECCHI DISC (METERS)	0.38	0.9	0.55	8
611	15801	11/4/1997	11/4/1997	00078	TRANSPARENCY, SECCHI DISC (METERS)	1.8	1.8	1.80	1
611	16290	6/29/1999	6/29/1999	00078	TRANSPARENCY, SECCHI DISC (METERS)	0.7	0.7	0.70	1
611	16291	6/29/1999	6/29/1999	00078	TRANSPARENCY, SECCHI DISC (METERS)	1	1	1.00	1
611	16292	8/18/1999	8/18/1999	00078	TRANSPARENCY, SECCHI DISC (METERS)	0.4	0.4	0.40	1
611	16298	10/26/1999	8/30/2000	00078	TRANSPARENCY, SECCHI DISC (METERS)	0.1	0.5	0.33	11
611	16301	10/21/1999	7/13/2000	00078	TRANSPARENCY, SECCHI DISC (METERS)	0.45	1	0.61	4
611	16304	8/18/1999	8/18/1999	00078	TRANSPARENCY, SECCHI DISC (METERS)	1	1	1.00	1
611	16586	10/19/2000	5/21/2002	00078	TRANSPARENCY, SECCHI DISC (METERS)	0.2	0.8	0.49	5
611	16587	7/14/1999	7/14/1999	00078	TRANSPARENCY, SECCHI DISC (METERS)	0.22	0.22	0.22	1
611	17103	12/5/2000	5/23/2002	00078	TRANSPARENCY, SECCHI DISC (METERS)	0.4	1	0.68	5
612	10636	6/13/1990	8/6/2002	00078	TRANSPARENCY, SECCHI DISC (METERS)	0.18	0.65	0.36	19
612	15253	1/6/1997	7/10/1997	00078	TRANSPARENCY, SECCHI DISC (METERS)	0.2	0.41	0.26	4
612	15802	11/5/1997	11/5/1997	00078	TRANSPARENCY, SECCHI DISC (METERS)	1.22	1.22	1.22	1
612	16076	10/21/1999	4/30/2002	00078	TRANSPARENCY, SECCHI DISC (METERS)	0.3	1	0.47	9

Table 5A-6. Summary of Surficial Total Phosphorus Data for Segments 0611 and 0612

Segment ID	Station ID	Period Begin	Period End	Depth	Storet ID	Parameter	Min	Max	Avg	N	N > Criteria	>TCEQ
611	10474	5/20/1999	7/11/2002	0.3	00665	PHOSPHORUS, TOTAL, WET METHOD (MG/L AS P)	0.043	7.3	2.56	14	13	11
611	10475	5/20/1999	7/11/2002	0.3	00665	PHOSPHORUS, TOTAL, WET METHOD (MG/L AS P)	0.013	2.55	0.38	14	13	1
611	10532	5/19/1999	7/22/2002	0.3	00665	PHOSPHORUS, TOTAL, WET METHOD (MG/L AS P)	0.071	1.5	0.52	14	14	3
611	10536	12/5/2000	8/1/2002	0.3	00665	PHOSPHORUS, TOTAL, WET METHOD (MG/L AS P)	0.387	1.62	0.87	7	7	3
611	10538	10/19/2000	7/25/2002	0.3	00665	PHOSPHORUS, TOTAL, WET METHOD (MG/L AS P)	0.055	8.3	2.11	8	8	7
611	10539	10/6/1994	6/21/1995	0.3	00665	PHOSPHORUS, TOTAL, WET METHOD (MG/L AS P)	0.23	1.75	0.73	4	4	1
611	10540	5/19/1999	7/22/2002	0.3	00665	PHOSPHORUS, TOTAL, WET METHOD (MG/L AS P)	0.133	5.6	1.96	14	14	9
611	10542	6/30/1999	6/30/1999	0.3	00665	PHOSPHORUS, TOTAL, WET METHOD (MG/L AS P)	0.04	0.04	0.04	1		
611	10551	4/29/1999	7/12/2000	0.3	00665	PHOSPHORUS, TOTAL, WET METHOD (MG/L AS P)	0.038	1.216	0.41	7	6	2
611	10552	4/29/1999	11/21/2002	0.3	00665	PHOSPHORUS, TOTAL, WET METHOD (MG/L AS P)	0.05	1.3	0.19	10	7	1
611	10552	11/29/2000	11/29/2000	0.4	00665	PHOSPHORUS, TOTAL, WET METHOD (MG/L AS P)	0.05	0.05	0.05	1		
611	10627	1/15/1990	11/12/2002	0.3	00665	PHOSPHORUS, TOTAL, WET METHOD (MG/L AS P)	0.05	0.2	0.12	36	35	
611	10630	11/17/1997	11/21/2002	0.3	00665	PHOSPHORUS, TOTAL, WET METHOD (MG/L AS P)	0.04	0.18	0.11	22	18	
611	10633	5/19/1999	7/22/2002	0.3	00665	PHOSPHORUS, TOTAL, WET METHOD (MG/L AS P)	0.076	1.6	0.46	13	13	3
611	10635	11/29/2000	11/21/2002	0.3	00665	PHOSPHORUS, TOTAL, WET METHOD (MG/L AS P)	0.09	0.88	0.32	8	8	1
611	13788	10/26/1993	7/22/1997	0.3	00665	PHOSPHORUS, TOTAL, WET METHOD (MG/L AS P)	0.01	0.12	0.05	8	3	
611	14470	10/31/1995	6/25/1997	0.3	00665	PHOSPHORUS, TOTAL, WET METHOD (MG/L AS P)	0.03	0.27	0.11	8	6	
611	14477	10/16/1995	8/1/2002	0.3	00665	PHOSPHORUS, TOTAL, WET METHOD (MG/L AS P)	0.19	2	0.71	12	12	4
611	15801	11/4/1997	11/4/1997	0.3	00665	PHOSPHORUS, TOTAL, WET METHOD (MG/L AS P)	0.01	0.01	0.01	3		
611	16289	4/29/1999	8/18/1999	0.3	00665	PHOSPHORUS, TOTAL, WET METHOD (MG/L AS P)	0.049	0.11	0.09	3	2	
611	16290	4/28/1999	8/18/1999	0.3	00665	PHOSPHORUS, TOTAL, WET METHOD (MG/L AS P)	0.096	1.116	0.46	3	3	1
611	16291	4/28/1999	8/18/1999	0.3	00665	PHOSPHORUS, TOTAL, WET METHOD (MG/L AS P)	0.061	1.003	0.38	3	3	1
611	16292	4/28/1999	8/18/1999	0.3	00665	PHOSPHORUS, TOTAL, WET METHOD (MG/L AS P)	0.033	0.318	0.14	3	2	
611	16294	4/29/1999	8/18/1999	0.3	00665	PHOSPHORUS, TOTAL, WET METHOD (MG/L AS P)	0.055	1.9	0.72	3	3	1
611	16300	3/31/1999	8/18/1999	0.3	00665	PHOSPHORUS, TOTAL, WET METHOD (MG/L AS P)	0.061	0.073	0.07	4	4	
611	16301	5/20/1999	7/13/2000	0.3	00665	PHOSPHORUS, TOTAL, WET METHOD (MG/L AS P)	0.045	0.8	0.24	6	5	
611	16302	4/28/1999	8/18/1999	0.3	00665	PHOSPHORUS, TOTAL, WET METHOD (MG/L AS P)	0.02	0.164	0.08	3	2	
611	16303	4/29/1999	6/22/1999	0.3	00665	PHOSPHORUS, TOTAL, WET METHOD (MG/L AS P)	0.082	0.129	0.11	2	2	
611	16304	4/28/1999	8/18/1999	0.3	00665	PHOSPHORUS, TOTAL, WET METHOD (MG/L AS P)	0.048	0.07	0.06	3	2	
611	16586	10/19/2000	7/25/2002	0.3	00665	PHOSPHORUS, TOTAL, WET METHOD (MG/L AS P)	0.006	1.47	0.56	8	7	1
611	16587	7/14/1999	7/14/1999	0.3	00665	PHOSPHORUS, TOTAL, WET METHOD (MG/L AS P)	0.48	0.48	0.48	1	1	
611	16950	3/27/2000	3/27/2000	0.30488	00665	PHOSPHORUS, TOTAL, WET METHOD (MG/L AS P)	0.06	0.06	0.06	1	1	
611	17103	12/5/2000	7/25/2002	0.3	00665	PHOSPHORUS, TOTAL, WET METHOD (MG/L AS P)	0.295	2.2	0.90	7	7	2
612	10636	6/13/1990	8/6/2002	0.3	00665	PHOSPHORUS, TOTAL, WET METHOD (MG/L AS P)	0.071	1.622	0.29	19	20	2
612	10636	8/18/1994	8/18/1994	0.30488	00665	PHOSPHORUS, TOTAL, WET METHOD (MG/L AS P)	0.1	0.1	0.10	1		
612	15253	1/6/1997	7/10/1997	0.3	00665	PHOSPHORUS, TOTAL, WET METHOD (MG/L AS P)	0.12	0.19	0.15	4	4	
612	15802	11/5/1997	11/5/1997	0.3	00665	PHOSPHORUS, TOTAL, WET METHOD (MG/L AS P)	0.02	0.02	0.02	1		
612	16076	5/20/1999	7/11/2002	0.3	00665	PHOSPHORUS, TOTAL, WET METHOD (MG/L AS P)	0.024	0.863	0.25	13	12	1
612	16082	11/19/1997	3/24/1998	0.3	00665	PHOSPHORUS, TOTAL, WET METHOD (MG/L AS P)	0.01	0.03	0.02	5		
612	16083	11/19/1997	5/27/1998	0.3	00665	PHOSPHORUS, TOTAL, WET METHOD (MG/L AS P)	0.01	0.1	0.05	7	4	
612	16084	11/19/1997	5/27/1998	0.3	00665	PHOSPHORUS, TOTAL, WET METHOD (MG/L AS P)	0.01	0.08	0.04	7	1	
612	16085	11/19/1997	5/27/1998	0.3	00665	PHOSPHORUS, TOTAL, WET METHOD (MG/L AS P)	0.01	0.06	0.03	7	1	

Table 5A-7. Summary of Surficial Orthophosphorus Data for Segments 0611 and 0612

Segment ID	Station ID	Period Begin	Period End	Sample Depth	Storet ID	Parameter	Min	Max	Avg	N	N > Criteria
611	10474	10/21/1999	7/11/2002	0.3	00671	PHOSPHORUS, DISSOLVED ORTHOPHOSPHORUS(MG/L AS P)	0.151	4.12	1.36	10	7
611	10475	10/21/1999	7/11/2002	0.3	00671	PHOSPHORUS, DISSOLVED ORTHOPHOSPHORUS(MG/L AS P)	0.03	0.209	0.07	10	
611	10532	10/27/1999	7/22/2002	0.3	00671	PHOSPHORUS, DISSOLVED ORTHOPHOSPHORUS(MG/L AS P)	0.036	0.825	0.18	12	1
611	10536	12/5/2000	8/1/2002	0.3	00671	PHOSPHORUS, DISSOLVED ORTHOPHOSPHORUS(MG/L AS P)	0.039	1.32	0.32	8	1
611	10538	10/19/2000	7/25/2002	0.3	00671	PHOSPHORUS, DISSOLVED ORTHOPHOSPHORUS(MG/L AS P)	0.001	2.298	0.61	8	3
611	10539	10/6/1994	6/21/1995	0.3	00671	PHOSPHORUS, DISSOLVED ORTHOPHOSPHORUS(MG/L AS P)	0.15	0.67	0.29	4	1
611	10540	10/26/1999	7/22/2002	0.3	00671	PHOSPHORUS, DISSOLVED ORTHOPHOSPHORUS(MG/L AS P)	0.016	2.008	0.97	12	10
611	10551	10/27/1999	7/12/2000	0.3	00671	PHOSPHORUS, DISSOLVED ORTHOPHOSPHORUS(MG/L AS P)	0.005	0.129	0.06	4	
611	10627	1/15/1990	8/26/1999	0.3	00671	PHOSPHORUS, DISSOLVED ORTHOPHOSPHORUS(MG/L AS P)	0.01	0.11	0.04	53	
611	10630	3/4/1998	3/4/1998	0.3	00671	PHOSPHORUS, DISSOLVED ORTHOPHOSPHORUS(MG/L AS P)	0.05	0.05	0.05	1	
611	10633	10/27/1999	7/22/2002	0.3	00671	PHOSPHORUS, DISSOLVED ORTHOPHOSPHORUS(MG/L AS P)	0.018	0.954	0.19	11	2
611	13788	10/26/1993	11/6/1996	0.3	00671	PHOSPHORUS, DISSOLVED ORTHOPHOSPHORUS(MG/L AS P)	0.02	0.05	0.03	7	
611	14470	10/31/1995	1/9/1996	0.3	00671	PHOSPHORUS, DISSOLVED ORTHOPHOSPHORUS(MG/L AS P)	0.08	0.15	0.12	2	
611	14477	10/16/1995	8/1/2002	0.3	00671	PHOSPHORUS, DISSOLVED ORTHOPHOSPHORUS(MG/L AS P)	0.064	1.476	0.34	10	2
611	16300	3/31/1999	3/31/1999	0.3	00671	PHOSPHORUS, DISSOLVED ORTHOPHOSPHORUS(MG/L AS P)	0.044	0.044	0.04	1	
611	16301	10/21/1999	7/13/2000	0.3	00671	PHOSPHORUS, DISSOLVED ORTHOPHOSPHORUS(MG/L AS P)	0.02	0.123	0.07	4	
611	16586	10/19/2000	7/25/2002	0.3	00671	PHOSPHORUS, DISSOLVED ORTHOPHOSPHORUS(MG/L AS P)	0.001	1.012	0.27	8	2
611	17103	12/5/2000	7/25/2002	0.3	00671	PHOSPHORUS, DISSOLVED ORTHOPHOSPHORUS(MG/L AS P)	0.035	1.962	0.47	8	2
612	10636	6/13/1990	7/17/2001	0.3	00671	PHOSPHORUS, DISSOLVED ORTHOPHOSPHORUS(MG/L AS P)	0.01	0.712	0.05	46	1
612	10636	8/18/1994	8/18/1994	0.30488	00671	PHOSPHORUS, DISSOLVED ORTHOPHOSPHORUS(MG/L AS P)	0.05	0.05	0.05	1	
612	16076	10/21/1999	7/11/2002	0.3	00671	PHOSPHORUS, DISSOLVED ORTHOPHOSPHORUS(MG/L AS P)	0.01	0.87	0.17	11	1
612	16082	12/19/1997	1/15/1998	0.3	00671	PHOSPHORUS, DISSOLVED ORTHOPHOSPHORUS(MG/L AS P)	0.01	0.01	0.01	2	
612	16083	12/19/1997	1/15/1998	0.3	00671	PHOSPHORUS, DISSOLVED ORTHOPHOSPHORUS(MG/L AS P)	0.02	0.05	0.04	2	
612	16084	12/19/1997	1/15/1998	0.3	00671	PHOSPHORUS, DISSOLVED ORTHOPHOSPHORUS(MG/L AS P)	0.01	0.03	0.02	2	
612	16085	12/19/1997	1/15/1998	0.3	00671	PHOSPHORUS, DISSOLVED ORTHOPHOSPHORUS(MG/L AS P)	0.01	0.02	0.02	2	

Table 5A-8. Summary of Surficial Total Nitrogen Data for Segments 0611 and 0612

Segment ID	Station ID	Period Begin	Period End	Parameter	Min	Max	Avg	N	N > Criteria
611	10539	10/6/1994	6/21/1995	Total Nitrogen (mg/l)	1.33	6.7	3.66	4	4
611	10627	2/23/1993	6/8/1994	Total Nitrogen (mg/l)	0.48	1.28	0.73	6	4
611	10630	3/4/1998	3/4/1998	Total Nitrogen (mg/l)	0.78	0.78	0.78	1	1
611	13788	10/26/1993	11/6/1996	Total Nitrogen (mg/l)	0.43	0.76	0.54	7	3
611	14470	10/31/1995	10/28/1996	Total Nitrogen (mg/l)	0.36	0.64	0.48	3	1
611	14477	10/16/1995	1/9/1996	Total Nitrogen (mg/l)	1.59	3.11	2.35	2	2
612	10636	8/4/1993	8/18/1994	Total Nitrogen (mg/l)	0.98	1.05	1.02	2	2
612	16082	12/19/1997	1/15/1998	Total Nitrogen (mg/l)	0.11	0.27	0.19	2	
612	16083	12/19/1997	1/15/1998	Total Nitrogen (mg/l)	0.45	0.52	0.49	2	1
612	16084	12/19/1997	1/15/1998	Total Nitrogen (mg/l)	0.78	0.79	0.79	2	2
612	16085	1/15/1998	1/15/1998	Total Nitrogen (mg/l)	0.34	0.34	0.34	1	

Table 5A-9. Summary of Surficial Nitrite and Nitrite Data for Segments 0611 and 0612

Segment ID	Station ID	Period Begin	Period End	Storet ID	Parameter	Min	Max	Avg	N	N > Criteria	>TCEQ
611	10474	7/23/1997	7/11/2002	00630	NITRITE PLUS NITRATE, TOTAL 1 DET. (MG/L AS N)	0.8	3.3	1.41	21	21	1
611	10475	7/23/1997	7/11/2002	00630	NITRITE PLUS NITRATE, TOTAL 1 DET. (MG/L AS N)	0.3	1.7	0.88	21	21	
611	10532	11/18/1997	7/22/2002	00630	NITRITE PLUS NITRATE, TOTAL 1 DET. (MG/L AS N)	0.1	9	1.68	20	20	3
611	10536	12/5/2000	8/1/2002	00630	NITRITE PLUS NITRATE, TOTAL 1 DET. (MG/L AS N)	0.3	5.3	2.20	8	8	2
611	10538	10/19/2000	7/25/2002	00630	NITRITE PLUS NITRATE, TOTAL 1 DET. (MG/L AS N)	0.6	7.9	2.80	8	8	3
611	10539	10/6/1994	6/21/1995	00630	NITRITE PLUS NITRATE, TOTAL 1 DET. (MG/L AS N)	0.4	5.81	2.95	4	4	2
611	10540	11/18/1997	7/22/2002	00630	NITRITE PLUS NITRATE, TOTAL 1 DET. (MG/L AS N)	0.8	13.4	4.39	20	20	15
611	10551	11/18/1997	7/12/2000	00630	NITRITE PLUS NITRATE, TOTAL 1 DET. (MG/L AS N)	0.15	1.6	0.60	14	14	
611	10552	10/13/1998	8/18/1999	00630	NITRITE PLUS NITRATE, TOTAL 1 DET. (MG/L AS N)	0.2	0.5	0.37	6	6	
611	10627	1/15/1990	1/18/1994	00630	NITRITE PLUS NITRATE, TOTAL 1 DET. (MG/L AS N)	0.03	0.42	0.20	13	11	
611	10630	3/4/1998	3/4/1998	00630	NITRITE PLUS NITRATE, TOTAL 1 DET. (MG/L AS N)	0.06	0.06	0.06	1		
611	10633	11/18/1997	7/22/2002	00630	NITRITE PLUS NITRATE, TOTAL 1 DET. (MG/L AS N)	0.1	2.65	0.81	19	19	
611	13788	10/26/1993	11/6/1996	00630	NITRITE PLUS NITRATE, TOTAL 1 DET. (MG/L AS N)	0.03	0.4	0.17	7	6	
611	14470	10/31/1995	10/28/1996	00630	NITRITE PLUS NITRATE, TOTAL 1 DET. (MG/L AS N)	0.01	0.24	0.11	3	2	
611	14477	10/16/1995	8/1/2002	00630	NITRITE PLUS NITRATE, TOTAL 1 DET. (MG/L AS N)	0.1	3.66	1.67	10	10	2
611	16289	10/12/1998	8/18/1999	00630	NITRITE PLUS NITRATE, TOTAL 1 DET. (MG/L AS N)	0.1	0.4	0.18	6	6	
611	16290	10/22/1998	8/18/1999	00630	NITRITE PLUS NITRATE, TOTAL 1 DET. (MG/L AS N)	0.2	0.6	0.34	6	6	
611	16291	10/22/1998	8/18/1999	00630	NITRITE PLUS NITRATE, TOTAL 1 DET. (MG/L AS N)	0.1	0.55	0.31	6	6	
611	16292	10/22/1998	8/18/1999	00630	NITRITE PLUS NITRATE, TOTAL 1 DET. (MG/L AS N)	0.3	1	0.60	6	6	
611	16294	10/12/1998	8/18/1999	00630	NITRITE PLUS NITRATE, TOTAL 1 DET. (MG/L AS N)	0.14	0.7	0.54	6	6	
611	16300	10/13/1998	8/18/1999	00630	NITRITE PLUS NITRATE, TOTAL 1 DET. (MG/L AS N)	0.2	0.9	0.61	7	7	
611	16301	11/5/1998	7/13/2000	00630	NITRITE PLUS NITRATE, TOTAL 1 DET. (MG/L AS N)	0.1	1.4	0.81	8	8	
611	16302	10/13/1998	8/18/1999	00630	NITRITE PLUS NITRATE, TOTAL 1 DET. (MG/L AS N)	0.3	0.75	0.53	6	6	
611	16303	10/13/1998	6/22/1999	00630	NITRITE PLUS NITRATE, TOTAL 1 DET. (MG/L AS N)	0.1	0.7	0.34	5	5	
611	16304	10/12/1998	8/18/1999	00630	NITRITE PLUS NITRATE, TOTAL 1 DET. (MG/L AS N)	0.02	0.6	0.42	6	5	
611	16586	10/19/2000	7/25/2002	00630	NITRITE PLUS NITRATE, TOTAL 1 DET. (MG/L AS N)	0.1	6.3	1.67	8	8	1
611	17103	12/5/2000	7/25/2002	00630	NITRITE PLUS NITRATE, TOTAL 1 DET. (MG/L AS N)	0.1	4.3	2.08	8	8	3
612	10636	6/25/1991	7/17/2001	00630	NITRITE PLUS NITRATE, TOTAL 1 DET. (MG/L AS N)	0.3	5.4	1.37	18	19	2
612	10636	8/18/1994	8/18/1994	00630	NITRITE PLUS NITRATE, TOTAL 1 DET. (MG/L AS N)	0.52	0.52	0.52	1		
612	16076	11/20/1997	7/11/2002	00630	NITRITE PLUS NITRATE, TOTAL 1 DET. (MG/L AS N)	0.2	1.6	0.86	20	20	
612	16082	12/19/1997	1/15/1998	00630	NITRITE PLUS NITRATE, TOTAL 1 DET. (MG/L AS N)	0.02	0.03	0.03	2		
612	16083	12/19/1997	1/15/1998	00630	NITRITE PLUS NITRATE, TOTAL 1 DET. (MG/L AS N)	0.2	0.3	0.25	2	2	
612	16084	12/19/1997	1/15/1998	00630	NITRITE PLUS NITRATE, TOTAL 1 DET. (MG/L AS N)	0.5	0.6	0.55	2	2	
612	16085	12/19/1997	1/15/1998	00630	NITRITE PLUS NITRATE, TOTAL 1 DET. (MG/L AS N)	0.1	0.1	0.10	2	2	

Table 5A-10. Summary of Surficial TKN Data for Segments 0611 and 0612

Segment ID	Station ID	Period Begin	Period End	Storet ID	Parameter	Min	Max	Avg	N	N > Criteria
611	10539	10/6/1994	6/21/1995	00625	NITROGEN, KJELDAHL, TOTAL (MG/L AS N)	0.38	0.88	0.68	4	3
611	10542	6/30/1999	6/30/1999	00625	NITROGEN, KJELDAHL, TOTAL (MG/L AS N)	0.54	0.54	0.54	1	1
611	10552	2/5/2001	11/21/2002	00625	NITROGEN, KJELDAHL, TOTAL (MG/L AS N)	0.17	0.4	0.31	7	1
611	10552	11/29/2000	11/29/2000	00625	NITROGEN, KJELDAHL, TOTAL (MG/L AS N)	0.47	0.47	0.47	1	
611	10627	2/23/1993	11/12/2002	00625	NITROGEN, KJELDAHL, TOTAL (MG/L AS N)	0.27	0.87	0.53	25	19
611	10630	11/17/1997	11/21/2002	00625	NITROGEN, KJELDAHL, TOTAL (MG/L AS N)	0.3	0.86	0.53	22	15
611	10635	11/29/2000	11/21/2002	00625	NITROGEN, KJELDAHL, TOTAL (MG/L AS N)	0.35	0.64	0.46	8	4
611	13788	10/26/1993	7/22/1997	00625	NITROGEN, KJELDAHL, TOTAL (MG/L AS N)	0.28	0.52	0.36	8	1
611	14470	10/31/1995	6/25/1997	00625	NITROGEN, KJELDAHL, TOTAL (MG/L AS N)	0.28	0.72	0.45	8	3
611	14477	10/16/1995	6/12/1996	00625	NITROGEN, KJELDAHL, TOTAL (MG/L AS N)	0.34	0.88	0.61	4	3
611	15801	11/4/1997	11/4/1997	00625	NITROGEN, KJELDAHL, TOTAL (MG/L AS N)	0.16	0.6	0.39	3	1
611	16587	7/14/1999	7/14/1999	00625	NITROGEN, KJELDAHL, TOTAL (MG/L AS N)	2.31	2.31	2.31	1	1
611	16950	3/27/2000	3/27/2000	00625	NITROGEN, KJELDAHL, TOTAL (MG/L AS N)	0.65	0.65	0.65	1	1
612	10636	8/4/1993	8/6/2002	00625	NITROGEN, KJELDAHL, TOTAL (MG/L AS N)	0.36	0.84	0.59	6	5
612	10636	8/18/1994	8/18/1994	00625	NITROGEN, KJELDAHL, TOTAL (MG/L AS N)	0.42	0.42	0.42	1	
612	15253	1/6/1997	7/10/1997	00625	NITROGEN, KJELDAHL, TOTAL (MG/L AS N)	0.46	0.94	0.77	4	4
612	15802	11/5/1997	11/5/1997	00625	NITROGEN, KJELDAHL, TOTAL (MG/L AS N)	0.54	0.54	0.54	1	1
612	16082	11/19/1997	3/24/1998	00625	NITROGEN, KJELDAHL, TOTAL (MG/L AS N)	0.04	0.36	0.21	5	
612	16083	11/19/1997	5/27/1998	00625	NITROGEN, KJELDAHL, TOTAL (MG/L AS N)	0.13	0.52	0.26	7	1
612	16084	11/19/1997	5/27/1998	00625	NITROGEN, KJELDAHL, TOTAL (MG/L AS N)	0.14	0.49	0.27	7	1
612	16085	11/19/1997	5/27/1998	00625	NITROGEN, KJELDAHL, TOTAL (MG/L AS N)	0.05	0.8	0.34	7	2

Table 5A-11. Summary of Surficial Amonia Data for Segments 0611 and 0612

Segment ID	Station ID	Period Begin	Period End	Storet ID	Parameter	Min	Max	Avg	N	N > Criteria
611	10474	7/23/1997	7/11/2002	00610	NITROGEN, AMMONIA, TOTAL (MG/L AS N)	0.01	0.38	0.16	19	7
611	10475	7/23/1997	7/11/2002	00610	NITROGEN, AMMONIA, TOTAL (MG/L AS N)	0.01	0.36	0.10	19	2
611	10532	11/18/1997	7/22/2002	00610	NITROGEN, AMMONIA, TOTAL (MG/L AS N)	0.01	0.41	0.10	21	4
611	10536	12/5/2000	8/1/2002	00610	NITROGEN, AMMONIA, TOTAL (MG/L AS N)	0.01	0.21	0.04	8	1
611	10538	10/19/2000	7/25/2002	00610	NITROGEN, AMMONIA, TOTAL (MG/L AS N)	0.01	0.18	0.05	8	1
611	10539	10/6/1994	6/21/1995	00610	NITROGEN, AMMONIA, TOTAL (MG/L AS N)	0.01	0.05	0.03	4	
611	10540	11/18/1997	7/22/2002	00610	NITROGEN, AMMONIA, TOTAL (MG/L AS N)	0.01	0.6	0.14	20	4
611	10542	6/30/1999	6/30/1999	00610	NITROGEN, AMMONIA, TOTAL (MG/L AS N)	0.07	0.07	0.07	1	
611	10551	11/18/1997	7/12/2000	00610	NITROGEN, AMMONIA, TOTAL (MG/L AS N)	0.02	0.23	0.07	15	1
611	10552	10/13/1998	11/21/2002	00610	NITROGEN, AMMONIA, TOTAL (MG/L AS N)	0.03	0.4	0.09	13	2
611	10552	11/29/2000	11/29/2000	00610	NITROGEN, AMMONIA, TOTAL (MG/L AS N)	0.05	0.05	0.05	1	
611	10627	1/15/1990	11/12/2002	00610	NITROGEN, AMMONIA, TOTAL (MG/L AS N)	0.01	0.12	0.05	37	
611	10630	11/17/1997	11/21/2002	00610	NITROGEN, AMMONIA, TOTAL (MG/L AS N)	0.05	0.24	0.06	22	1
611	10633	11/18/1997	7/22/2002	00610	NITROGEN, AMMONIA, TOTAL (MG/L AS N)	0.01	0.23	0.05	20	1
611	10635	11/29/2000	11/21/2002	00610	NITROGEN, AMMONIA, TOTAL (MG/L AS N)	0.05	0.09	0.06	8	
611	13788	10/26/1993	7/22/1997	00610	NITROGEN, AMMONIA, TOTAL (MG/L AS N)	0.01	0.08	0.04	8	
611	14470	10/31/1995	6/25/1997	00610	NITROGEN, AMMONIA, TOTAL (MG/L AS N)	0.01	0.13	0.06	8	
611	14477	10/16/1995	8/1/2002	00610	NITROGEN, AMMONIA, TOTAL (MG/L AS N)	0.01	0.2	0.07	12	1
611	15801	11/4/1997	11/4/1997	00610	NITROGEN, AMMONIA, TOTAL (MG/L AS N)	0.05	0.22	0.16	3	2
611	16289	10/12/1998	8/18/1999	00610	NITROGEN, AMMONIA, TOTAL (MG/L AS N)	0.03	0.15	0.06	6	
611	16290	12/9/1998	8/18/1999	00610	NITROGEN, AMMONIA, TOTAL (MG/L AS N)	0.04	0.11	0.06	5	
611	16291	2/9/1999	8/18/1999	00610	NITROGEN, AMMONIA, TOTAL (MG/L AS N)	0.03	0.06	0.05	4	
611	16292	12/9/1998	8/18/1999	00610	NITROGEN, AMMONIA, TOTAL (MG/L AS N)	0.03	0.56	0.18	4	1
611	16294	10/12/1998	8/18/1999	00610	NITROGEN, AMMONIA, TOTAL (MG/L AS N)	0.03	0.12	0.06	6	
611	16300	10/13/1998	8/18/1999	00610	NITROGEN, AMMONIA, TOTAL (MG/L AS N)	0.03	0.4	0.13	7	1
611	16301	11/5/1998	7/13/2000	00610	NITROGEN, AMMONIA, TOTAL (MG/L AS N)	0.03	0.21	0.09	7	2
611	16302	10/13/1998	8/18/1999	00610	NITROGEN, AMMONIA, TOTAL (MG/L AS N)	0.03	0.08	0.06	6	
611	16303	10/13/1998	6/22/1999	00610	NITROGEN, AMMONIA, TOTAL (MG/L AS N)	0.03	0.78	0.29	5	3
611	16304	10/12/1998	8/18/1999	00610	NITROGEN, AMMONIA, TOTAL (MG/L AS N)	0.03	8.95	1.55	6	1
611	16586	10/19/2000	7/25/2002	00610	NITROGEN, AMMONIA, TOTAL (MG/L AS N)	0.01	0.3	0.07	8	1
611	16587	7/14/1999	7/14/1999	00610	NITROGEN, AMMONIA, TOTAL (MG/L AS N)	1.72	1.72	1.72	1	1
611	16950	3/27/2000	3/27/2000	00610	NITROGEN, AMMONIA, TOTAL (MG/L AS N)	0.05	0.05	0.05	1	
611	17103	12/5/2000	7/25/2002	00610	NITROGEN, AMMONIA, TOTAL (MG/L AS N)	0.01	0.11	0.04	8	
612	10636	6/13/1990	8/6/2002	00610	NITROGEN, AMMONIA, TOTAL (MG/L AS N)	0.01	1.01	0.10	24	2
612	10636	8/18/1994	8/18/1994	00610	NITROGEN, AMMONIA, TOTAL (MG/L AS N)	0.04	0.04	0.04	1	
612	15253	1/6/1997	7/10/1997	00610	NITROGEN, AMMONIA, TOTAL (MG/L AS N)	0.02	0.05	0.03	4	
612	15802	11/5/1997	11/5/1997	00610	NITROGEN, AMMONIA, TOTAL (MG/L AS N)	0.17	0.17	0.17	1	
612	16076	11/20/1997	7/11/2002	00610	NITROGEN, AMMONIA, TOTAL (MG/L AS N)	0.01	1.4	0.16	20	2
612	16082	11/19/1997	3/24/1998	00610	NITROGEN, AMMONIA, TOTAL (MG/L AS N)	0.01	0.05	0.04	5	
612	16083	11/19/1997	5/27/1998	00610	NITROGEN, AMMONIA, TOTAL (MG/L AS N)	0.01	0.14	0.06	7	
612	16084	11/19/1997	5/27/1998	00610	NITROGEN, AMMONIA, TOTAL (MG/L AS N)	0.01	0.1	0.05	7	
612	16085	11/19/1997	5/27/1998	00610	NITROGEN, AMMONIA, TOTAL (MG/L AS N)	0.01	0.16	0.06	6	

Table 5A-12. Summary of Surficial BOD Data for Segments 0611 and 0612

Segment ID	Station ID	Period Begin	Period End	Depth	Storet ID	Parameter	Min	Max	Avg	N	N > Criteria
611	10474	11/5/1998	3/9/2000	0.3	00310	BIOCHEMICAL OXYGEN DEMAND (MG/L, 5 DAY - 20DEG C	2.07	15.4	4.0	7	NA
611	10475	11/5/1998	3/9/2000	0.3	00310	BIOCHEMICAL OXYGEN DEMAND (MG/L, 5 DAY - 20DEG C	2.07	2.07	2.1	7	NA
611	10532	11/17/1998	4/5/2000	0.3	00310	BIOCHEMICAL OXYGEN DEMAND (MG/L, 5 DAY - 20DEG C	2.07	2.07	2.1	7	NA
611	10540	11/16/1998	5/10/2000	0.3	00310	BIOCHEMICAL OXYGEN DEMAND (MG/L, 5 DAY - 20DEG C	2.07	2.07	2.1	7	NA
611	10551	10/13/1998	4/5/2000	0.3	00310	BIOCHEMICAL OXYGEN DEMAND (MG/L, 5 DAY - 20DEG C	2.07	2.07	2.1	9	NA
611	10552	10/13/1998	8/18/1999	0.3	00310	BIOCHEMICAL OXYGEN DEMAND (MG/L, 5 DAY - 20DEG C	2.07	2.07	2.1	5	NA
611	10627	1/27/1994	8/26/1999	0.3	00310	BIOCHEMICAL OXYGEN DEMAND (MG/L, 5 DAY - 20DEG C	0.6	3.1	1.5	36	NA
611	10633	11/17/1998	4/5/2000	0.3	00310	BIOCHEMICAL OXYGEN DEMAND (MG/L, 5 DAY - 20DEG C	2.07	2.07	2.1	7	NA
611	16289	10/12/1998	8/18/1999	0.3	00310	BIOCHEMICAL OXYGEN DEMAND (MG/L, 5 DAY - 20DEG C	2.07	2.07	2.1	6	NA
611	16290	10/22/1998	8/18/1999	0.3	00310	BIOCHEMICAL OXYGEN DEMAND (MG/L, 5 DAY - 20DEG C	2.07	4.02	2.4	6	NA
611	16291	10/22/1998	8/18/1999	0.3	00310	BIOCHEMICAL OXYGEN DEMAND (MG/L, 5 DAY - 20DEG C	2.07	2.07	2.1	5	NA
611	16292	10/22/1998	8/18/1999	0.3	00310	BIOCHEMICAL OXYGEN DEMAND (MG/L, 5 DAY - 20DEG C	2.07	2.07	2.1	6	NA
611	16294	10/12/1998	8/18/1999	0.3	00310	BIOCHEMICAL OXYGEN DEMAND (MG/L, 5 DAY - 20DEG C	2.07	2.07	2.1	6	NA
611	16300	10/13/1998	8/18/1999	0.3	00310	BIOCHEMICAL OXYGEN DEMAND (MG/L, 5 DAY - 20DEG C	2.07	2.07	2.1	7	NA
611	16301	11/5/1998	3/9/2000	0.3	00310	BIOCHEMICAL OXYGEN DEMAND (MG/L, 5 DAY - 20DEG C	2.07	4.03	2.6	7	NA
611	16302	10/13/1998	8/18/1999	0.3	00310	BIOCHEMICAL OXYGEN DEMAND (MG/L, 5 DAY - 20DEG C	2.07	2.15	2.1	6	NA
611	16303	10/13/1998	6/22/1999	0.3	00310	BIOCHEMICAL OXYGEN DEMAND (MG/L, 5 DAY - 20DEG C	2.07	2.07	2.1	5	NA
611	16304	10/12/1998	8/18/1999	0.3	00310	BIOCHEMICAL OXYGEN DEMAND (MG/L, 5 DAY - 20DEG C	2.07	2.07	2.1	6	NA
612	10636	11/17/1998	8/26/1999	0.3	00310	BIOCHEMICAL OXYGEN DEMAND (MG/L, 5 DAY - 20DEG C	0.5	2.5	1.5	41	NA
612	16076	11/5/1998	4/18/2000	0.3	00310	BIOCHEMICAL OXYGEN DEMAND (MG/L, 5 DAY - 20DEG C	2.07	2.07	2.1	7	NA

Table 5A-13. Summary of Surficial TOC Data for Segments 0611 and 0612

Segment ID	Station ID	Period Begin	Period End	Depth	Storet ID	Parameter	Min	Max	Avg	N
611	10539	10/6/1994	6/21/1995	0.3	00680	CARBON, TOTAL ORGANIC (MG/L AS C)	1	11	6.00	4
611	10542	6/30/1999	6/30/1999	0.3	00680	CARBON, TOTAL ORGANIC (MG/L AS C)	9	9	9.00	1
611	10552	2/5/2001	11/21/2002	0.3	00680	CARBON, TOTAL ORGANIC (MG/L AS C)	1	5	3.57	7
611	10552	11/29/2000	11/29/2000	0.4	00680	CARBON, TOTAL ORGANIC (MG/L AS C)	6	6	6.00	1
611	10627	1/15/1990	11/12/2002	0.3	00680	CARBON, TOTAL ORGANIC (MG/L AS C)	1	19	8.16	70
611	10630	11/17/1997	11/21/2002	0.3	00680	CARBON, TOTAL ORGANIC (MG/L AS C)	5	12	6.97	22
611	10635	11/29/2000	11/21/2002	0.3	00680	CARBON, TOTAL ORGANIC (MG/L AS C)	4	6	5.13	8
611	13788	10/26/1993	7/22/1997	0.3	00680	CARBON, TOTAL ORGANIC (MG/L AS C)	2	7	4.50	8
611	14470	10/31/1995	6/25/1997	0.3	00680	CARBON, TOTAL ORGANIC (MG/L AS C)	1	8	5.75	8
611	14477	10/16/1995	6/12/1996	0.3	00680	CARBON, TOTAL ORGANIC (MG/L AS C)	5	11	7.25	4
611	15801	11/4/1997	11/4/1997	0.3	00680	CARBON, TOTAL ORGANIC (MG/L AS C)	1	7	4.67	3
611	16587	7/14/1999	7/14/1999	0.3	00680	CARBON, TOTAL ORGANIC (MG/L AS C)	15	15	15.00	1
611	16950	3/27/2000	3/27/2000	0.30488	00680	CARBON, TOTAL ORGANIC (MG/L AS C)	6	6	6.00	1
612	10636	6/13/1990	8/6/2002	0.3	00680	CARBON, TOTAL ORGANIC (MG/L AS C)	3	14	7.22	42
612	10636	8/18/1994	8/18/1994	0.30488	00680	CARBON, TOTAL ORGANIC (MG/L AS C)	5	5	5.00	1
612	15253	1/6/1997	7/10/1997	0.3	00680	CARBON, TOTAL ORGANIC (MG/L AS C)	7	11	9.25	4
612	15802	11/5/1997	11/5/1997	0.3	00680	CARBON, TOTAL ORGANIC (MG/L AS C)	6	6	6.00	1
612	16082	11/19/1997	3/24/1998	0.3	00680	CARBON, TOTAL ORGANIC (MG/L AS C)	3	11	6.40	5
612	16083	11/19/1997	5/27/1998	0.3	00680	CARBON, TOTAL ORGANIC (MG/L AS C)	3	7	4.71	7
612	16084	11/19/1997	5/27/1998	0.3	00680	CARBON, TOTAL ORGANIC (MG/L AS C)	3	6	4.57	7
612	16085	11/19/1997	5/27/1998	0.3	00680	CARBON, TOTAL ORGANIC (MG/L AS C)	1	5	2.71	7

Table 5A-14. Summary of Dissolved Aluminum Data for Segment 0611

Station	Start Date	End Date	Dissolved Aluminum (µg/L)				
			Number of Observations	Average	Minimum	Maximum	Number of Exceedances[a]
10474	4/11/1989	7/11/2002	5	74.4	<20	270	0
10475	6/23/1998	7/11/2002	4	20	<20	20.1	0
10532	6/17/1998	7/22/2002	4	269	<10	1026	1
10539	10/6/1994	2/22/1995	3	43	34	57	0
10540	11/16/1998	7/22/2002	3	16.4	<10	20	0
10551	6/17/1998	2/16/1999	2	15	<10	20	0
10552	2/16/1999	2/27/2002	7	84.8	<10	217	0
10627	1/28/1985	4/29/2002	46	585.8	0.6	2720	8
10630	10/14/1998	5/1/2001	6	252	136	418	0
10633	6/17/1998	7/22/2002	4	199.5	<10	748	0
10635	5/1/2001	5/1/2001	2	80	26	134	0
14470	4/16/1997	6/25/1997	2	151.5	121	182	0
15801	11/4/1997	11/4/1997	3	41	<41	<41	0
16289	2/16/1999	2/16/1999	1	10	<10	<10	0
16294	2/16/1999	2/16/1999	1	10	<10	<10	0
16301	11/5/1998	5/20/1999	2	20	<20	<20	0
16302	2/10/1999	2/10/1999	1	10	<10	<10	0

[a] Exceedance of TWQS 991 µg/L.

Table 5A-15. Summary of Dissolved Aluminum Data for Segment 0612

Station	Start Date	End Date	Dissolved Aluminum (µg/L)				
			Number of Observations	Average	Minimum	Maximum	Number of Exceedances[a]
10636	12/11/1984	7/11/2002	22	547.4	2.9	3800	3
15253	7/10/1997	7/10/1997	1	215	215	215	0
15802	11/5/1997	11/5/1997	1	41	<41	<41	0
16076	6/23/1998	7/11/2002	4	49.8	<20	139	0
16083	4/22/1998	4/22/1998	1	15	<15	<15	0
16084	4/22/1998	4/22/1998	1	22	<22	<22	0
16085	4/22/1998	4/22/1998	1	15	<15	<15	0

[a] Exceedance of TWQS 991 µg/L.

Table 5A-16. Summary of Dissolved Arsenic Data for Segments 0611 and 0612

Station	Start Date	End Date	Dissolved Arsenic (µg/L)				
			Number of Observations	Average	Minimum	Maximum	Number of Exceedances[a]
Segment 0611							
10539	10/6/1994	2/22/1995	3	2.45	<2	3.34	0
10552	11/29/2000	2/27/2002	6	1.4	<1	2.42	0
10627	11/4/1997	4/29/2002	35	1.79	1	<8	0
10630	10/14/1998	5/1/2001	6	2.37	1.68	4.21	0
10635	5/1/2001	5/1/2001	2	1.23	<1	1.46	0
13788	10/26/1993	10/26/1993	1	2	<2	<2	0
14470	4/16/1997	6/25/1997	2	2	<2	<2	0
15801	11/4/1997	11/4/1997	3	3.33	<2	<6	0
Segment 0612							
10636	1/27/1994	3/13/2002	21	1.04	1	1.64	0
15253	7/10/1997	7/10/1997	1	2	<2	<2	0
15802	11/5/1997	11/5/1997	1	2	<2	<2	0
16083	4/22/1998	4/22/1998	1	3	<3	<3	0
16084	4/22/1998	4/22/1998	1	3	<3	<3	0

Station	Start Date	End Date	Dissolved Arsenic (µg/L)				
			Number of Observations	Average	Minimum	Maximum	Number of Exceedances[a]
16085	4/22/1998	4/22/1998	1	3	<3	<3	0

[a] Exceedance of chronic or acute TSWQS (190 µg/L and 390 µg/L).

Table 5A-17. Dissolved Copper Detections Exceeding Chronic and Acute Criteria for Segment 0611

Station	Date	Dissolved Copper (µg/L)	Sample Specific Hardness (mg/L)	Sample Specific Criteria (µg/L)	
				Chronic	Acute
10475	3/7/2001	11	52	7.0	9.9
10536	5/9/2001	16	56	7.5	10.7
10532	5/8/2002	6	NA	NA	NA
10538	5/2/2001	8	64	8.4	12.1
10540	5/10/2000	6	25.1	3.8	5.0
10540	5/2/2001	11	92	11.4	17.0
10633	5/8/2001	8	34	4.9	6.7
13788	10/26/1997	11	NA	NA	NA
14470	6/25/1997	6	36	5.1	7.0
14477	5/8/2001	6	58	7.7	11.0
16586	5/2/2001	8	38	5.4	7.4
17103	5/9/2001	12	60	7.9	11.4

Table 5A-18. Summary of Dissolved Copper Data for Segment 0611

Station	Start Date	End Date	Dissolved Copper (µg/L)				
			Number of Observations	Average	Minimum	Maximum	Number of Exceedances[a]
10474	3/9/2000	7/11/2002	3	2.77	1.32	4	0
10475	3/9/2000	7/11/2002	3	4.87	0.62	11	1
10532	4/5/2000	7/22/2002	4	2.61	<1	6	1
10536	5/9/2001	5/9/2001	1	16	16	16	1
10538	5/2/2001	5/2/2001	1	8	8	8	1
10539	10/6/1994	2/22/1995	3	4	<4	<4	0
10540	5/10/2000	7/22/2002	3	6.59	2.77	11	2
10551	4/5/2000	4/5/2000	1	2	<2	2	0
10552	11/29/2000	2/27/2002	6	6	<6	<6	6[b]
10627	11/4/1997	4/29/2002	35	6.41	1.285	<10	21[b]
10630	10/14/1998	5/1/2001	6	3.5	<3	<6	1[b]
10633	4/5/2000	7/22/2002	4	3.34	<1	8	1
10635	5/1/2001	5/1/2001	2	6	<6	<6	2[b]
13788	10/26/1993	10/26/1993	1	11	11	11	1
14470	4/16/1997	6/25/1997	2	5	4	6	1
14777	5/8/2001	5/8/2001	1	6	6	6	1
15801	11/4/1997	11/4/1997	3	3	<3	<3	0
16301	3/9/2000	3/9/2000	1	4	4	4	0
16586	5/2/2001	5/2/2001	1	8	8	8	1
17103	5/9/2001	5/9/2001	1	12	12	12	1

[a] Exceedances of calculated acute (5.9 µg/L) and or chronic (4.4 µg/L) criteria for segment 0611.
[B] Exceedances based on nondetects.

Table 5A-19. Summary of Dissolved Copper Data for Segment 0612

Station	Start Date	End Date	Dissolved Copper (µg/L)				
			Number of Observations	Average	Minimum	Maximum	Number of Exceedances[a]
10636	3/9/2000	7/11/2002	22	7.87	0.83	<10	18[b]
15253	3/9/2000	7/11/2002	1	3	<3	<3	0
15802	4/5/2000	7/22/2002	1	3	<3	<3	0
16076	5/9/2001	5/9/2001	2	2.82	0.64	5	1
16083	5/2/2001	5/2/2001	1	4	4	4	0
16084	10/6/1994	2/22/1995	1	3	<3	<3	0
16085	5/10/2000	7/22/2002	1	3	<3	<3	0

[a] Exceedances of calculated acute (5.6 µg/L) and or chronic (4.1 µg/L) criteria for segment 0611.
[b] Exceedances based on nondetects.

Table 5A-20. Dissolved Lead Detections Exceeding Chronic Criteria for Segment 0611

Station	Date	Dissolved Lead (µg/L)	Sample Specific Hardness (mg/L)	Sample Specific Criteria (µg/L)	
				Chronic	Acute
10475	3/7/2001	10	52	1.1	31.6
10532	7/22/2002	0.91	NA	NA	NA
10540	5/10/2000	16	25.1	0.43	12.5
10633	7/22/2002	0.77	NA	NA	NA

Table 5A-21. Summary of Dissolved Lead Data for Segment 0611

Station	Start Date	End Date	Dissolved Lead (µg/L)				
			Number of Observations	Average	Minimum	Maximum	Number of Exceedances[a]
10474	3/9/2000	7/11/2002	3	1.47	0.4	<2	2[b]
10475	3/9/2000	7/11/2002	3	4.03	0.1	10	2[c]
10532	4/5/2000	7/22/2002	4	1.64	0.91	<2	3[d]
10536	5/9/2001	5/9/2001	1	2	<2	<2	1[b]
10538	5/2/2001	5/2/2001	1	2	<2	<2	1[b]
10539	10/6/1994	2/22/1995	3	1	<1	<1	3[b]
10540	5/10/2000	7/22/2002	3	6.03	0.1	16	2[c]
10551	4/5/2000	4/5/2000	1	2	<2	<2	1[b]
10552	11/29/2000	2/27/2002	6	1	<1	<1	6[b]
10627	11/4/1997	4/29/2002	35	43.57	<1	<100	35[b]
10630	10/14/1998	5/1/2001	6	1.17	<1	<2	6[b]
10633	4/5/2000	7/22/2002	4	1.59	0.77	<2	3[d]
10635	5/1/2001	5/1/2001	2	1	<1	<1	2[b]
13788	10/26/1993	10/26/1993	1	1	<1	<1	1[b]
14470	4/16/1997	6/25/1997	2	1	<1	<1	2[b]
14777	5/8/2001	5/8/2001	1	2	<2	<2	1[b]
15801	11/4/1997	11/4/1997	3	1	<1	<1	3[b]
16301	3/9/2000	3/9/2000	1	2	<2	<2	1[b]
16586	5/2/2001	5/2/2001	1	2	<2	<2	1[b]
17103	5/9/2001	5/9/2001	1	2	<2	<2	1[b]

[a] Exceedances of chronic criterion (0.54 µg/L).
[b] Exceedances based on nondetects.
[c] All but one exceedances based on nondetects.
[d] All but two exceedances based on nondetects.

Table 5A-22. Dissolved Lead Detections Exceeding Chronic Criteria for Segment 0612

Station	Date	Dissolved Lead (µg/L)	Sample Specific Hardness (mg/L)	Sample Specific Criteria (µg/L)	
				Chronic	Acute
10636	5/11/2001	7	58	1.3	36.3
10636	7/11/2002	0.63	NA	NA	NA

Table 5A-23. Summary of Dissolved Lead Data for Segment 0612

Station	Start Date	End Date	Dissolved Lead (µg/L)				
			Number of Observations	Average	Minimum	Maximum	Number of Exceedances[a]
10636	3/9/2000	7/11/2002	24	63.15	0.63	<100	24[c]
15253	3/9/2000	7/11/2002	1	1	<1	<1	1[b]
15802	4/5/2000	7/22/2002	1	1	<1	<1	1[b]
16076	5/9/2001	5/9/2001	3	1.48	0.45	<2	2[b]
16083	5/2/2001	5/2/2001	1	2	<2	<2	1[b]
16084	10/6/1994	2/22/1995	1	2	<2	<2	1[b]
16085	5/10/2000	7/22/2002	1	2	<2	<2	1[b]

[a] Exceedances of chronic criterion (0.5 µg/L).
[b] Exceedances based on nondetects.
[c] All but two exceedances based on nondetects.

Table 5A-24. Summary of Total Selenium Data for Segment 0611

Station	Start Date	End Date	Dissolved Selenium (µg/L)				
			Number of Observations	Average	Minimum	Maximum	Number of Exceedances[a]
10474	4/6/1975	3/7/2001	8	8.63	<1	<20	3[b]
10475	5/20/1999	3/7/2001	4	2	<2	<2	0
10532	8/28/1997	3/5/2002	6	2.95	<2	<5	0
10536	5/9/2001	5/9/2001	1	2	<2	<2	0
10538	5/2/2001	5/2/2001	1	2	<2	<2	0
10540	5/19/1999	5/2/2001	4	2	<2	<2	0
10551	8/28/1997	4/5/2000	5	3.2	<2	<5	0
10552	12/14/1998	2/27/2002	3	2.7	<1.1	<5	0
10627	11/4/1997	4/29/2002	13	3.35	<1	<25	1[b]
10630	10/14/1998	6/16/1999	4	1.35	<1	<2.2	0
10633	8/28/1997	3/5//2002	6	2.5	<1	<5	0
14470	4/16/1997	6/25/1997	2	2.65	2.08	3.22	0
14777	5/8/2001	5/8/2001	1	3.5	<2	<2	0
15801	11/4/1997	11/4/1997	3	3.5	<2	<2	0
16289	12/14/1998	6/24/1999	2	3.5	<2	<5	0
16290	12/9/1998	6/29/1999	2	3.5	<2	<5	0
16291	12/9/1998	6/29/1999	2	3.5	<2	<5	0
16292	12/9/1998	6/17/1999	2	3.5	<2	<5	0
16294	12/14/1998	6/24/1999	2	3.5	<2	<5	0
16300	12/9/1998	6/22/1999	2	3.5	<2	<5	0
16301	5/20/1999	3/9/2000	3	2	<2	<2	0
16302	12/9/1998	6/22/1999	2	3.5	<2	<5	0
16303	12/14/1998	6/22/1999	2	3.5	<2	<5	0
16304	12/9/1998	6/22/1999	2	3.5	<2	<5	0
16586	5/2/2001	5/2/2001	1	2.8	2.8	2.8	0
17103	5/9/2001	5/9/2001	1	2	<2	<2	0

[a] Exceedances of chronic TSWQS for total selenium (5 µg/L).
[b] Exceedances based on nondetects.

Table 5A-25. Summary of Total Selenium Data for Segment 0612

Station	Start Date	End Date	Total Selenium (µg/L)				
			Number of Observations	Average	Minimum	Maximum	Number of Exceedances[a]
10636	7/11/1974	3/13/2002	7	1.32	<2	<2	0
15253	7/10/1997	7/10/1997	1	2	<2	<2	0
15802	11/5/1997	11/5/1997	1	2	<2	<2	0
16076	5/20/1999	3/7/2001	4	2	<2	<2	0
10682	2/18/1998	2/18/1998	1	25	<25	<25	1[b]
16083	2/18/1998	2/18/1998	1	25	<25	<25	1[b]
16084	2/18/1998	2/18/1998	1	25	<25	<25	1[b]
16085	2/18/1998	2/18/1998	1	25	<25	<25	1[b]

[a] Exceedances of chronic and acute criteria for total selenium (5 µg/L and 20µg/L).
[b] Exceedances based on nondetects.

Table 5A-26. Dissolved Zinc Detections Exceeding Chronic and Acute Criteria for Segment 0611

Station	Date	Dissolved Zinc (µg/L)	Sample Specific Hardness (mg/L)	Sample Specific Criteria (µg/L)	
				Chronic	Acute
10532	5/8/2001	80	38	46.0	50.4
10536	5/9/2001	151	56	63.9	70.0
10538	5/2/2001	83	64	71.6	78.4
10539	2/22/2001	40	76	82.8	90.7
10540	5/2/2001	90	92	97.4	106.6
10633	5/8/2001	77	34	41.9	45.9
13788	10/26/1993	48	NA	NA	NA
14477	5/8/2001	75	58	65.9	72.1
16586	5/2/2001	82	38	46.0	50.4
17103	5/9/2001	92	60	67.8	74.2

Table 5A-27. Summary of Dissolved Zinc Data for Segment 0611

Station	Start Date	End Date	Dissolved Zinc (µg/L)				
			Number of Observations	Average	Minimum	Maximum	Number of Exceedances[a]
10474	3/9/2000	7/11/2002	3	22.6	13	32	0
10475	3/9/2000	7/11/2002	3	12.9	0.74	34	0
10532	4/5/2000	7/22/2002	4	22.1	1	80	1
10536	5/9/2001	5/9/2001	1	151	151	151	1
10538	5/2/2001	5/2/2001	1	83	83	83	1
10539	10/6/1994	2/22/1995	3	23.1	<6.6	40	1
10540	5/10/2000	7/22/2002	3	34.6	1	90	1
10551	4/5/2000	4/5/2000	1	9	9	9	0
10552	11/29/2000	2/27/2002	6	8.3	<8	10	0
10627	11/4/1997	4/29/2002	35	9.79	<1	29.343	0
10630	10/14/1998	5/1/2001	6	13.5	<8	21.4	0
10633	4/5/2000	7/22/2002	4	22.4	<1	77	1
10635	5/1/2001	5/1/2001	2	8	<8	<8	0
13788	10/26/1993	10/26/1993	1	48	48	48	1
14470	4/16/1997	6/25/1997	2	5	<4	6	0
14777	5/8/2001	5/8/2001	1	75	75	75	1
15801	11/4/1997	11/4/1997	3	17.3	12	26	0
16301	3/9/2000	3/9/2000	1	4	4	4	0
16586	5/2/2001	5/2/2001	1	82	82	82	1
17103	5/9/2001	5/9/2001	1	92	92	92	1

[a] Exceedances of calculated chronic (37.7 µg/L) and acute (41.3 µg/L) criteria for segment 0611.

Table 5A-28. Summary of Dissolved Zinc Data for Segment 0612

Station	Start Date	End Date	Dissolved Zinc (µg/L)				
			Number of Observations	Average	Minimum	Maximum	Number of Exceedances[a]
10636	1/27/1994	7/11/2002	24	11.9	<1	41	1
15253	7/10/1997	7/10/1997	1	4	<4	<4	0
15802	11/5/1997	11/5/1997	1	4	<4	<4	0
16076	4/18/2000	7/11/2002	3	10.74	<1	30	0
16083	4/22/1998	4/22/1998	1	24	24	24	0
16084	4/22/1998	4/22/1998	1	227	27	27	0
16085	4/22/1998	4/22/1998	1	18	18	18	0

[a] Exceedances of chronic (35.5 µg/L) and acute (38.9 µg/L) criteria for segment 0611.

[a]Observations compared to metals water quality criteria for segment 612 (Source: Texas Administrative Code 307.6(c)(1) and 307.6(d)(1))

[b] All or some of the observations were below the detection limit

Table 5A-29. Summary of Surficial Fecal Coliform Bacteria Data for Segments 0611 and 0612

Segment ID	Station ID	Period Begin	Period End	Storet ID	Parameter	Min	Max	Avg	N	N > Criteria
611	10474	10/1/1996	7/11/2002	31616	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH, #/100ML	7	4900	634.70	27	8
611	10475	10/1/1996	7/11/2002	31616	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH, #/100ML	4	15000	1479.30	27	15
611	10532	9/5/1996	7/22/2002	31616	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH, #/100ML	1	8100	753.11	28	8
611	10536	12/5/2000	8/1/2002	31616	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH, #/100ML	1	210	69.00	7	
611	10538	10/19/2000	7/25/2002	31616	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH, #/100ML	27	210	90.13	8	
611	10539	2/22/1995	6/21/1995	31616	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH, #/100ML	97	800	345.67	3	1
611	10540	11/18/1997	7/22/2002	31616	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH, #/100ML	16	300	98.25	20	
611	10551	9/5/1996	7/12/2000	31616	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH, #/100ML	2	5800	641.35	20	4
611	10552	10/13/1998	11/29/2000	31616	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH, #/100ML	69	180	115.67	6	
611	10627	1/15/1990	11/12/2002	31616	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH, #/100ML	10	1240	196.29	45	3
611	10630	11/17/1997	8/28/2002	31616	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH, #/100ML	22	1400	218.67	18	2
611	10633	9/5/1996	7/22/2002	31616	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH, #/100ML	1	2200	410.96	27	9
611	10635	11/29/2000	11/29/2000	31616	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH, #/100ML	190	190	190.00	1	
611	13788	10/26/1993	11/6/1996	31616	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH, #/100ML	53	200	110.67	6	
611	14470	10/31/1995	6/25/1997	31616	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH, #/100ML	52	190	103.22	9	
611	14477	10/16/1995	8/1/2002	31616	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH, #/100ML	2	1000	163.00	13	2
611	16289	10/12/1998	8/18/1999	31616	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH, #/100ML	39	280	118.80	5	
611	16290	10/22/1998	8/18/1999	31616	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH, #/100ML	100	390	236.67	6	
611	16291	10/22/1998	8/18/1999	31616	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH, #/100ML	160	380	282.00	5	
611	16292	10/22/1998	8/18/1999	31616	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH, #/100ML	120	400	243.33	6	
611	16294	10/12/1998	8/18/1999	31616	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH, #/100ML	110	1850	562.00	5	2
611	16300	10/13/1998	8/18/1999	31616	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH, #/100ML	93	380	260.43	7	
611	16301	11/5/1998	7/13/2000	31616	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH, #/100ML	2	1050	257.00	7	1
611	16302	10/13/1998	8/18/1999	31616	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH, #/100ML	90	580	321.67	6	2
611	16303	10/13/1998	6/22/1999	31616	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH, #/100ML	90	400	250.00	5	
611	16304	10/12/1998	8/18/1999	31616	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH, #/100ML	70	1030	310.00	6	1
611	16586	10/19/2000	7/25/2002	31616	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH, #/100ML	53	200	102.88	8	
611	16587	7/14/1999	7/14/1999	31616	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH, #/100ML	2000	2000	2000.00	1	1
611	17103	12/5/2000	7/25/2002	31616	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH, #/100ML	1	196	63.57	7	
612	10636	6/13/1990	8/6/2002	31616	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH, #/100ML	1	1520	218.28	25	4
612	15253	1/6/1997	7/10/1997	31616	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH, #/100ML	83	1600	715.00	4	2
612	16076	11/20/1997	7/11/2002	31616	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH, #/100ML	2	2300	418.58	19	6
612	16082	11/19/1997	3/24/1998	31616	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH, #/100ML	1	130	42.20	5	
612	16083	11/19/1997	5/27/1998	31616	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH, #/100ML	140	800	414.29	7	3
612	16084	11/19/1997	5/27/1998	31616	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH, #/100ML	140	380	285.71	7	
612	16085	11/19/1997	5/27/1998	31616	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH, #/100ML	1	1950	333.43	7	1

Table 5A-30. Summary of Surficial *E. coli* Data for Segments 0611 and 0612

Segment ID	Station ID	Period Begin	Period End	Storet ID	Parameter	Min	Max	Avg	N	N > Criteria
611	10474	10/25/2000	7/11/2002	31699	E. COLI, COLILERT, IDEXX METHOD, MPN/100ML	29.8	2420	811.65	8	3
611	10475	10/25/2000	7/11/2002	31699	E. COLI, COLILERT, IDEXX METHOD, MPN/100ML	19.9	3970	1657.89	8	6
611	10532	12/5/2000	7/22/2002	31699	E. COLI, COLILERT, IDEXX METHOD, MPN/100ML	35	727	176.53	8	1
611	10536	12/5/2000	8/1/2002	31699	E. COLI, COLILERT, IDEXX METHOD, MPN/100ML	35.9	397	132.19	7	1
611	10538	10/19/2000	7/25/2002	31699	E. COLI, COLILERT, IDEXX METHOD, MPN/100ML	36.8	727	178.55	8	1
611	10540	10/19/2000	7/22/2002	31699	E. COLI, COLILERT, IDEXX METHOD, MPN/100ML	31	290.89999	154.70	8	
611	10552	2/5/2001	11/21/2002	31699	E. COLI, COLILERT, IDEXX METHOD, MPN/100ML	35	210	91.13	8	
611	10627	2/7/2002	11/12/2002	31699	E. COLI, COLILERT, IDEXX METHOD, MPN/100ML	143	1842	641.00	4	2
611	10630	2/5/2001	11/21/2002	31699	E. COLI, COLILERT, IDEXX METHOD, MPN/100ML	30	122	56.14	7	
611	10633	12/5/2000	7/22/2002	31699	E. COLI, COLILERT, IDEXX METHOD, MPN/100ML	38.8	602	170.16	7	1
611	10635	2/5/2001	11/21/2002	31699	E. COLI, COLILERT, IDEXX METHOD, MPN/100ML	36	272	101.29	7	
611	14477	12/5/2000	8/1/2002	31699	E. COLI, COLILERT, IDEXX METHOD, MPN/100ML	14.8	1120	176.15	8	1
611	16586	10/19/2000	7/25/2002	31699	E. COLI, COLILERT, IDEXX METHOD, MPN/100ML	32.4	197	81.40	8	
611	17103	12/5/2000	7/25/2002	31699	E. COLI, COLILERT, IDEXX METHOD, MPN/100ML	33	313	95.31	7	
612	10636	11/15/2000	8/6/2002	31699	E. COLI, COLILERT, IDEXX METHOD, MPN/100ML	32.4	1373	376.22	9	3
612	16076	11/15/2000	7/11/2002	31699	E. COLI, COLILERT, IDEXX METHOD, MPN/100ML	95.9	461	286.11	8	2

Table 5A-31. Summary of Surficial Alkalinity Data for Segments 0611 and 0612

Segment ID	Station ID	Period Begin	Period End	Storet ID	Parameter	Min	Max	Avg	N	N > Criteria
611	10475	7/19/1999	7/19/1999	00410	ALKALINITY, TOTAL (MG/L AS CACO3)	46.7	46.7	46.7	1	NA
611	10539	10/6/1994	6/21/1995	00410	ALKALINITY, TOTAL (MG/L AS CACO3)	16.0	79.0	43.8	4	NA
611	10542	6/30/1999	6/30/1999	00410	ALKALINITY, TOTAL (MG/L AS CACO3)	82.0	82.0	82.0	1	NA
611	10552	2/5/2001	11/21/2002	00410	ALKALINITY, TOTAL (MG/L AS CACO3)	13.0	22.0	16.9	7	NA
611	10552	11/29/2000	11/29/2000	00410	ALKALINITY, TOTAL (MG/L AS CACO3)	15.0	15.0	15.0	1	NA
611	10627	1/15/1990	11/12/2002	00410	ALKALINITY, TOTAL (MG/L AS CACO3)	4.0	90.0	23.7	37	NA
611	10630	11/17/1997	11/21/2002	00410	ALKALINITY, TOTAL (MG/L AS CACO3)	8.0	44.0	23.5	22	NA
611	10635	11/29/2000	11/21/2002	00410	ALKALINITY, TOTAL (MG/L AS CACO3)	21.0	48.0	30.6	8	NA
611	13788	10/26/1993	7/22/1997	00410	ALKALINITY, TOTAL (MG/L AS CACO3)	6.0	26.0	16.6	8	NA
611	14470	10/31/1995	6/25/1997	00410	ALKALINITY, TOTAL (MG/L AS CACO3)	5.0	66.0	23.8	8	NA
611	14477	10/16/1995	6/12/1996	00410	ALKALINITY, TOTAL (MG/L AS CACO3)	20.0	60.0	35.5	4	NA
611	15801	11/4/1997	11/4/1997	00410	ALKALINITY, TOTAL (MG/L AS CACO3)	16.0	22.0	19.7	3	NA
611	16587	7/14/1999	7/14/1999	00410	ALKALINITY, TOTAL (MG/L AS CACO3)	130.0	130.0	130.0	1	NA
611	16950	3/27/2000	3/27/2000	00410	ALKALINITY, TOTAL (MG/L AS CACO3)	10.0	10.0	10.0	1	NA
612	10636	6/13/1990	8/6/2002	00410	ALKALINITY, TOTAL (MG/L AS CACO3)	12.0	69.0	29.9	9	NA
612	10636	8/18/1994	8/18/1994	00410	ALKALINITY, TOTAL (MG/L AS CACO3)	22.0	22.0	22.0	1	NA
612	15253	1/6/1997	7/10/1997	00410	ALKALINITY, TOTAL (MG/L AS CACO3)	12.0	25.0	20.3	4	NA
612	15802	11/5/1997	11/5/1997	00410	ALKALINITY, TOTAL (MG/L AS CACO3)	18.0	18.0	18.0	1	NA
612	16082	12/19/1997	3/24/1998	00410	ALKALINITY, TOTAL (MG/L AS CACO3)	5.0	10.0	7.5	2	NA
612	16083	12/19/1997	5/27/1998	00410	ALKALINITY, TOTAL (MG/L AS CACO3)	5.0	20.0	13.6	5	NA
612	16084	12/19/1997	5/27/1998	00410	ALKALINITY, TOTAL (MG/L AS CACO3)	6.0	14.0	10.8	5	NA
612	16085	12/19/1997	5/27/1998	00410	ALKALINITY, TOTAL (MG/L AS CACO3)	5.0	8.0	5.8	5	NA

Table 5A-32. Summary of Surficial Chloride Data for Segments 0611 and 0612

Segment ID	Station ID	Period Begin	Period End	Depth	Storet ID	Parameter	Min	Max	Avg	N	N > Criteria
611	10474	7/23/1997	7/11/2002	0.3	00940	CHLORIDE (MG/L AS CL)	10.5	97	33.96	20	
611	10475	7/23/1997	7/11/2002	0.3	00940	CHLORIDE (MG/L AS CL)	7.5	22.5	12.38	20	
611	10475	7/19/1999	7/19/1999	0.30488	00940	CHLORIDE (MG/L AS CL)	8.62	8.62	8.62	1	
611	10532	11/18/1997	7/22/2002	0.3	00940	CHLORIDE (MG/L AS CL)	9.5	35.9	19.08	20	
611	10536	12/5/2000	8/1/2002	0.3	00940	CHLORIDE (MG/L AS CL)	10.5	30.5	24.65	8	
611	10538	10/19/2000	7/25/2002	0.3	00940	CHLORIDE (MG/L AS CL)	15.5	33	27.00	8	
611	10539	10/6/1994	6/21/1995	0.3	00940	CHLORIDE (MG/L AS CL)	9	44	27.50	4	
611	10540	11/18/1997	7/22/2002	0.3	00940	CHLORIDE (MG/L AS CL)	17.5	51	37.32	20	
611	10542	6/30/1999	6/30/1999	0.3	00940	CHLORIDE (MG/L AS CL)	29	29	29.00	1	
611	10551	11/18/1997	7/12/2000	0.3	00940	CHLORIDE (MG/L AS CL)	6.8	17.5	11.26	14	
611	10552	10/13/1998	11/21/2002	0.3	00940	CHLORIDE (MG/L AS CL)	6	142.39999	20.92	13	1
611	10627	1/15/1990	11/12/2002	0.3	00940	CHLORIDE (MG/L AS CL)	8	47	16.57	72	
611	10630	11/17/1997	11/21/2002	0.3	00940	CHLORIDE (MG/L AS CL)	8	35	18.90	22	
611	10633	11/18/1997	7/22/2002	0.3	00940	CHLORIDE (MG/L AS CL)	10.5	39	21.68	19	
611	10635	11/29/2000	11/21/2002	0.3	00940	CHLORIDE (MG/L AS CL)	13	26	16.88	8	
611	13788	10/26/1993	7/22/1997	0.3	00940	CHLORIDE (MG/L AS CL)	8	11	9.63	8	
611	14470	10/31/1995	6/25/1997	0.3	00940	CHLORIDE (MG/L AS CL)	15	68	28.63	8	
611	14477	10/16/1995	8/1/2002	0.3	00940	CHLORIDE (MG/L AS CL)	4	29	21.96	12	
611	15801	11/4/1997	11/4/1997	0.3	00940	CHLORIDE (MG/L AS CL)	2.6	7.3	5.72	3	
611	16289	10/12/1998	8/18/1999	0.3	00940	CHLORIDE (MG/L AS CL)	7.5	153.39999	33.37	6	1
611	16290	10/22/1998	8/18/1999	0.3	00940	CHLORIDE (MG/L AS CL)	8.5	182.39999	41.57	6	1
611	16291	10/22/1998	8/18/1999	0.3	00940	CHLORIDE (MG/L AS CL)	8.2	474.89999	123.42	6	2
611	16292	10/22/1998	8/18/1999	0.3	00940	CHLORIDE (MG/L AS CL)	13.5	171.39999	41.15	6	1
611	16294	10/12/1998	8/18/1999	0.3	00940	CHLORIDE (MG/L AS CL)	7.5	95	25.15	6	
611	16300	10/13/1998	8/18/1999	0.3	00940	CHLORIDE (MG/L AS CL)	18.5	197.39999	60.11	7	1
611	16301	1/5/1999	7/13/2000	0.3	00940	CHLORIDE (MG/L AS CL)	11.2	16.5	13.90	7	
611	16302	10/13/1998	8/18/1999	0.3	00940	CHLORIDE (MG/L AS CL)	8	134.5	32.75	6	1
611	16303	10/13/1998	6/22/1999	0.3	00940	CHLORIDE (MG/L AS CL)	16.5	25	19.70	5	
611	16304	10/12/1998	8/18/1999	0.3	00940	CHLORIDE (MG/L AS CL)	9.5	103	27.75	6	
611	16586	10/19/2000	7/25/2002	0.3	00940	CHLORIDE (MG/L AS CL)	13.5	34.5	21.56	8	
611	16587	7/14/1999	7/14/1999	0.3	00940	CHLORIDE (MG/L AS CL)	29	29	29.00	1	
611	16950	3/27/2000	3/27/2000	0.30488	00940	CHLORIDE (MG/L AS CL)	53	53	53.00	1	
611	17103	12/5/2000	7/25/2002	0.3	00940	CHLORIDE (MG/L AS CL)	12	31.5	24.06	8	
612	10636	6/13/1990	8/6/2002	0.3	00940	CHLORIDE (MG/L AS CL)	3	21.5	9.80	58	
612	10636	8/18/1994	8/18/1994	0.30488	00940	CHLORIDE (MG/L AS CL)	7	7	7.00	1	
612	15253	1/6/1997	7/10/1997	0.3	00940	CHLORIDE (MG/L AS CL)	7.26	18	12.32	4	
612	15802	11/5/1997	11/5/1997	0.3	00940	CHLORIDE (MG/L AS CL)	5.73	5.73	5.73	1	
612	16076	11/20/1997	7/11/2002	0.3	00940	CHLORIDE (MG/L AS CL)	7.9	18.5	12.05	19	
612	16082	11/19/1997	3/24/1998	0.3	00940	CHLORIDE (MG/L AS CL)	8.2	84.4	25.10	5	1
612	16083	11/19/1997	5/27/1998	0.3	00940	CHLORIDE (MG/L AS CL)	7.8	12	10.24	7	
612	16084	11/19/1997	5/27/1998	0.3	00940	CHLORIDE (MG/L AS CL)	7	11	9.17	7	
612	16085	11/19/1997	5/27/1998	0.3	00940	CHLORIDE (MG/L AS CL)	7.6	14.5	9.81	7	

Table 5A-33. Summary of Surficial Sulfate Data for Segments 0611 and 0612

Segment ID	Station ID	Period Begin	Period End	Depth	Storet ID	Parameter	Min	Max	Avg	N	N > Criteria
611	10474	7/23/1997	7/11/2002	0.3	00945	SULFATE (MG/L AS SO4)	21.81	108	36.60	21	1
611	10475	7/23/1997	7/11/2002	0.3	00945	SULFATE (MG/L AS SO4)	9.3	35.8	22.36	21	
611	10475	7/19/1999	7/19/1999	0.30488	00945	SULFATE (MG/L AS SO4)	11.6	11.6	11.60	1	
611	10532	11/18/1997	7/22/2002	0.3	00945	SULFATE (MG/L AS SO4)	10.7	80	43.11	20	6
611	10536	12/5/2000	8/1/2002	0.3	00945	SULFATE (MG/L AS SO4)	16.59	40.4	27.84	8	
611	10538	10/19/2000	7/25/2002	0.3	00945	SULFATE (MG/L AS SO4)	21.35	38.1	29.44	8	
611	10539	10/6/1994	6/21/1995	0.3	00945	SULFATE (MG/L AS SO4)	3	28	17.00	4	
611	10540	11/18/1997	7/22/2002	0.3	00945	SULFATE (MG/L AS SO4)	29.16	49.6	40.72	20	
611	10542	6/30/1999	6/30/1999	0.3	00945	SULFATE (MG/L AS SO4)	29	29	29.00	1	
611	10551	11/18/1997	7/12/2000	0.3	00945	SULFATE (MG/L AS SO4)	5.5	276.29999	35.92	14	1
611	10552	10/13/1998	11/21/2002	0.3	00945	SULFATE (MG/L AS SO4)	4	24	12.79	13	
611	10627	1/15/1990	11/12/2002	0.3	00945	SULFATE (MG/L AS SO4)	11	63	21.58	72	1
611	10630	11/17/1997	11/21/2002	0.3	00945	SULFATE (MG/L AS SO4)	8	48	27.57	22	
611	10633	11/18/1997	7/22/2002	0.3	00945	SULFATE (MG/L AS SO4)	9.7	49.3	27.38	19	
611	10635	11/29/2000	11/21/2002	0.3	00945	SULFATE (MG/L AS SO4)	10	22	14.75	8	
611	13788	10/26/1993	7/22/1997	0.3	00945	SULFATE (MG/L AS SO4)	8	21	13.13	8	
611	14470	10/31/1995	6/25/1997	0.3	00945	SULFATE (MG/L AS SO4)	12	80	27.00	8	1
611	14477	10/16/1995	8/1/2002	0.3	00945	SULFATE (MG/L AS SO4)	3	45.3	27.35	12	
611	15801	11/4/1997	11/4/1997	0.3	00945	SULFATE (MG/L AS SO4)	1	11.3	7.77	3	
611	16289	10/12/1998	8/18/1999	0.3	00945	SULFATE (MG/L AS SO4)	6.4	17.44	11.94	6	
611	16290	10/22/1998	8/18/1999	0.3	00945	SULFATE (MG/L AS SO4)	7.1	40.4	25.67	6	
611	16291	10/22/1998	8/18/1999	0.3	00945	SULFATE (MG/L AS SO4)	5.8	3272	557.62	6	1
611	16292	10/22/1998	8/18/1999	0.3	00945	SULFATE (MG/L AS SO4)	10.3	34.8	23.99	6	
611	16294	10/12/1998	8/18/1999	0.3	00945	SULFATE (MG/L AS SO4)	3.52	15.18	7.66	6	
611	16300	10/13/1998	8/18/1999	0.3	00945	SULFATE (MG/L AS SO4)	0.3	25	8.24	7	
611	16301	11/5/1998	7/13/2000	0.3	00945	SULFATE (MG/L AS SO4)	16.9	46.9	33.09	8	
611	16302	10/13/1998	8/18/1999	0.3	00945	SULFATE (MG/L AS SO4)	0.37	31.7	7.61	6	
611	16303	10/13/1998	6/22/1999	0.3	00945	SULFATE (MG/L AS SO4)	56	100.2	72.50	5	5
611	16304	10/12/1998	8/18/1999	0.3	00945	SULFATE (MG/L AS SO4)	3.74	30.9	13.57	6	
611	16586	10/19/2000	7/25/2002	0.3	00945	SULFATE (MG/L AS SO4)	8.7	23.4	16.56	8	
611	16587	7/14/1999	7/14/1999	0.3	00945	SULFATE (MG/L AS SO4)	21	21	21.00	1	
611	16950	3/27/2000	3/27/2000	0.30488	00945	SULFATE (MG/L AS SO4)	24	24	24.00	1	
611	17103	12/5/2000	7/25/2002	0.3	00945	SULFATE (MG/L AS SO4)	19.14	39	27.82	8	
612	10636	6/13/1990	8/6/2002	0.3	00945	SULFATE (MG/L AS SO4)	0.1	162.5	19.45	58	1
612	10636	8/18/1994	8/18/1994	0.30488	00945	SULFATE (MG/L AS SO4)	13	13	13.00	1	
612	15253	1/6/1997	7/10/1997	0.3	00945	SULFATE (MG/L AS SO4)	13	33	22.75	4	
612	15802	11/5/1997	11/5/1997	0.3	00945	SULFATE (MG/L AS SO4)	5.24	5.24	5.24	1	
612	16076	11/20/1997	7/11/2002	0.3	00945	SULFATE (MG/L AS SO4)	4.03	47.6	19.15	20	
612	16082	11/19/1997	3/24/1998	0.3	00945	SULFATE (MG/L AS SO4)	11.3	444	100.62	5	1
612	16083	11/19/1997	5/27/1998	0.3	00945	SULFATE (MG/L AS SO4)	7.9	41.8	26.47	7	
612	16084	11/19/1997	5/27/1998	0.3	00945	SULFATE (MG/L AS SO4)	4.2	42.6	24.73	7	
612	16085	11/19/1997	5/27/1998	0.3	00945	SULFATE (MG/L AS SO4)	18.9	30	23.10	7	

Table 5A-34. Summary of Surficial TSS Data for Segments 0611 and 0612

Segment ID	Station ID	Period Begin	Period End	Depth	Storet ID	Parameter	Min	Max	Avg	N
611	10474	7/23/1997	7/11/2002	0.3	00530	RESIDUE, TOTAL NONFILTRABLE (MG/L)	1	23.3	9.27	20
611	10475	7/23/1997	7/11/2002	0.3	00530	RESIDUE, TOTAL NONFILTRABLE (MG/L)	1	47.3	6.46	21
611	10475	7/19/1999	7/19/1999	0.30488	00530	RESIDUE, TOTAL NONFILTRABLE (MG/L)	4	4	4.00	1
611	10532	11/18/1997	7/22/2002	0.3	00530	RESIDUE, TOTAL NONFILTRABLE (MG/L)	2.33	37	10.42	21
611	10536	12/5/2000	8/1/2002	0.3	00530	RESIDUE, TOTAL NONFILTRABLE (MG/L)	4	198	33.24	7
611	10538	10/19/2000	7/25/2002	0.3	00530	RESIDUE, TOTAL NONFILTRABLE (MG/L)	3	28.33	9.54	8
611	10539	10/6/1994	6/21/1995	0.3	00530	RESIDUE, TOTAL NONFILTRABLE (MG/L)	5	25	11.25	4
611	10540	11/18/1997	7/22/2002	0.3	00530	RESIDUE, TOTAL NONFILTRABLE (MG/L)	1.67	23.7	7.59	20
611	10542	6/30/1999	6/30/1999	0.3	00530	RESIDUE, TOTAL NONFILTRABLE (MG/L)	6	6	6.00	1
611	10551	11/18/1997	7/12/2000	0.3	00530	RESIDUE, TOTAL NONFILTRABLE (MG/L)	2	33.5	13.23	15
611	10552	10/13/1998	11/21/2002	0.3	00530	RESIDUE, TOTAL NONFILTRABLE (MG/L)	3	20	9.18	13
611	10552	11/29/2000	11/29/2000	0.4	00530	RESIDUE, TOTAL NONFILTRABLE (MG/L)	34	34	34.00	1
611	10627	1/15/1990	11/12/2002	0.3	00530	RESIDUE, TOTAL NONFILTRABLE (MG/L)	1	65	22.99	71
611	10630	11/17/1997	11/21/2002	0.3	00530	RESIDUE, TOTAL NONFILTRABLE (MG/L)	4	64	20.27	22
611	10633	11/18/1997	7/22/2002	0.3	00530	RESIDUE, TOTAL NONFILTRABLE (MG/L)	2.33	31.3	8.49	20
611	10635	11/29/2000	11/21/2002	0.3	00530	RESIDUE, TOTAL NONFILTRABLE (MG/L)	4	58	22.00	8
611	13788	10/26/1993	7/22/1997	0.3	00530	RESIDUE, TOTAL NONFILTRABLE (MG/L)	1	14	6.25	8
611	14470	10/31/1995	6/25/1997	0.3	00530	RESIDUE, TOTAL NONFILTRABLE (MG/L)	3	33	16.88	8
611	14477	10/16/1995	8/1/2002	0.3	00530	RESIDUE, TOTAL NONFILTRABLE (MG/L)	1.67	35	13.90	12
611	15801	11/4/1997	11/4/1997	0.3	00530	RESIDUE, TOTAL NONFILTRABLE (MG/L)	1	3	2.33	3
611	16289	10/12/1998	8/18/1999	0.3	00530	RESIDUE, TOTAL NONFILTRABLE (MG/L)	1	3	1.72	6
611	16290	10/22/1998	8/18/1999	0.3	00530	RESIDUE, TOTAL NONFILTRABLE (MG/L)	2.33	11	8.05	6
611	16291	10/22/1998	8/18/1999	0.3	00530	RESIDUE, TOTAL NONFILTRABLE (MG/L)	1	17.8	8.01	5
611	16292	10/22/1998	8/18/1999	0.3	00530	RESIDUE, TOTAL NONFILTRABLE (MG/L)	1.33	12.3	8.74	6
611	16294	10/12/1998	8/18/1999	0.3	00530	RESIDUE, TOTAL NONFILTRABLE (MG/L)	2.67	15	7.64	6
611	16300	10/13/1998	8/18/1999	0.3	00530	RESIDUE, TOTAL NONFILTRABLE (MG/L)	3	20.3	10.17	7
611	16301	11/5/1998	7/13/2000	0.3	00530	RESIDUE, TOTAL NONFILTRABLE (MG/L)	2	13.7	5.57	8
611	16302	10/13/1998	8/18/1999	0.3	00530	RESIDUE, TOTAL NONFILTRABLE (MG/L)	7	16.7	13.12	6
611	16303	10/13/1998	6/22/1999	0.3	00530	RESIDUE, TOTAL NONFILTRABLE (MG/L)	4.33	13.5	7.50	5
611	16304	10/12/1998	8/18/1999	0.3	00530	RESIDUE, TOTAL NONFILTRABLE (MG/L)	5	16.8	10.18	6
611	16586	10/19/2000	7/25/2002	0.3	00530	RESIDUE, TOTAL NONFILTRABLE (MG/L)	1.33	21.3	8.33	8
611	16587	7/14/1999	7/14/1999	0.3	00530	RESIDUE, TOTAL NONFILTRABLE (MG/L)	62	62	62.00	1
611	16950	3/27/2000	3/27/2000	0.30488	00530	RESIDUE, TOTAL NONFILTRABLE (MG/L)	2	2	2.00	1
611	17103	12/5/2000	7/25/2002	0.3	00530	RESIDUE, TOTAL NONFILTRABLE (MG/L)	1.33	18	6.29	7
612	10636	6/13/1990	8/6/2002	0.3	00530	RESIDUE, TOTAL NONFILTRABLE (MG/L)	4	100	31.70	59
612	10636	8/18/1994	8/18/1994	0.30488	00530	RESIDUE, TOTAL NONFILTRABLE (MG/L)	14	14	14.00	1
612	15253	1/6/1997	7/10/1997	0.3	00530	RESIDUE, TOTAL NONFILTRABLE (MG/L)	21	63	41.00	4
612	15802	11/5/1997	11/5/1997	0.3	00530	RESIDUE, TOTAL NONFILTRABLE (MG/L)	4	4	4.00	1
612	16076	11/20/1997	7/11/2002	0.3	00530	RESIDUE, TOTAL NONFILTRABLE (MG/L)	2.33	44.7	16.97	20
612	16082	11/19/1997	3/24/1998	0.3	00530	RESIDUE, TOTAL NONFILTRABLE (MG/L)	3	19	8.00	4
612	16083	11/19/1997	5/27/1998	0.3	00530	RESIDUE, TOTAL NONFILTRABLE (MG/L)	3	10	6.86	7
612	16084	11/19/1997	5/27/1998	0.3	00530	RESIDUE, TOTAL NONFILTRABLE (MG/L)	5	20	10.29	7
612	16085	11/19/1997	5/27/1998	0.3	00530	RESIDUE, TOTAL NONFILTRABLE (MG/L)	2	113	21.43	7

Table 5A-35. Summary of Surficial TDS Data for Segments 0611 and 0612

Segment ID	Station ID	Period Begin	Period End	Storet ID	Parameter	Min	Max	Avg	N	N > Criteria
611	10474	11/5/1998	7/11/2002	70300	TDS (MG/L)	87	313	195.81	16	4
611	10475	11/5/1998	7/11/2002	70300	TDS (MG/L)	68	154	112.98	16	
611	10532	11/17/1998	7/22/2002	70300	TDS (MG/L)	82	320	167.56	16	2
611	10536	12/5/2000	8/1/2002	70300	TDS (MG/L)	98	216	147.71	7	
611	10538	10/19/2000	7/25/2002	70300	TDS (MG/L)	128	200	159.38	8	
611	10539	10/6/1994	6/21/1995	70300	TDS (MG/L)	113	258	168.25	4	1
611	10540	11/16/1998	7/22/2002	70300	TDS (MG/L)	126.7	376	236.92	16	7
611	10542	6/30/1999	6/30/1999	70300	TDS (MG/L)	196	196	196	1	
611	10551	10/13/1998	7/12/2000	70300	TDS (MG/L)	30	174	80.922	9	
611	10552	10/13/1998	11/21/2002	70300	TDS (MG/L)	63.3	109	83.071	14	
611	10627	8/25/1993	11/12/2002	70300	TDS (MG/L)	93	256	138.74	23	1
611	10630	11/17/1997	11/21/2002	70300	TDS (MG/L)	58	374	160.27	22	2
611	10633	11/17/1998	7/22/2002	70300	TDS (MG/L)	56	218	122.18	15	
611	10635	11/29/2000	11/21/2002	70300	TDS (MG/L)	97	162	119.25	8	
611	13788	10/26/1993	7/22/1997	70300	TDS (MG/L)	48	120	85.125	8	
611	14470	10/31/1995	6/25/1997	70300	TDS (MG/L)	104	266	162.75	8	1
611	14477	10/16/1995	8/1/2002	70300	TDS (MG/L)	106	230	163.33	12	
611	15801	11/4/1997	11/4/1997	70300	TDS (MG/L)	9	82	52.333	3	
611	16289	10/12/1998	8/18/1999	70300	TDS (MG/L)	60	83.3	72.767	6	
611	16290	10/22/1998	8/18/1999	70300	TDS (MG/L)	83.3	145	110.25	6	
611	16291	10/22/1998	8/18/1999	70300	TDS (MG/L)	62.5	117	86.56	5	
611	16292	10/22/1998	8/18/1999	70300	TDS (MG/L)	83.3	163	110.6	6	
611	16294	10/12/1998	8/18/1999	70300	TDS (MG/L)	50	83.3	63.467	6	
611	16300	10/13/1998	8/18/1999	70300	TDS (MG/L)	73.3	96.7	85.243	7	
611	16301	11/5/1998	7/13/2000	70300	TDS (MG/L)	93	174	129.63	8	
611	16302	10/13/1998	8/18/1999	70300	TDS (MG/L)	36.7	96.7	71.117	6	
611	16303	10/13/1998	6/22/1999	70300	TDS (MG/L)	140	247	198.4	5	
611	16304	10/12/1998	8/18/1999	70300	TDS (MG/L)	60	107	83.433	6	
611	16586	10/19/2000	7/25/2002	70300	TDS (MG/L)	72	194	117.88	8	
611	16587	7/14/1999	7/14/1999	70300	TDS (MG/L)	312	312	312	1	1
611	16950	3/27/2000	3/27/2000	70300	TDS (MG/L)	606	606	606	1	1
611	17103	12/5/2000	7/25/2002	70300	TDS (MG/L)	96	194	151.43	7	
612	10636	8/18/1994	8/6/2002	70300	TDS (MG/L)	54	140	98.462	21	21
612	15253	1/6/1997	7/10/1997	70300	TDS (MG/L)	107	164	146.25	4	4
612	15802	11/5/1997	11/5/1997	70300	TDS (MG/L)	10100	10100	10100	1	1
612	16076	11/5/1998	7/11/2002	70300	TDS (MG/L)	44	147	89.981	16	15
612	16082	11/19/1997	3/24/1998	70300	TDS (MG/L)	69	748	225	5	5
612	16083	11/19/1997	5/27/1998	70300	TDS (MG/L)	82	134	106	7	7
612	16084	11/19/1997	5/27/1998	70300	TDS (MG/L)	64	690	183.29	7	7
612	16085	11/19/1997	5/27/1998	70300	TDS (MG/L)	84	113	98.429	7	7

Table 5A-36. Summary of Surficial Water Temperature Data for Segments 0611 and 0612

Segment ID	Station ID	Period Begin	Period End	Depth	Storet ID	Parameter	Min	Max	Avg	N	N > Criteria
611	10474	10/28/1996	7/11/2002	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	4.2	27.7	18.40	29	
611	10475	10/28/1996	7/11/2002	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	2.7	28	17.52	29	
611	10532	9/5/1996	7/22/2002	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	6.5	30.4	17.59	31	
611	10536	12/5/2000	8/1/2002	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	7	26.8	16.59	8	
611	10538	10/19/2000	7/25/2002	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	9.9	27	18.14	8	
611	10539	2/22/1995	6/21/1995	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	11.2	22.9	16.10	3	
611	10540	11/18/1997	7/22/2002	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	9.8	27.9	19.30	20	
611	10542	12/29/1998	7/30/1999	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	8.7	28.5	19.03	9	
611	10551	9/5/1996	7/12/2000	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	6.3	27.3	17.74	24	
611	10552	10/13/1998	11/21/2002	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	6.8	25.3	16.55	15	
611	10627	1/15/1990	11/12/2002	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	7.6	32	21.08	81	
611	10630	11/17/1997	11/21/2002	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	7.8	30.2	18.70	24	
611	10633	9/5/1996	7/22/2002	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	6.4	28.8	17.36	30	
611	10635	11/29/2000	11/21/2002	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	7.9	24.6	14.20	7	
611	13788	10/26/1993	11/6/1996	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	7.5	25.6	18.18	6	
611	14470	10/31/1995	6/25/1997	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	3.5	25.1	15.44	9	
611	14477	10/16/1995	8/1/2002	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	2.8	27.7	15.51	13	
611	15801	11/4/1997	11/4/1997	0.305	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	18.8	18.8	18.80	1	
611	15806	10/21/1997	8/27/1996	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	16.4	24.4	20.40	2	
611	15807	10/21/1997	8/27/1996	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	16.6	25.1	20.85	2	
611	16289	10/12/1998	8/18/1999	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	11.5	24.8	18.88	6	
611	16290	10/22/1998	8/18/1999	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	12.1	25.9	20.03	6	
611	16291	10/22/1998	8/18/1999	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	11.6	27.8	20.40	6	
611	16292	10/22/1998	3/26/1999	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	12.4	24.9	18.69	7	
611	16294	10/12/1998	3/26/1999	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	12.1	23.9	18.76	7	
611	16298	10/27/1998	8/30/2000	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	5.8	28	18.95	23	
611	16300	10/13/1998	8/18/1999	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	12.1	27.8	20.57	7	
611	16301	11/5/1998	7/13/2000	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	4.9	27.5	16.58	9	
611	16302	10/13/1998	8/18/1999	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	11.9	23.6	19.58	6	
611	16303	10/13/1998	6/22/1999	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	9.7	22.5	17.80	5	
611	16304	10/12/1998	8/18/1999	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	12	24.1	19.83	6	
611	16586	10/19/2000	7/25/2002	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	8.5	27.1	18.11	8	
611	16587	7/14/1999	7/14/1999	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	24.1	24.1	24.10	1	
611	17103	12/5/2000	7/25/2002	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	6.8	27	16.56	8	
612	10636	6/13/1990	7/11/2002	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	6.1	29	20.30	61	
612	10636	8/18/1994	8/18/1994	0.30488	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	24.8	24.8	24.80	1	
612	15253	1/6/1997	7/10/1997	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	14.2	24.8	17.98	4	
612	15802	11/5/1997	11/5/1997	0.305	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	17.7	17.7	17.70	1	
612	16076	11/20/1997	7/11/2002	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	2.2	26.4	16.35	20	
612	16082	11/19/1997	3/24/1998	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	8.9	19.8	14.62	5	
612	16083	11/19/1997	4/22/1998	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	9.6	16.1	12.38	6	
612	16084	11/19/1997	4/22/1998	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	10.4	15.1	12.18	6	
612	16085	11/19/1997	4/22/1998	0.3	00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	9.7	16.7	12.73	6	

Table 5A-37. Summary of Surficial pH Data for Segments 0611 and 0612

Segment ID	Station ID	Period Begin	Period End	Depth	Storet ID	Parameter	Min	Max	Avg	N	N Outside Criteria
611	10474	10/28/1996	7/11/2002	0.3	00400	PH (STANDARD UNITS)	6.2	7.4	7.05	29	
611	10475	10/28/1996	7/11/2002	0.3	00400	PH (STANDARD UNITS)	6.9	7.7	7.27	29	
611	10532	9/5/1996	7/22/2002	0.3	00400	PH (STANDARD UNITS)	6.1	7.9	6.98	31	
611	10536	12/5/2000	8/1/2002	0.3	00400	PH (STANDARD UNITS)	6.7	8	7.05	8	
611	10538	10/19/2000	7/25/2002	0.3	00400	PH (STANDARD UNITS)	7	7.9	7.38	8	
611	10539	2/22/1995	6/21/1995	0.3	00400	PH (STANDARD UNITS)	6.5	7.2	6.90	3	
611	10540	11/18/1997	7/22/2002	0.3	00400	PH (STANDARD UNITS)	6.6	7.5	7.12	20	
611	10542	12/29/1998	7/30/1999	0.3	00400	PH (STANDARD UNITS)	6.6	7.2	7.00	9	
611	10551	9/5/1996	7/12/2000	0.3	00400	PH (STANDARD UNITS)	5.8	7.9	6.87	24	1
611	10552	10/13/1998	11/21/2002	0.3	00400	PH (STANDARD UNITS)	5.5	7.1	6.69	15	1
611	10627	1/15/1990	11/12/2002	0.3	00400	PH (STANDARD UNITS)	5.4	7.9	6.76	81	5
611	10627	10/12/1999	8/15/2001	0.5	00400	PH (STANDARD UNITS)	7	7.4	7.18	4	
611	10627	10/27/1993	11/12/2002	1	00400	PH (STANDARD UNITS)	6.2	7.6	6.71	16	
611	10627	6/8/1994	11/12/2002	1.5	00400	PH (STANDARD UNITS)	6.2	6.7	6.45	2	
611	10627	1/18/1994	1/18/1994	1.6	00400	PH (STANDARD UNITS)	7.5	7.5	7.50	1	
611	10627	11/4/1997	4/29/2002	2	00400	PH (STANDARD UNITS)	6.2	6.9	6.54	10	
611	10627	11/4/1997	1/20/1999	2.5	00400	PH (STANDARD UNITS)	6.3	6.7	6.43	3	
611	10627	2/18/1998	2/7/2002	3	00400	PH (STANDARD UNITS)	6.2	6.9	6.60	3	
611	10627	2/18/1998	2/18/1998	3.5	00400	PH (STANDARD UNITS)	6.2	6.2	6.20	1	
611	10627	5/22/2001	5/22/2001	4	00400	PH (STANDARD UNITS)	6.7	6.7	6.70	1	
611	10627	5/22/2001	5/22/2001	5	00400	PH (STANDARD UNITS)	6.7	6.7	6.70	1	
611	10627	5/22/2001	5/22/2001	5.5	00400	PH (STANDARD UNITS)	6.7	6.7	6.70	1	
611	10630	11/17/1997	11/21/2002	0.3	00400	PH (STANDARD UNITS)	6.3	7.5	6.90	22	
611	10630	10/14/1998	10/14/1998	1	00400	PH (STANDARD UNITS)	6.9	6.9	6.90	1	
611	10633	9/5/1996	7/22/2002	0.3	00400	PH (STANDARD UNITS)	5.5	8	6.86	30	2
611	10635	11/29/2000	11/21/2002	0.3	00400	PH (STANDARD UNITS)	6.6	7.1	6.86	7	
611	10635	7/11/2001	7/11/2001	0.4	00400	PH (STANDARD UNITS)	6.9	6.9	6.90	1	
611	13788	10/26/1993	11/6/1996	0.3	00400	PH (STANDARD UNITS)	6.4	6.8	6.60	6	
611	14470	10/31/1995	6/25/1997	0.3	00400	PH (STANDARD UNITS)	5.6	7.1	6.60	9	1
611	14477	10/16/1995	8/1/2002	0.3	00400	PH (STANDARD UNITS)	6.3	7.7	6.95	13	
611	15801	11/4/1997	11/4/1997	0.305	00400	PH (STANDARD UNITS)	8.2	8.2	8.20	1	
611	15801	11/4/1997	11/4/1997	1.52439	00400	PH (STANDARD UNITS)	8.1	8.1	8.10	1	
611	15801	11/4/1997	11/4/1997	3.04878	00400	PH (STANDARD UNITS)	8.1	8.1	8.10	1	
611	15801	11/4/1997	11/4/1997	4.57317	00400	PH (STANDARD UNITS)	8	8	8.00	1	
611	15801	11/4/1997	11/4/1997	6.09756	00400	PH (STANDARD UNITS)	8	8	8.00	1	
611	15801	11/4/1997	11/4/1997	7.62195	00400	PH (STANDARD UNITS)	8	8	8.00	1	
611	15801	11/4/1997	11/4/1997	9.14634	00400	PH (STANDARD UNITS)	7.9	7.9	7.90	1	
611	15801	11/4/1997	11/4/1997	10.67073	00400	PH (STANDARD UNITS)	7.8	7.8	7.80	1	
611	15801	11/4/1997	11/4/1997	12.19512	00400	PH (STANDARD UNITS)	7.8	7.8	7.80	1	
611	15806	10/21/1997	8/27/1996	0.3	00400	PH (STANDARD UNITS)	7.1	7.2	7.15	2	
611	15807	10/21/1997	8/27/1996	0.3	00400	PH (STANDARD UNITS)	6.9	7.1	7.00	2	
611	16289	10/12/1998	8/18/1999	0.3	00400	PH (STANDARD UNITS)	5.5	7	6.48	6	1
611	16290	10/22/1998	8/18/1999	0.3	00400	PH (STANDARD UNITS)	5	7	6.37	6	1
611	16291	10/22/1998	8/18/1999	0.3	00400	PH (STANDARD UNITS)	4.9	7.2	6.67	6	1
611	16292	10/22/1998	3/26/1999	0.3	00400	PH (STANDARD UNITS)	5.6	8.5	6.77	7	1
611	16294	10/12/1998	3/26/1999	0.3	00400	PH (STANDARD UNITS)	5.6	7.5	6.83	7	1
611	16298	10/27/1998	8/30/2000	0.3	00400	PH (STANDARD UNITS)	7	7.9	7.53	23	
611	16300	10/13/1998	8/18/1999	0.3	00400	PH (STANDARD UNITS)	4.8	7.5	6.49	7	1
611	16301	11/5/1998	7/13/2000	0.3	00400	PH (STANDARD UNITS)	6.4	7.6	7.04	9	
611	16302	10/13/1998	8/18/1999	0.3	00400	PH (STANDARD UNITS)	5	7.2	6.57	6	1
611	16303	10/13/1998	6/22/1999	0.3	00400	PH (STANDARD UNITS)	5.5	6.7	6.16	5	2
611	16304	10/12/1998	8/18/1999	0.3	00400	PH (STANDARD UNITS)	4.8	7	6.47	6	1
611	16586	10/19/2000	7/25/2002	0.3	00400	PH (STANDARD UNITS)	6.6	7.8	7.24	8	
611	16587	7/14/1999	7/14/1999	0.3	00400	PH (STANDARD UNITS)	6.8	6.8	6.80	1	
611	17103	12/5/2000	7/25/2002	0.3	00400	PH (STANDARD UNITS)	6.7	7.7	7.00	8	
612	10636	6/13/1990	7/11/2002	0.3	00400	PH (STANDARD UNITS)	5.7	8.9	6.97	61	4
612	10636	8/18/1994	8/18/1994	0.30488	00400	PH (STANDARD UNITS)	7	7	7.00	1	4
612	10636	6/13/1990	6/13/1990	1.01	00400	PH (STANDARD UNITS)	6.5	6.5	6.50	1	1
612	10636	7/15/1992	7/15/1992	1.52	00400	PH (STANDARD UNITS)	7.1	7.1	7.10	1	
612	10636	6/13/1990	6/13/1990	2.01	00400	PH (STANDARD UNITS)	6.5	6.5	6.50	1	
612	15253	1/6/1997	7/10/1997	0.3	00400	PH (STANDARD UNITS)	6.6	7.4	7.08	4	
612	15802	11/5/1997	11/5/1997	0.305	00400	PH (STANDARD UNITS)	7.9	7.9	7.90	1	
612	15802	11/5/1997	11/5/1997	1.52439	00400	PH (STANDARD UNITS)	7.9	7.9	7.90	1	

612	15802	11/5/1997	11/5/1997	3.04878	00400	PH (STANDARD UNITS)	7.9	7.9	7.90	1	
612	15802	11/5/1997	11/5/1997	4.57317	00400	PH (STANDARD UNITS)	7.8	7.8	7.80	1	
612	15802	11/5/1997	11/5/1997	6.09756	00400	PH (STANDARD UNITS)	7.8	7.8	7.80	1	
612	15802	11/5/1997	11/5/1997	7.62195	00400	PH (STANDARD UNITS)	7.5	7.5	7.50	1	
612	15802	11/5/1997	11/5/1997	9.14634	00400	PH (STANDARD UNITS)	7.3	7.3	7.30	1	
612	16076	11/20/1997	7/11/2002	0.3	00400	PH (STANDARD UNITS)	6.4	7.8	6.97	20	
612	16082	11/19/1997	3/24/1998	0.3	00400	PH (STANDARD UNITS)	5.7	6	5.82	5	4
612	16083	11/19/1997	4/22/1998	0.3	00400	PH (STANDARD UNITS)	6.2	7	6.66	5	
612	16084	11/19/1997	4/22/1998	0.3	00400	PH (STANDARD UNITS)	6.2	7.1	6.68	6	
612	16085	11/19/1997	4/22/1998	0.3	00400	PH (STANDARD UNITS)	5.9	7.4	6.58	6	1

Table 5A-38. Summary of Surficial Conductivity Data for Segments 0611 and 0612

Segment ID	Station ID	Period Begin	Period End	Depth	Storet ID	Parameter	Min	Max	Avg	N
611	10474	10/28/1996	7/11/2002	0.3	00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	126	516	292.82	28
611	10475	10/28/1996	7/11/2002	0.3	00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	51	227	160.75	28
611	10532	9/5/1996	7/22/2002	0.3	00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	68	523	187.42	31
611	10536	12/5/2000	8/1/2002	0.3	00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	99	287	183.75	8
611	10538	10/19/2000	7/25/2002	0.3	00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	117	295	223.25	8
611	10539	2/22/1995	6/21/1995	0.3	00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	84	257	189.33	3
611	10540	11/18/1997	7/22/2002	0.3	00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	246	738	382.89	19
611	10542	12/29/1998	7/30/1999	0.3	00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	240	322	277.44	9
611	10551	9/5/1996	7/12/2000	0.3	00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	35	133	80.71	24
611	10552	10/13/1998	11/21/2002	0.3	00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	41	122	82.33	15
611	10627	1/15/1990	11/12/2002	0.3	00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	101	355	163.67	46
611	10630	11/17/1997	11/21/2002	0.3	00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	106	259	168.09	22
611	10633	9/5/1996	7/22/2002	0.3	00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	56	217	130.03	30
611	10635	11/29/2000	11/21/2002	0.3	00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	135	206	151.29	7
611	13788	10/26/1993	11/6/1996	0.3	00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	80	112	95.83	6
611	14470	10/31/1995	6/25/1997	0.3	00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	132	298	180.78	9
611	14477	10/16/1995	8/1/2002	0.3	00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	131	271	198.00	12
611	15801	11/4/1997	11/4/1997	0.305	00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	93	93	93.00	1
611	15806	10/21/1997	8/27/1996	0.3	00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	102	138	120.00	2
611	15807	10/21/1997	8/27/1996	0.3	00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	230	252	241.00	2
611	16289	10/12/1998	8/18/1999	0.3	00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	33	74	49.83	6
611	16290	10/22/1998	8/18/1999	0.3	00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	83	120	101.50	6
611	16291	10/22/1998	8/18/1999	0.3	00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	64	111	87.50	6
611	16292	10/22/1998	3/26/1999	0.3	00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	74	123	98.86	7
611	16294	10/12/1998	3/26/1999	0.3	00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	33	58	45.00	7
611	16298	10/27/1998	8/30/2000	0.3	00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	118	394	276.35	23
611	16300	10/13/1998	8/18/1999	0.3	00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	62	111	85.29	7
611	16301	11/5/1998	7/13/2000	0.3	00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	136	219	182.67	9
611	16302	10/13/1998	8/18/1999	0.3	00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	21	100	40.83	6
611	16303	10/13/1998	6/22/1999	0.3	00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	196	304	240.40	5
611	16304	10/12/1998	8/18/1999	0.3	00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	44	92	67.33	6
611	16586	10/19/2000	7/25/2002	0.3	00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	81	337	169.25	8
611	16587	7/14/1999	7/14/1999	0.3	00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	460	460	460.00	1
611	17103	12/5/2000	7/25/2002	0.3	00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	107	273	192.75	8
612	10636	6/13/1990	7/11/2002	0.3	00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	63	187	106.11	27
612	10636	8/18/1994	8/18/1994	0.30488	00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	102	102	102.00	1
612	15253	1/6/1997	7/10/1997	0.3	00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	75	193	135.00	4
612	15802	11/5/1997	11/5/1997	0.305	00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	74	74	74.00	1
612	16076	11/20/1997	7/11/2002	0.3	00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	42	145	91.79	19
612	16082	11/19/1997	3/24/1998	0.3	00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	35	1110	268.40	5
612	16083	11/19/1997	4/22/1998	0.3	00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	76	140	119.00	6
612	16084	11/19/1997	4/22/1998	0.3	00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	46	144	111.67	6

612	16085	11/19/1997	4/22/1998	0.3	00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	62	120	84.83	6

Appendix 5B
Summary Tables for STORET Water Quality Monitoring Data for Sam Rayburn Reservoir

Table 5B-1. Summary of Dissolved Oxygen Data for Segment 0611

Station ID	Start Date	End Date	Dissolved Oxygen (mg/L)				
			Number of Observations	Minimum	Maximum	Average	Number of Exceedances[a]
08037000	1/27/94	3/27/97	20	5.5	10.4	7.1	0
06110100	1/15/90	2/23/93	13	5.8	9.9	7.6	0
10633	9/5/96	5/21/98	11	6.0	10.5	7.5	0
14470	10/31/95	1/16/97	7	4.7	12.0	7.9	0
10551	9/5/96	5/21/98	9	6.5	10.9	8.3	0
13788	10/26/93	11/6/96	6	6.5	10.9	8.1	0
10532	9/5/96	5/21/98	10	5.5	10.8	7.8	0
14477	10/16/95	6/12/96	5	5.5	12.4	8.1	0
10540	11/18/97	5/21/98	3	5.5	9.9	8.2	0

[a]Observations compared to water quality criterion of 5.0 mg/L for segment 0611 (Source: Texas Administrative Code 307.10(1))

Table 5B-2. Summary of Dissolved Oxygen Data for Segment 0612

Station ID	Start Date	End Date	Dissolved Oxygen (mg/L)				
			Number of Observations	Minimum	Maximum	Average	Number of Exceedances[a]
06120100	6/13/90	7/15/92	6	6.1	7.3	6.45	0
08038000	1/27/94	3/27/97	20	6.4	11.6	7.74	0

[a]Observations compared to water quality criterion of 5.0 mg/L for degment 0612 (Source: Texas Administrative Code 307.10(1))

Table 5B-3. Summary of Chlorphyll a Data for Segment 0611

Station ID	Start Date	End Date	Chlorophyll a (µg/L)				Number of Exceedances[a]	
			Number of Observations	Minimum	Maximum	Average	Reference Criteria	Screening Level
06110100	1/15/90	2/23/96	13	1.0	9.1	3.2	5	0
14470	10/31/95	10/28/96	5	1.0	17.7	5.8	2	1
13788	10/26/93	11/6/96	7	1.0	9.2	3.2	3	0
14477	10/16/95	6/12/96	4	1.7	8.6	3.6	3	0

[a]Compared to 11.6 mg/L screening level for secondary concerns (Source: Guidance for Assessing Texas Surface and Finished Drinking Water Quality Data, 2002)

Table 5B-4. Summary of Chlorphyll a Data for Segment 0612

Station ID	Start Date	End Date	Chlorophyll a (µg/L)				Number of Exceedances[a]	
			Number of Observations	Minimum	Maximum	Average	Reference Criteria	Screening Level
06120100	6/13/90	7/15/92	3	1.0	10.2	4.4	1	0

[a]Compared to 11.6 mg/L screening level for secondary concerns (Source: Guidance for Assessing Texas Surface and Finished Drinking Water Quality Data, 2002)and reference criterion of 2.834 µg/L (EPA 2002)

Table 5B-5. Summary of Secchi Depth Data for Segment 0611

Station ID	Start Date	End Date	Secchi Depth (m)			
			Number of Observations	Minimum	Maximum	Average
06110100	1/15/90	2/23/93	13	0.20	0.72	0.39
14470	10/16/95	6/12/96	5	0.38	0.80	0.53
10551	5/21/98	5/21/98	1	0.50	0.50	0.50
13788	10/26/93	11/6/96	6	0.40	0.90	0.67
10532	5/21/98	5/21/98	1	0.15	0.15	0.15
14477	10/16/95	6/12/96	5	0.38	0.80	0.53

Table 5B-6. Summary of Secchi Depth Data for Segment 0612

Station ID	Start Date	End Date	Secchi Depth (m)			
			Number of Observations	Minimum	Maximum	Average
06120100	6/13/90	7/15/92	3	0.18	0.5	0.32

Table 5B-7. Summary of Total Phosphorus Data for Segment 0611

Station ID	Start Date	End Date	Total Phosphorus (mg/L)				Number of Exceedances[a]	
			Number of Observations	Minimum	Maximum	Average	Reference Criteria	Screening Level
06110100	1/15/90	2/23/96	12	0.05	0.16	0.11	11	0
14470	10/31/95	10/28/96	5	0.05	0.27	0.13	4	0
13788	10/26/93	11/6/96	7	0.01	0.12	0.05	2	0
14477	10/16/95	6/12/96	4	0.20	0.53	0.32	4	0

[a]Compared to 0.8 mg/L screening level for secondary concerns (Source: Guidance for Assessing Texas Surface and Finished Drinking Water Quality Data, 2002) and the 0.05 mg/L reference criterion (Source: EPA 2000)

Table 5B-8. Summary of Total Phosphorus Data for Segment 0612

Station ID	Start Date	End Date	Total Phosphorus (mg/L)				Number of Exceedances[a]	
			Number of Observations	Minimum	Maximum	Average	Reference Criteria	Screening Level
06120100	6/13/90	7/15/92	3	0.08	0.15	0.11	3	0

[a]Compared to 0.8 mg/L screening level for secondary concerns (Source: Guidance for Assessing Texas Surface and Finished Drinking Water Quality Data, 2002)

Table 5B-9. Summary of Orthophosphorus Data for Segment 0611

Station ID	Start Date	End Date	Total Ortho Phosphorus (mg/L)				
			Number of Observations	Minimum	Maximum	Average	Number of Exceedances[a]
10633	3/3/98	5/21/98	2	0.50	0.98	0.74	1
14470	4/10/96	6/12/96	2	0.10	0.10	0.10	0
10551	3/3/98	5/21/98	2	0.28	0.30	0.29	0
10532	3/3/98	5/21/98	2	0.60	1.55	1.08	2
10540	3/3/98	5/21/98	2	1.00	2.20	1.60	2

[a]Compared to 0.5 mg/L screening level for secondary concerns (Source: Guidance for Assessing Texas Surface and Finished Drinking Water Quality Data, 2002).

Table 5B-10. Summary of NO_2+NO_3 Data for Segment 0611

Station ID	Start Date	End Date	NO2+NO3 (mg/L)				Number of Exceedances[a]	
			Number of Observations	Minimum	Maximum	Average	Reference Criteria	Screening Level
10633	11/18/97	5/21/98	3	0.20	0.80	0.40	3	0
14470	10/31/95	10/28/96	3	0.01	0.24	0.11	2	0
10551	11/18/97	5/21/98	3	0.40	0.90	0.60	3	0
13788	8/7/95	11/6/96	2	0.03	0.22	0.13	1	0
10532	11/18/97	5/21/98	3	0.20	1.30	0.77	3	0
14477	10/16/95	1/9/96	2	1.19	2.42	1.81	2	0
10540	11/18/97	5/21/98	3	3.40	10.40	7.60	4	3

[a]Compared to the screening level of 2.76 mg/L (Source: Guidance for Assessing Texas Surface and Finished Drinking Water Quality Data, 2002) and the 0.067 mg/L reference criterion (Source: EPA 2000).

Table 5B-11. Summary of NO_2+NO_3 Data for Segment 0612

Station ID	Start Date	End Date	NO2+NO3 (mg/L)				Number of Exceedances[a]	
			Number of Observations	Minimum	Maximum	Average	Reference Criteria	Screening Level
06120100	6/25/91	7/15/92	2	0.53	0.72	0.63	2	0

[a]Compared to the screening level of 2.76 mg/L (Source: Guidance for Assessing Texas Surface and Finished Drinking Water Quality Data, 2002) and the 0.067 mg/L reference criterion (Source: EPA 2000).

Table 5B-12. Summary of TKN Data for Segment 0611

Station ID	Start Date	End Date	TKN (mg/L)				
			Number of Observations	Minimum	Maximum	Average	Number of Exceedances[a]
06110100	2/23/93	2/23/93	1	0.47	0.47	0.47	1
14470	10/31/95	10/28/96	5	0.28	0.72	0.40	1
13788	10/26/93	11/6/96	7	0.28	0.42	0.34	0
14477	10/16/95	6/12/96	4	0.34	0.88	0.61	3

[a]Compared to the 0.44 mg/L reference criterion (Source: EPA 2000).

Table 5B-13. Summary of Ammonia Data for Segment 0611

Station	Start Date	End Date	Ammonia (mg/L)				
			Number of Observation	Minimum	Maximum	Average	Number of Exceedances[a]
08037000	1/27/94	3/27/97	20	0.000006	0.0004	0.0000837	0
06110100	1/15/90	2/23/93	13	0.000004	0.0001	0.00006	0
10633	8/28/97	5/21/98	4	0.00002	0.0003	0.000155	0
14470	6/12/96	6/12/96	1	0.0006	0.0006	0.0006	0
10551	11/18/97	5/21/98	3	0.00007	0.0003	0.00019	0
13788	5/26/94	7/21/94	2	0.0001	0.0002	0.00015	0
10532	11/18/97	5/21/98	3	0.00004	0.0005	0.00028	0
14477	6/12/96	6/12/96	1	0.0004	0.0004	0.0004	0
10540	11/18/97	5/21/98	3	0.0004	0.0009	0.0005667	0

[a]Observations compared to water quality screening level of 0.17 mg/L for freshwater streams (Source: TNRCC 2002)

Table 5B-14. Summary of Ammonia Data for Segment 0612

Station ID	Start Date	End Date	Ammonia (mg/L)				
			Number of Observations	Minimum	Maximum	Average	Number of Exceedances*
06120100	6/13/90	7/15/92	3	0.00004	0.001	0.0006467	0
08038000	1/27/94	3/27/97	20	0.00001	0.0002	0.0000845	0

*Observations compared to water quality screening level of 0.17 mg/L for freshwater streams (Source: TNRCC 2002)

Table 5B-15. Summary of BOD_5 Data for Segment 0611

Station ID	Start Date	End Date	BOD_5 (mg/L)			
			Number of Observations	Minimum	Maximum	Average
08037000	1/27/94	3/27/97	20	0.6	2.4	1.4

Table 5B-16. Summary of the BOD_5 Data for Segment 0612

Station ID	Start Date	End Date	BOD_5 (mg/L)			
			Number of Observations	Minimum	Maximum	Average
08038000	1/27/94	3/27/97	20	0.5	2.3	1.4

Table 5B-17. Summary of Total Organic Carbon Data for Segment 0611

Station ID	Start Date	End Date	TOC (mg/L)			
			Number of Observations	Minimum	Maximum	Average
08037000	1/27/94	2/13/97	19	4.6	19.0	9.5
06110100	1/15/90	2/23/96	13	4.0	14.0	7.3
14470	10/31/95	10/28/96	5	4.0	8.0	6.4
13788	10/26/93	11/6/96	7	2.0	7.0	4.3
14477	10/16/95	6/12/96	4	5.0	11.0	7.3

Table 5B-18. Summary of Total Organic Carbon Data for Segment 0612

Station ID	Start Date	End Date	TOC (mg/L)			
			Number of Observations	Minimum	Maximum	Average
06120100	6/13/90	7/15/92	3	3.0	8.0	6.0
08038000	1/27/94	2/12/97	18	4.2	11.0	7.1

Table 5B-19. Summary of Metals Data for Segment 0611

Metals (µg/L)	Station ID	Start Date	End Date	Number of Observations	Minimum	Maximum	Average	Number of Exceedances[a]
Dissolved Arsenic (As)	08037000	1/27/94	2/13/97	10	1.0	2.0	1.2	0
	13788	10/26/93	10/26/93	1	2.0	2.0	2.0	0
Dissolved Aluminum (Al)	06110100	1/15/90	8/28/91	7	310.0	2410.0	1,059.3	3
Dissolved Copper (Cu)	08037000	1/27/94	2/13/97	10	10.0	10.0	10.0	0[b]
	13788	10/26/93	10/26/93	1	11.0	11.0	11.0	1
Dissolved Lead (Pb)	08037000	1/27/94	2/13/97	10	10.0	20.0	11.0	4
	13788	10/26/93	10/26/93	1	1.0	1.0	1.0	0
Total Selenium (Se)	10633	8/28/97	8/28/97	1	5.0	5.0	5.0	0
Dissolved Zinc (Zn)	08037000	1/27/94	2/13/97	10	3.0	18.0	8.2	0
	13788	10/26/93	10/26/93	1	48.0	48.0	48.0	1

[a]Observations compared to metals water quality criteria for segment 0611 (Source: Texas Administrative Code 307.6(c)(1) and 307.6(d)(1))
[b] All or some samples below detection limit.

Table 5B-20. Summary of Metals Data for Segment 0612

Metals (µg/L)	Station ID	Start Date	End Date	Number of Observations	Minimum	Maximum	Average	Number of Exceedances[a]
Dissolved Arsenic (As)	08038000	1/27/94	2/12/97	10	1	1	1	0
Dissolved Aluminum (Al)	06120100	6/25/91	6/25/91	1	3560	3560	3560	1
Dissolved Copper (Cu)	08038000	1/27/94	2/12/97	10	10	10	10	0[b]
Dissolved Lead (Pb)	08038000	1/27/94	2/12/97	10	10	10	10	0
Dissolved Zinc (Zn)	08038000	1/27/94	2/12/97	10	3	20	9.4	0

[a]Observations compared to metals water quality criteria for segment 612 (Source: Texas Administrative Code 307.6(c)(1) and 307.6(d)(1))
[b] All or some of the observations were below the detection limit

Table 5B-21. Summary of Fecal Coliform Bacteria Data for Segment 0611

Station ID	Start Date	End Date	Fecal Coliform Bacteria (counts/100mL)				
			Number of Observations	Minimum	Maximum	Average	Number of Exceedances[a]
06110100	1/15/90	2/23/96	12	10	805	183	1
10633	9/5/96	5/21/98	13	110	2200	665	6
14470	10/31/95	1/16/97	7	52	190	104	0
10551	9/5/96	5/21/98	11	120	5800	1028	4
13788	10/26/93	11/6/96	6	53	200	111	0
10532	9/5/96	5/21/98	12	130	8100	1197	4
14477	10/16/95	6/12/96	5	40	490	166	1
10540	11/18/97	5/21/98	3	40	150	93	0

[a]Observations compared to water quality criterion of 400 counts/100mL for segment 0611 (Source: Texas Administrative Code 307.10(1))

Table 5B-22. Summary of Fecal Coliform Bacteria Data for Segment 0612

Station ID	Start Date	End Date	Fecal Coliform Bacteria (counts/100mL)				
			Number of Observations	Minimum	Maximum	Average	Number of Exceedances[a]
06120100	6/13/90	6/25/91	2	97	1,520	808.5	1

[a]Observations compared to water quality criterion of 400 counts/100mL for segment 0612 (Source: Texas Administrative Code 307.10(1))

Table 5B-23. Summary of Total Alkalinity Data for Segment 0611

Station ID	Start Date	End Date	Total Alkalinity as CaCO3 (mg/L)			
			Number of Observations	Minimum	Maximum	Average
08037000	3/22/94	8/31/95	10	15	34	23
06110100	1/15/90	2/23/93	13	4	29	16
14470	10/31/95	10/28/96	5	5	66	27
13788	10/26/93	11/6/96	7	6	20	15
14477	10/16/95	6/12/96	4	20	60	36

Table 5B-24. Summary of Total Alkalinity Data for Segment 0612

Station ID	Start Date	End Date	Total Alkalinity as CaCO3 (mg/L)			
			Number of Observations	Minimum	Maximum	Average
06120100	6/13/90	7/15/92	3	16	44	27
08038000	1/27/94	8/29/95	11	16	28	21

Table 5B-25. Summary of Chloride Data for Segment 0611

Station ID	Start Date	End Date	Chloride (mg/L)				
			Number of Observations	Minimum	Maximum	Average	Number of Exceedances[a]
08037000	1/27/94	2/13/97	19	7.0	47.0	17.6	0
06110100	1/15/90	2/23/96	13	8.0	22.0	15.4	0
10633	11/18/97	5/21/98	3	13.0	26.0	18.3	0
14470	10/31/95	10/28/96	5	15.0	68.0	29.2	0
10551	11/18/97	5/21/98	3	7.0	12.0	9.7	0
13788	10/26/93	11/6/96	7	8.0	11.0	9.6	0
10532	11/18/97	5/21/98	3	12.0	27.0	18.7	0
14477	10/16/95	6/12/96	4	4.0	28.0	19.5	0
10540	11/18/97	5/21/98	3	31.0	51.0	38.3	0

[a]Observations compared to water quality criterion of 125 mg/L for segment 0611 (Source: Texas Administrative Code 307.10(1))

Table 5B-26. Summary of Chloride Data for Segment 0612

Station ID	Start Date	End Date	Chloride (mg/L)				
			Number of Observations	Minimum	Maximum	Average	Number of Exceedances[a]
06120100	6/13/90	7/15/92	3	3.0	9.0	7.0	0
08038000	1/27/94	2/12/97	19	7.0	15.0	9.7	0

[a]Observations compared to water quality criterion of 75 mg/L for segment 0612 (Source: Texas Administrative Code 307.10(1))

Table 5B-27. Summary of Sulfate Data for Segment 0611

Station ID	Start Date	End Date	Sulfate (mg/L)				
			Number of Observations	Minimum	Maximum	Average	Number of Exceedances[a]
08037000	1/27/94	2/13/97	19	11.0	27.0	19.2	0
06110100	1/15/90	2/23/96	13	16.0	36.0	24.5	0
10633	11/18/97	5/21/98	3	12.0	22.0	18.0	0
14470	10/31/95	10/28/96	5	12.0	80.0	30.4	0
10551	11/18/97	5/21/98	3	12.0	276.0	104.0	0
13788	10/26/93	11/6/96	7	9.0	21.0	13.9	0
10532	11/18/97	5/21/98	3	26.0	39.0	32.3	0
14477	10/16/95	6/12/96	4	3.0	28.0	19.8	0
10540	11/18/97	5/21/98	3	29.0	45.0	38.3	0

[a]Observations compared to water quality criterion of 50 mg/L for segment 0611 (Source: Texas Administrative Code 307.10(1))

Table 5B-28. Summary of Sulfate Data for Segment 0612

Station ID	Start Date	End Date	Sulfate (mg/L)				
			Number of Observations	Minimum	Maximum	Average	Number of Exceedances[a]
06120100	6/13/90	7/15/92	3	1.0	16.0	9.7	0
08038000	1/27/94	2/12/97	19	4.0	47.0	15.5	0

[a]Observations compared to water quality criterion of 50 mg/L for segment 0612 (Source: Texas Administrative Code 307.10(1))

Table 5B-29. Summary of TSS and TDS Data for Segment 0611

Station ID	Start Date	End Date	TSS (mg/L)			
			Number of Observations	Minimum	Maximum	Average
08037000	1/27/94	2/13/97	19	10.0	64.0	29.5
06110100	1/15/90	2/23/93	13	4.0	41.0	18.8
10633	8/28/97	5/21/98	4	3.0	19.0	8.5
14470	10/31/95	10/28/96	5	3.0	29.0	15.6
13788	10/26/93	11/6/96	7	1.0	14.0	5.9
10532	11/18/97	5/21/98	3	3.0	26.0	11.7
14477	10/16/95	6/12/96	4	5.0	35.0	20.0
10540	11/18/97	5/21/98	3	4.0	7.0	5.0

Station ID	Start Date	End Date	TDS (mg/L)				
			Number of Observations	Minimum	Maximum	Average	Number of Exceedances[a]
14470	10/31/95	10/28/96	5	111.0	266.0	172.4	0
14477	10/16/95	6/12/96	4	146.0	230.0	188.5	0

[a]Observations compared to water quality criterion of 6-8.5 pH for segment 0611 (Source: Texas Administrative Code 307.10(1))

Table 5B-30. Summary of TSS Data for Segment 0612

Station ID	Start Date	End Date	TSS (mg/L)			
			Number of Observations	Minimum	Maximum	Average
06120100	6/13/90	7/15/92	3	10.0	87.0	53.3
08038000	1/27/94	2/12/97	19	4.0	100.0	36.4

Table 5B-31. Summary of Water Temperature Data for Segment 0611

Station ID	Start Date	End Date	Temperature (°F)				
			Number of Observations	Minimum	Maximum	Average	Number of Exceedances[a]
08037000	1/27/94	3/27/97	20	46.4	86.0	69.7	0
06110100	1/15/90	2/33/93	13	49.1	81.0	64.2	0
10633	9/5/96	5/21/98	14	46.9	83.8	63.8	0
14470	10/31/95	1/16/97	7	38.3	73.4	58.0	0
10551	9/5/96	5/21/98	12	46.0	81.0	62.2	0
13788	10/26/93	11/6/96	6	45.5	78.1	64.7	0
10532	9/5/96	5/21/98	13	46.0	86.7	64.6	0
14477	10/16/95	6/12/96	5	37.0	71.2	57.7	0
10540	11/18/97	5/21/98	3	52.0	76.3	60.8	0

[a]Observations compared to water quality criterion of 90.0°F for egment 0611 (Source: Texas Administrative Code 307.10(1))

Table 5B-32. Summary of Water Temperature Data for Segment 0612

Station ID	Start Date	End Date	Temperature (°F)				
			Number of Observations	Minimum	Maximum	Average	Number of Exceedances[a]
06120100	6/13/90	7/15/92	6	76.1	81.5	79.0	0
08038000	1/27/1994	3/27/1997	20	48.2	84.2	69.1	0

[a]Observations compared to water quality criterion of 90.0°F for segment 0612 (Source: Texas Administrative Code 307.10(1))

Table 5B-33. Summary of pH Data for Segment 0611

Station ID	Start Date	End Date	pH				
			Number of Observations	Minimum	Maximum	Average	Number of Exceedances[a]
08037000	1/27/94	3/27/97	20	5.7	7.5	6.7	2
06110100	1/15/90	2/23/93	13	5.5	7.1	6.4	2
10633	9/5/96	5/21/98	14	6.1	7.2	6.8	0
14470	10/31/95	1/16/97	7	5.6	7.1	6.6	1
10551	9/5/96	5/21/98	12	6.3	7.1	6.8	0
13788	10/26/93	11/6/96	6	6.4	6.8	6.6	0
10532	9/5/96	5/21/98	13	6.1	7.3	6.8	0
14477	10/16/95	6/12/96	5	6.3	7.1	6.8	0
10540	11/18/97	5/21/98	3	6.9	7.2	7.1	0

[a]Observations compared to water quality criterion of 6-8.5 pH for segment 0611 (Source: Texas Administrative Code 307.10(1))

Table 5B-34. Summary of pH Data for Segment 0612

Station ID	Start Date	End Date	pH				
			Number of Observations	Minimum	Maximum	Average	Number of Exceedances*
06120100	6/13/90	7/15/92	6	6.5	7.5	6.9	0
08038000	1/27/94	3/27/97	20	5.9	7.4	6.8	1

*Observations compared to water quality criterion of 6-8.5 pH for segment 0611 (Source: Texas Administrative Code 307.10(1))

Table 5B-35. Summary of Conductivity Data for Segment 0611

Station ID	Start Date	End Date	Conductivity (µmos)			
			Number of Observations	Minimum	Maximum	Average
08037000	1/27/94	3/27/97	20	88	280	156
06110100	1/15/90	2/23/93	13	111	232	153
10633	9/5/96	5/21/98	14	56	200	126
14470	10/31/95	1/16/97	7	133	298	192
10551	9/5/96	5/21/98	12	42	132	88
13788	10/26/93	11/6/96	6	80	112	96
10532	9/5/96	5/21/98	13	79	273	153
14477	10/16/95	6/12/96	5	170	259	209
10540	11/18/97	5/21/98	3	325	467	383

Table 5B-36. Summary of Conductivity Data for Segment 0612

Station ID	Start Date	End Date	Conductivity (µmos)			
			Number of Observations	Minimum	Maximum	Average
06120100	6/13/90	7/15/92	6	86	109	100
08038000	1/27/94	3/27/97	20	84	200	118

6.0 Source Assessment

6.1 Nonpoint Sources

Nonpoint sources represent contributions from diffuse, non-permitted sources. While they likely have a significant impact on water quality in Sam Rayburn Reservoir, it is difficult to generally assess the contribution. This section presents information on potential nonpoint sources in the watershed. It is expected that future modeling efforts will be used to represent and quantify nonpoint source pollutant loads.

Principal economic interests in the Sam Rayburn Reservoir watershed include lumbering, paper and wood products manufacturing, oil field pumping, recreation (water sports and fishing), tourism, education, and agriculture (poultry, dairy products, beef cattle, vegetables and fruits) (ACE 1998). El Hage and Moulton (1998) of the Texas Parks and Wildlife Department described in *Evaluation of Selected Natural Resources in Angelina, Cherokee, Gregg, Nacogdoches, Rusk, and Smith Counties, Texas* that "...the economy of the 6 county area consists primarily of petroleum production and refining, lumbering, beef cattle, poultry, and agribusiness. The agriculture market value in the study area is $286.8 million, mostly generated from timber production (Dallas Morning News 1997)." The economics of the area and the use of abundant natural resources likely affects the nonpoint source contributions to the watershed and reservoir.

Two primary nonpoint source categories (agriculture and urbanization) have been identified for this evaluation because of their potential for contributing to the impairments exhibited by the reservoir. For the purposes of this discussion, agricultural nonpoint sources may include crop farming, livestock operations (including beef, poulty, swine, or other livestock), and silviculture.

6.1.1 Agriculture

Agricultural practices in Texas are largely overseen by the Texas State Soil and Water Conservation Board (TSSWCB). This agency is the lead agency in planning, management, and abatement of agricultural and silvicultural nonpoint source pollution. Senate Bill 503, passed in 1993, authorized this agency to assist agricultural and silvicultural producers to meet state water quality goals through an incentive based voluntary program.

National Agricultural Statistics Service data for 1997 for the nine counties in the Sam Rayburn Reservoir watershed were reviewed to evaluate the magnitude of agricultural activities in the watershed that can potentially deliver pollutant loads to the reservoir. Table 6-1 summarizes the relevant data on crop and livestock related activities in the counties.

Table 6-1. National Agricultural Statistics Data from 1997 for the Nine County Region comprising the Sam Rayburn River Watershed

	County									
	Angelina	**Cherokee**	**Jasper**	**Nacogdoches**	**Newton**	**Rusk**	**Sabine**	**San Augustine**	**Shelby**	**Smith**
Number of Farms	790	1,429	639	1,200	294	1,296	194	291	1,047	1,844
Number of acres in Farms	117,920	283,241	87,079	372,451	62,108	267,448	25,103	65,250	201,427	250,855
Total croplands (acres)	47,705	140,367	26,116	101,669	10,376	131,072	12,568	25,628	86,490	127,336
Harvested croplands (acres)	12,080	51,190	9,186	26,482	3936	30,662	3,788	7,149	22,463	44,129
Irrigated land (acres)	92	542	287	463	63	93	NA	17	324	1,069
Cattle and Calves (total number)	26,176	82,595	14,570	59,460	6,416	57,513	6,915	11,135	46,895	59,968
Beef Cows (total number)	16,154	36,354	8,551	36,582	3,725	33,732	3,758	7,035	30,011	32,285
Milk Cows (total number)	8	14,275	20	2,641	7	1,013	15	125	284	2,864
Cattle and Calves sold (total number)	15,972	39,681	7,015	32,029	3,365	29,450	3,363	5,727	23,567	31,449
Hogs and Pigs (total number)	243	123	319	480	88	537	78	39	60	241
Hogs and Pigs sold (total number)	218	109	327	693	121	711	118	NA	NA	278
Sheep and Lambs (total number)	208	34	NA	117	NA	262	0	12	NA	63
Layers and Pullets (total number)	420	NA	875	839,651	577	NA	NA	82,745	2,030,083	999
Broilers and meat-type chickens sold (total number)	5,056,373	2,578,104	NA	69,164,986	NA	3,774,133	5,566,080	11,792,703	72,928,627	0
Total non Poultry	58,979	173,171	30,802	132,002	13,722	123,218	14,247	24,073	100,817	127,148
Total Animal Units	5,115,772	2,751,275	31,677	70,136,639	14,299	3,897,351	5,580,327	11,899,521	75,059,527	128,147

6.1.1.1 Crop Distribution

As summarized in Table 6-1, estimates of total cropland from the Agricultural Census data of 1997 identify that within the nine counties located at least partially in the watershed, 709,327 acres of land are cropland. MRLC (1992) data suggests that for the nine county region about 1,015,021 acres of land are cropland and about 66,069 acres are pasture or hay. Time periods and the proportion of the counties included in the landuse coverage of the watershed may explain some of the discrepancies.

Approximately 80 percent of the total cropland in the Sam Rayburn Reservoir watershed are in the northern half of the drainage in Cherokee, Nacogdoches, Rusk, Shelby, and Smith counties. The amount of harvested cropland is substantially smaller than the total amount of cropland suggesting that not all of the lands are in production. The amount of irrigated cropland is very low with respect to the total amount of cropland cited. Irrigation returns are often a potentially large nonpoint source of pollution in areas where crop farming on irrigated lands is high. However, given the small amount of irrigated acres, these returns are likely negligible sources to the Sam Rayburn Reservoir watershed.

Agricultural runoff can contribute increased pollutant loads when farm management practices allow soils rich in nutrients from fertilizers or animal waste to be washed into the stream, increasing in-stream sediment and phosphorus levels. The erosion potential of cropland and over-grazed pasture land is particularly high due to the lack of year-round vegetative cover. The use of cover crops and other management practices have been shown to reduce the transport of pollutant loads from agricultural lands.

6.1.1.2 Livestock Management

Based on the 1997 Agricultural Census data, poultry production is the largest livestock-related agricultural practice within the Sam Rayburn Reservoir watershed, followed by cattle production. Over 80 percent of the poultry production within the watershed occurs in the Attoyac Bayou (segment 0612) drainage area in Nacogdoches, San Augustine, and Shelby counties. Seven of the nine counties have poultry operations that sold several million birds, ranging from as 2.5 million in Cherokee County to over 70 million in Shelby County. Figure 6-1 illustrates the locations of poultry operations in the watershed. These facilities provide the potential for direct runoff from farms to headwater creeks that ultimately discharge to the reservoir. While unconfirmed, it is understood that waste from these facilities is applied to the land and managed under BMPs from Water Quality Management Plans developed in conjunction with the TSSWCB.

Overall, total animal production (summed number of animal units) ranged from about 14,300 in Newton County to over 75 million in Shelby County, the largest proportion of which is comprised of poultry. Only a portion of Shelby County lies within the Sam Rayburn Reservoir watershed. However, given the concentration of production facilities in nearby northeastern Nacogdoches County, the portion of Shelby County in the watershed may have a substantial number of production houses.

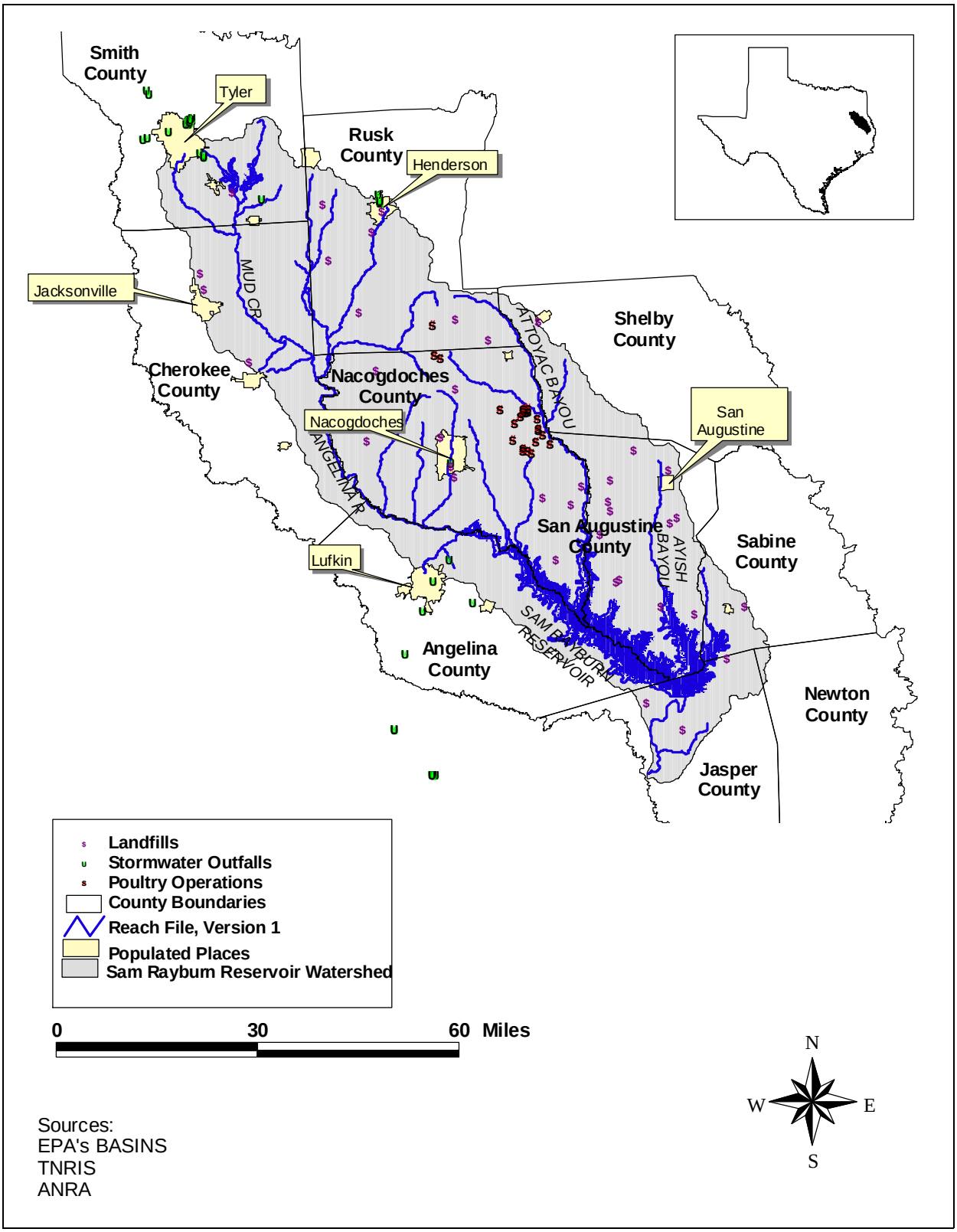

Figure 6-1. Potential nonpoint sources of pollution in the Sam Rayburn Reservoir watershed

Not including poultry, total animal units produced in the nine county region are relatively low, ranging from about 14,000 units in Sabine County to more than 170,000 units in Cherokee County. Cattle production is more prominent in the northern half of the watershed, in Cherokee, Nacogdoches, Rusk, Shelby and Smith counties. Cattle and other grazing animals can represent a significant source of nutrients and bacteria to streams, both through deposition on watershed surfaces and direct access to streams.

6.1.1.3 Silviculture

MRLC (1992) data presented in Section 3.0 indicate that forested land represents a substantial amount of the total acreage in the watershed. These lands represent a combination of national, state, and privately held properties. Data from the U.S. Forest Service's Forest Inventory and Analysis Database Retrieval System were used to generate Tables 6-2 and 6-3. Table 6-2 indicates that a majority of the county lands are forested and that the bulk of those lands are considered to be timberland. Table 6-3 indicates ownership of these lands, of which a large proportion of the land is either privately held by the timber industry or other private individuals. Angelina, Jasper, Nacogdoches, Sabine, San Augustine, and Shelby Counties all contain portions of National Forest Lands. These data do not represent the number of acres in actual timber production, however, they do indicate the large acreage of land potentially available for timbering practices.

Table 6-2. Area by county and land class of forested lands in the nine county region of the Sam Rayburn Reservoir watershed

County		Forested Lands				
	All Land	Total	Timberland	Other Forest Land	Reserved Timberland	Nonforest Land
	Thousands of acres					
Angelina	516.2	380.9	370	0	10.8	135.4
Cherokee	673.3	411.2	411.2	0	0	262.1
Jasper	589.5	520.6	508.9	0	11.8	68.9
Nacogdoches	601.1	379.7	379.7	0	0	221.4
Rusk	596.7	336.7	336.7	0	0	260
Sabine	310.8	276.2	265.1	0	11	34.6
San Augustine	335.3	283.7	278.4	0	5.3	51.6
Shelby	506	357.7	357.7	0	0	148.3
Smith	596.6	255.8	255.8	0	0	340.8
All counties	4,725.7	3,202.5	3,163.6	0	38.9	1,523.2

Source: Forest Inventory and Analysis Data Base Retrieval System

Table 6-3. Area of timberland by county and ownership class in the nine county region of the Sam Rayburn Reservoir watershed

County	All Ownerships	National Forest	Bureau of Land Mngt.	Tribal Trust	Misc. Federal	State	County and Municipal	Forest Industry	Farmer/ Rancher	Private Corp.	Private Individual
	Thousand Acres										
Angelina	370	43.1	0	0	0	0	0	183.1	0	6.5	137.3
Cherokee	411.2	0	0	0	0	5.9	11.7	141	64.6	17.6	170.3
Jasper	508.9	18.1	0	0	0	6.2	0	378.9	6.2	6.2	93.2
Nacogdoches	379.7	9.2	0	0	0	0	6	113.5	6	6	239
Rusk	336.7	0	0	0	0	0	0	17.7	26.6	8.9	283.5
Sabine	265.1	82.9	0	0	0	0	0	129.5	0	4.8	48
San Augustine	278.4	57.2	0	0	0	0	0	137.5	6	0	77.7
Shelby	357.7	58.2	0	0	0	0	0	62.7	27.9	0	208.9
Smith	255.8	0	0	0	0	6.2	0	6.2	87.3	43.7	112.3
All counties	3163.6	268.8	0	0	0	18.3	17.7	1170.1	224.6	93.7	1370.3

- Timberland consist of nonreserved land only in this table for the following states: (TX).
- Numbers in rows and columns may not add to totals due to rounding.
- The data are derived by sampling and are subject to statistical error.
- Source Southern FIA : Asheville, NC
  States:(AL,AR,FL,GA,KY,LA,MS,NC,OK,SC,TN,TX,VA)
  For assistance contact: Joe Glover 704-257-4350
  homepage http://www.srsfia.usfs.msstate.edu

Given these statistics, the timber and forest products industries may be significant nonpoint sources of nutrients, metals, and sedimentation in the Sam Rayburn Reservoir watershed. Communication with forest industry representatives as well as the TSSWCB indicate that BMPs are implemented to control soil loss and erosion from timbered areas to protect nearby watercourses. Investigation into the BMP process was from telephone conversations, thus data to examine where and to what extent BMPs have been implemented on National Forest and private forest lands are anecdotal. A number of sources indicate that the Texas Soil and Water Conservation Board is working closely with the forest products industry to implement and assess the effectiveness of the BMPs currently in place.

One such effort highlighted by ANRA's Upper Neches Basin Highlights Report (2002) discusses a cooperative study called the Texas Intensive Forestry Study. Cooperators include Stephen F. Austin State University, Temple Inland Forest Products, and the National Council for Air and Stream Improvement. The study being conducted in the Alto Watershed in Cherokee County is focusing on the impacts that current silviculture practices have on nonpoint source water pollution. New data from this study will be used to assess the effectiveness of BMPs as compared to historical data. More information is available for this study at http://fri.sfasu.edu/projects/alto/alto.html.

6.1.2 Urban

Urban nonpoint sources may include runoff from population centers via stormwater, landfills, and septic systems among others and can contribute a variety of pollutants, including nutrients, bacteria, metals and sediment.

6.1.2.1 Population Centers

The population of the basin was determined by reviewing the Texas State Library and Archives Commission (TSLAC) Web Site, which reports various tables of Texas data from the Bureau of the Census (2000). Table 6-4 summarizes the available population data for the Sam Rayburn Reservoir counties.

Table 6-4. 2000 Census data for nine counties in the Sam Rayburn Reservoir watershed

County	Population[a]
Angelina	80,130
Cherokee	46,659
Jasper	35,604
Nacogdoches	59,203
Rusk	47,372
Sabine	10,469
San Augustin	8,946
Shelby	25,224
Smith	174,706

[a] per the Bureau of the Census (2000 Census) as reported at http://castor.tsl.state.tx.us/ref/abouttx/popcnty12000.html

Smith County has the largest county population, but only approximately one-third of its largest population center (Tyler with a population of 83,650) is in the watershed. The city of Nacogdoches (population of 29,914) is the largest population center completely contained within the basin. Figure 6-1 illustrates the primary population centers within the watershed. Figure 6-1 also illustrates available information on stormwater outfalls. These are not classified as industrial or municipal. Runoff from urbanized areas, either through stormwater outfalls or as direct runoff to nearby ditches or streams, may carry large amounts of contaminants, including nutrients, sediment, and bacteria. However, the Sam Rayburn Reservoir watershed is largely rural, and the major populations centers are relatively small when compared to a large metropolitan city such as Dallas or Fort Worth. Structures that reduce soil permeability, such as road surfaces, buildings, or other hard surfaces that would facilitate increased runoff appear to be low in this watershed.

6.1.2.2 Land Fills

Figure 6-1 illustrates landfills known to exist within the watershed. These include both historic and currently operating facilities. Several are found in and around the Lufkin area, but how many of these are currently operating is unknown. Land fills can contribute to nonpoint source pollution in a variety of ways, including leaching through soils to groundwater tables or acting as impoundment structures that retain water that must be discharged.

6.1.2.3 On Site Sewage Facilities

ANRA currently enforces a permit and compliance system for on site sewage facilities (OSSF) that fall within a 2000 foot buffer around the reservoir. Currently, ANRA has on record 3,834 seperate OSSFs. By County, OSSFs are distributed as follows: Jasper County 262 (7 %), San Augustine 1,159 (30 %), Sabine 283 (7 %), Angelina 1,475 (38.5 %), Nacogdoches 651 (17 %). Over 60 percent of the OSSFs around the reservoir are located in these counties. In December 2000, ANRA began documenting the locations of these OSSFs using GPS equipment. Locations of GPS identified systems are illustrated in Figure 6-2. This figure represents only those OSSFs that have been recently installed or updated through the permit system and identified using GPS coordinates (approximately 188 OSSFs). Many permitted facilities exist and are known by physical address location, but are not represented in Figure 6-2. Many unpermitted systems are also known to exist as well. Some of these unpermitted systems are a direct pipe discharge of septic effluent, which can represent significant sources of such pollutants as nutrients and bacteria.

Based on the distribution of OSSFs illustrated in Figure 6-2, it does appear that more OSSFs are found in the northwestern section of the reservoir (segment 0610) as opposed to the southwestern section; however, the numbers of OSSFs represented in Figure 6-2 represent a small fraction of the total number documented by ANRA.

Septic facilities, given their numbers and proximity to the reservoir, may contribute elevated nutrients and bacteria to the reservoir. These systems do not account for those septic systems that fall outside of the 2000 foot buffer zone, however, in a rural population such as exhibited in the counties making up the Sam Rayburn Reservoir watershed, septic systems are often the dominant means of sewage disposal. Most are not likely to contribute to reservoir nutrient or bacteria levels; however, those in close proximity to streams and those not functioning properly may contribute nutrients and bacteria that may result in observed water quality impairments in the

reservoir.

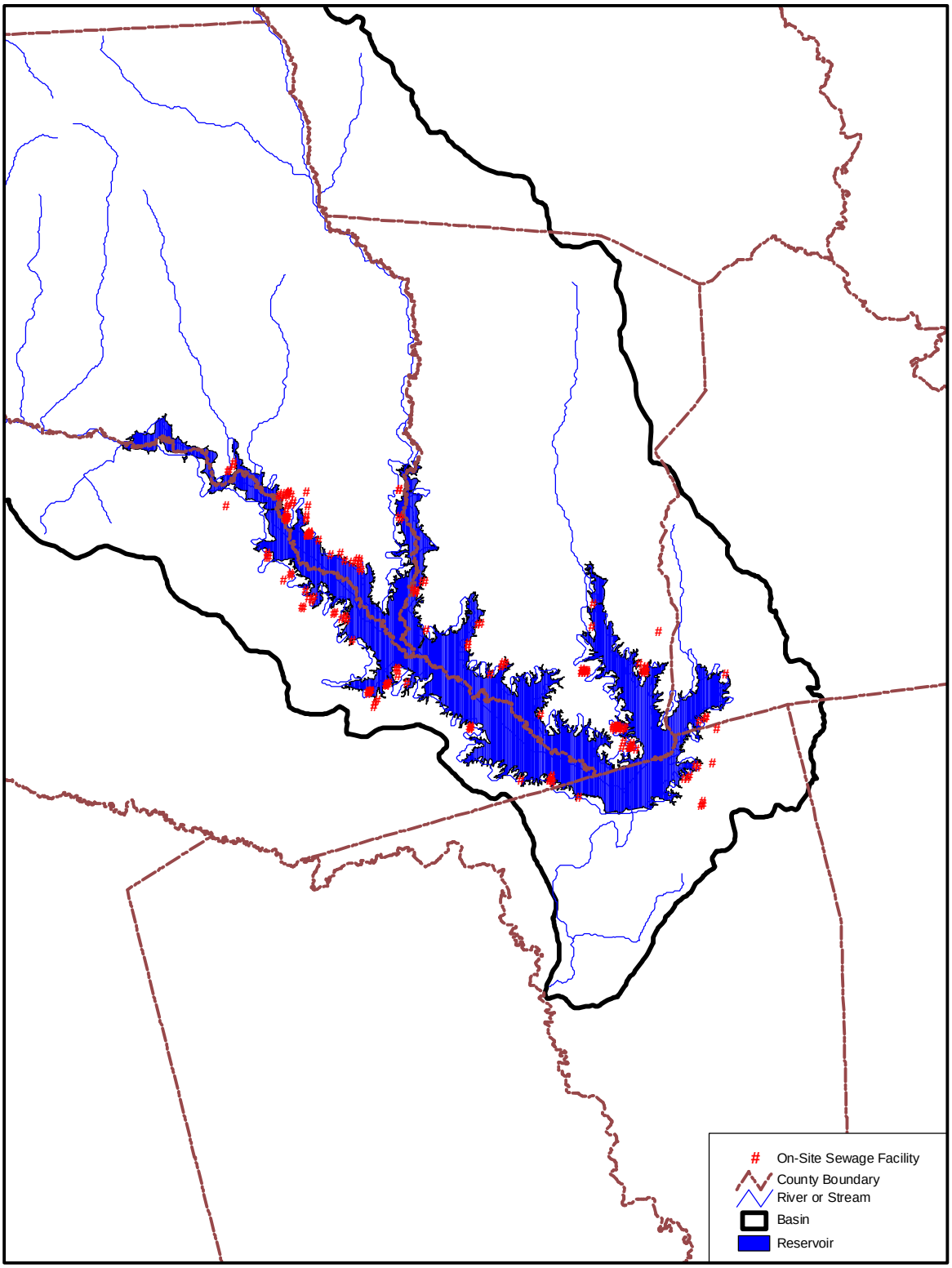

Figure 6-2. Location of GPS located OSSFs in the Sam Rayburn Reservoir watershed

6.2 Point Sources

6.2.1 Permitted Facility Overview

Texas Pollutant Discharge Elimination System (TPDES) facilities were identified to characterize the contributing point sources in the Sam Rayburn Reservoir watershed. Locations of TPDES facilities, permit limits, and discharge monitoring data were obtained from TCEQ. Attribute data for point source facilities contributing to segments 0610, 0611, 0612, and 0613 are found in Table 6-5. There are no permitted facilities in the Angelina River/Sam Rayburn Reservoir (segment 0615) watershed. Additionally, no confined animal feeding operations (CAFO) are located in any of the five segments. Figure 6-3 presents the locations of the point source facilities in the Sam Rayburn Reservoir watershed.

There are currently 19 point source facilities discharging into the Sam Rayburn Reservoir (segment 0610). One of the permitted facilities is classified as a major discharge facility, while all others are classified as minor discharge facilities. Most of the point sources located in segment 0610 are corporations or government facilities.

Twenty point source facilities discharge into the Angelina River above Sam Rayburn Reservoir (segment 0611). Six of these point source sites are classified as major discharge facilities. Segment 0611 is dominated by government point source facilities.

There are four permitted facilities discharging into Attoyac Bayou (Segment 612). All four facilities are classified as minor discharge sources. The four facilities are comprised of two independent school districts, one government facility, and a clay mine corporation.

One point source facility is permitted within Lake Tyler/Lake Tyler East (segment 0613). The facility is an independent school district, classified as a minor point source.

Table 6-5. TPDES Point Source Facilities

TWC Permit	EPA-Permit/ TPDES	Facility Name	County	Permit Type	Facility Type
Segment 610: Sam Rayburn Reservoir					
WQ0011620-001	TX0056154-000	Angelina and Neches River Authority	Angelina	Private Domestic Minor	Corporation
WQ0000368-000	TX0001643-000	Lufkin Mill	Angelina	Industrial Major	Corporation
WQ0011588-001	TPDES0054127	Twin Oaks Mobile Home/Oak Haven Subdivision	Angelina	Private Domestic Minor	Corporation
WQ0011895-001	TPDES0068039	Texas Air Stream Harbor	Angelina	Private Domestic Minor	Corporation
*WQ0012263-005	TPDES0020699	Caney Creek Facility	Angelina	Private Domestic Minor	Federal Government
WQ0010788-001	TPDES0023701	Rayburn County Municipal Utilities District	Jasper	Private Domestic Minor	Corporation
WQ0011337-001	TPDES0031275	Westwood Subdivision	Jasper	Private Domestic Minor	Water Supply Co.
*WQ0013903-001	TPDES0118419	Community Estates Trailer Park	Nacogodoches	Private Domestic Minor	Corporation
*WQ0003759-000		Pilgrims Pride Nacogodoches	Nacogodoches	Industrial Minor	Corporation
WQ0010947-001	TPDES0054224	Shirley Creek Park	Nacogodoches	Private Domestic Minor	Corporation
WQ0013092-001	TPDES0099082	Brookeland Independent School District	Sabine	Public Domestic Minor	Independent School
WQ0010249-001	TPDES0027154	City of Pineland	Sabine	Public Domestic Minor	Municipal Government
WQ0001820-000	TPDES0036892	Temple-Inland Forest Products - Pineland Facility	Sabine	Industrial Minor	Corporation
WQ0003848-000	TPDES0113689	Temple-Inland Forest Products - Pineland Logyard Facility	Sabine	Industrial Minor	Corporation

Table 6-5. TPDES Point Source Facilities (cont.)

WQ0011772-001	TPDES0057673	City of Broaddus	San Augustine	Public Domestic Minor	Municipal Government
WQ0010268-001	TPDES0022349	City of San Augustine	San Augustine	Public Domestic Minor	Municipal Government
*WQ0010268-002	TPDES0122351	City of San Augustine	San Augustine	Public Domestic Minor	Municipal Government
*WQ0004251-000	TPDES0123447	L & R Timber Co Inc.	San Augustine	Industrial Minor	Corporation
WQ0013161-001	TPDES0098744	Stephen F. Austin State University Piney Woods Conservation CNT	San Augustine	Private Domestic Minor	State Government
Segment 611: Angelina River Above Sam Rayburn Reservoir					
WQ0010557-001	TPDES0030708	Texas Department of Mental Health & Lufkin State School	Angelina	Private Domestic Minor	State Government
WQ0010693-001	TPDES0024392	Canada Street	Cherokee	Public Domestic Major	Municipal Government
WQ0010693-003	TPDES0100587	Double Creek Plant	Cherokee	Public Domestic Major	Municipal Government
WQ0013585-001	TPDES0107875	City of New Summerfield	Cherokee	Public Domestic Minor	County Government
WQ0010304-001	TPDES0033529	City of Troup	Cherokee	Public Domestic Minor	Municipal Government
WQ0000946-000	TPDES0001066	Tueco Stryker Creek SES	Cherokee	Industrial Major	Partnership
WQ0002973-000	TPDES0104175	Troup Operations	Cherokee	Industrial Minor	Partnership
*WQ0004198-000	TPDES0121053	Cal-Tex Lumber Company Inc.	Nacogodoches	Industrial Minor	Corporation
WQ0010437-001	TPDES0053937	City of Cushing	Nacogodoches	Public Domestic Minor	Corporation

Table 6-5. TPDES Point Source Facilities (cont.)

TWC Permit	EPA-Permit/ TPDES	Facility Name	County	Permit Type	Facility Type
WQ0010342-004	TPDES0055123	City of Nacogdoches - Plant 2A	Nacogodoches	Public Domestic Major	Municipal Government
WQ0014027-001	TPDES0067806	Caraban Motor Motel	Nacogodoches	Private Domestic Minor	Private Ownership
WQ0010187-001	TPDES0052779	City of Henderson - Southside Wastewater Treatment Plant	Rusk	Public Domestic Major	Municipal Government
*WQ0014283-001	TPDES0122173	City of Mount Enterprise	Rusk	Public Domestic Minor	Municipal Government
WQ0012376-001	TPDES0087360	City of New London-South Plant	Rusk	Public Domestic Minor	Municipal Government
WQ0010511-001	TPDES0054194	City of Arp	Smith	Public Domestic Minor	Municipal Government
WQ0010653-002	TPDES0047988	City of Tyler-Southside Plant	Smith	Public Domestic Major	Municipal Government
WQ0011222-001	TPDES0072770	City of Whitehouse - Blackhawk Creek	Smith	Public Domestic Minor	Municipal Government
WQ0012910-001	TPDES0095419	City of Whitehouse - Quail Lane Facility	Smith	Private Domestic Minor	Local Government
WQ0013000-001	TPDES0101010	Tall Timbers STP	Smith	Private Domestic Minor	Corporation
WQ0013168-001	TPDES0098795	Woodmark Utilities	Smith	Private Domestic Minor	Corporation
Segment 612: Attoyac Bayou					
WQ0003888-000	TPDES0117790	Garrison Clay Mine	Nacogodoches	Industrial Minor	Corporation
WQ0011304-001	TPDES0076503	City of Garrison Waste Water Treatment Plant	Nacogodoches	Private Domestic Minor	Municipal Government
*WQ0013917-001	TPDES0118915	Chireno Independent School District	Nacogodoches	Public Domestic Minor	Independent School

Table 6-5. TPDES Point Source Facilities (cont.)

*WQ0014027-001	TPDES0118354	Martinville Independent School District	Nacogodoches	Public Domestic Minor	Independent School
Segment 613: Lake Tyler/Lake Tyler East					
WQ0011857-001		Chapel Hill Independent School District	Smith	Public Domestic Minor	Independent School

*No Data Monitoring Report (DMR) information available.

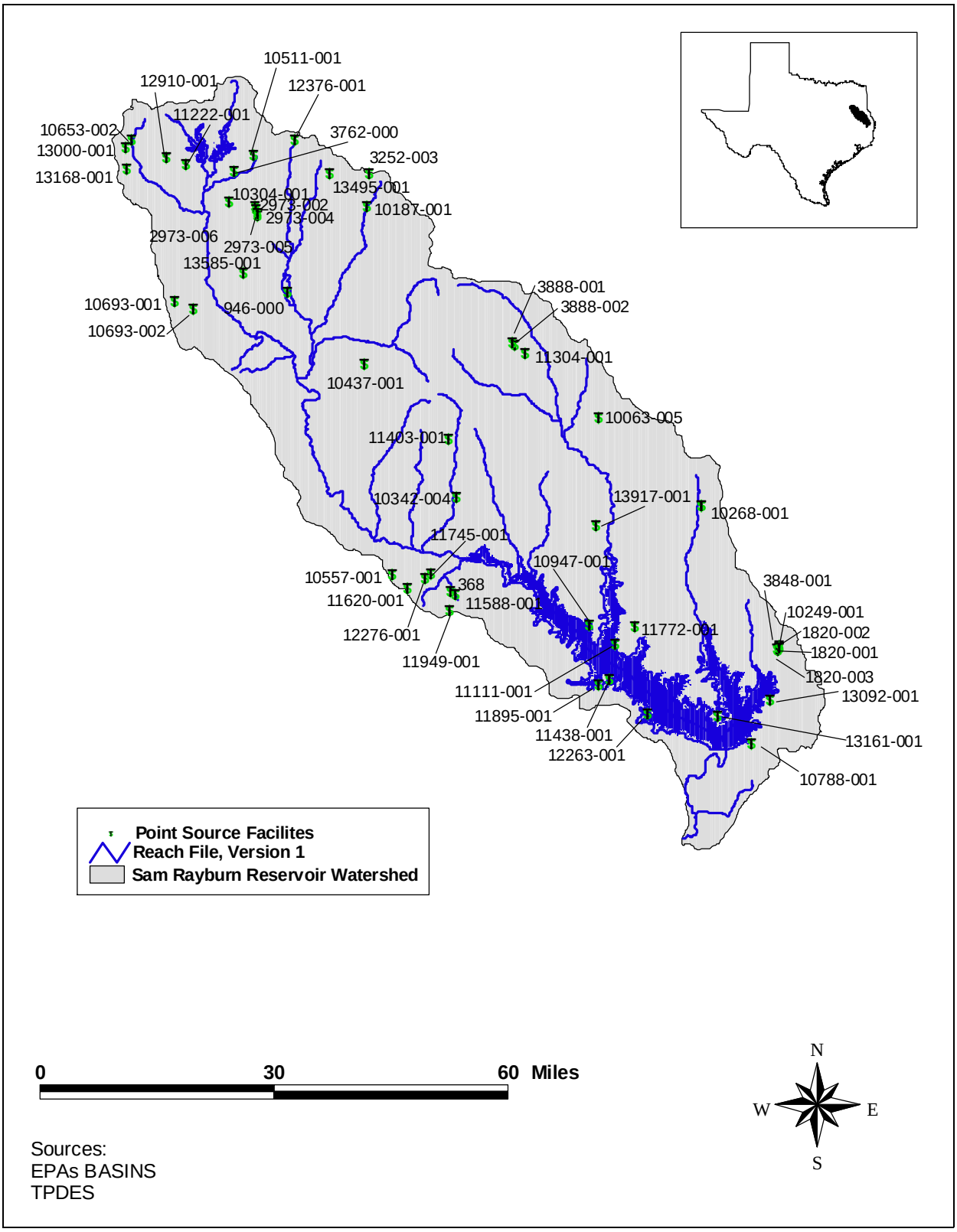

Figure 6-3. Location of point source facilities in the Sam Rayburn Reservoir watershed

6.2.2 Permit Limits and Discharge Monitoring Report Data

Permit and Discharge Monitoring Report (DMR) data for active (standard permit type) facilities are summarized in Tables 6-1 through 6A-35 in Appendix 6 for the period January 1997 through 2002 (where available). DMR data were not available for five facilities located within segment 0610, two facilities within segment 0611, and two facilities located within segment 0612. These facilities are identified with an asterisk in Table 6-5. This period was selected in order to provide insight into current contributions from these facilities and to be consistent with the period of time used to identify impairments in the Sam Rayburn Reservoir. The following parameters are included in the tables, however, reported parameters vary with each facility.

- Discharge (day)
- pH (standard units)
- Dissolved oxygen (DO, mg/L)
- Total suspended solids (TSS, mg/L)
- Biochemical oxygen demand - 5-day (BOD5, mg/L)
- Carbonaceous BOD5 (BOD Carb, mg/L)
- Ammonia nitrogen (NH3-N, mg/L)
- Flow in facility (mgd)
- Total residual chlorine (CL2 Res, mg/L)
- Chlorination after dechlorination (De-Chlor, mg/L)
- Fecal coliform bacteria (Fec Coli, cfu/100mL)
- Chemical oxygen demand (COD, mg/L)
- Zinc (lbs/day)
- Aluminum (lbs/day, mg/L)
- Copper (mg/L)
- Sulfate (mg/L)
- Total dissolved solids (TDS, mg/L)
- 2, 3,7, 8 Tetrachlorodibenzo-P-Dioxion (TCDD, ppq)
- Halogens, adsorbable organic (HAL, AD, O, lbs/day)

High concentrations of pollutant parameters in effluent discharges can lead to poor water quality in receiving waters in concert with Texas Surface Water Quality Standards and TPDES program guidelines. Tables 6-1 through 6-35 in Appendix 6 provide information on the number of permit limit exceedances (by parameter) for each facility. Effluent data and associated permit limits will be used to determine loading values for critical parameters in support of future water quality modeling activities for these watersheds.

6.2.3 Permit Limit Exceedances

Among the 35 facilities with available DMR data, three facilities had not exceeded the permit limits any monitored parameters between 1997 and July 2002. Two facilities had only exceeded a permit limit once in the five year time span. There are only seven point source facilities in the Sam Rayburm Reservoir watershed that are considered major facilities (refer to Table 6-5). There are two additional facilities that are not considered major facilities, but have average daily flows greater than 1.0 mgd according to their DMR data (Troup Operations (0104175) and Garrison Clay Mine (0117790)). All of the major facilites had exceedances of their TSS limits and some had exceedances of BOD, COD, pH, and NH_3-N. In addition, Troup Operations (0104175), located in the upper portion of segment 0611, had several exceedances of its sulfate, copper, and zinc limits. Several of the minor facilities in the watershed also had a significant number of exceedances of their applicable permit limits for various pollutants. Tables 6-1 through 6-35 present the number of exceedances at each of the facilities.

Appendix 6
Permit and Discharge Monitoring Data for Permitted Facilities in the Sam Rayburn Reservoir Watershed

Table 6-1. TPDES Permit Limits and Discharge Monitoring Data for TPDES 0056154 (Angelina and Neches River Authority).

Data Source: TCEQ Period: January 1997-July 2002 Segment: 610

	Discharge (day)	**DO (mg/L)**	**BOD5 (mg/L)**		**pH**	
	days/month	min	daily avg	lbs/day	max	min
Limit (no. of exceedances)	N/A	4 (1)	20 (2)	10 (2)* 31 (0)**	9 (0)	6 (0)
Max	31	7.52	31.88	14.71	8.16	7.84
Min	22	3.54	2	0.94	6.48	6.4
Mean	30.12	5.86	5.49	3.02	7.58	7.23
Count	66	66	66	66	66	66

	TSS (mg/L)		**Flow (mgd)**		**CL2 Res (mg/L)**	
	daily avg	lbs/day	daily avg	daily max	max	min
Limit (no. of exceedances)	20 (8)	10 (7)* 31 (1)**	0.06 (6)* 0.185(0)**	N/A	4 (2)	1 (3)
Max	55.4	64.3	0.150136	0.755	5	1.6
Min	1.6	0.8	0.01542	0.044	1.8	0.2
Mean	11.08	6.93	0.078	0.219	3.65	1.19
Count	66	66	66	66	66	66

*Limits range from 1997-September 1998.

**Limits range from October 1998-2002.

Table 6-2. TPDES Permit Limits and Discharge Monitoring Data for TX 0001643-000 (Lufkin Mill).

Data Source: TCEQ Period: January 1997-July 2002 Segment: 610

	Discharge (day)	**pH**		**BOD5 (lbs/day)**		**Fec Coli (#/100 mL)**
	days/month	max	min	daily avg	daily max	daily avg
Limit (no. of exceedances)	N/A	9 (1)	6 (2)	2900 (0)	5400 (3)	N/A
Max	31	9.05	9.05	2811	6243	120
Min	0	6.55	6.19	475	868	1.1
Mean	22.03	7.47	7.09	1761.46	3187.23	18.75
Count	157	167	167	65	66	20

	TSS (lbs/day)		**Zinc (lbs/day)**		**Aluminum (lbs/day)**	
	daily avg	daily max	daily avg	daily max	daily avg	daily max
Limit (no. of exceedances)	6670 (0)	10095 (3)	N/A	N/A	N/A	N/A
Max	5589	12711	43.171	26.238	900.57	1652.32
Min	819	1421	0	0	111.24	265.35
Mean	2426.37	4937.79	5.74	8.46	490.22	657.95
Count	66	66	66	66	66	66

	Flow (mgd)		**TCDD (ppq)**		**HAL, AD, O (lbs/day)**	**COD (mg/L)**
	daily avg	daily max	daily avg	daily max	daily max	daily max
Limit (no. of exceedances)	20 (0)	22 (0)	10 (0)	28.9 (0)	N/A	200 (4)
Max	16.7	20.34	10	10	4151.651	1141
Min	0.127	5.489	10	10	98.121	0
Mean	10.11	11.55	10	10	2389.77	108.47
Count	66	66	20	22	22	112

Table 6-3. TPDES Permit Limits and Discharge Monitoring Data for TPDES 0054127 (Twin Oaks Mobile Home).

Data Source: TCEQ Period: January 1997-July 2002 Segment: 610

	Discharge (day)	**DO (mg/L)**	**BOD5 (mg/L)**		**pH**	
	days/month	min	daily avg	lbs/day	max	min
Limit (no. of exceedances)		4 (12)	10 (6)	4.2 (1)	9 (1)	6 (0)
Max	31	6.16	41.14	6.77	9.69	7.54
Min	20	0	1.42	0	7.17	6
Mean	26.19	3.76	7.84	0.569	7.76	6.96
Count	36	36	36	36	36	36

	TSS (mg/L)		**Flow (mgd)**		**CL2 Res (mg/L)**	
	daily avg	lbs/day	daily avg	daily max	max	min
Limit (no. of exceedances)	15 (9)	6.3 (0)	0.05 (1)		4 (4)	1 (11)
Max	32.5	4	0.1495	0.3212	5.8	1.4
Min	1.3	0	0.000203	0.001774	1.6	0
Mean	10.63	0.717	0.012	0.048	3.2	0.881
Count	36	36	36	36	36	36

Table 6-4. TPDES Permit Limits and Discharge Monitoring Data for TPDES 0068039 (Texas Air Stream Harbor).

Data Source: TCEQ Period: January 1997-July 2002 Segment: 610

	Discharge (day)	**DO (mg/L)**	**BOD5 (mg/L)**		**pH**	
	days/month	min	daily avg	lbs/day	max	min
Limit (no. of exceedances)	N/A	4 (2)	10 (0)	0.83 (2)	9 (2)	6 (0)
Max	31	8.1	9.35	1.02	9.1	8.8
Min	21	2.9	1.49	0.03	0.86	7.2
Mean	30.08	6.34	5.14	0.197	8.34	7.96
Count	37	37	37	37	37	37

	TSS (mg/L)		**Flow (mgd)**		**CL2 Res (mg/L)**	
	daily avg	lbs/day	daily avg	daily max	max	min
Limit (no. of exceedances)	15 (2)	1.3 (0)	0.1 (0)	N/A	4 (0)	1 (0)
Max	28	0.9	0.0326	0.0189	4	1.6
Min	0.9	0	0.0011	0.0007	2	1
Mean	7.8	0.238	0.005	0.007	2.43	1.11
Count	37	37	37	37	37	37

Table 6-5. TPDES Permit Limits and Discharge Monitoring Data for TPDES 0023701 (Rayburn County Municipal Utilities District).

Data Source: TCEQ Period: January 1997-July 2002 Segment: 610

	Discharge (day)	**DO (mg/L)**	**BOD5 (mg/L)**		**pH**	
	days/month	min	daily avg	lbs/day	max	min
Limit (no. of exceedances)	N/A	4 (0)	10 (1)	25 (1)	9 (0)	6 (0)
Max	31	9.7	14.57	105.54	8.5	7.5
Min	28	4.5	1.5	1.28	6.7	6
Mean	30.35	7.76	3.77	6.61	7.66	7.06
Count	52	52	52	52	52	52

	TSS (mg/L)		**Flow (mgd)**		**CL2 Res (mg/L)**	
	daily avg	lbs/day	daily avg	daily max	max	min
Limit (no. of exceedances)	15 (6)	38 (9)	0.3 (2)	N/A	4 (8)	1 (16)
Max	83.8	668.2	0.3484	1.1508	5	1.6
Min	2	1.3	0.09397	0.1203	2.7	0
Mean	9.18	29.61	0.163	0.42	3.89	0.932
Count	52	52	52	16	52	52

Table 6-6. TPDES Permit Limits and Discharge Monitoring Data for TPDES 0031275 (Westwood Subdivision).

Data Source: TCEQ Period: January 1997-July 2002 Segment: 610

	Discharge (day)	**DO (mg/L)**	**BOD5 (mg/L)**		**pH**	
	day/month	min	daily avg	lbs/day	max	min
Limit (no. of exceedances)	N/A	4 (0)	10 (2)	1.7 (1)	9 (0)	6 (1)
Max	31	9.1	26.7	2.23	7.7	7.7
Min	28	4	0.15	0.02	6.1	5.34
Mean	30.44	6.44	5.41	0.394	6.76	6.56
Count	59	59	59	59	59	59

	TSS (mg/L)		**Flow (mgd)**		**CL2 Res (mg/L)**	
	daily avg	lbs/day	daily avg	daily max	max	min
Limit (no. of exceedances)	15 (28)	2.5 (7)	0.02 (4)	N/A	4 (5)	1 (3)
Max	54	6.6	0.0568	0.25	5	1.8
Min	5.2	0	0.000477	0.0038	1.7	0.7
Mean	17.31	1.19	0.009	0.03	2.6	1.26
Count	59	59	59	59	59	59

Table 6-7. TPDES Permit Limits and Discharge Monitoring Data for TPDES 0054224 (Shirley Creek Park).

Data Source: TCEQ Period: January 1997-December 1999 Segment: 610

	Discharge (day)	**DO (mg/L)**	**BOD5 (mg/L)**		**pH**	
	days/month	min	daily avg	lbs/day	max	min
Limit (no. of exceedances)	N/A	4 (12)	10 (8)	0.48 (2)	9 (0)	6 (4)
Max	31	6.4	56.29	6.94	8.96	8.96
Min	14	0	2.25	0	4.6	4.1
Mean	23.89	4.2	8.26	0.303	7.62	6.98
Count	36	36	35	35	35	35

	TSS (mg/L)		**Flow (mgd)**		**CL2 Res (mg/L)**	
	daily avg	lbs/day	daily avg	daily max	max	min
Limit (no. of exceedances)	15 (10)	0.7 (2)	0.006 (0)	N/A	4 (1)	1 (5)
Max	49.1	40	0.0006	0.0089	4.4	1.8
Min	3.4	0	0	0.0001	0	0
Mean	14.67	1.29	0.00015	0.0015	3.04	1.14
Count	35	35	36	36	36	36

Table 6-8. TPDES Permit Limits and Discharge Monitoring Data for TPDES 0099082 (Brookeland Independent School District).

Data Source: TCEQ Period: January 1997-July 2002 Segment: 610

	Discharge (day)	**DO (mg/L)**	**BOD5 (mg/L)**		**pH**	
	days/month	min	daily avg	lbs/day	max	min
Limit (no. of exceedances)	N/A	4 (1)	10 (0)	0.33 (0)	9 (0)	6 (0)
Max	23	7	9	0.19	7.7	7.3
Min	0	4	2	0.04	6.8	6.3
Mean	15.03	4.51	5.42	0.111	7.3	6.87
Count	37	31	31	31	31	31

	TSS (mg/L)		**Flow (mgd)**		**CL2 Res (mg/L)**	
	daily avg	lbs/day	daily avg	daily max	max	min
Limit (no. of exceedances)	15 (0)	0.5 (0)	0.004 (0)	N/A	4 (0)	1 (0)
Max	15	0.3	0.0024	0.026	3.8	2.5
Min	2.5	0.1	0.0024	0.0026	1	1
Mean	9.25	0.194	0.0024	0.003	2.44	1.76
Count	31	31	31	31	31	31

Table 6-9. TPDES Permit Limits and Discharge Monitoring Data for TPDES 0027154 (City of Pineland).

Data Source: TCEQ Period: January 1997-July 2002 Segment: 610

	Discharge (day)	**DO (mg/L)**	**pH**		**TSS (mg/L)**	
	days/month	min	max	min	daily avg	lbs/day
Limit (no. of exceedances)	N/A	4 (0)	9 (0)	6 (0)	15 (3)	27 (3)
Max	31	8.8	7.8	7.5	22.5	76.2
Min	0	4	7.3	6.7	1	0.6
Mean	58.84	7.54	7.43	7.17	5.15	7.87
Count	55	53	53	53	53	53

	NH3-N (mg/L)		**Flow (mgd)**		**CL2 Res (mg/L)**	
	daily avg	lbs/day	daily avg	daily max	max	min
Limit (no. of exceedances)	3 (8)	5.4 (1)	0.214 (3)	N/A	4 (0)	1 (0)
Max	6.2	8.9	0.232	0.872	3.7	2.4
Min	0.043	0.07	0	0.1	2	1
Mean	1.18	1.24	0.118	0.38	2.71	1.81
Count	53	53	76	53	53	53

	BOD Carb (mg/L)		**BOD5***	**Fec Coli (#/100 mL)***
	daily avg	lbs/day	lbs/day	daily avg
Limit (no. of exceedances)	10 (0)	N/A	20 (0)	200 (0)
Max	8.3	12.7	3.9	89
Min	1.3	0.82	0	0
Mean	3.43	3.92	2.26	13.64
Count	53	17	11	11

*Data available for these parameters range from August 2000-September 2001

Table 6-10. TPDES Permit Limits and Discharge Monitoring Data for TPDES 0036892 (Temple-inland Forest Products Pineland Facility).

Data Source: TCEQ Period: January 1997-July 2002 Segment: 610

	Discharge (day)	**DO (mg/L)**	**pH**		**BOD5 (mg/L)**	
	days month	min	max	min	daily avg	daily max
Limit (no. of exceedances)	N/A	4 (0)	9 (0)	6 (2)	30 (0)	60 (1)
Max	31	8.9	8.85	8.09	28	64
Min	0	4	6.35	5.91	4	6
Mean	10.68	6.4	7.37	7	10.73	19.9
Count	144	40	110	111	40	40

	COD (mg/L)		**Copper (mg/L)**		**Fec Coli (#/100 mL)**	
	daily avg	max	daily avg	daily max	daily avg	daily max
Limit (no. of exceedances)	250 (11)	350 (11)	0.012 (10)	0.026 (6)	N/A	N/A
Max	356	6950	1	1	20356	610000
Min	57	7	0	0.001	400	10
Mean	193.03	247.28	0.019	0.023	8464.86	65681.5
Count	35	85	76	76	14	14

	Flow (mgd)		**TDS (mg/L)**
	daily avg	daily max	max
Limit (no. of exceedances)	N/A	N/A	1200 (3)
Max	5.28	13.22	1405
Min	0.00037	0.00037	9
Mean	0.578	1.11	924.43
Count	112	111	14

Table 6-11. TPDES Permit Limits and Discharge Monitoring Data for TPDES 0036892 (Temple-inland Forest Products Pineland Logyard Facility).

Data Source: TCEQ Period: January 1997-July 2002 Segment: 610

	Discharge (day)	**COD (mg/L)**	**pH**		**Flow (mgd)**	
	days/month	max	max	min	daily avg	daily max
Limit (no. of exceedances)	N/A	300 (0)	9 (0)	6 (0)	N/A	N/A
Max	30	142.9	7.8	7.8	2.1625	2.895
Min	0	26	6.72	6.72	0.001026	0.001154
Mean	0.811	68.36	7.33	7.29	0.998	1.21
Count	54	7	7	7	7	7

Table 6-12. TPDES Permit Limits and Discharge Monitoring Data for TPDES 0057673 (City of Broaddus).

Data Source: TCEQ Period: January 1997-December 1999 Segment: 610

	Discharge (day)	**DO (mg/L)**	**pH**		**BOD5 (mg/L)**	
	days/month	min	max	min	daily avg	lbs/day
Limit (no. of exceedances)	N/A	4 (3)	9 (0)	6 (1)	10 (6)	11 (0)
Max	31	10.5	8.2	8	14.62	6.2
Min	20	3.4	0	0	0	0
Mean	27.03	5.72	7.67	7.43	5.25	1.07
Count	33	33	33	33	31	31

	TSS (mg/L)		**Flow (mgd)**		**CL2 Res (mg/L)**	
	daily avg	lbs/day	daily avg	daily max	max	min
Limit (no. of exceedances)	15 (6)	17 (0)	0.135 (0)	N/A	4 (0)	1 (1)
Max	34	15.2	0.075	0.13	4	2.6
Min	0	0	0.000418	0	1.97	0.92
Mean	7.71	1.67	0.021	0.028	3.08	1.6
Count	31	31	34	34	34	34

Table 6-13. TPDES Permit Limits and Discharge Monitoring Data for TPDES 0022349 (City of San Augustine).

Data Source: TCEQ Period: January 1997-December 1999 Segment: 610

	Discharge (day)	**DO (mg/L)**	**pH**		**Flow (mgd)**	
	days/month	min	max	min	daily avg	daily max
Limit (no. of exceedances)	N/A	4 (1)	9 (0)	6 (2)	0.9 (0)	N/A
Max	31	6.7	7.96	6.8	0.889	2.31
Min	28	3.9	6.6	5.1	0.0157	0.087
Mean	30.4	4.29	7.08	6.38	0.471	1.27
Count	35	35	35	35	35	35

	NH3-N (mg/L)			**TSS (mg/L)**		
	daily avg	daily max	lbs/day	daily avg	daily max	lbs/day
Limit (no. of exceedances)	3 (8)	10 (4)	23 (2)	15 (4)	40 (1)	113 (4)
Max	5.7	21.9	90.15	31.7	81.3	222.7
Min	0.06	0.086	0.361	2.4	3.7	4.2
Mean	1.91	4.32	10.23	8.56	15.83	48.97
Count	35	35	35	35	35	35

	CL2 Res (mg/L)		**BOD Carb (mg/L)**		
	max	min	daily avg	daily max	lbs/day
Limit (no. of exceedances)	4 (1)	1 (0)	10 (0)	25 (0)	75 (0)
Max	5	1.5	5.05	13.5	42.69
Min	3.2	1	2.07	2.07	2.25
Mean	3.65	1.05	2.74	3.93	15.86
Count	35	35	35	35	35

Table 6-14. TPDES Permit Limits and Discharge Monitoring Data for TPDES 0098744 (Stephen F. Austin University).

Data Source: TCEQ Period: January 1997-December 1999 Segment: 610

	Discharge (day)	**DO (mg/L)**	**BOD5 (mg/L)**		**pH**	
	days month	min	daily avg	lbs/day	max	min
Limit (no. of exceedances)	N/A	4 (0)	10 (4)	1.7 (0)	9 (0)	6 (0)
Max	18	4	62	1.04	8.3	8.1
Min	0	4	0.13	0	6.9	6.8
Mean	6.81	4	8.65	0.125	7.8	7.23
Count	36	25	25	25	25	25

	TSS (mg/L)		**Flow (mgd)**		**CL2 Res (mg/L)**	
	daily avg	lbs/day	daily avg	daily max	max	min
Limit (no. of exceedances)	15 (6)	2.5 (0)	0.2 (1)	N/A	4 (1)	1 (0)
Max	60	1	0.575	0.0006	4.2	3.6
Min	0.3	0	0.000021	0.0006	2.6	2
Mean	11.24	0.144	0.023	0.0006	3.3	2.728
Count	25	25	25	25	25	25

Table 6-15. TPDES Permit Limits and Discharge Monitoring Data for TPDES 0030708 (Texas Department of Mental Health & Lufkin State School).

Data Source: TCEQ Period: January 1997-December 1999 Segment: 611

	Discharge (day)	**DO (mg/L)**	**pH**		**BOD5 (mg/L)**	
	days/month	min	max	min	daily avg	lbs/day
Limit (no. of exceedances)	N/A	5 (0)	9 (0)	6 (0)	20 (0)	33 (0)
Max	31	6.2	8.88	7.18	10.4	11.89
Min	28	5	7.61	6.47	2.12	2.11
Mean	30.42	5.63	8.08	6.97	4.93	4.87
Count	36	36	36	36	36	36

	TSS (mg/L)		**Flow (mgd)**		**CL2 Res (mg/L)**	
	daily avg	lbs/day	daily avg	daily max	max	min
Limit (no. of exceedances)	20 (0)	33 (0)	0.2 (0)	N/A	4 (1)	1 (0)
Max	16.1	23.8	0.123	0.388	4.7	2.3
Min	2.2	1.9	0.052	0.1004	1.6	1
Mean	8.28	8.4	0.091	0.17	3.12	1.32
Count	36	36	36	36	36	36

Table 6-16. TPDES Permit Limits and Discharge Monitoring Data for TPDES 0024392 (Canada Street).

Data Source: TCEQ Period: January 1997-July 2002 Segment: 611

	Discharge (day)	DO (mg/L)	BOD5 (mg/L)			pH	
	days/month	min	daily avg	daily max	lbs/day	max	min
Limit (no. of exceedances)	N/A	4 (0)* 6 (0)	10 (10)	25 (0)	125 (3)	9 (0)	6 (1)
Max	31	7.1	18.2	22.9	166.2	8.46	7.1
Min	28	4	2	23.5	8	6.91	5.12
Mean	30.37	5.67	7.86	12.16	57.61	7.39	6.68
Count	57	57	38	38	38	57	57

	TSS (mg/L)			NH3-N (mg/L)		
	daily avg	daily max	lbs/day	daily avg	daily max	lbs/day
Limit (no. of exceedances)	15 (1)	40 (1)	188 (0)** 125 (0)	2 (0)	5 (0)	17 (2)
Max	17	84	126	2.58	4.81	29.4
Min	1.2	1.8	6.1	0.247	0.383	1.18
Mean	5.12	9.94	36.78	0.972	1.75	7.94
Count	57	57	57	19	19	19

	Flow (mgd)		De-chlor (mg/L)	CL2 Res (mg/L)	BOD Carb (mg/L)		
	daily avg	daily max	max	min	daily avg	daily max	lbs/day
Limit (no. of exceedances)	1.5 (0)	N/A	0.1 (1)	1 (0)	10 (0)	25 (0)	83 (2)
Max	1.42	3.65	2.3	1.6	9.56	16.1	94.3
Min	0.12	0.041	0.02	1	2.43	3.6	9.8
Mean	0.611	1.1	0.11	1.05	5.43	9.11	39.09
Count	57	57	57	57	19	19	19

*Limits for DO (mg/L) shift between 4 and 6 multiple times from 1997- 2002

**Limits range from April 1997-March 2000 and April 2000 and September 2002, respectively

Table 6-17. TPDES Permit Limits and Discharge Monitoring Data for TPDES 0100587 (Double Creek Plant).

Data Source: TCEQ Period: January 1997-July 2002 Segment: 611

	Discharge (day)	**DO (mg/L)**	**pH**		**BOD5 (mg/L)**		
	days month	min	max	min	daily avg	daily max	lbs/day
Limit (no. of exceedances)	N/A	4 (0)* 6(3)	9 (0)	6 (0)	10 (0)	25 (0)	146 (0)
Max	31	7.3	7.92	7.24	5.5	16.2	116
Min	28	3.17	7.15	6.45	1.5	2.28	24
Mean	30.41	5.31	7.47	6.86	2.86	5.04	45.39
Count	66	66	66	66	31	31	31

	TSS (mg/L)			**NH3-N (mg/L)**		
	daily avg	daily max	lbs/day	daily avg	daily max	lbs/day
Limit (no. of exceedances)	15 (3)	40 (2)	219 (5)	2 (0)	10 (0)	29 (4)
Max	27	126	479	0.76	3.12	15.6
Min	1	1.8	14	0.072	0.153	0.98
Mean	5.02	13.22	85.93	0.234	0.645	4.17
Count	66	66	66	35	35	35

	Flow (mgd)		**De-chlor (mg/L)**	**CL2 Res (mg/L)**	**BOD Carb (mg/L)**		
	daily avg	daily max	max	min	daily avg	daily max	lbs/day
Limit (no. of exceedances)	1.75 (19)	N/A	0.1 (0)	1 (0)	10 (0)	25 (1)	146 (1)
Max	3.906	5.9182	0.09	1.2	10	46	158
Min	0.01	1.491	0.06	1	1.33	1	13
Mean	1.17	2.97	0.084	1.04	3.27	6.63	54.1
Count	66	66	66	66	35	35	35

*Limits range from December 1996-July 1999 and August 1999-October 2002, respectively.

Table 6-18. TPDES Permit Limits and Discharge Monitoring Data for TPDES 0107875 (City of New Summerfield).

Data Source: TCEQ Period: January 1997-July 2002 Segment: 611

	Discharge (day)	**DO (mg/L)**	**pH**		**BOD5 (mg/L)**	
	days/month	min	max	min	daily avg	lbs/day
Limit (no. of exceedances)	N/A	4 (9)	9 (4)	6 (1)	30 (27)	15 (10)
Max	31	8.4	9.58	8.8	59.9	59.9
Min	0	0.2	8	5.1	0	1.6
Mean	29.6	4.83	8.8	8.05	32.78	11.57
Count	42	42	42	42	42	42

	TSS (mg/L)		**Flow (mgd)**	
	daily avg	lbs/day	daily avg	daily max
Limit (no. of exceedances)	90 (7)	45 (6)	0.06 (4)	N/A
Max	141.3	75.5	0.07504	0.165
Min	11.6	1.1	0.0166	0.018
Mean	63.5	21.41	0.04	0.073
Count	42	42	42	42

Table 6-19. TPDES Permit Limits and Discharge Monitoring Data for TPDES 0033529 (City of Troup).

Data Source: TCEQ Period: January 1997- October 1999 Segment: 611

	Discharge (day)	**DO (mg/L)**	**pH**		**TSS (mg/L)**	
	days month	min	max	min	daily avg	lbs/day
Limit (no. of exceedances)	N/A	4 (0)	9 (0)	6 (0)	20 (1)	51 (0)
Max	31	8	8	7.7	23.5	40.1
Min	28	5.4	7.4	6.6	2.1	3.2
Mean	30.41	6.61	7.7	7.33	8.8	13.056
Count	34	34	34	34	34	34

	NH3-N (mg/L)		**Flow (mgd)**		**CL2 Res (mg/L)**	
	daily avg	lbs/day	daily avg	daily max	max	min
Limit (no. of exceedances)	3 (0)	7.7 (0)	0.308 (0)	N/A	4 (1)	1 (0)
Max	0.47	0.58	0.2433	0.521	10	1.9
Min	0.1	0.1	0.12	0.156	2.2	1
Mean	0.172	0.255	0.177	0.294	3.18	1.27
Count	11	11	34	34	34	34

	BOD Carb (mg/L)		**BOD5 (mg/L)**	
	daily avg	lbs/day	daily avg	lbs/day
Limit (no. of exceedances)	20 (0)	51 (0)	20 (0)	51 (0)
Max	3.32	5.3	3.82	6.28
Min	2.12	2.23	2	2.71
Mean	2.52	3.83	2.63	3.93
Count	11	11	23	23

Table 6-20. TPDES Permit Limits and Discharge Monitoring Data for TPDES 0001066 (Tueco Stryker Creek Ses).

Data Source: TCEQ Period: January 1997-July 2002 Segment: 611

	Discharge (day)	**pH**		**Flow (mgd)**		**TSS (mg/L)**	
	days/month	max	min	daily avg	daily max	daily avg	max
Limit (no. of exceedances)	N/A	9 (1)	6 (0)	575 (0)	575 (0)	30 (1)	100 (1)
Max	31	8.9	8.2	98	560	60	178
Min	28	7.1	6.1	0.0163	0.043	1	1
Mean	30.39	7.79	7.06	18.8	166.9	4.73	9.57
Count	150	101	101	150	150	101	100

Table 6-21. TPDES Permit Limits and Discharge Monitoring Data for TPDES 0104175 (Troup Operations).

Data Source: TCEQ Period: January 1997-December 1999 Segment: 611

	Discharge (day)	**pH**		**TSS (mg/L)**		**Flow (mgd)**	
	days/month	max	min	daily avg	daily max	daily avg	daily max
Limit (no. of exceedances)	N/A	9 (0)	5 (8)	35 (8)	70 (10)	N/A	N/A
Max	12	8.9	8.2	294.8	525	2400	554.052
Min	0	5.1	5	1	1	0.024	0.024
Mean	1.1	5.99	5.59	19.02	31.57	106.56	105.07
Count	153	65	66	66	66	66	65

	Sulfate (mg/L)		**Copper (mg/L)**		**Zinc (mg/L)**	
	daily avg	daily max	daily avg	daily max	daily avg	daily max
Limit (no. of exceedances)	600 (11)	900 (8)	0.016 (4)	0.034 (3)	0.13 (12)	0.28 (8)
Max	1280	1485	5.38	5.38	8.5	6.1
Min	11.8	22	0.005	0.005	0.0345	0.017
Mean	291.2	345.43	0.463	0.466	1.41	0.875
Count	66	66	13	13	15	15

Table 6-22. TPDES Permit Limits and Discharge Monitoring Data for TPDES 0053937 (City of Cushing).

Data Source: TCEQ Period: January 1997-July 2002 Segment: 611

	Discharge (day)	**DO (mg/L)**	**pH**		**BOD5 (mg/L)**	
	days/month	min	max	min	daily avg	lbs/day
Limit (no. of exceedances)	N/A	4 (13)	9 (48)	6 (0)	30 (18)	20 (3)
Max	31	12.2	12.02	9.6	86.6	28.8
Min	28	0.3	7.2	7	8.8	2.6
Mean	30.42	6.29	9.42	8.04	29.77	9.44
Count	60	60	60	60	60	60

	TSS (mg/L)		**Flow (mgd)**	
	daily avg	lbs/day	daily avg	daily max
Limit (no. of exceedances)	90 (9)	61 (3)	0.081 (0)	N/A
Max	531.3	159.5	0.048	0.104
Min	13	4.2	0.024	0.036
Mean	69.22	22.29	0.038	0.042
Count	60	60	60	60

Table 6-23. TPDES Permit Limits and Discharge Monitoring Data for TPDES 0055123 (City of Nacogdoches - Plant 2a).

Data Source: TCEQ Period: January 1997-July 2002 Segment: 611

	Discharge (day)	**DO (mg/L)**	**pH**		**TSS (mg/L)**		
	days/month	min	max	min	daily avg	daily max	lbs/day
Limit (no. of exceedances)		6 (3)	9 (0)	6 (0)	15 (0)	40 (9)	1611 (0)
Max	31	8.09	7.99	7.4	11.5	129	710
Min	28	5.48	7.21	6.49	1.1	1.6	35
Mean	30.43	6.89	7.56	6.91	4.27	22.22	204.22
Count	56	56	56	56	56	56	56

	NH3-N (mg/L)			**Copper (mg/L)**		
	daily avg	daily max	lbs/day	daily avg	daily max	lbs/day
Limit (no. of exceedances)	2 (10)	10 (6)	215 (0)	0.02 (1)	0.043 (2)	2.15 (0)
Max	8.07	15.8	156.65	0.111	0.426	3
Min	0.107	0.0345	2.079	0	0	0
Mean	0.968	3.77	31.61	0.005	0.015	0.319
Count	56	56	56	56	56	36

	Flow (mgd)		**De-chlor (mg/L)**	**CL2 Res (mg/L)**	**BOD Carb (mg/L)**		
	daily avg	daily max	max	min	daily avg	daily max	lbs/day
Limit (no. of exceedances)	12.88 (0)		0.1 (1)	1 (2)	10 (0)	25 (3)	1074 (0)
Max	8.779	22.08	1.22	8	9.1	31	508
Min	0.016	4.45	0	0.9	1.2	2.1	42
Mean	2.37	9.09	0.049	1.31	2.74	8.61	128.12
Count	56	56	56	56	56	56	56

Table 6-24. TPDES Permit Limits and Discharge Monitoring Data for TPDES 0067806 (Caraban Motor Motel).

Data Source: TCEQ Period: January 1997-July 2002 Segment: 611

	Discharge (day)	**DO (mg/L)**	**pH**		**BOD5 (mg/L)**	
	days/month	min	max	min	daily avg	lbs/day
Limit (no. of exceedances)	N/A	4 (28)	9 (0)	6 (13)	10 (23)	1 (1)
Max	31	8.2	7.8	7.2	34.8	1.34
Min	25	0	5.4	4.1	3.86	0.01
Mean	30.27	3.01	6.93	6.15	11.2	0.187
Count	46	46	45	45	45	45

	TSS (mg/L)		**Flow (mgd)**		**CL2 Res (mg/L)**	
	daily avg	lbs/day	daily avg	daily max	max	min
Limit (no. of exceedances)	15 (27)	1.6 (3)	0.013 (0)	N/A	4 (3)	1 (9)
Max	135	9.1	0.008	0.011	4.2	1.9
Min	5	0	0.0002	0.0004	1.2	0
Mean	23.68	0.584	0.001	0.003	3.17	1.04
Count	45	45	37	37	34	34

Table 6-25. TPDES Permit Limits and Discharge Monitoring Data for TPDES 0052779 (Southside Wastewater Treatment Plant).

Data Source: TCEQ Period: January 1997-July 2002 Segment: 611

	Discharge (day)	**DO (mg/L)**	**pH**		**TSS (mg/L)**		
	days/month	min	max	min	daily avg	daily max	lbs/day
Limit (no. of exceedances)	N/A	4 (0)	9 (0)	6 (1)	20 (0)	45 (2)	334 (0)
Max	31	8	7.6	7.6	18.2	66	286.1
Min	28	4	6.1	5.7	0.6	2	8.1
Mean	30.4	6.04	6.84	6.27	4.86	11.9	62.35
Count	42	42	42	42	42	42	42

	NH3-N (mg/L)			**Flow (mgd)**	
	daily avg	daily max	lbs/day	daily avg	daily max
Limit (no. of exceedances)	3 (11)	10 (2)* 7(3)**	50 (3)	2 (0)	N/A
Max	15.12	18.7	154.664	1.788	7.886
Min	0.092	0.167	0.912	0.057	1.348
Mean	2.29	4.14	22.01	0.605	3.25
Count	42	38	42	42	42

	DE-CHLOR (mg/L)	**CL2 Res (mg/L)**	**BOD Carb (mg/L)**		
	max	min	daily avg	daily max	lbs/day
Limit (no. of exceedances)	0.01 (3)	1 (4)	20 (1)	45 (2)	334 (1)
Max	1.8	1.6	23.55	108	533.38
Min	0.02	0	1.62	2	17.74
Mean	0.155	0.983	5.85	13.57	77.16
Count	42	42	42	42	42

*Limit ranges from July 1996-January 2000

**Limit ranges from January 2000-August 2001

Table 6-26. TPDES Permit Limits and Discharge Monitoring Data for TPDES 0087360 (City of New London).

Data Source: TCEQ Period: January 1997-July 2002 Segment: 611

	Discharge (day)	**DO (mg/L)**	**pH**		**BOD5 (mg/L)**	
	days/month	min	max	min	daily avg	lbs/day
Limit (no. of exceedances)	N/A	4 (2)	9 (0)	6 (0)	30 (3)	25(5)
Max	31	8.75	8.95	8.14	35.5	40
Min	28	2.85	7.51	7	8.5	3.47
Mean	30.41	5.25	8.07	7.64	19.06	12.55
Count	56	56	56	56	56	56

	TSS (mg/L)		**Flow (mgd)**	
	daily avg	lbs/day	daily avg	daily max
Limit (no. of exceedances)	90 (0)	75 (1)	0.1 (0)	N/A
Max	69.6	75.6	0.0941	0.42428
Min	5.2	2.4	0.02509	0.04127
Mean	31.9	21.86	0.056	0.157
Count	56	56	56	56

Table 6-27. TPDES Permit Limits and Discharge Monitoring Data for TPDES 0054194 (City of Arp).

Data Source: TCEQ Period: January 1997-July 2002 Segment: 611

	Discharge (day)	**DO (mg/L)**	**pH**		**BOD5 (mg/L)**	
	days/month	min	max	min	daily avg	lbs/day
Limit (no. of exceedances)	N/A	2 (0)	9 (0)	6 (0)	20 (0)	35 (0)
Max	31	8.2	7.8	7.8	8.8	11.4
Min	28	3.8	6.9	6.9	2	0.6
Mean	30.44	5.6	7.36	7.36	4.22	2.72
Count	48	48	48	48	48	48

	TSS (mg/L)		**Flow (mgd)**		**CL2 Res (mg/L)**	
	daily avg	lbs/day	daily avg	daily max	max	min
Limit (no. of exceedances)	20 (3)	35 (2)	0.211 (1)	N/A	4 (3)	1 (10)
Max	25.8	90.7	0.231	0.489	4.8	1.2
Min	1.5	0.6	0.031	0.049	2.2	0.3
Mean	9.03	8.66	0.078	0.18	3.53	0.967
Count	48	48	48	48	48	48

Table 6-28. TPDES Permit Limits and Discharge Monitoring Data for TPDES 0047988 (City of Tyler - Southside Plant).

Data Source: TCEQ Period: January 1997-July 2002 Segment: 611

	Discharge (day)	DO (mg/L)	pH		Flow (mgd)	
	days/month	min	max	min	daily avg	daily max
Limit (no. of exceedances)	N/A	5 (0)* 4 (0)	9 (0)	6 (0)	9 (0)	N/A
Max	31	6.6	7.25	7	5.801	11.433
Min	28	5	6.42	6.15	4.087	0.74
Mean	30.39	5.74	6.98	6.48	4.9	6.28
Count	38	38	38	38	38	38

	NH3-N (mg/L)			TSS (mg/L)		
	daily avg	daily max	lbs/day	daily avg	daily max	lbs/day
Limit (no. of exceedances)	3 (0)* 15 (0)	10 (1)	225 (0)* 1126 (0)	15 (0)	40 (1)	1126 (0)
Max	2.9	10.6	98.6	11.4	60	598.5
Min	0.1	0.1	2.2	2.1	4	84.7
Mean	0.713	2.57	29.26	5.16	11.49	225.24
Count	38	38	38	38	38	38

	De-chlor (mg/L)	CL2 Res (mg/L)	BOD Carb (mg/L)		
	max	min	daily avg	daily max	lbs/day
Limit (no. of exceedances)	0.1 (0)	1 (0)	10 (0)	25 (0)	751 (0)
Max	0	1.3	6.7	13.6	259.8
Min	0	1	2	2.2	73.5
Mean	0	1.04	2.7	4.62	111.54
Count	38	38	38	38	38

*Limits for these parameters shift between the listed values multiple times from 1997- 2002

Table 6-29. TPDES Permit Limits and Discharge Monitoring Data for TPDES 0072770

(City of Whitehouse - Blackhawk Creek).

Data Source: TCEQ Period: January 1997-July 2002 Segment: 611

	Discharge (day)	**DO (mg/L)**	**pH**		**Flow (mgd)**	
	days/month	min	max	min	daily avg	daily max
Limit (no. of exceedances)	N/A	6 (6)	9 (0)	6 (0)	0.68 (3)	N/A
Max	31	8.2	7.84	7.3	0.809807	1058.9
Min	28	5.2	6.18	6	0.299056	0.37125
Mean	30.43	6.66	7.17	6.67	0.462	18.29
Count	60	60	60	60	60	60

	NH3-N (mg/L)			**TSS (mg/L)**		
	daily avg	daily max	lbs/day	daily avg	daily max	lbs/day
Limit (no. of exceedances)	2 (22)	10 (6)	11 (18)	15 (1)	40 (2)	85 (1)
Max	11.63	16.42	186	39	133	141.1
Min	0.026	0.084	0.095	1	1	3.6
Mean	2.19	3.96	11.37	4.93	10.28	19.34
Count	60	60	60	60	60	60

	CL2 Res (mg/L)		**BOD Carb (mg/L)**		
	max	min	daily avg	daily max	lbs/day
Limit (no. of exceedances)	4 (4)	1 (0)	10 (1)	25 (1)	57 (1)
Max	4.8	1.7	26.71	38	90.72
Min	1.8	1	2	2	5.6
Mean	3.32	1.08	3.61	6.11	13.62
Count	60	60	60	60	60

Table 6-30. TPDES Permit Limits and Discharge Monitoring Data for TPDES 0095419 (City of Whitehouse - Quail Lane Facility).

Data Source: TCEQ Period: January 1997-July 2002 Segment: 611

	Discharge (day)	**DO (mg/L)**	**pH**		**BOD5 (mg/L)**	
	days/month	min	max	min	daily avg	lbs/day
Limit (no. of exceedances)	N/A	2 (0)	9 (0)	6 (0)	20 (0)	6.9 (0)
Max	31	6.4	7.7	7.5	10.6	1.9
Min	28	2.6	7.19	6.7	2.8	0.08
Mean	30.41	3.97	7.46	7.16	5.93	0.639
Count	37	37	37	37	37	37

	TSS (mg/L)		**Flow (mgd)**		**CL2 Res (mg/L)**	
	daily avg	lbs/day	daily avg	daily max	max	min
Limit (no. of exceedances)	20 (0)	6.9 (0)	0.041 (0)	N/A	4 (0)	1 (0)
Max	15.4	2	0.0292	0.0365	3.4	2.1
Min	1.4	0.1	0.0037	0.0076	2.2	1
Mean	4.46	0.503	0.015	0.023	2.49	1.79
Count	37	37	37	37	37	37

Table 6-31. TPDES Permit Limits and Discharge Monitoring Data for TPDES 0101010 (Tall Timbers Utilities).

Data Source: TCEQ Period: January 1997-March 2000 Segment: 611

	Discharge (day)	DO (mg/L)	pH		TSS (mg/L)	
	days/month	min	max	min	daily avg	lbs/day
Limit (no. of exceedances)	N/A	4 (0)* 6(0)	9 (0)	6 (0)	15 (2)	31 (0)
Max	31	9.85	7.99	7.63	18.4	30.1
Min	0	6	7.43	7	3.5	4.6
Mean	29.59	7.42	7.69	7.33	7.86	11.75
Count	37	37	37	37	37	37

	NH3-N (mg/L)		Flow (mgd)		CL2 Res (mg/L)	
	daily avg	lbs/day	daily avg	daily max	max	min
Limit (no. of exceedances)	3 (1)	6.3 (1)	0.25 (0)	N/A	4 (0)	1 (0)
Max	6.89	10.61	0.204291	0.4139	4	1.6
Min	0.03	0.06	0.1231	0.1585	1.54	1
Mean	0.999	1.55	0.168	0.218	2.39	1.12
Count	16	16	37	37	37	37

	BOD Carb (mg/L)		BOD5 (mg/L)**	
	daily avg	lbs/day	daily avg	lbs/day
Limit (no. of exceedances)	10 (0)	21 (0)	10 (1)	16 (1)
Max	4.2	6.53	21	27.2
Min	1.4	2.2	1.4	2.64
Mean	2.34	3.58	5.61	7.75
Count	16	16	21	21

*DO (mg/L) has a limit of 4 mg/L from October 1998-October 1999 and a limit of 6 mg/L from October 1996-September 1998 and October 1999-June 2002.

**Data presented for BOD5 (mg/L) ranges from January 1997-September 1998

Table 6-32. TPDES Permit Limits and Discharge Monitoring Data for TPDES 0098795 (Woodmark Utilities).

Data Source: TCEQ Period: January 1997- September 1999 Segment: 611

	Discharge (day)	DO (mg/L)	pH		BOD5 (mg/L)	
	days/month	min	max	min	daily avg	lbs/day
Limit (no. of exceedances)		2 (0)	9 (0)	6 (0)	20 (1)	16 (0)
Max	31	3	7.9	7.9	21.5	13.98
Min	28	2.2	6.8	6.8	2	1.21
Mean	30.39	2.62	7.38	7.38	9.81	6.6
Count	33	33	33	33	25	25

	TSS (mg/L)		Flow (mgd)	
	daily avg	lbs/day	daily avg	daily max
Limit (no. of exceedances)	20 (7)	16 (2)	0.094 (0)	
Max	45.5	32.3	0.089	0.089
Min	2.3	1.5	0.045	0.049
Mean	13.83	8.91	0.0748	0.077
Count	33	33	33	

	CL2 Res (mg/L)		BOD Carb (mg/L)	
	max	min	daily avg	lbs/day
Limit (no. of exceedances)	4 (0)	1 (0)	20 (0)	16 (0)
Max	3.5	2.9	16.5	9.63
Min	1.9	1.5	4.3	2.3
Mean	2.65	2.12	9.53	4.89
Count	33	33	8	8

Table 6-33. TPDES Permit Limits and Discharge Monitoring Data for TPDES 0117790 (Garrison Clay Mine).

Data Source: TCEQ Period: January 1997-March 2001 Segment: 612

	Discharge (day)	**pH**		**TSS (mg/L)**	**Aluminum (mg/L)**	**Flow (mgd)**	
	days/month	max	min	daily max	daily avg	daily avg	daily max
Limit (no. of exceedances)	N/A	9 (0)	6 (0)	60 (7)	N/A	N/A	N/A
Max	10	8.97	8.97	112	16.6	6800	54000
Min	0	6.7	6.7	4	0.01	0.296	0.403
Mean	1.31	7.7	7.67	30.36	2.77	327.71	2158.36
Count	93	36	36	36	36	33	33

Table 6-34. TPDES Permit Limits and Discharge Monitoring Data for TPDES 0076503 (City of Garrison Wwtp).

Data Source: TCEQ Period: January 1997-July 2002 Segment: 612

	Discharge (day)	**DO (mg/L)**	**pH**		**BOD5 (mg/L)**	
	days/month	min	max	min	daily avg	lbs/day
Limit (no. of exceedances)	N/A	4 (35)	9 (1)	6 (2)	30 (14)	30 (3)
Max	31	5.89	9.45	8.68	50.3	36.49
Min	0	2.29	6.71	5.37	2.68	1.64
Mean	22.52	3.76	7.67	7.05	20.61	15.58
Count	65	67	67	67	67	67

	TSS (mg/L)		**Flow (mgd)**		**CL2 Res (mg/L)**	
	daily avg	lbs/day	daily avg	daily max	max	min
Limit (no. of exceedances)	90 (0)	90 (0)	0.12 (0)	N/A	4 (3)	1 (31)
Max	71.9	55.6	0.117	0.842	5	2
Min	3.3	2.3	0.072	0.084	1.3	0.01
Mean	16.5	12.07	0.084	0.125	2.73	0.95
Count	67	67	67	67	67	67

Table 6-35. Permit Limits and Discharge Monitoring Data for WQ0011857-001 (Chapel Hill Independent School District).

Data Source: TCEQ Period: January 1997-July 2002 Segment: 613

	pH	**Total Nitrogen (mg/kg)**	**Total Phosphorus (mg/kg)**	**Potassium (mg/kg)**	**Conductivity**
	max	ind grab	ind grab	ind grab	max
Limit (no. of exceedances)	9 (0)	N/A	N/A	N/A	N/A
Max	7.2	935	290	650	250
Min	4.9	42.1	26.9	140	56
Mean	6.13	344.85	142.84	377.27	151.94
Count	11	11	11	11	11

7.0 Preliminary Model Selection

Segments of the Sam Rayburn Reservoir (0610 and 0615) are on the 2000 Texas section 303(d) list due to impairments by depressed dissolved oxygen, pH, aluminum, and other constituents of concern. The objective of this section is to present a potential modeling approach capable of meeting TMDL development needs for Sam Rayburn Reservoir. This document presents selection criteria, modeling options, and the preliminary proposed modeling approach. The modeling approach presented is based on review of the data available for the watershed and reservoir data. Future phases of this project may indicate that modifications of the proposed approach are necessary.

7.1 Selection Criteria

In selecting an appropriate modeling platform for Sam Rayburn Reservoir TMDL development, the following criteria have been considered and addressed (expanding on classification of Mao, 1992):

- Technical Criteria
- Regulatory Criteria
- User Criteria

Technical criteria refer to the model's simulation of the physical system in question, including watershed and/or stream characteristics/processes and constituents of interest. Regulatory criteria make up the constraints imposed by regulations, such as water quality standards or procedural protocol. User criteria comprise the operational or economical constraints imposed by the end-user and include factors such as hardware/software compatibility and financial resources. The following discussion details considerations within each of these categories specific to Sam Rayburn Reservoir.

7.1.1 Technical Criteria

7.1.1.1 Physical Domain

Representation of the physical domain is perhaps the most important consideration in selecting a model. The physical domain refers to the focus of the modeling effort - typically either the receiving water itself or a combination of the contributing watershed and the receiving water. Selection of the appropriate modeling domain depends on the constituents of interest and the conditions under which the waterbody exhibits impairment. For a waterbody dominated by point source inputs that exhibits impairments under only low-flow conditions, a steady-state approach is typically undertaken. This type of modeling approach focuses only on in-stream (receiving water) processes during a user-specified condition, such as 7Q2 flow.

For waterbodies impacted additionally or solely by nonpoint sources or primarily rainfall-driven flow and pollutant contributions, a dynamic approach is recommended. Dynamic watershed models consider time-variable nonpoint source contributions from a watershed surface or subsurface. Some models consider monthly or seasonal variability while others enable assessment of conditions immediately before, during, and after individual rainfall events. A dynamic receiving water model is recommended for Sam Rayburn Reservoir due to the considerable variability in hydrodynamic and water quality conditions it exhibits throughout the year and from one year to the next. The necessity for a dynamic watershed component will be addressed later in this section.

7.1.1.2 Critical Conditions

The goal of the TMDL is to determine the assimilative capacity of a waterbody and to identify potential allocation scenarios that enable the waterbody to achieve water quality criteria under all conditions. The critical condition is the set of environmental conditions for which controls designed to protect water quality will ensure attainment of objectives for all other conditions. This is typically the period of time in which the stream exhibits the most vulnerability.

Based on a review of the available data, critical conditions for dissolved oxygen in Sam Rayburn Reservoir occur mostly in late spring, summer, and early fall (refer to Appendices 4B and 4D). The lowest dissolved oxygen was observed in Sam Rayburn Reservoir during late summer in the hypolimnion.

With the critical period being from mid-summer to late-fall, it's possible that DO levels are depressed due to any of a number of reasons:

- point source contributions (facilities are identified in Section 6.2)
- excessive growth of algae or aquatic vegetation
- contributions from nonpoint sources that cumulatively impact the reservoir
- internal recycling of nutrients (release and settling from bottom sediments)
- a combination of the above in conjunction with specific climatic conditions

7.1.1.3 Constituents

Another important consideration in model selection and application is choosing appropriate constituents to simulate. Choice of state variables is a critical part of model implementation. The more state variables included, the more difficult the model will be to implement and calibrate. However, if key state variables are omitted from the simulation, the model may not simulate all necessary aspects of the system and may produce unrealistic results. A delicate balance must be met between minimal constituent simulation and maximum applicability.

While it is desirable to model only state variables for which data are available, this is not always appropriate when unmonitored components are essential to the understanding of key state variables. For instance, both dissolved and particulate phases must generally be included. Simulation models have differing abilities to represent types of constituents. Distinctions may include conservative vs. degrading, dissolved vs. sediment sorbed, and organic vs. inorganic constituents.

The focus of TMDL development for Sam Rayburn Reservoir is on DO and possibly metals, although additional monitoring will be necessary to confirm metals impairments. Reservoir DO dynamics can be extremely complex, and accurate estimation of DO levels relies on a host of interrelated factors. DO in the water column may be influenced by reaeration, oxidation of carbonaceous and nitrogenous materials, aquatic life respiration, algae and plant productivity, and oxygen demand exerted by sediments. Each of these components is impacted by numerous additional factors, such as temperature, light availability, salinity, and contributions of nutrients and biochemical oxygen demand from point and nonpoint sources.

Based on a review of the available data, some preliminary conclusions can be made regarding DO dynamics in the impaired waterbody:

- Depth profile data indicate that dissolved oxygen stratification occurs during summer months, resulting in hypolimnetic oxygen deficits.
- Nutrient concentrations (nitrogen and phosphorus) were often very high when compared to the nutrient screening levels and EPA nutrient reference criteria under all conditions (Section 4.0). This may indicate that storm washoff as well as agricultural infiltration and septic systems impact the reservoir.

7.1.1.4 Source Contributions

Primary sources of pollution to a waterbody must be considered in the model selection process. Accurately representing contributions from permitted point sources and nonpoint source contributions from urban, agricultural, and natural areas is critical in properly representing the system and ultimately evaluating potential load reduction scenarios. Likely contributors have been identified in Section 6.0 of this document.

Sam Rayburn Reservoir and many of its tributaries receive contributions from 44 permitted facilities and a range of nonpoint sources. The Sam Rayburn Reservoir watershed is composed of predominantly forest land, although there are pockets of pasture, cropland, and silviculture throughout the watershed as well as small populated areas. These types of landuses have potential to contribute significant amounts of carbonaceous and nitrogenous materials that may have a detrimental impact on reservoir DO levels. There are clearly a number of stressors in the Sam Rayburn Reservoir watershed that can detrimentally impact DO concentrations.

Also multiple nonpoint and point sources are likely impacting the level of metals, therefore the modeling platform must be able to account for their contributions and represent key processes. For example, aluminum contributions from natural background/geological conditions or bentonite/clay mining operations impact the stream under different conditions and in a different manner than those from a permitted facility, such as a paper mill.

7.1.2 Regulatory Criteria

A properly designed and applied model provides the source-response linkage component of the TMDL and enables accurate assimilative capacity assessment and allocation proposition. A waterbody's assimilative capacity is determined through adherence to predefined water quality criteria. Texas Surface Water Quality Standards define applicable dissolved oxygen and metals criteria for Sam Rayburn Reservoir (Section 1.3). These criteria are the target for TMDL modeling exercises. Therefore, the proposed modeling platform must enable direct comparison of model results to both daily mean and minimum oxygen values and other listed constituents such as metals.

7.1.3 User Criteria

User criteria are determined by the needs, expectations, and resources of TCEQ and the Sam Rayburn Reservoir stakeholders. A number of these criteria are defined in TCEQ's TMDL guidance document, including compatibility with TCEQ platforms and funding resource availability (TNRCC, 1999). Modeling software must be compatible with existing TNRCC UNIX- or personal-computer-based hardware platforms and due to future use for planning and permitting decisions should be well-documented, tested, and accepted. From a resource perspective, the level of effort required to develop, calibrate, and apply the model must be commensurate with available funding, without compromising the ability to meet technical criteria. In addition to these primary criteria, the required time-frame for model development, application, and completion is important, as well as the level of concern or priority of the impaired stream.

7.2 Proposed Modeling Approach

The technical, regulatory, and user criteria identified in the previous section of the report helped to narrow the field of appropriate models. The following discussion recommends one general approach with a number of available modeling options, as well as general data needs to support model development, calibration, and verification in both cases.

7.2.1 Proposed Approach

Model application and TMDL development for Sam Rayburn Reservoir will likely require combination of a watershed loading model and a reservoir model. This preliminary assessment is based on review of available data and the technical criteria defined above. A watershed component is necessary to simulate the dynamic contribution of nonpoint source oxygen-impacting contributions as well as metals and other constituents of concern. This will support evaluation of the impact of different sources, differentiation between natural and anthropogenic contributions, and testing implementation scenarios for watershed management. Lead candidates for the watershed modeling component include two models of variable complexity:

- **Loading Simulation Program in C++ (LSPC) -** a GIS-based watershed assesssment, analysis, and TMDL development system with similar capabilities as the Hydrologic Simulation Program in FORTRAN (HSPF).
- **Generalized Watershed Laoding Function (GWLF) -** a simplified watershed hydrologic and water quality model (that primarily supports nutrient and sediment analyses). Metal analysis would require a separate model or analytical method.

A dynamic reservoir modeling component is necessary to evaluate the response of the reservoir to dynamic loadings from point and nonpoint sources, including potential in-reservoir sources such as sediment oxygen demand. It will receive time-variable outputs (flow and pollutant loads) directly from the watershed model. With the variability in impairment locations exhibited by the reservoir (e.g., aluminum and pH impairments that tend to be in isolated regions of the reservoir), it's expected that a multi-dimensional model will need to be applied. A two- (2D) or three-dimensional (3D) model will permit evaluation of vertical or lateral variability in the reservoir, as is exhibited in available monitoring data. Lead candidates for the reservoir modeling component are:

- **Environmental Fluid Dynamics Code (EFDC) -** a dynamic 2D/3D model capable of simulating temperature stratification, complex transport, and water quality processes including eutrophication and sediment diagenesis in reservoir systems and
- **CE-QUAL-W2** - a dynamic 2D model that simulates hydrodynamics and water quality processes . CE-QUAL-W2 does not explicitly simulate aluminum, however, model results can be used to support additional analyses.

Regardless of the specific models selected, the same general approach will apply for any combination of the watershed and reservoir models. Therefore, since there is potential for application to more parameters than DO, the following discussion presents linkage of the two more complex and comprehensive models (LSPC and EFDC)

7.2.2 LSPC

LSPC is proposed for simulation of watershed processes, including hydrology and pollutant accumulation and washoff. LSPC is a re-coded version of EPA's HSPF that has been developed through a joint effort between EPA and Tetra Tech, Inc. and offers a number of advantages over HSPF (Bicknell et al., 1996). The program is non-proprietary, supported by EPA, and will be one of the core models in the next generation modeling toolbox being developed by EPA Region 4. It integrates a geographical information system (GIS), comprehensive data storage and management capabilities, dynamic watershed model algorithms (HSPF), and a data analysis/post-processing system into a convenient PC-based windows interface that dictates no software requirements. Direct linkages are also available to the EFDC, an advanced 1-, 2-, or 3-D hydrodynamic and water quality model, which is proposed for simulation of reservoir processes for Sam Rayburn Reservoir (Hamrick, 1996).

Application of the watershed modeling component will entail subdivision of upstream tributaries into smaller subwatersheds with distinct hydrologic components. Each of these subwatersheds will be represented by a suite of parameters that characterize hydrology and water quality constituent loading characteristics. Hydrologic parameters will be based primarily on soil and landuse characteristics and will define the amount of surface runoff, infiltration, interflow, and groundwater flow occurring. Water quality constituent characteristics will additionally vary by landuse. These characteristics will define the loading of primary parameters that impact in-stream DO, such as nitrogen, phosphorus, BOD, and total suspended solids/sediment. If required the model can also simulate metals. Using continuous observed rainfall and meteorological data from stations identified during the data review as the driver, the model will estimate flow and water quality characteristics (loadings and/or concentrations) on a time-variable basis.

7.2.3 EFDC

Flow and water quality characteristics from LSPC will, in turn, be applied directly to the EFDC receiving water model. EFDC is a comprehensive 1-, 2-, or 3-dimensional model capable of simulating hydrodynamics, salinity, temperature, suspended sediment, water quality, algae, and the fate of toxic materials. The model uses stretched or sigma vertical coordinates and Cartesian or curvilinear, orthogonal horizontal coordinates to represent the physical characteristics of a waterbody. The hydrodynamic portion of the model solves three-dimensional, vertically hydrostatic, free surface, turbulent averaged equations of motion for a variable-density fluid. Dynamically-coupled transport

equations for turbulent kinetic energy, turbulent length scale, salinity and temperature are also solved. The EFDC model also simultaneously solves an arbitrary number of Eulerian transport-transformation equations for dissolved and suspended materials. The EFDC model allows for drying and wetting in shallow areas by a mass conservation scheme. The physics of the EFDC model and many aspects of the computational scheme are equivalent to the widely used Blumberg-Mellor model (Blumberg & Mellor, 1987) and U. S. Army Corps of Engineers' Chesapeake Bay model (Johnson, et al, 1993).

The water quality portion of the model simulates the spatial and temporal distributions of 22 water quality parameters including dissolved oxygen, suspended algae (3 groups),attached algae, various components of carbon, nitrogen, phosphorus and silica cycles, and fecal coliform bacteria. Salinity, water temperature, and total suspended solids are needed for computation of the twenty-two state variables, and they are provided by the hydrodynamic model. The kinetic processes included in this model use the Chesapeake Bay three-dimensional water quality model, CE-QUAL.ICM (Cerco & Cole, 1994).

A sediment process model with 27 state variable is also included in the EFDC model. It uses a slightly modified version of the Chesapeake Bay three-dimensional model (DiToro & Fitzpatrick, 1993). The sediment process model, upon receiving the particulate organic matter deposited from the overlying water column, simulates their diagenesis and the resulting fluxes of inorganic substances (ammonium, nitrate, phosphate and silica) and sediment oxygen demand back to the water column. The coupling of the sediment process model with the water quality model not only enhances the model's predictive capability of water quality parameters but also enables it to simulate the long-term changes in water quality conditions in response to changes in nutrient loads. The EFDC model also has a toxicant model that can used to simulate metals if desired. The output of the hydrodynamic and sediment model are linked to the toxicant model to simulate metals.

Application of EFDC will require segmentation of the reservoir into multiple grid cells and definition of hydraulic characteristics and boundary conditions. A 3-dimensional representation is expected. Boundary conditions will include nonpoint source contributions from the watershed and point source contributions (defined by discharge monitoring report data identified during the data review process). Due to the inherent solutions of the water quality model, it will be necessary to convert the BOD from the point sources and the LSPC model to TOC. EFDC is a carbon-based water quality model, and therefore, the model simulates organic matter as carbon rather than BOD. This conversion will be based on an analysis of BOD-TOC ratios. An average ratio will be calculated from monitoring data for each watershed (since these ratios vary dramatically, particularly by landuse). The watershed loads simulated by LSPC are with respect to BOD, TN, TP, and TSS (although individual nitrogen and phosphorus components can be simulated explicitly, if deemed necessary). The EFDC model will be applied for a selected time period leading up to, during, and after critical conditions occur.

8.0 Conclusions

Sam Rayburn Reservoir was placed on Texas's 2000 and 2002 section 303(d) lists of impaired waterbodies for dissolved oxygen, pH, and aluminum impairments, therefore, these three parameters were analyzed for the reservoir. Any parameters that affect dissolved oxygen (i.e., nutrients and chlorophyll a) were also included in the analysis. Additional parameters were included in the analysis at the request of TCEQ to determine whether there are any other potential impairments of the reservoir. Data for the reservoir, its tributaries, and any potential pollutant sources were analyzed to better understand their influences on the reservoir. This section provides conclusion based on the data analysis.

8.1 Sam Rayburn Reservoir (Segment 0610 and 0615)

Dissolved Oxygen

The bulk of Sam Rayburn Reservoir generally meets the water quality criteria prescribed by TCEQ. Based on the data analysis for 1990 through 2002, a total of 3 exceedances were observed throughout the main body of the reservoir (segments 0610. 0610A, and 0615). Two exceedances were observed on Ayish Bayou (segment 0610A) and one exceedance in the main pool of the reservoir (segment 0610). There were no exceedances on Attoyac Bayou, but both Attoyac Bayou and Ayish Bayou showed very low hypolimnetic DO at times. Segment 0615 of the reservoir had several more DO exceedances than segment 0610, with 19 exceedances of the DO minimum and 6 exceedances of the DO average criteria. The low DO concentrations occurred mainly in August of 1996 , which was a wet month after a long drought. The reservoir was at its lowest levels in several years.

The reservoir stratifies in the summer months and has very low DO in the hypolimnion during stratification with concentrations often below 3.0 mg/L. The DO criteria only apply to the mixed layer, which can be very shallow at times. During summer stratification the DO concentrations are almost always low in the hypolimnion, however, very low DO concentrations are also observed in the epilimnion. The mixed layer (based on water temperature) often does not include the entire epilimnion, resulting in high dissolved oxygen concentrations at the surface of the reservoir, but severe oxygen deficits not far below the surface.

Segment 0615 is shallower than segment 0610 and has more direct impact from upstream tributaries (segment 0611 and its subsegments). Nutrient concentrations in the contributing tributaries were high throughout the watershed and were often associated with low DO concentrations in the reservoir. Likely sources of nutrients to the watershed include urbanization, pasture land, point sources, failing septic systems, and erosion. Nutrients can often be associated with high levels of erosion and some tributaries had high TSS observations.

Concentrations of phosphorus, nitrogen, chlorophyll a, and transparency were regularly higher than both the Texas nutrient screening levels and EPA's nutrient reference criteria. Concentrations were high in both segment 0610 and 0615. The STORET nutrient data show especially high concentrations in the arms of the reservoir in August 1996. This was at a time of significant rainfall after a very long drought, allowing for build-up of nutrients in the watershed that were potentially washed off in very large amounts in August 1996. Several of the low DO

concentrations coincided with the high nutrient levels. Potential sources of nutrients to the arms of the reservoir include urbanization, pasture land, and poultry farms along Attoyac Bayou and Moss Creek. There are also several point sources that discharge to Mill Creek and Papermill Creek above segment 0615. While low DO does not appear to be a major problem at this time, there is potential for it to become a problem with the high nutrient concentrations observed at times in the reservoir and the surrounding watershed.

Metals

Dissolved aluminum, dissolved copper, dissolved lead, and dissolved zinc all showed some exceedances of the applicable criteria in the reservoir, but high detection limits made much of the data unusable. There were several exceedances of the 991 µg/L dissolved aluminum criterion. The detection limits for metals in the watershed will be reduced by ANRA and TCEQ for future sampling efforts to obtain data that can be compared to the criteria.

Bacteria

About eight percent of the bacteria samples exceeded the criteria for segment 0610. Most of the exceedances were observed on Ayish Bayou where potential bacteria sources include pasture land, the city of San Augustine at the headwaters, and failing septic systems.

There were many more exceedances of the bacteria criteria on segment 0615 (40 percent). The potential bacteria sources to segment 0615 include several point sources (schools and subdivisions) on Mill Creek and Papermill Creek, the City of Lufkin, the City of Nacogdoches, pasture land, and failing septic systems.

Other Constituents

There were not many exceedances of cloride, sulfate, and TDS in the reservoir, but there were many more exceedances in segment 0615 than 0610.

8.2 Tributaries to Sam Rayburn Reservoir (Segment 0611 and 0612)

The tributaries draining to the Sam Rayburn Reservoir were evaluated to identify spatial influences on the problems in the reservoir.

Dissolved Oxygen

There were not many DO exceedances on segment 0611 and 0612. There were 3 exceedances on segment 0611; one each on La Nana Bayou, Ragsdale Creek at Canada Street, and Caney Creek southeast of the City of Troup. There were no exceedances on segment 0612 (Attoyac Bayou).

Nutrient concentrations were high throughout the watershed. Mud Creek and West Mud Creek, below the City of Tyler, had several observations of high nutrient data. Likely sources of nutrients to the watershed include urbanization, pasture land, point sources, failing septic systems, and erosion. Nutrients can often be associated with high levels of erosion. The highest TSS observations in the watershed were observed at Mud Creek, Attoyac Bayou, and the Angelina

River below La Nana Bayou. High nutrient concentrations appear to be associated with the low DO levels in the reservoir. It is likely that controlling sources of sediment and nutrients to the reservoir would have an affect on the DO concentrations.

Metals

There were exceedances of metals criteria in several of the streams in segment 0611 and 0612. These streams include Mud Creek, the Angelina River, Attoyac Bayou, West Mud Creek, and East Fork Angelina River. Potential sources of metals in the watershed include point sources as well as natural sources. Metals may exist in naturally high levels in the local soils, thereby being washed into the waterbodies with erosion of the soil. Further research into the background levels of metals in soils in the Sam Rayburn Reservoir watershed needs to be conducted. This will help ascertain whether the high metals are anthropogenic or natural.

Bacteria

There were several exceedances of the bacteria criteria on La Nana Bayou and Attoyac Bayou. The Angelina River, East Fork Angelina River, and Mud Creek also showed some bacteria exceedances. The bacteria sources in the watershed are most likely nonpoint and point sources because a strong correlation between streamflow and bacteria concentrations was not identified for any of the stations. It is likely that point sources contribute bacteria to the waterbodies under all flow conditions and nonpoint sources contribute bacteria in washoff to the waterbodies during storm events. Several of the streams in the watershed either flow through cities or have cities at their headwaters that can be major sources of bacteria. Areas of pasture and poultry operations are also potential bacteria sources to the watershed.

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